Southern Company

Southern Company Generation.
241 Ralph McGill Boulevard, NE
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December 20, 2018

FERC Project No. 2336-094
Lloyd Shoals Project
Proposed Study Plan, Georgia Power Response to Stakeholder Scoping Comments and FERC Additional Information Request (AIR) dated November 05, 2018

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Dear Ms. Bose:

On behalf of Georgia Power Company, Southern Company is filing this letter to provide the Proposed Study Plan for relicensing the Lloyd Shoals Project, to respond to stakeholder scoping comments, and to also respond to FERC's Additional Information Request (AIR), dated November 05, 2018.

There are two parts to this filing with five components total:

Part 1 of 2

1) Cover Letter
2) Appendix A – Lloyd Shoals Proposed Study Plan
3) Appendix B – Response to Scoping Comments

Part 2 of 2

4) Cover Letter
5) Appendix C - Response to AIR

If you require further information, please contact me at 404.506.7219.

Sincerely,

Courtenay R. O'Mara

Courtenay R. O'Mara, P.E.
Hydro Licensing and Compliance Supervisor

cc: FERC/OEP – Neetu Deo, Allan Creamer
Geosyntec – Cristin Krachon
Kleinschmidt – Steven Layman, Ph.D.
Troutman Sanders – Hallie Meushaw

APPENDIX C

Lloyd Shoals Project
Response to FERC Additional Information Request
November 5, 2018 (Schedule A)
P-2336-094

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON, D.C. 20426
November 5, 2018

OFFICE OF ENERGY PROJECTS

Project No. 2336-094 – Georgia
Lloyd Shoals Hydroelectric Project
Georgia Power Company

Courtenay O'Mara, P.E.
Hydro Licensing and Compliance Supervisor
Southern Company Generation
241 Ralph McGill Boulevard, NE
BIN 10193
Atlanta, GA 30308-3374

Reference: Staff Comments on the Pre-Application Document and Preliminary Study Proposals for the Lloyd Shoals Hydroelectric Project

Dear Ms. O'Mara:

We have reviewed the Pre-Application Document (PAD) for the Lloyd Shoals Hydroelectric Project No. 2336-094 (Lloyd Shoals Project), filed on July 3, 2018, and participated in the scoping meetings for the project during the week of October 8, 2018.

Based on staff's review of the PAD and the scoping meetings, we need additional information and clarification on the material presented in the PAD. Unless otherwise indicated in the specific request, the information requested (*see* attached Schedule A) should be filed with the proposed study plan on, or before, December 20, 2018. If the requested information is not readily available, the proposed study plan should discuss Georgia Power's plans for gathering the information prior to filing the final license application. In addition, if the requested information causes another part of the PAD to be inaccurate, that part must be revised and provided as well. Please be aware that further requests for additional information may be sent to you at any time before the Commission takes final action on your application. We also provide comments on the preliminary study proposals in Schedule B.

If you have any questions, please contact Navreet Deo at (202) 502-6304, or navreet.deo@ferc.gov.

Sincerely,

Stephen Bowler, Chief
South Branch
Division of Hydropower Licensing

Attachments: Schedule A
Schedule B

SCHEDULE A
ADDITIONAL INFORMATION REQUESTS

Project Description

1. The PAD, on page 7, states that a 19-foot by 12-foot trash gate is located within the spillway section of the dam. Please provide a description of the trash gate, including the capacity, and clarify whether the gate is currently operable. Please describe the past and present uses of the gate (if operable).

2. The PAD, on page 8, describes steel trash rack structures in front of the powerhouse intake(s). The PAD indicates that the trash racks have a clear bar spacing of 1.3125 inches. No other design specifications are provided. To assist us in our review of the project, please include in the Preliminary Licensing Proposal (PLP) and license application: (a) the overall dimensions of each trash rack panel protecting the project intake(s); (b) the number and width of the individual bar racks; and (c) an estimate of the intake velocity for the trash racks, along with the calculations and/or methods used to develop the estimate(s). If any of this information is not available, such information should be obtained as part of the project's study plan.

3. The PAD, on page 8, states that in 2012 an Obermeyer gate system was installed to replace the spillway flashboards. Please provide a description of the Obermeyer gates, including the: (a) composition; (b) operation, including the time required to inflate and deflate each section of gates; (c) conditions under which the gates would fail; and (d) method and frequency of repair.

4. The PAD, on page 8, describes a 500-foot-long auxiliary spillway topped with 10-foot-high flashboards. Please provide: (a) the crest elevation of the auxiliary spillway; (b) the conditions under which the spillway is operated, including the design flow or reservoir elevation which would trigger use of the spillway, and the frequency of use; and (c) a description of the auxiliary spillway flashboards, including the (i) composition, (ii) method of installation, (iii) reservoir elevation at which the flashboards are designed to fail, and (iv) method and frequency of repair.

5. The PAD, on page 9, describes a substation located at the west dam abutment. Please clarify whether the substation is project-owned.

6. Please provide a description of the intake headgates, including the number, composition, and method of operation.

7. Please provide a description of the project tailrace, including the dimensions and normal surface water elevation.

Project Operation

8. The PAD, on page 8, states that the maximum hydraulic capacity of each turbine unit is 620 cubic feet per second. Please provide the minimum hydraulic capacity of each unit.

9. The PAD, on page 9, states that the project is operated in a modified run-of-river mode, where inflow is temporarily stored during periods outside of peak power demand (off-peak hours) and released through the powerhouse to generate energy during periods of peak power demand (on-peak hours). You state that this cycle repeats daily and varies seasonally with peak power demands. Please provide the average number, timing, and duration of peak power demand periods per day, seasonally.

10. The PAD, on page 9, states that the dependable capacity of the project is 22.5 megawatts (MW), while the nameplate rated capacity of the project is 18 MW. Please explain how, and under what conditions, the dependable capacity of the project exceeds the rated generating capacity of the project.

11. The PAD, on page 9, describes two, 2.3-kilovolt project generator leads, which exit the powerhouse and goes to two step-up transformers located in the substation at the west dam abutment. Please provide the length of each generator lead.

12. The PAD, on page 9, states that the project is operated to maintain reservoir elevations between approximately 530 feet and 527 feet Plant Datum[1] (PD) year-round, excluding planned drawdowns. Please provide a record of all planned and unplanned drawdowns that have occurred at the project, including emergency, homeowner maintenance, and dam maintenance drawdowns. For each record please provide the cause, duration, frequency, and extent (feet) of the drawdown, as well as any adverse impacts observed to the aquatic environment.

13. The PAD, on page 10, states that the U.S. Geological Survey (USGS) gage No. 02210500, used to develop the flow and discharge statistics for the Lloyd Shoals Project, is located on the Ocmulgee River, 1.5 miles downstream from Lloyd Shoals Dam (Ocmulgee River near Jackson, Georgia). The PAD, on

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[1] Plant datum = mean sea level elevation (NAVD88, or North American Vertical Datum of 1988) + 0.45 feet.

page 19, states that this gage is located approximately 1 mile downstream from the project dam. Please clarify the location of this gage relative to Lloyd Shoals Dam.

14. The PAD, on page 10, states that during high-flow events, all flows are first passed through the turbine-generator units and, once the maximum hydraulic capacity of the units is exceeded, spillway gates are opened incrementally to approximate inflow. Please clarify the order in which each of the three sections of Obermeyer spillway gates are operated (lowered or deflated) to pass inflow.

15. During the scoping meetings held on October 9, 2018, Georgia Power presented a graph which showed that dissolved oxygen (DO) dropped below the minimum state standard of 4.0 milligrams per liter (mg/L) when the existing draft tube aeration system is offline. To assist us in our review of the project, please provide information on: (a) the frequency and duration of any periods during which the aeration system has not been operational since its installation; (b) the reasons for the system not operating; (c) the ability of the existing minimum flow to maintain the state's DO standard[2] when the system is not operating; and (d) any known effects of low DO on the fish and aquatic community in the Ocmulgee River downstream from Lloyd Shoals Dam.

Geology and Soil Resources

16. The PAD, on page 18, states that potential impacts of continued project operation on geology and soil resources would be limited mainly to Lake Jackson and the tailrace area downstream from the dam. To assist us in determining whose lands and property may be affected by erosion and sedimentation, please provide a map delineating ownership of lands along the reservoir and tailrace shorelines. Please indicate whether land is privately or project-owned. If this information is not available, please obtain the information as part of the project's study plan.

17. The PAD, on page 18, states that the effects of project operations on shoreline erosion and sedimentation within the project boundary will be evaluated. To assist us in our review of erosion and sedimentation issues at the project, please provide any available historical data, including bathymetry, topography, and/or aerial photography that shows how erosion and sedimentation within the project boundary has changed over time.

[2] The applicable DO standard for the project includes a daily average DO of 5.0 mg/L, and no less than 4.0 mg/L DO, at all times.

18. On February 26, 1993, Georgia Power submitted an application to amend the existing license to implement a small dredging permit program at the project, which was approved by the Commission on June 28, 1993. The permit program authorizes Georgia Power to issue permits for minor dredging activities involving 1 to 500 cubic yards of material within the project boundary (e.g., for repair of bulkheads and boat docks), and requires the filing of an annual report listing any dredging permits issued for between 25 and 500 cubic yards of material. To assist our review of how project operation may affect geology and soil resources, for all dredging permits issued at the project please provide: (a) a description of each event, including the purpose, volume of material removed, and equipment used; (b) the date(s) and duration of each event; (b) the location and site characteristics (e.g. soil or substrate composition, vegetative cover, proximity to wetland habitats, etc.) of each event, including a map; (c) the location and characteristics of all disposal sites, including a map; and (d) methods used to prevent turbidity and the transport of the disturbed material downstream.

Water Quality, Fisheries, and Aquatic Resources

19. During the environmental site review on October 10, 2018, Georgia Power staff referenced a 2014 Ocmulgee Water Quality Study. The PAD does not appear to reference this study. Please describe the study referenced during the site review and provide a copy of the final study report.

20. During the October 9, 2018, scoping meetings, there was mention of work done in 2012 by Dr. Alan Wilson, an Auburn University Professor, regarding water quality issues (e.g., algal blooms [including cyanobacteria], sedimentation, nutrients, etc.) in Lake Jackson. This work was also referenced by Ms. Julia Haar in her September 25, 2018, filing with the Commission. More specifically, Ms. Haar provided a copy of a presentation given to the Jackson Lake Homeowners Association (Homeowners Association) on June 22, 2012, by Dr. Wilson and two Georgia Power staff members that addressed water quality issues in Lake Jackson. The PAD does not reference Dr. Wilson's work, and it is unclear if the June 22, 2012, presentation to the Homeowners Association is based on a report, or some other work done by Dr. Wilson.[3] To assist us in understanding the issues being raised in the September 25, 2018, filing, and at the October 9, 2018, scoping meeting, please provide a copy of any report(s) that served as the basis for the June 22, 2012, presentation to the Homeowners Association, if available.

[3] We are aware that Dr. Alan Wilson helped produce a water quality report for Alabama in 2012.

21. The PAD, on page 24, describes the DO issues that occurred historically at the project. The PAD states that, in 2006, Georgia Power fitted three of the project's six turbine units with passive draft tube aeration systems. We observed one of the units operating (with the aeration system on) during the October 10, 2018, environmental site review. The PAD, however, does not describe the systems or their operation. Therefore, please provide: (a) a detailed description of the aeration technology, and its installation and operation at the Lloyd Shoals Project; (b) a description of which units are equipped with the draft tube aeration systems; (c) the dates when the systems are turned on and turned off for the year; and (d) the number of times, since the systems were installed, that any or all of the system(s) were not operating during their normal operational period, and, for each event, a description why the system(s) were not operating and any known consequence (e.g., a drop in DO concentrations and any effects on the downstream aquatic community). Item (d) can be addressed as part of your response to AIR#15.

22. The PAD, on page 8, states that the invert elevation of the project intake is 495 feet PD, which is 35 feet below the normal full-pool elevation of Lake Jackson. To assist us in reviewing water quality issues at the project, please describe the relationship between the intake's invert elevation and the typical depth at which thermal and DO stratification occurs in Lake Jackson.

23. The PAD, on pages 25 and 26, lists a variety of information that is available to: (a) characterize the fish and aquatic resources in the vicinity of the Lloyd Shoals Project; and (b) evaluate the potential resource effects of continued project operation. None of the references are provided as part of the PAD. Please provide copies of:

    a. the instream flow study report prepared by EA Engineering, Science, and Technology, Inc. (1990);
    b. the angler catch data collected by the Georgia Bass Chapter Federation for Lake Jackson and other Georgia lakes from bass tournaments for the past 20 years (GBCF, 1996-2015);
    c. the American shad habitat plan (Georgia DNR, 2014) and the American shad stocking plan for the Altamaha River (Atlantic States Marine Fisheries Commission, 2013);
    d. the scientific literature on the distribution of fishes in the Ocmulgee River (Bart *et al*., 1994; Nuckols and Roghair, 2004), habitat use and movements of robust redhorse (Jennings and Shepard, 2003; Grabowski and Jennings, 2009; Pruitt, 2013), and spawning migrations and habitat use of Atlantic sturgeon in the Altamaha River basin (Ingram and Peterson, 2016); and
    e. Georgia DNR-Nongame Conservation Section's records of mollusks in the

upper Ocmulgee River Basin, 2008-2014; and the scientific literature on the distribution of, and suitable host fishes for, freshwater mussels from the Altamaha River Basin (Wisniewski *et al*., 2005; Johnson *et al*., 2012).

24. The PAD, on page 27, references the Ocmulgee Candidate Conservation Agreement with Assurances for Robust Redhorse (Georgia Power, 2016, as cited in the PAD). The agreement is described in some detail in the PAD on pages 45 and 46. Please file a copy of this agreement. In addition, the PAD, on page 30, indicates that this agreement expires with the current license term in December 2023. The PAD is silent with regard to any new agreement for the robust redhorse. Please clarify whether Georgia Power intends to pursue an extension of the existing agreement, or a new agreement for the species.

25. Ms. Julie Haar, in a September 25, 2018, filing, and in speaking at the October 9, 2018, scoping meeting, presented documentation (including a picture) of a fish kill in a cove of Lake Jackson near Elizabeth Circle in Butts County, Georgia. This fish kill also involved an unspecified number of turtles. The PAD provides no information on this event, or any other similar events. To assist us in understanding such occurrences, including cause and severity, please provide: (a) a description of the fish kill that occurred in 2012, as referenced in the September 25, 2018, filing, including its cause, severity, and what measures, if any, were taken to prevent future fish kills; (b) a list of other species that were affected by the event; and (c) a description of any other known fish kills that have occurred during the current license term at the Lloyd Shoals Project, including their cause, severity, and measures taken to address them.

Wildlife, Botanical Resources, and Threatened and Endangered Species

26. The PAD, on pages 46 and 47, describes the Ocmulgee Candidate Conservation Agreement for Mollusks of the Altamaha River Basin (Georgia Power, 2017b, as cited in the PAD). Please file a copy of this agreement.

27. The PAD, on pages 36, 39 and 40, references previous studies conducted by Georgia Power for the prior relicensing effort that identified upland and wetland plant community/cover types. To facilitate our review of the project and environmental analysis regarding changes to the project area since the previous relicensing, please file a copy of *Wetland plant communities of the Lloyd Shoals hydroelectric project (Gaddy, 1989*).

28. The PAD, on page 38, indicates that Georgia Power's timber and land management activities on undeveloped lands within, and next to, the project boundary support wildlife habitat and avoid disturbance to active bald eagle nests

on Lake Jackson. To facilitate our review of timber and land management activities at the project, please file any existing Georgia Power timber and/or land management plans, programs, and/or policies that apply to Lake Jackson and the lands around it described above.

29. The PAD, on page 39, mentions Georgia Power's efforts to control non-native invasive plants[4] within the project boundary.[5] However, it does not describe the methods used to treat non-native invasive terrestrial and aquatic plants, or any other regular vegetation management practices within the project boundary. To facilitate our review of the project's potential effects on botanical resources and wildlife habitat, please provide a more detailed description of existing vegetation management practices throughout the Lloyd Shoals Project area (e.g., project recreation sites, access roads, and other project facilities or areas that Georgia Power maintains). Specifically, please include detailed information on: (a) the areas of vegetation that are maintained; (b) the goals, objectives, and methods of vegetation management (e.g., manual, mechanical, or chemical treatments, regular plantings) used in each area; (c) the frequency of treatments; and (d) any vegetation monitoring that is conducted. If the information is not currently compiled, please include a provision to gather and provide information on existing and proposed invasive species and vegetation management practices with the results of your proposed Wildlife and Botanical Resource Study and Wetlands, Riparian, and Littoral Habitat Study.

30. Section 5.6(d)(3)(vi) of the Commission's regulations require that the PAD include estimates of acreage for each type of wetland, riparian, and littoral habitat, including variability in such availability as a function of storage at a project that is not operated in a run-of-river mode. The PAD, on pages 39 and 110, provides estimates of total wetland acreage in the project boundary, but does not discuss the variability in these habitats associated with project operation. The Lloyd Shoals Project is operated in a modified run-of-river mode, with up to a 3-foot reservoir drawdown on a daily basis. Thus, if available, please provide the estimated

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[4] Table 16 on page 100 of the PAD lists the noxious weeds and non-native invasive plants (i.e., Category 1 and Category 1 Alert Invasive Plant Species) identified in Butts, Henry, Jasper, and Newton Counties, and in the Oconee National Forest and Piedmont National Wildlife Refuge (Georgia Exotic Pest Plant Council, 2006).

[5] "Georgia Power proactively monitors the occurrence of and periodically treats invasive terrestrial and aquatic plants within the project boundary…and has occasionally treated the emergence of aquatic weeds in Lake Jackson. Identified taxa include the cyanobacteria *Microcystis* spp., *Lyngbya* spp., and *Cylindrospermopsis raciborskii*; and the vascular aquatic plant alligatorweed (*Alternanthera philoxeroides*)."

variability (in acres) of each type of wetland, riparian, and littoral habitat as a function of storage at the project. If this information is not currently available, please collect it as part of your study plan and include the results in the proposed Wildlife and Botanical Resource Study Report and/or Wetlands, Riparian, and Littoral Habitat Study Report.

31. The PLP and the license application are required to include information regarding the potential effects of existing and proposed project operation, maintenance, and project-related recreation on project resources, including botanical and wildlife resources; wetlands, riparian, and littoral habitat; and RTE species and habitats (§5.16(b)(3); §5.18(b)(5)(ii)(B)). Therefore, please file an evaluation of project effects on the aforementioned environmental resources, as well as other project resources, with the PLP and the license application.

Recreation and Land Use

32. The PAD, on pages 50 through 52, refers to resource management plans for three Regional Commissions (RC): Three Rivers RC, Northeast Georgia RC, and Atlanta RC. To facilitate our review, please file these resource management plans with the Commission.

33. The PAD mentions Georgia Power's general guidelines for the management of shorelines. To ensure that recreation facilities are managed for the term of a new license, the PLP should contain information about the plans for developing and implementing any new recreation enhancements, operation and maintenance of recreation facilities, and plans for periodic monitoring and review of recreation use and needs.

34. The PAD, on page 53, states that Georgia Power's existing Shoreline Management Guidelines include general permitting steps applicable to all Georgia Power lakes, as well as specific requirements for Lake Jackson. To facilitate our review of shoreline management policies at the project, please file a copy of the existing Shoreline Management Guidelines and, if available, a shoreline management plan for Lake Jackson. In addition, please note that because Commission licenses are project-specific, any shoreline management plans and guidelines filed with the PLP and license application should be specific to the Lloyd Shoals Project (i.e., and not include requirements or guidelines for other projects).

35. The PAD, on page 47, indicates that there are four project recreation facilities at the project: Lloyd Shoals Park, Lloyd Shoals Tailrace Fishing Pier, Ocmulgee River Park Public Access, and Jane Lofton Public Access Area. While a

schematic drawing was included for Lloyd Shoals Park, which allows us to see distances between amenities, no such drawings (only photographs) were included for the three remaining facilities. Please include a map or drawing for each facility which shows all amenities, to scale, including parking areas. Please also provide the lengths of the trails/paths at Lloyd Shoals Tailrace Fishing Pier and Ocmulgee River Park Public Access.

36. The PAD, in Table 22, lists several non-project recreation facilities that are located within the project boundary. To facilitate our review of all the existing recreation facilities at the project, please identify these facilities on a map(s) with respect to the project boundary.

37. In an incident report filed on September 14, 2018, Georgia Power described damage to two sections of the auxiliary spillway flashboards that was caused by a brush fire which occurred at the east spillway abutment on September 2, 2018. Please describe the location where the fire originated, and any authorized recreational uses within that location. In addition, please describe the location of any formal and/or informal fire pits at the project recreation sites, including any that exist at the swimming beach near the auxiliary spillway.

SCHEDULE B
COMMENTS ON PRELIMINARY STUDY PROPOSAL

PRELIMINARY STUDY PROPOSAL COMMENTS

Geology and Soil Resources

1. The proposed *Geology and Soils* study consists of a shoreline reconnaissance survey of the reservoir and tailrace area to inventory and characterize existing sources of erosion and sedimentation, and a literature review and analysis of the effects of shoreline structural stabilization practices. When you characterize the erosion areas, please denote whether the erosion is project related, non-project related, or a combination of both. Further, to assist us in our analysis of the effects of project operations and project-related recreation on both existing and historic sedimentation and erosion, please include a provision to analyze spatial and temporal changes in geomorphology through a comparison of new and historical data, such as bathymetry, topography, and/or aerial photography. Also, please include a description of existing available sources of data, and a methodology to collect additional field data if necessary.

Fish and Aquatic Resources

2. The proposed *Fish and Aquatic Resources* study includes an evaluation of the potential for fish entrainment and turbine-induced mortality at the project through a desktop study. The description of the proposed methodology for the study indicates that you would apply trends and data from other hydroelectric sites to the physical, operational, and fisheries characteristics of the Lloyd Shoals Project. To assist us in our analysis of fish entrainment and mortality, as well as the need for potential fish protection measures at the project, please develop, as part of the study plan, an estimate of the total number of fish entrained annually, by species, size class, and season.

Wildlife, Botanical Resources, and Threatened and Endangered Species

3. In the wildlife and botanical resources; wetlands, riparian, and littoral habitat; and rare, threatened, and endangered (RTE) species sections of the PAD (sections 4.5, 4.6, and 4.7, respectively), you provide some local and regional-level information on terrestrial natural resources, including a list of non-native, invasive species that may occur in the project vicinity. You also propose to conduct reconnaissance-

level surveys to document wildlife and botanical resources; wetlands, riparian, and littoral habitat; and RTE species[6] and suitable RTE habitat in the project area.

We will need sufficient project-specific information for our analysis of potential project-related effects on these natural resources, including information regarding non-native invasive species, RTE species, and their habitats. Please ensure that your proposed study plans include methodologies for collecting sufficient detail for us to: (a) accurately describe the existing natural resources in the project area; and (b) assess potential project-related effects on those resources within the project boundary, including at existing formal and informal project facilities (e.g., recreation access sites), and at any areas under consideration for potential development as part of the licensing proposal. In addition, please ensure that the timing of the surveys for the botanical RTE coincides with each species' flowering or fruiting period, as appropriate, for accurate identification.

4. The proposed *Rare, Threatened and Endangered Species* study includes the following objectives: (a) reviewing the lists of federal and state RTE plant and animal species, and species currently under federal status review, with known occurrence records near the project; (b) identifying the habitat requirements of these species; and (c) describing the distributions and habitat use of RTE species presently occurring near the project. Please ensure that the results of the RTE Species study include an assessment of the potential effects of project operation on these species and/or their habitats. In addition, please file documentation of occurrences of federally-listed species, or their habitats, with the Commission as "Not for Public Disclosure, Privileged."

Recreation and Land Use

5. The proposed *Recreation and Land Use* study states Georgia Power will review and analyze recreation use and assess the adequacy of existing facilities. To facilitate our review, please also address the condition of the project recreation facilities, including any erosion due to project-related recreational use at the four project recreation facilities.

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[6] As noted in scoping document 1, little amphianthus, Michaux's sumac, relict trillium, and black-spored quillwort were included in the official species list for the Lloyd Shoals Project generated on the U.S. Fish and Wildlife Service's (FWS) ECOS-IPaC website (https://ecos.fws.gov/ipac/) on August 3, 2018, and filed on August 6, 2018. In addition, Georgia Power identified Gulf moccasinshell, oval pigtoe, shinyrayed pocketbook, purple bankclimber, red-cockaded woodpecker, robust redhorse, Altamaha arcmussel, inflated floater, and reverse pebblesnail in the PAD.

Cultural

6. The proposed *Cultural Resources* study indicates that the area of potential effects (APE) will be identified in consultation with Georgia Historic Preservation Division (Georgia HPD) and the Commission, and will preliminarily include the area between the lower daily water pool elevation and the project boundary. As part of the cultural resources study, please prepare map(s) that clearly identify the APE in relation to the project boundary, and provide documentation of concurrence on the proposed APE from the Georgia HPD and potentially-affected Indian tribes. Please file with the Commission a letter transmitting this information, including the map(s). Please mark the document, “Not for Public Disclosure, Privileged.”

GEORGIA POWER RESPONSE TO FEDERAL ENERGY REGULATORY COMMISSION ADDITIONAL INFORMATION REQUEST (SCHEDULE A) ISSUED NOVEMBER 5, 2018

Project Description

Response 1

A vertical-lift trash gate was installed on the west abutment of the spillway in 1971. A new trash gate was installed in 2007. The trash gate is currently operable and functions both as a trash gate for passing drift material as it collects at the dam and as a flow control gate. When open, the gate, which is bottom hinged, provides a free surface to allow drift material to pass unobstructed over the spillway. The dimensions of the trash gate are 19 feet (ft) wide by 12 ft high. The bottom elevation of the gate opening is at elevation 518 ft plant datum (PD)[1] and the top is at elevation 530 ft PD. Approximately 2,100 cubic feet per second (cfs) can be passed through the trash gate when the reservoir elevation is at 530 ft and the gate is open 100 percent. This gate can only be operated locally.

The Federal Energy Regulatory Commission (FERC) accepted Georgia Power Company's (Georgia Power's) proposed installation of the new trash gate on October 2, 2006.

Response 2

Regarding design specifications of the trash racks, Georgia Power will include this information in the Preliminary Licensing Proposal and license application, as requested.

Response 3

An Obermeyer gate system was installed at the Lloyd Shoals Project in 2012. From west to east, the dam has three major, separate zones of spillway gates: Zone 1, Zone 2 and Zone 3. Zone 1 includes a 2-ft-high, 98.5-ft-wide Obermeyer-gated spillway section with a concrete crest elevation of 528 ft PD. Zone 2 includes a 5-ft-high, 420-ft-wide Obermeyer-gated spillway section with a concrete crest elevation of 525 ft PD. Zone 3 includes a 2-ft-high, 180-ft-wide Obermeyer-gated spillway section with a concrete crest elevation of 528 ft PD. The top elevation of all three Obermeyer gates is equivalent to the normal full-pool elevation of 530 ft PD. The Obermeyer gates are bottom-hinged, each consisting of a 20-ft-wide steel gate panel supported by an inflatable rubber bladder, which acts as a pneumatically-operated spillway gate. The system includes a controlled source of compressed air to inflate and deflate rubber bladders to control the water level in the upstream reservoir.

The Obermeyer gates are manually operated and only used during high flow conditions. During high flow conditions, when inflows are rising or exceeding powerhouse turbine capacity and the reservoir elevation is near 530 ft, the operators begin to manually open sections of the Obermeyer

[1] Plant datum = mean sea level elevation (NAVD88) + 0.45 ft.

gates to pass inflow. This keeps the lake level more stable during storm events than the flashboards, which allowed the lake to rise before reaching the trip point. The Obermeyer gates are operated to release only the amount of flow coming into to the Project. Gates are always operated as a zone and not as individual gates. It takes approximately 20 minutes to lower the 5-ft high gates and 5 to 10 minutes to lower the 2-ft high gates. It takes 10 minutes to raise Zones 1 and 3 gates and 1 hour to raise Zone 2 gates.

The Obermeyer gates have never failed. As a safety measure, however, they are designed to open (lower) automatically when overtopped by 12 inches. If there is excessive buildup of air pressure in the bladders resulting from the hydrostatic loads against the gates, the pressure relief valves release air to lower the gates. The major gate zones are installed as a series of interconnected bladders, with the longest length of gate with interconnection bladders being the 420-ft, 5-ft high gates. Each zone has its own interconnected bladder. If one bladder in an interconnected series were to deflate, the other interconnection bladders would also lose air pressure and the associated steel panels would open (lower), so that a gate within a zone lowers evenly.

Failure of the gates could occur if any of the air bladders were damaged, or if the air compressors or interconnecting piping were damaged. However, this would be limited to the individual damaged zone and not the entire spillway. The bladder material is specifically made for harsh outside conditions and this spillway gate application.

Safety of the gates is monitored and tested annually by Georgia Power dam safety personnel and FERC’s Atlanta Regional Office (ARO) as part of the Project’s dam safety program.

Response 4

An auxiliary (emergency) spillway is located at the west abutment of the dam. The location is downstream of the main dam axis. The auxiliary spillway is an excavated channel in rock, 500-ft wide, with the top of the concrete sill at elevation 526 ft PD. There are 25 sections of wooden flashboards, 19-ft by 10-ft high, that are hinged at the bottom to a concrete sill, which is set on and anchored in rock.

Aluminum pipes, which are designed to fail in bending when the reservoir reaches the top of the flashboards at elevation 536.0 ft PD, support these flashboards. The highest water level recorded was 534.4 ft during the flooding caused by Tropical Storm Alberto in July 1994. The flashboards have never tripped. The auxiliary spillway gates are repaired as needed as indicated by dam safety inspections.

Response 5

Appendix C of the PAD includes single line diagrams of the substation on the Lloyd Shoals west dam abutment. These diagrams demonstrate that the substation is the plant’s connection point to the transmission system. The substation is described in the Project’s Exhibit A, is within the project boundary, and is project-owned.

Response 6

Lloyd Shoals powerhouse headworks contains 12 headgates, one for each of the two intake openings per unit. Each gate consists of a 12-ft by 8-ft structural steel frame with a skin plate welded to the upstream side. Because the gate is sometimes underwater it was covered in a coal tar epoxy coating at the time of fabrication. An approximate 2-ft-wide by 2.5-ft-high opening in the center of the headgate is controlled by a Waterman cast steel filler valve. During an outage, a headgate is in the closed position and the unit is drained of all water. When the unit is being prepared to be placed back in service, the filler valve is opened to refill the unit. This allows the equalization of water pressure on each side of the headgate so that the headgate can be lifted back into its docked position. A structural steel frame connects the gate to the lifting mechanism.

A 20-ton gantry crane with two 10-ton hoists, which can be operated independently or in synchronized mode, serves as the headgate lifting mechanism. The gantry crane is permanently stationed at the plant's headworks and traverses the deck on a set of rails.

Response 7

The Project discharges directly into the Ocmulgee River. The tailrace spans the length of the spillway and the dam, then narrows to 150 ft wide approximately 200 ft downstream of the powerhouse. The tailwater surface elevation ranges from 423 ft to 429 ft PD during normal operations.

<u>Project Operation</u>

Response 8

The units do not have a known minimum hydraulic capacity. Currently the Lloyd Shoals Project operates to release a minimum flow of 400 cfs, as required by Article 402 of the current license. Although the license article allows for the Project to release calculated inflows below the 400-cfs minimum flow requirement during periods of drought, Georgia Power continues to release a 250-cfs minimum to ensure adequate stream flows for aquatic life and other downstream uses. The units are able to operate at this flow of 250 cfs.

Response 9

The transmission grid in the southeastern region of the U.S. experiences peak power demand periods that vary seasonally and from year to year depending on weather conditions. Because of this expected variation, Georgia Power does not track actual timing or duration values for seasonal peak power demand periods. Georgia Power schedules Lloyd Shoals unit operations one day in advance on a daily basis, based on water availability and the most up-to-date forecast for the region. Typically, a summer peak is experienced one time per day from June through September from 2:00 p.m. to 7:00 p.m. The remainder of the year, from October through May, it is typical for the transmission grid to experience two peaks in demand from 6:00 a.m. to 11:00 a.m. and from 5:00 p.m. to 9:00 p.m.

Response 10

The powerhouse contains six horizontal Francis-type double runner turbines, each rated at 5,650 horsepower under 96.8 ft of head, directly connected to six horizontal generators, each rated 3,000 kilowatts (kW) at 300 revolutions per minute. Total nameplate capacity of the plant is 18,000 kW. These ratings are the result of rehabilitation and upgrades made from 1996 through 1998. The hydraulic turbines in the powerhouse were rehabilitated from 1996 through 1998 under a contract with American Hydro Corporation of York, Pennsylvania. On each unit, new stainless-steel runners, turbine shafts, shifting rings, and stainless-steel wicket gates were installed. Stationary and non-rotating parts were rehabilitated to restore clearances and proper function. Greaseless bushings were installed throughout.

The capacity rating of a project is influenced by many inputs, such as maximum net differential head, efficiency of the turbine and generator units, and flow. Therefore, actual maximum capacity often differs from the theoretical, design, or rated capacity. The 18 MW corresponds with the current best wicket gate setting on the turbines and a 2,700 cfs flow rate at 96.8 ft of head. At a maximum wicket gate setting, Georgia Power produces a maximum of 22.5 MW with a 3,700 cfs flow. Using the full pool elevation of 530 ft and subtracting the 96.8 ft of gross head tied to the nameplate rating (ignoring net head for this simple analysis) yields an expected tailrace elevation of 433.2 ft. As indicated in Response 7, tailwater surface elevation ranges from 423 ft to 429 ft PD during normal operations, which indicates that the index testing for the units that was completed after the last turbine refurbishment was testing at a headwater level below the normal reservoir range. The index testing was also only completed around the most efficient/best wicket gate setting and not a full gate setting. Therefore, the nameplate output from the plant will be exceeded during times when all six turbine units are operating at a full wicket gate setting and a close to full-pool elevation. These conditions almost always happen during a high flow condition, and not during normal flow ranges or when less than six turbines are running.

Response 11

Housed in adjacent cable trays, two 2.3-kilovolt project generator leads exit the western side of the powerhouse. The cable trays and generator leads extend up the bank to the west of the powerhouse. Inside the Lloyd Shoals substation are two three-phase outdoor step-up transformers rated 10/12-megavoltampere (MVA) and 10-MVA. These transformers are positioned approximately 25 ft apart. The approximate length of the generator lead that connects to the northern-most transformer is 250 ft from where it exits the powerhouse to where it is connected to the transformer. The approximate length of the generator lead that connects to the southern-most transformer is 230 ft from where it exits the powerhouse to where it is connected to the transformer.

Response 12

Prior to 2012, in order to prevent spilling water during the high inflows normally experienced in the winter and spring months, Lloyd Shoals reservoir conducted annual seasonal drawdowns of about 8 ft from full pool. During November and December, the reservoir was gradually drawn down and was held at a low elevation of 522 ft January through February. During March and April, the reservoir was allowed to refill and was operated at a higher level from May through October.

In 2012, Obermeyer gates were installed at the Project. The installation of these gates allows operators to have more control over the water levels in the reservoir. Prior to the installation of the Obermeyer gates, flashboards on top of the spillway were designed to trip in order to release the water. The water level would then have to fall below the crest of the spillway at elevation 525 ft PD for the flashboards to be safely reset. With the Obermeyer gates, the water releases are controlled to match inflows, resulting in less fluctuation in the reservoir.

Because the Obermeyer gates provide more control over the reservoir elevation, it is no longer necessary to draw the lake down during November through February. This practice ended once the Obermeyers began operation in 2012.

The elevation plots at the end of this section highlight the cause, duration, frequency, and extent of drawdowns since the last license issuance. Georgia Power is not aware of any adverse impacts to the aquatic environment as a result of these drawdowns.

Response 13

The U.S. Geological Survey describes the location of Gage No. 02210500 (Ocmulgee River near Jackson, Georgia) as 1,500 ft upstream of the Georgia Highway 16 bridge and 1.5 miles downstream of Lloyd Shoals Dam. However, based on examination of aerial photography on Google Earth Pro and use of the ruler tool in that application, we measure the distance from the dam to the gage to be approximately 1 mile.

Response 14

Obermeyer gates are operated as the reservoir elevation approaches 530 ft PD (full pool elevation) and inflows exceed the flow capacity of the turbine units. First, all available turbine units in the powerhouse are loaded. Then the trash gate will be opened prior to opening Obermeyer gates. The sequence of Obermeyer gate operation begins with Zone 1 (west section of 2-ft-high gates), followed second by Zone 3 (east section of 2-ft-high gates), and last by Zone 2 (middle section of 5-ft-high gates). Once the reservoir elevation starts dropping below 530 ft (full pond) due to decreased inflow, the operator will begin adjusting the Obermeyer gate openings to maintain a maximum pool level of 530 ft.

Response 15

Lloyd Shoals Units 2, 4, and 3 were retrofitted with draft tube aerations systems (two per unit) in 2004, 2005, and 2006, respectively, to improve dissolved oxygen (DO) concentrations in downstream releases. Adding aeration to three of the six units provides redundant systems in the event one or two of the units incur an unscheduled outage. Georgia Power opens aeration system valves at Lloyd Shoals from May 15 through September 30 each year.

The passive draft tube aeration system cannot operate unless its valve is open and the unit is generating. Because of this design, Georgia Power's unit outage data provides a reliable way to identify when aeration systems were not operational. These data show that at least one of the three aerated units was operational every year during the critical period of May 15 through September 30. Additionally, the studies conducted in the summer of 2006 and 2007 on Units 2 and 4 to test the aeration system indicated that one aerated unit was effective for maintaining Georgia Environmental Protection Division (GEPD) DO criteria even when multiple units were operating. Further, one test indicated that both Unit 2 and 4 aeration units were running when the plant output was 18 MW.

Monitoring of the draft tube aeration system showed the aeration systems to be effective. After GEPD accepted the results of the aeration system, the DO monitoring was discontinued. We are not aware of any evidence of effects of low DO on the fish and aquatic community in the Ocmulgee River downstream of Lloyd Shoals Dam since the draft tube aeration was installed. Moreover, GEPD currently assesses the use attainability status of the 3-mile reach of the Ocmulgee River downstream of Lloyd Shoals Dam as supporting its designated Drinking Water use, which also includes fishing uses.

As part of its Proposed Study Plan, Georgia Power is proposing to conduct a Water Quality Study that will include one year of continuous water quality monitoring in the tailrace area beginning in summer 2019 to further document the performance of the passive draft tube aeration systems in Units 2, 3, and 4 during normal project operations.

Geology and Soil Resources

Response 16

Regarding a map delineating ownership of lands along the reservoir and tailrace shorelines, Georgia Power proposes as part of the Recreation and Land Use Study to provide a map of land ownership within the project boundary indicating whether land is privately owned or owned by Georgia Power.

Response 17

Georgia Power proposes as part of its Geology and Soils Study to review available historical aerial photography for representative shoreline areas within the project boundary to characterize how erosion and sedimentation have changed over time. There is no bathymetry data for the Project.

Response 18

Georgia Power proposes as part of the Geology and Soils Study to provide a summary of all dredging permits issued at the Project and available information pertaining to each dredging event.

Water Quality, Fisheries, and Aquatic Resources

Response 19

Georgia Power staff does not recall referencing a 2014 Ocmulgee Water Quality Study at the scoping meeting site visit. Paul Lamarre of GEPD, who was also present at the site visit, has confirmed to Georgia Power that he mentioned a model calibration field study that the agency performed during the summer of 2014. In its study request comments filed November 2, 2018, GEPD refers to the 2014 water quality model calibration field study, noting that the data for the upstream model boundary were gathered at Georgia Highway 16 about 1.2 miles downstream of Lloyd Shoals Dam, not in the tailrace, and are limited in their duration and parameters monitored. No final report is available for the study.

Georgia Power has also learned that GEPD conducted continuous water quality monitoring in the Ocmulgee River downstream of the Lloyd Shoals Project from September 13, 2010 to October 4, 2010 as part of efforts to develop a water quality model downstream of Lake Jackson in the Altamaha River basin. GEPD has shared the spreadsheet data. Georgia Power will review, evaluate, and summarize relevant water quality data, as appropriate, in the proposed Water Resources Study.

Response 20

In November 2018, Georgia Power contacted Dr. Alan Wilson by email seeking clarification as to the level of analysis he performed for the water quality presentation given to the Jackson Lake Association on June 22, 2012. The attached email correspondence documents his reply of November 18, 2018, as well as his prior email correspondence with Julia Haar and Georgia Power biologists Tom Broadwell and Tony Dodd leading up to the 2012 presentation.

Dr. Wilson recalls being contacted by Ms. Haar on April 6, 2012 about giving a talk on water quality issues in Lake Jackson after she had communicated with Dr. Elizabeth Booth of GEPD. He communicated with the two Georgia Power biologists in organizing and developing the presentation. Dr. Wilson's portion of the talk used water quality data provided by Georgia Power as well as publicly available data for Lake Jackson. He did not prepare a report serving as the basis of his presentation to the homeowners association.

Response 21

Definitions

Passive draft tube aeration. A vacuum is created when generation discharge water is flowing vertically downward across the turbine and into the draft tube. Passive draft tube aeration uses this vacuum to naturally aspirate air into generation releases through an air opening in the scroll case or draft tube. As the air/water mixture traverses the draft tube, it is subjected to extreme turbulence and high pressure resulting in the formation of very small bubbles. The small bubbles provide an excellent condition for gas-transfer (oxygen transfer) to the water and the draft tube provides sufficient contact time for the process to take place. There is additional contact time, or gas transfer, as the bubbles rise to the surface in the tailrace.

A **deflector plate** is a steel plate mounted onto the draft tube wall above a passive draft tube aeration air injector port and parallel to the angle of water flowing off the turbine blade. The plates increase the pressure differential between the air injector port and the draft tube by creating a pocket of low pressure, and therefore, increase the air flow capability via natural aspiration.

Installation and Operation

The Lloyd Shoals powerhouse has six generating units, three of which have passive draft tube aeration systems to enhance DO during generation turbine discharges. Units 2, 4, and 3 were retrofitted with two passive draft tube aeration systems per unit in 2004, 2005, and 2006 respectively. Each aeration system is valve operated such that turbine discharges are only aerated when the valves are open. When open, the valves allow air to aspirate through the aeration system's piping, and discharge into the draft tube. In order to initiate aeration, plant personnel must manually open the gate valve, and conversely, in order to terminate aeration, plant personnel must manually close the gate valve. The passive draft tube aeration system valves are opened May 15 through September 30 each year and the systems aerate during all generation periods regardless of water quality conditions.

Because of the double runner configuration of the turbines at Lloyd Shoals, it was necessary to install two passive draft tube aeration systems per unit. The passive draft tube aeration system design includes a piping scheme that provides atmospheric air to two air injector ports in the draft tube below each turbine runner. Each aeration system consists of a horizontal air intake pipe that pulls atmospheric air directly from inside the plant through a muffler, a 6-inch check valve, and a 6-inch gate valve. After the air passes through the gate valve, it turns into the powerhouse wall to the unit inside. Once inside the unit, a 4-inch diameter header ports air through the draft tube wall to two separate injector ports at a point just below the turbine blades. The installation includes deflector plates which are welded above each air injector port in the draft tube to increase air flow through the aeration system and thereby increase the aeration capability of the units.

Response 22

The PAD, on page 23 (Water Quality), describes the summertime vertical profiles in the forebay of Lake Jackson (Station JA01). Based on 10 years of summer profiles, as shown in Figure 8 of the PAD, a pronounced thermocline develops about 10 meters (33 ft) beneath the surface, below which water temperatures decline steadily with increasing depth. Also shown in Figure 8 of the PAD, summer DO concentrations decrease rapidly with increasing depth at 2.5 to 7.0 meters (8 to 23 ft) beneath the surface. Below this depth, DO steadily declines to values below 0.5 mg/L. This pattern of summer thermal and DO stratification is typical of southeastern reservoirs. The intake's invert elevation, at 35 ft below normal full pool, is at or slightly below the thermocline and 12 to 27 ft below the DO chemocline in most years.

Response 23

Copies of the specific PAD references requested by FERC staff are provided in the attachments.

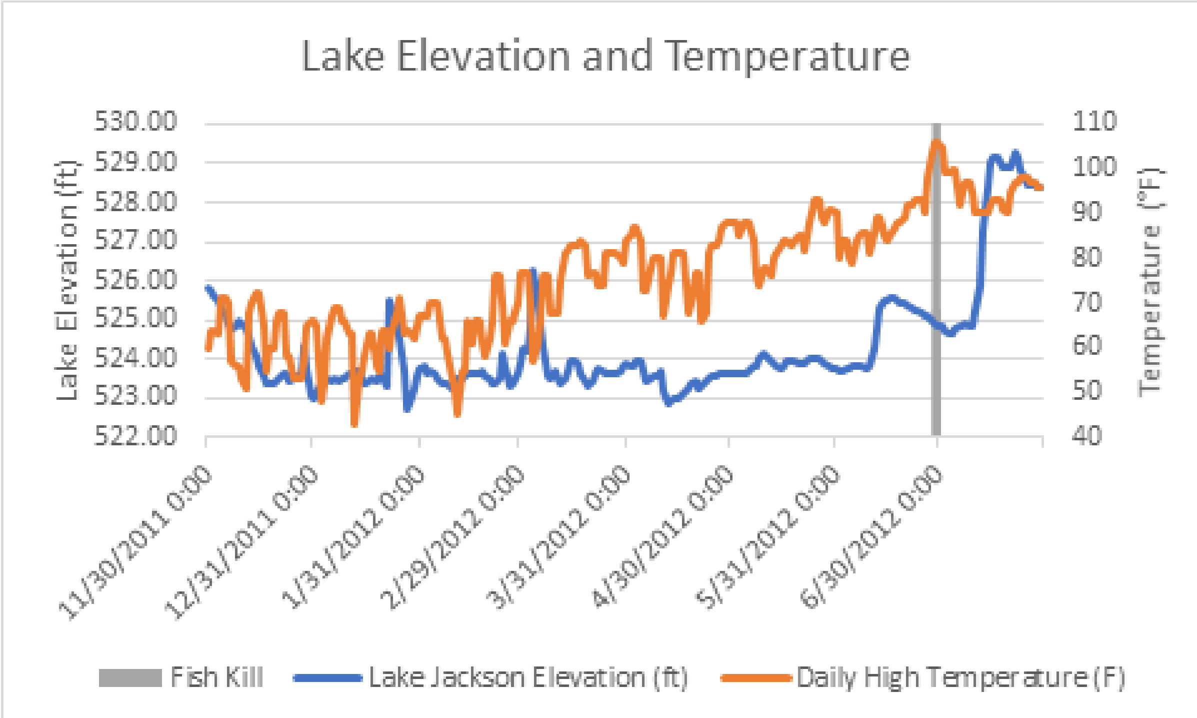
Response 24

As requested, the Ocmulgee Candidate Conservation Agreement with Assurances (CCAA) for Robust Redhorse is provided as an attachment. Although the agreement expires at the end of 2023, Georgia Power has formally indicated to current Ocmulgee CCAA signatory representatives its intention to renew or extend the agreement. Georgia Power met with the U.S. Fish and Wildlife Service Region 4 At-Risk Species Program on September 19, 2018, and with the Georgia Department of Natural Resources (GDNR) Wildlife Resources Division (WRD) Wildlife Conservation Section on December 6, 2018.

Response 25

On July 16, 2012, Georgia Power notified FERC of the July 2012 fish kill identified by Ms. Haar and others and provided a copy of the investigation report prepared by WRD's Fisheries Section. The filing is provided as an attachment to this filing. According to the GDNR report, the fish-kill occurred on June 30 or July 1, 2012 in approximately 8 acres of shallow water in the cove on the west side of the South River arm of Lake Jackson immediately upstream of the Georgia Highway 36 bridge. GDNR biologists counted 2,471 dead juvenile and adult fish, including gizzard shad, crappie, catfish, largemouth bass, and sunfish; no other species were noted in the report. The cove had been cut off from the South River embayment flow due to low inflow from the South River over the spring and the low level in the reservoir, which was below normal pool level. Prior to and during the fish kill, the region was experiencing severe drought and the weather was hot, with air temperatures above 100°F on both June 30 and July 1. The fish apparently succumbed to low DO levels and high temperatures in shallow water. GDNR had stated that similar fish kills were happening all over the state at the time due to the combined effects of drought and record high temperatures. No further action was taken.

The fish kill occurred on a day when air temperatures in the region reached a high of 106°F, as measured at the closest National Weather Service weather station located at Atlanta Hartsfield-Jackson International Airport (see figure below). The average high temperature for the 8-day period from June 29 through July 6, 2012 was over 102°F.



A factor contributing to the low level of the reservoir before the July 2012 fish kill was the planned drawdown that had been conducted for installation of the Obermeyer gates on the Lloyd Shoals spillway. The drawdown began November 16, 2011 (timed to coincide with the drawdown for homeowners), reached a minimum level of 522.63 ft plant datum (4.37 ft below normal low pool) and ended on July 13, 2012. The contractor demobilized from the site on June 5, 2012, and the reservoir was refilling but could not do so quickly because of low inflows into the Project. Refill was well underway by the time of the fish kill, and in fact, the reservoir never dropped below 524.75 ft on June 30 and July 1, 2012.

On June 7, 2018, GDNR reported on its website a common carp die-off on Lake Jackson that occurred over a few weeks in May and early June 2018. A copy of the article is provided as an attachment. The die-off appeared to be a natural occurrence resulting from aggressive spawning activities, which can weaken fish immune systems and allow bacterial or viral infections to spread. GDNR noted that water quality appeared to be normal and concluded that the fish kill posed no danger to anglers or lake visitors. No further action was taken.

Georgia Power is unaware of any other fish kills that may have occurred during the current license term; however, as part of the proposed Fish and Aquatic Resources Study, we will request and review available reports and information from GDNR on fish kills in the project waters and describe these events in the resource study report.

Wildlife, Botanical Resources, and Threatened and Endangered Species

Response 26

The Candidate Conservation Agreement for Mollusks of the Altamaha River Basin is provided as an attachment.

Response 27

The wetland plant communities report by Gaddy (1989), which was filed as part of the previous Lloyd Shoals license application (1991, Volume 2, Appendix C), is provided as an attachment.

Response 28

Georgia Power owns approximately 250 acres of land suitable for timber management around Lake Jackson. There are no formal written timber and land management plans that apply specifically to Lake Jackson and the lands around it; however, Georgia Power manages these lands according to the Georgia Forestry Commission's Best Management Practices for Forestry (http://www.gfc.state.ga.us/resources/publications/BMPManualGA0609.pdf) and in partnership with GDNR through its Forestry for Wildlife Partnership (https://georgiawildlife.com/FWP).

The one known bald eagle nest on Lake Jackson is located on Georgia Power land just outside of the project boundary. Georgia Power follows the bald eagle nest management guidance in the FWS's National Bald Eagle Management Guidelines dated May 2007 (https://www.fws.gov/northeast/ecologicalservices/pdf/NationalBaldEagleManagementGuidelines.pdf) and on FWS' Eagle Technical Assistance website (https://www.fws.gov/southeast/our-services/eagle-technical-assistance/). Georgia Power also consults with GDNR as needed and exchanges eagle nest survey and monitoring information annually.

Georgia Power is a long-standing participant in GDNR's Forestry for Wildlife Partnership (FWP). This program recognizes large landowners who go above and beyond standard wildlife habitat recommendations and sustainable forestry practices. As a FWP partner, Georgia Power's approach to forestry and wildlife habitat management on its lands centers on the following goals and objectives:

- Develop and implement forest management plans that blend wildlife and timber management.
- Protect sensitive sites and endangered species along with other assets.
- Increase public awareness of Georgia Power's environmental commitment.
- Continue to encourage and support partnerships.
- Utilize wildlife management practices at stand and landscape levels.
- Promote the public use of company owned forest lands and its water resources.

Response 29

Georgia Power proposes as part of its Terrestrial, Wetland, and Riparian Resources Study to review and provide information on its existing invasive species and vegetation management practices, including existing vegetation management practices, the methods used to treat non-native invasive terrestrial and aquatic plants, areas that have been treated, frequency of treatments, and any vegetation monitoring efforts.

Response 30

The PAD describes the wetlands and estimates the area of each wetland type within the project boundary and within a zone extending an additional 2,000 ft beyond the project boundary based on reasonably available information. Information sources included the wetland plant study conducted for the previous relicensing (Gaddy, 1989) and review of FWS National Wetlands Inventory information on the distribution of wetlands in the project area. PAD Figure 12 depicts the location of the principal wetland types identified in the NWI database.

The modified run-of-river operation of the Lloyd Shoals Project does not result in daily reservoir fluctuations of up to 3 ft. As described in the PAD, on page 9 (Normal Operation) and in Appendix D (Operations Primer), Georgia Power maintains reservoir elevations within a 3-ft range (530 and 527 ft PD). In Appendix D of the PAD, Figure 28 shows for the years 1997 through 2016 that daily reservoir fluctuations were less than 1.5 ft 98-percent of the time and less than 1.0 ft 95-percent of the time. Moreover, since the installation of the Obermeyer gate system in 2012, reservoir fluctuations have been reduced (see Figures 28-32 of the Operations Primer in Appendix D of the PAD).

Because daily reservoir fluctuations are low, daily variability in wetland, riparian, and littoral habitats would be expected to be small. As part of the proposed Terrestrial, Wetland, and Riparian Resources Study, Georgia Power will evaluate the reservoir elevation-area relationship for Lake Jackson to estimate the area of wetland and littoral zone habitats potentially affected by daily reservoir fluctuations.

Response 31

Georgia Power's PLP and license application will analyze the potential effects of continued project operation, maintenance, and project-related recreation by environmental resource area in accordance with 18 CFR § 5.16(b)(3) and § 5.18(b)(5)(ii)(B).

Recreation and Land Use

Response 32

The three regional resource plans summarized in the PAD are provided as an attachment.

Response 33

Georgia Power's PLP will contain information about its proposed measures and plans pertaining to any recreation enhancements, operation and maintenance of recreation facilities, and periodic monitoring and review of recreation use and needs.

Response 34

Georgia Power's Shoreline Management Guidelines, which include guidelines specific to the Lloyd Shoals Project, are provided as an attachment. There is no shoreline management plan for the Project.

Response 35

Schematics of the four project recreation facilities are provided as attachments. The Emergency Spillway South End Fishing Access, as labeled on two of the drawings, has been renamed the Jane Lofton Public Access Area.

The length of the barrier-free boardwalk path to the Tailrace Fishing Pier is approximately 350 ft. There are no formal trails/paths at Ocmulgee River Park Public Access, although some bank fishers use an informal path extending about 750 ft upstream to the eastern side of the spillway area.

Response 36

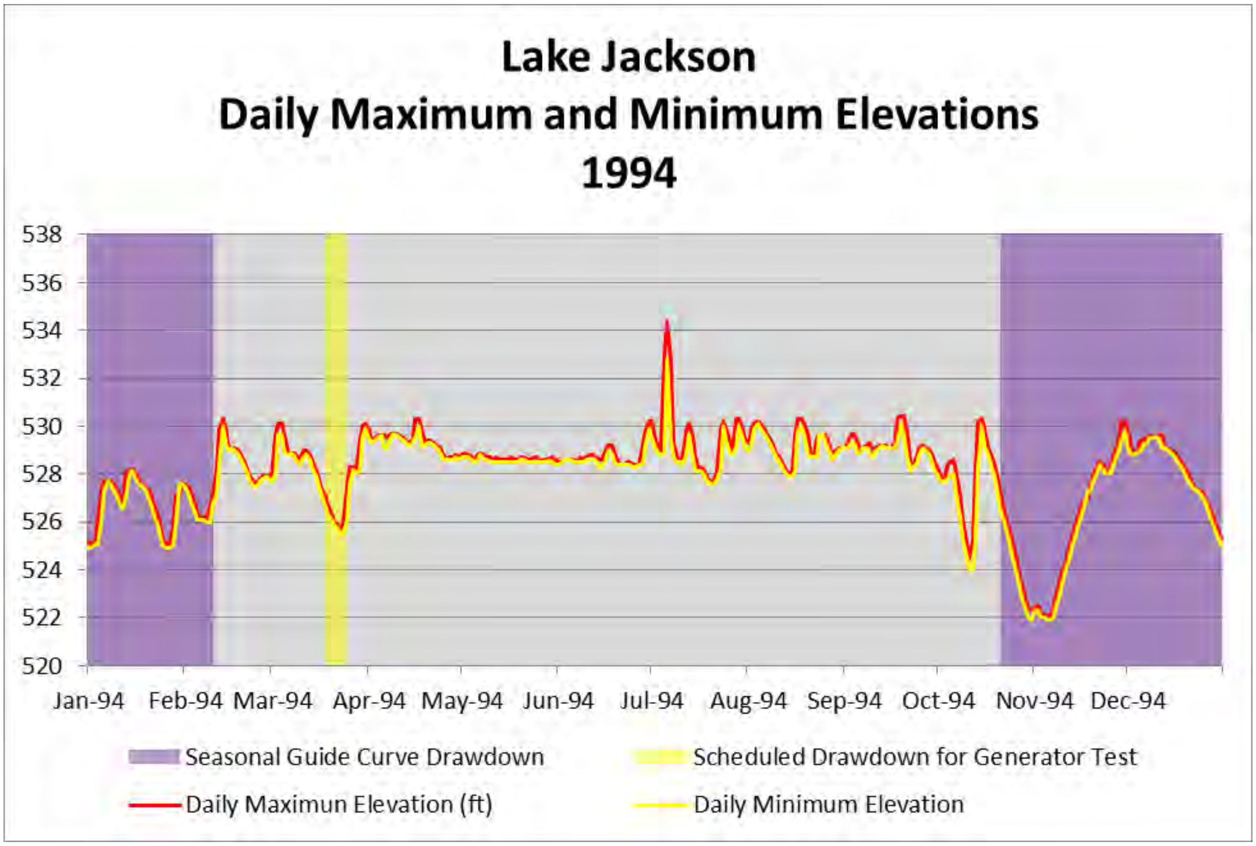
The PAD, in Figure 3, depicts the locations of five non-project recreation facilities that are partially located within the project boundary. Georgia Power proposes as part of the proposed Recreation and Land Use Study to identify all nine non-project recreation facilities listed in the PAD, in Table 21, on a map with respect to the project boundary.

Response 37

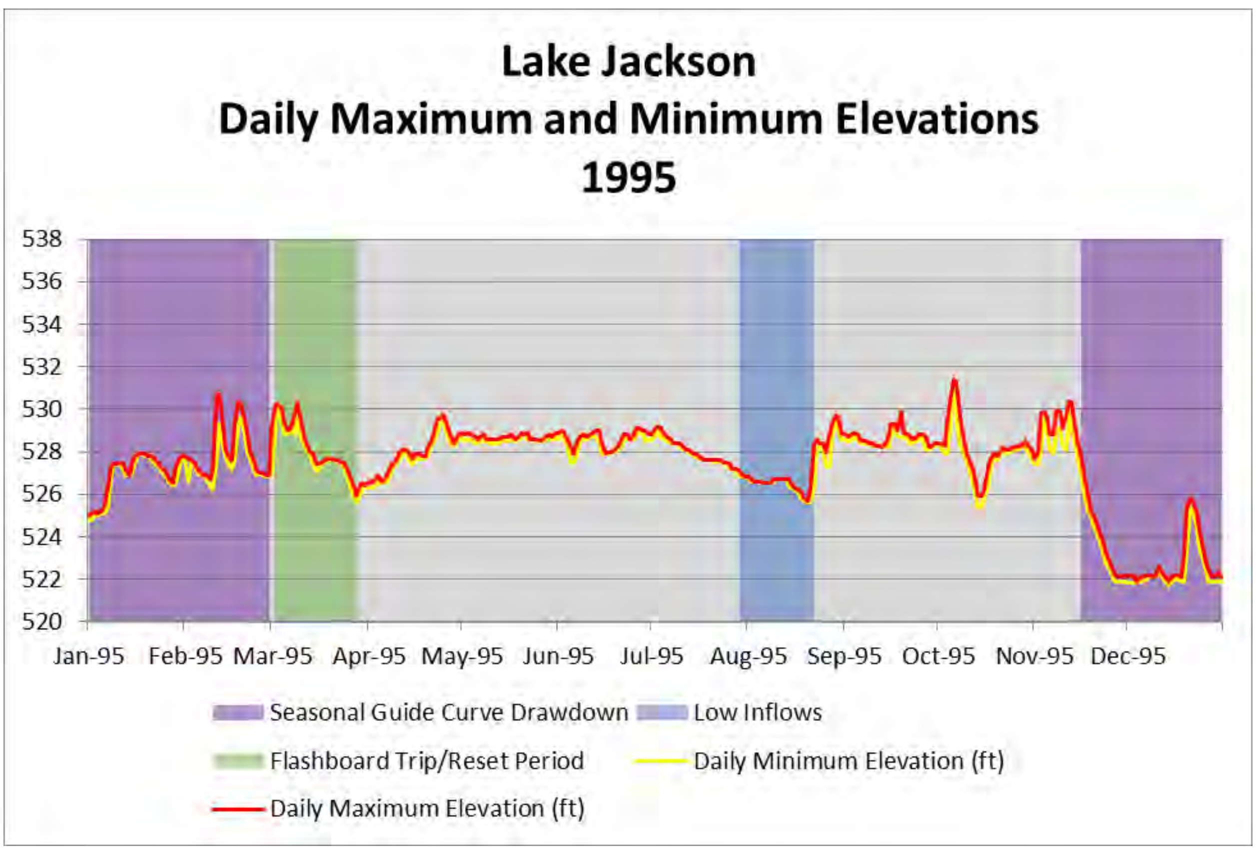
The location of the fire is depicted on the map below that was included in Georgia Power's September 14, 2018 incident report. Access to the auxiliary spillway is restricted by a 6-ft-high chain link fence with barbed wire around the top. There is a stand of pine woods between the public recreation area and the axillary spillway flashboards. Georgia Power does not authorize fire pits, formal or informal, at any of its project recreation sites. The Lloyd Shoals Park recreation site does include picnic areas with tables, grills, trash cans, and parking, as noted on the FERC Form 80, filed on March 31, 2015. Georgia Power suspects that a recreation user dumped hot coals in the wooded area between Lloyd Shoals Park and the auxiliary spillway and the fire spread to the auxiliary spillway. As is stated in the incident report, the local fire department was called to Lloyd Shoals Dam (by Georgia Power) in the evening of September 2, 2018, to extinguish the fire. A park crew member noticed the fire was burning again in the morning of September 3, 2018, and it was again extinguished. The fire apparently started in the public beach area and traveled down the hillside on both sides of the concrete abutment. The fire flamed up between the two east sections of the flashboards. Georgia Power dam safety personnel have inspected the boards and determined that there is no structural damage to them and are in the process of finding suitable repair material in coordination with FERC's ARO. FERC ARO also saw the fire damage in the most recent Part 12 inspection at the facility.

Figure 1. – Location Map for Lloyd Shoals Dam.

ATTACHMENTS



Lake Jackson
Daily Maximum and Minimum Elevations
1994
538
536
534
532
530
528
526
524
522
520
Jan-94
Feb-94
Mar-94
Apr-94
May-94
Jun-94
Jul-94
Aug-94
Sep-94
Oct-94
Nov-94
Dec-94
Seasonal Guide Curve Drawdown
Scheduled Drawdown for Generator Test
Daily Maximun Elevation (ft)
Daily Minimum Elevation



Lake Jackson
Daily Maximum and Minimum Elevations
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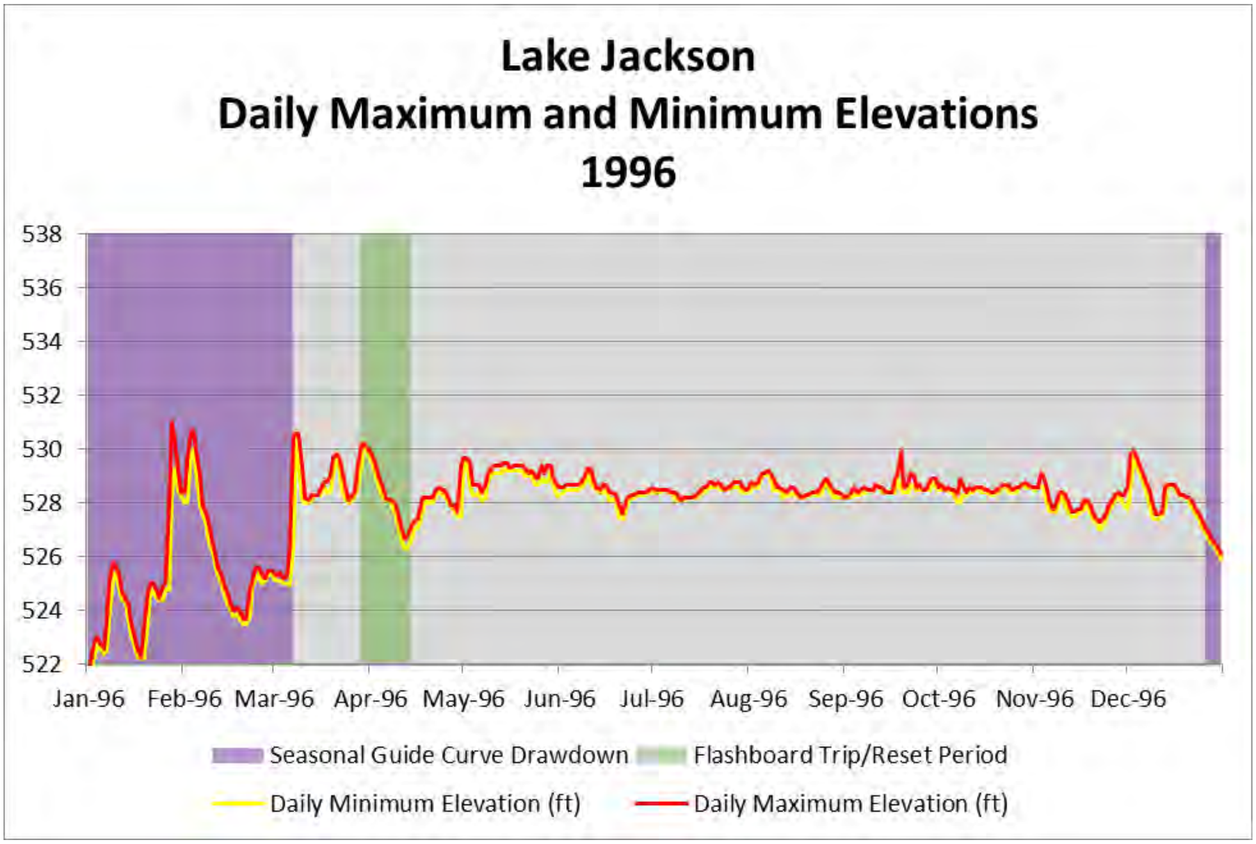
Jan-95
Feb-95
Mar-95
Apr-95
May-95
Jun-95
Jul-95
Aug-95
Sep-95
Oct-95
Nov-95
Dec-95
Seasonal Guide Curve Drawdown
Low Inflows
Flashboard Trip/Reset Period
Daily Minimum Elevation (ft)
Daily Maximum Elevation (ft)


Lake Jackson
Daily Maximum and Minimum Elevations
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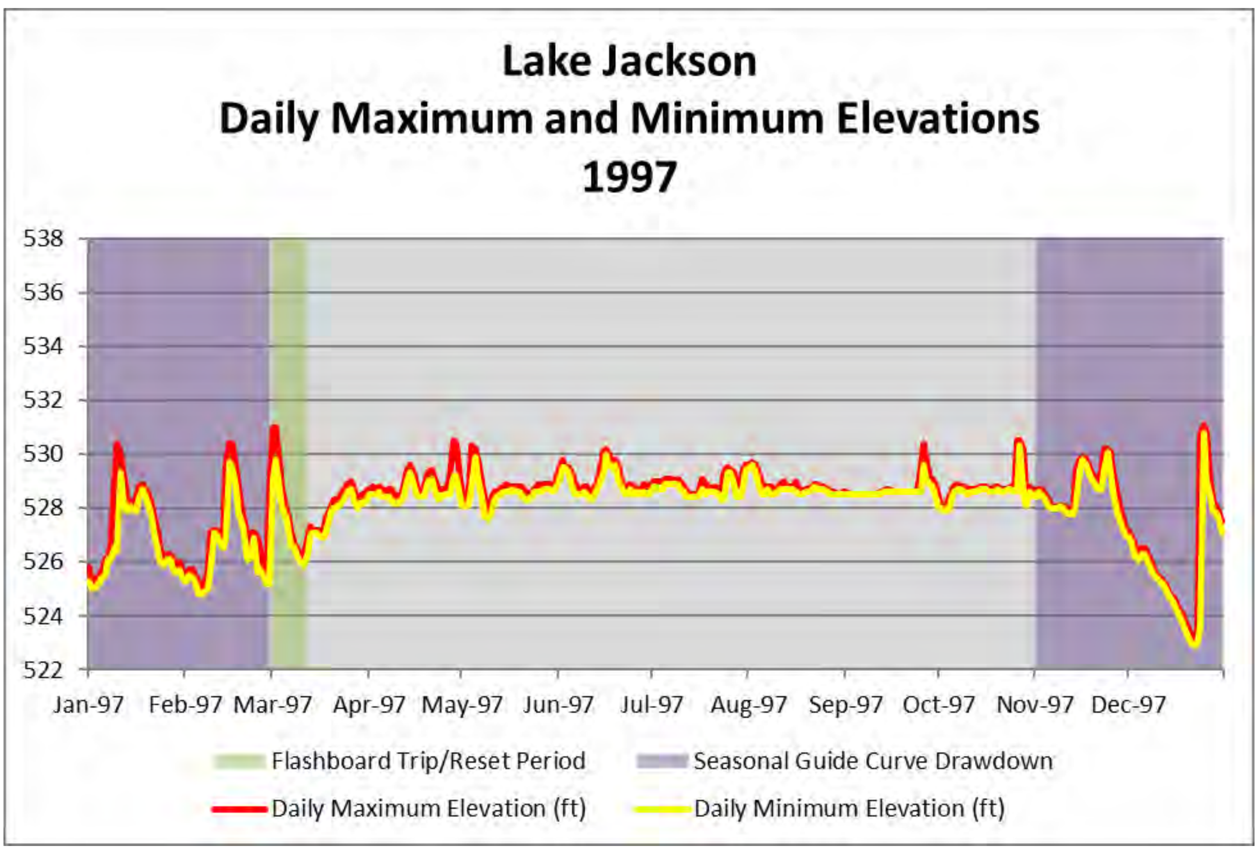
Jan-96
Feb-96
Mar-96
Apr-96
May-96
Jun-96
Jul-96
Aug-96
Sep-96
Oct-96
Nov-96
Dec-96
Seasonal Guide Curve Drawdown
Flashboard Trip/Reset Period
Daily Minimum Elevation (ft)
Daily Maximum Elevation (ft)


Lake Jackson
Daily Maximum and Minimum Elevations
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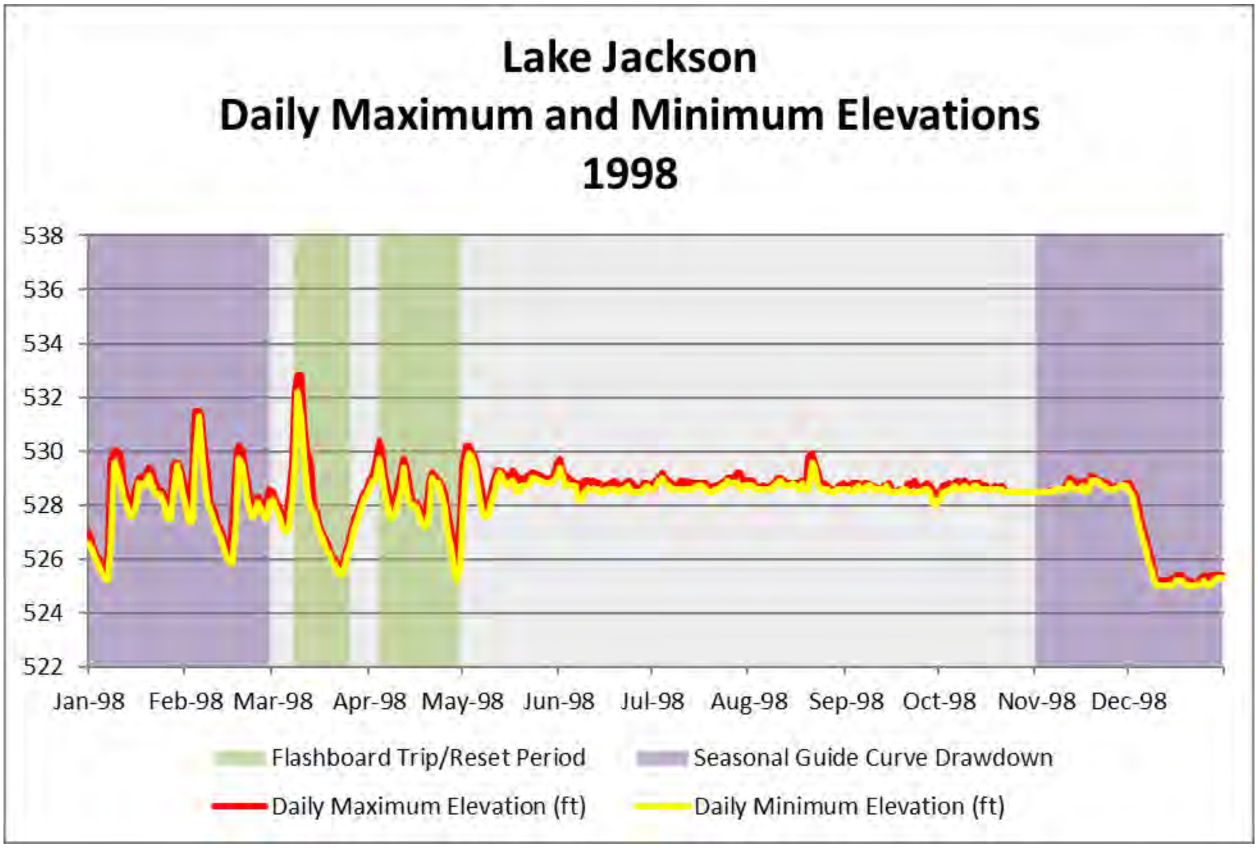
Mar-97
Apr-97
May-97
Jun-97
Jul-97
Aug-97
Sep-97
Oct-97
Nov-97
Dec-97
Flashboard Trip/Reset Period
Seasonal Guide Curve Drawdown
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)



Lake Jackson
Daily Maximum and Minimum Elevations
1998
538
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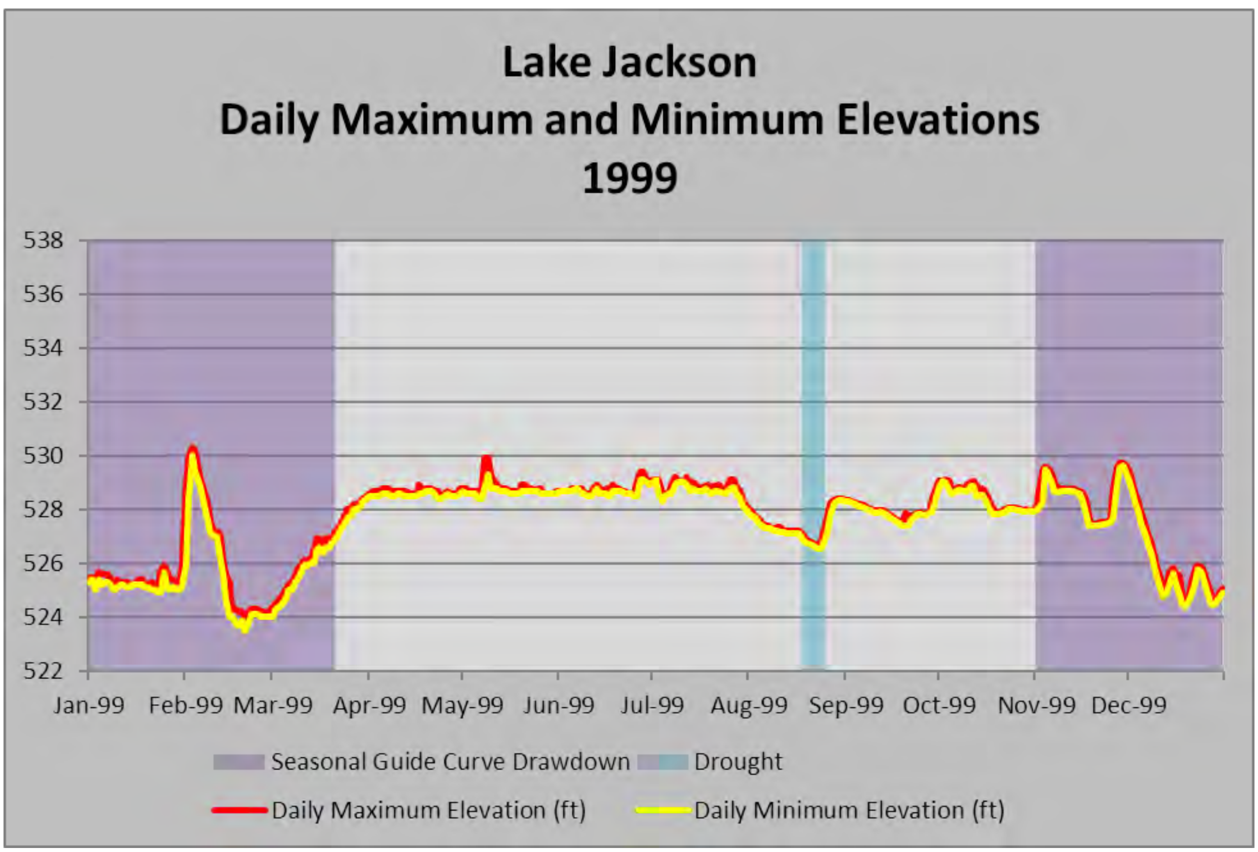
Jan-98
Feb-98
Mar-98
Apr-98
May-98
Jun-98
Jul-98
Aug-98
Sep-98
Oct-98
Nov-98
Dec-98
Flashboard Trip/Reset Period
Seasonal Guide Curve Drawdown
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)



Lake Jackson
Daily Maximum and Minimum Elevations
1999
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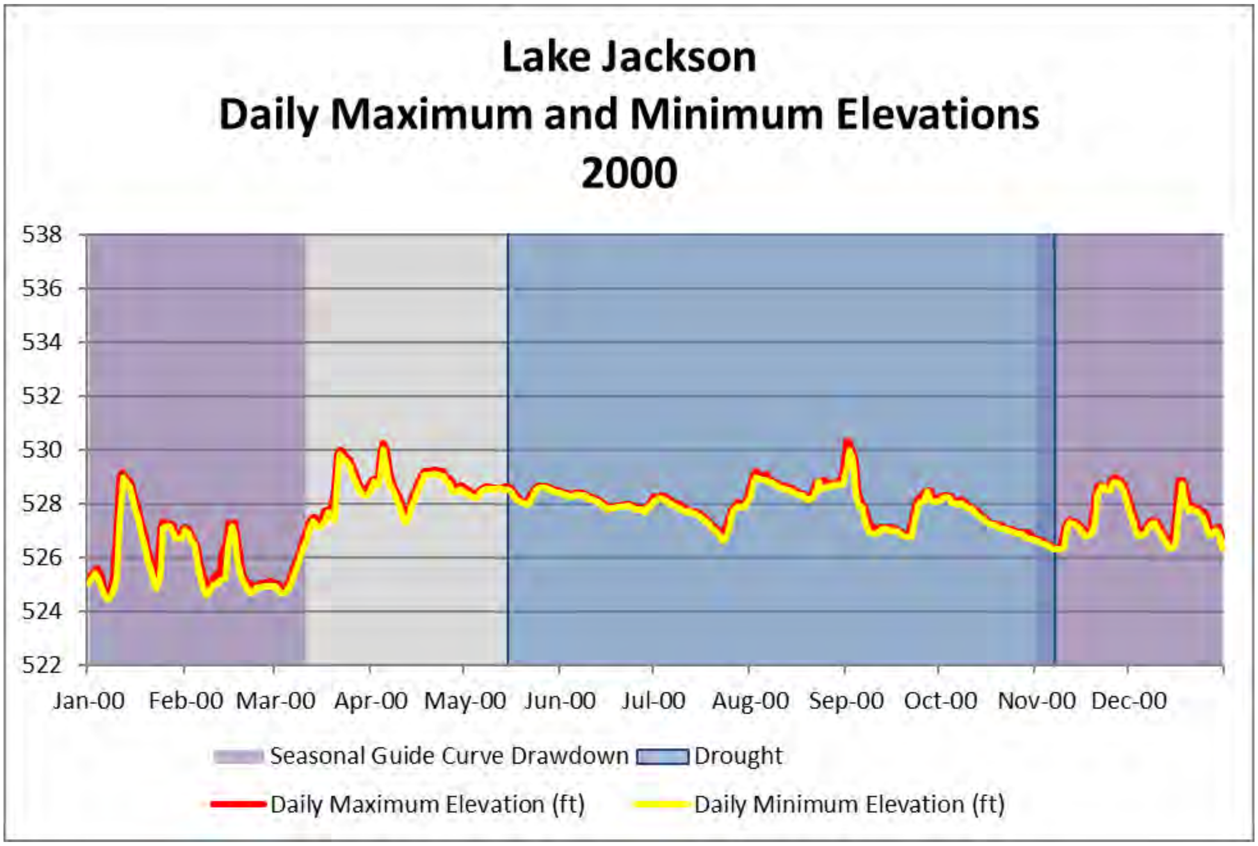
Jan-99
Feb-99
Mar-99
Apr-99
May-99
Jun-99
Jul-99
Aug-99
Sep-99
Oct-99
Nov-99
Dec-99
Seasonal Guide Curve Drawdown
Drought
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)


Lake Jackson
Daily Maximum and Minimum Elevations
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Jan-00
Feb-00
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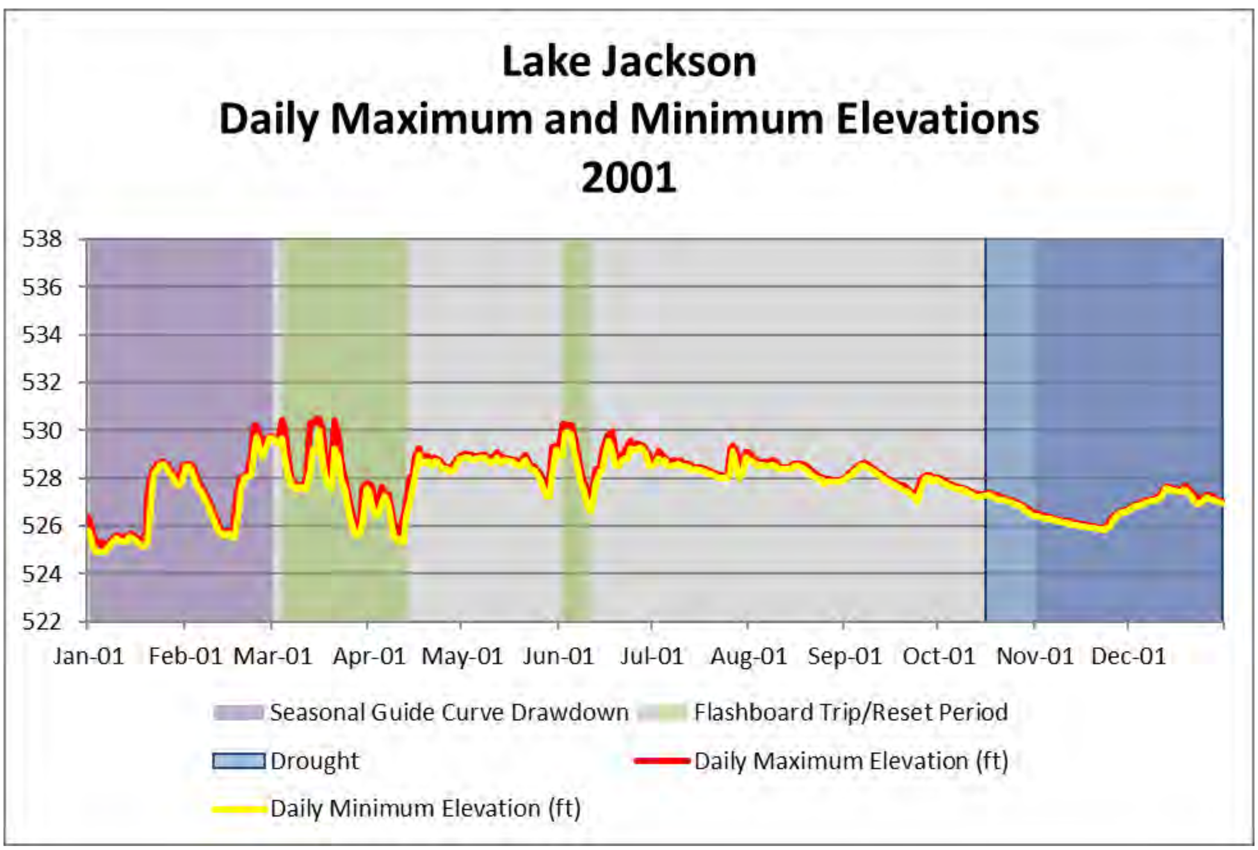
Oct-00
Nov-00
Dec-00
Seasonal Guide Curve Drawdown
Drought
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)


Lake Jackson
Daily Maximum and Minimum Elevations
2001
538
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Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
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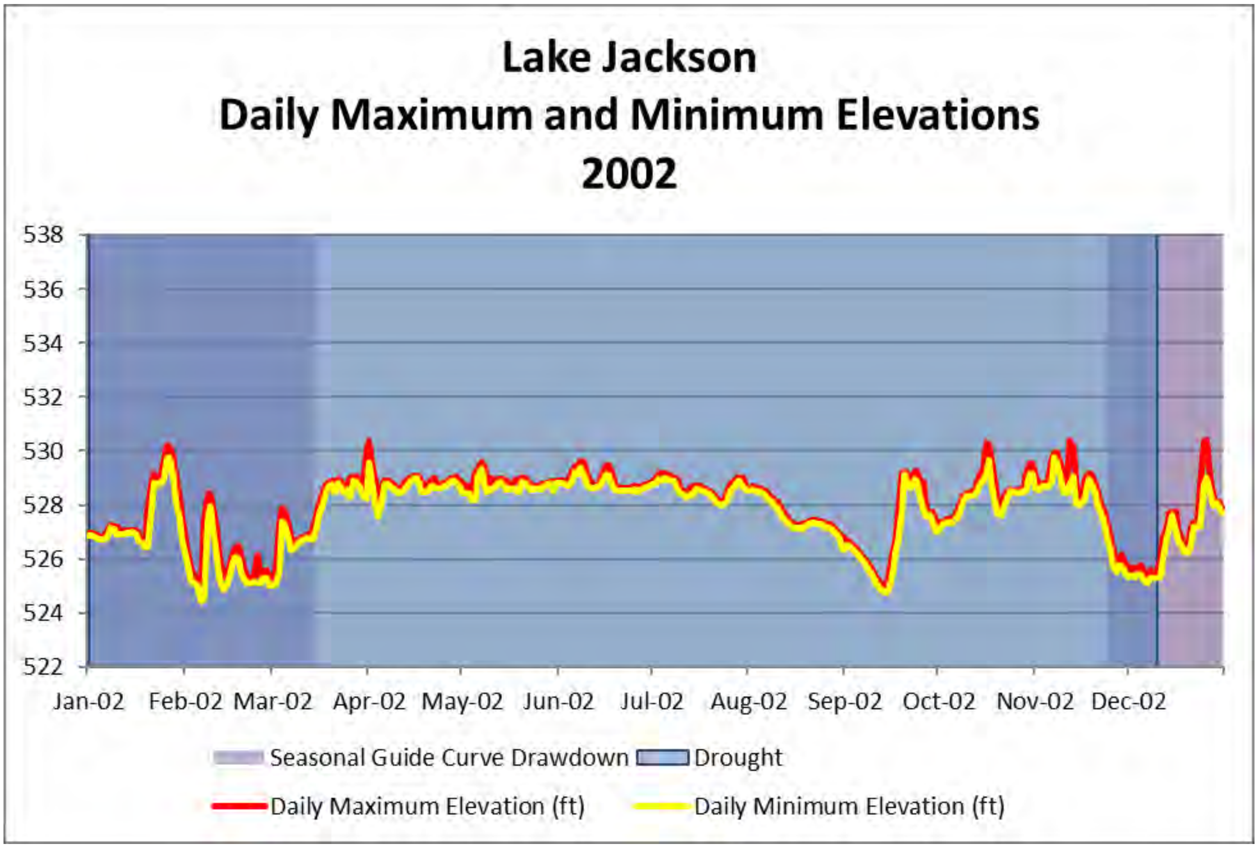
Nov-01
Dec-01
Seasonal Guide Curve Drawdown
Flashboard Trip/Reset Period
Drought
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)



Lake Jackson
Daily Maximum and Minimum Elevations
2002
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Jan-02
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Apr-02
May-02
Jun-02
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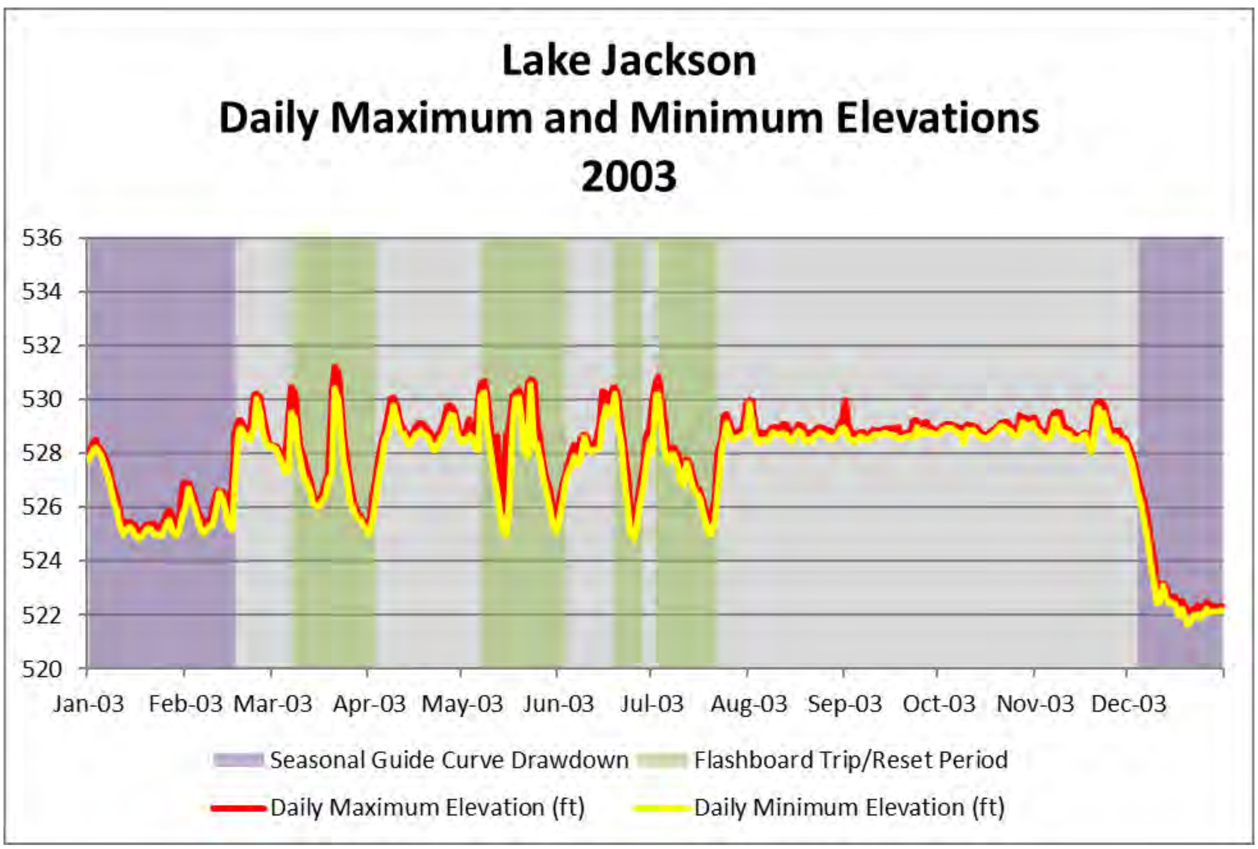
Dec-02
Seasonal Guide Curve Drawdown
Drought
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)



Lake Jackson
Daily Maximum and Minimum Elevations
2003
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Jan-03
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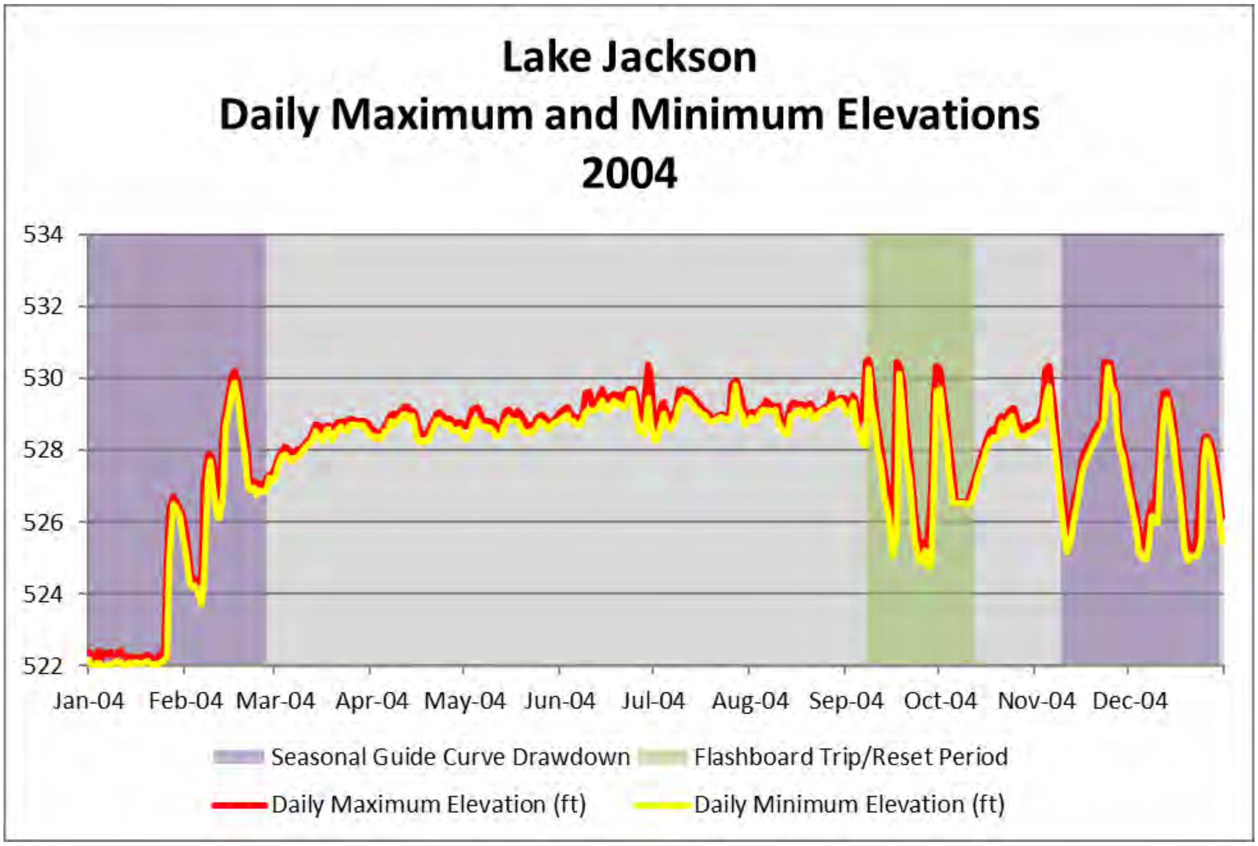
Flashboard Trip/Reset Period
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)



Lake Jackson
Daily Maximum and Minimum Elevations
2004
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Jan-04
Feb-04
Mar-04
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May-04
Jun-04
Jul-04
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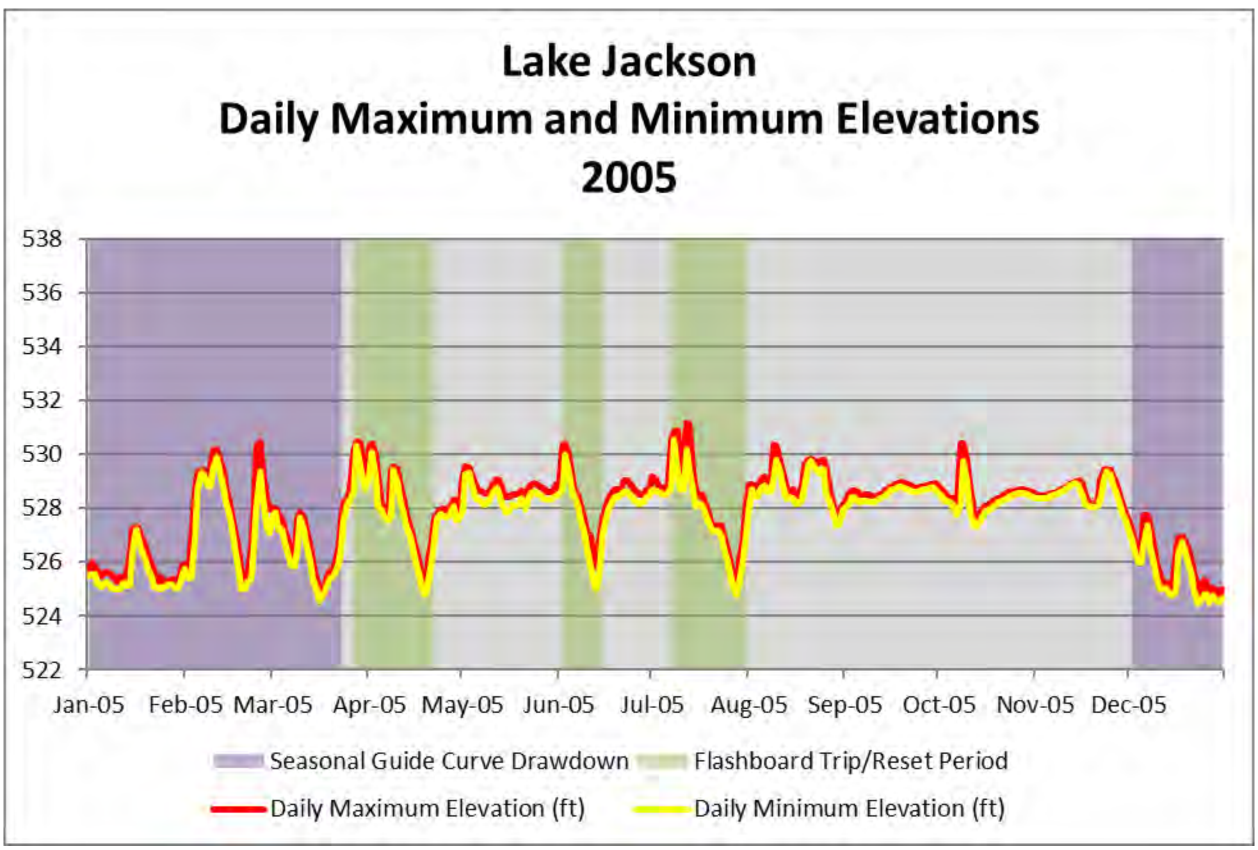
Dec-04
Seasonal Guide Curve Drawdown
Flashboard Trip/Reset Period
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)



Lake Jackson
Daily Maximum and Minimum Elevations
2005
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Jan-05
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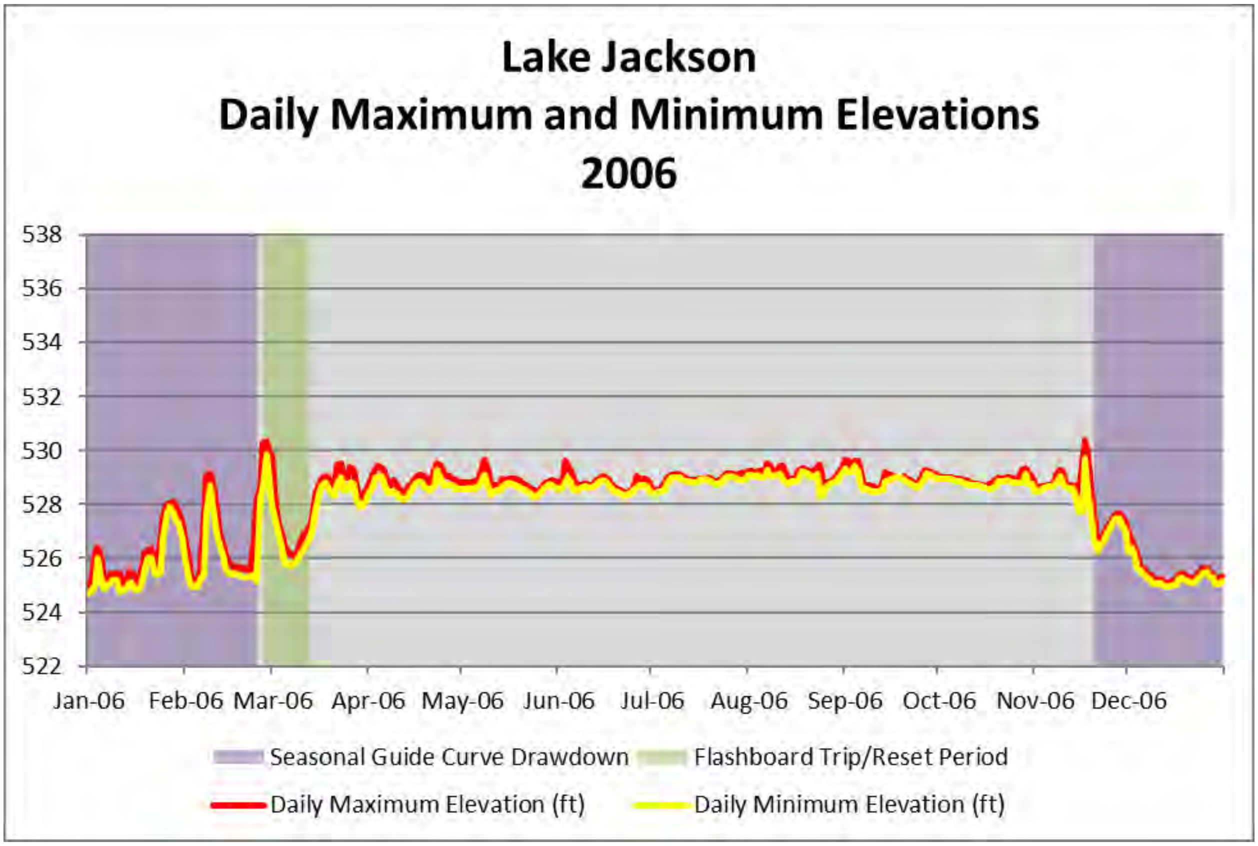
Seasonal Guide Curve Drawdown
Flashboard Trip/Reset Period
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)


Lake Jackson
Daily Maximum and Minimum Elevations
2006
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Jan-06
Feb-06
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Jun-06
Jul-06
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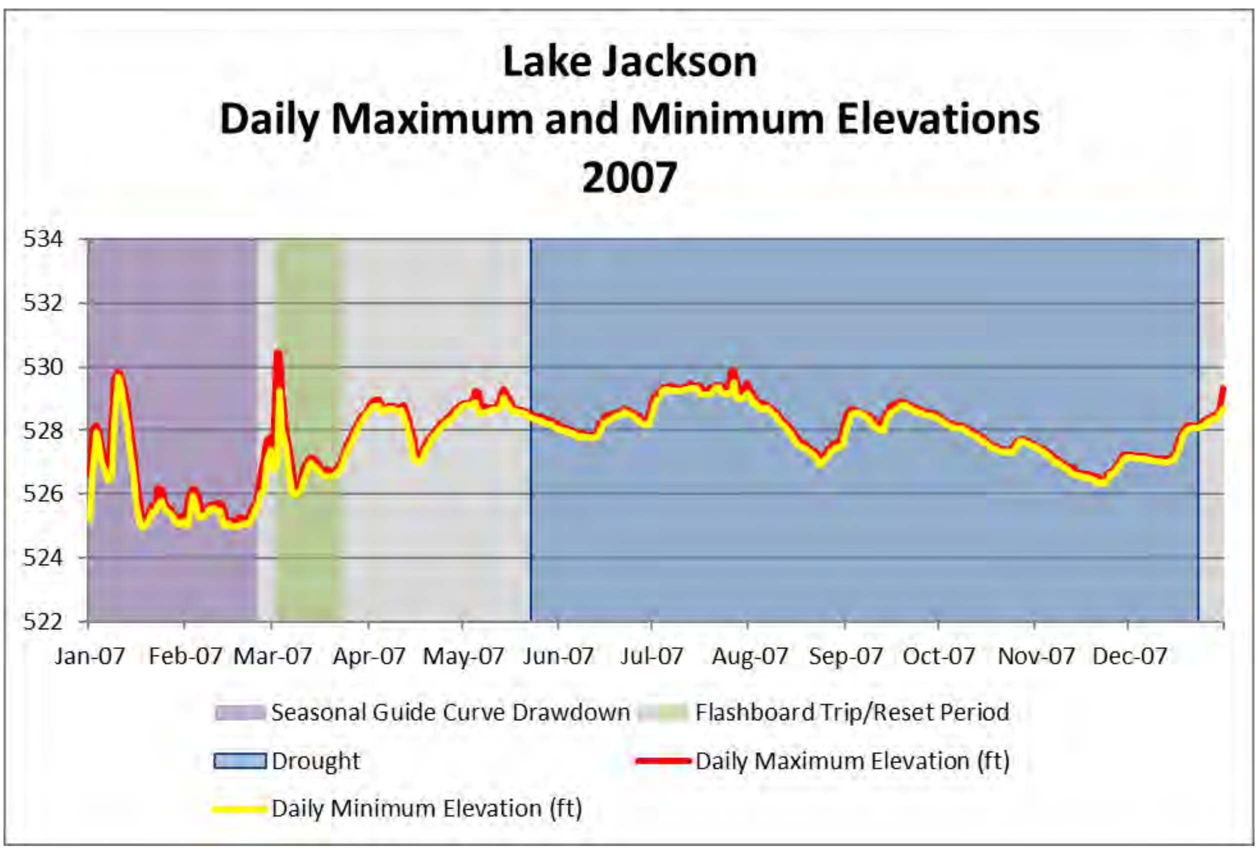
Nov-06
Dec-06
Seasonal Guide Curve Drawdown
Flashboard Trip/Reset Period
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)


Lake Jackson
Daily Maximum and Minimum Elevations
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Jan-07
Feb-07
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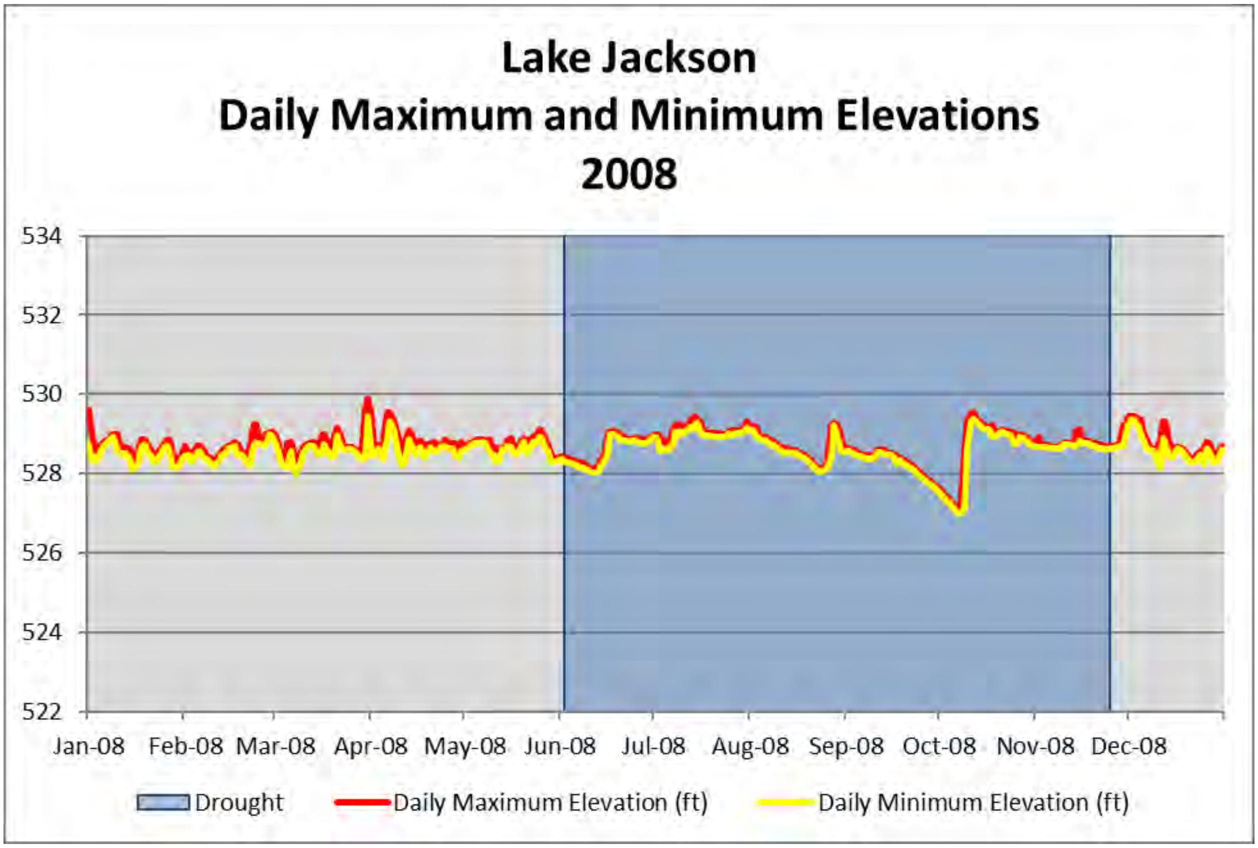
Nov-07
Dec-07
Seasonal Guide Curve Drawdown
Flashboard Trip/Reset Period
Drought
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)


Lake Jackson
Daily Maximum and Minimum Elevations
2008
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Jan-08
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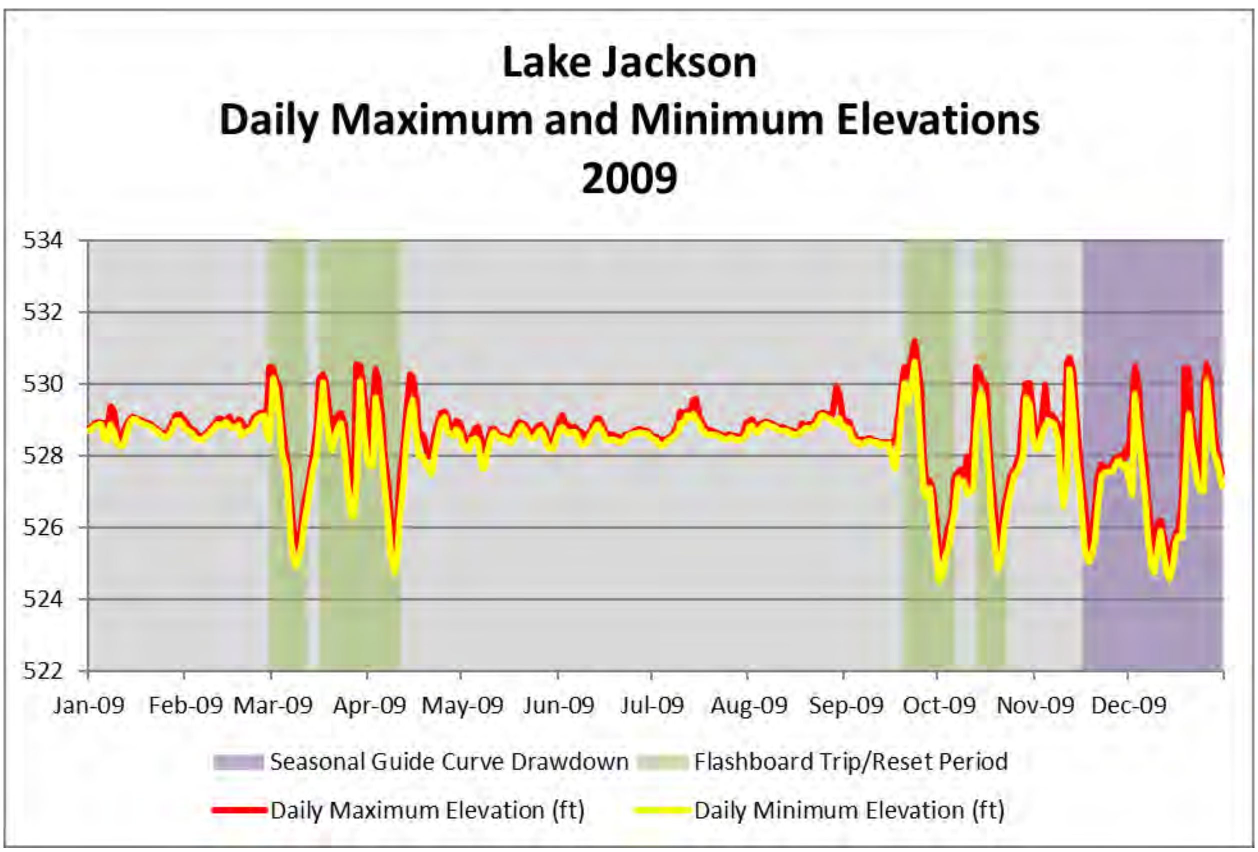
Nov-08
Dec-08
Drought
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)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Daily Maximum and Minimum Elevations
2009
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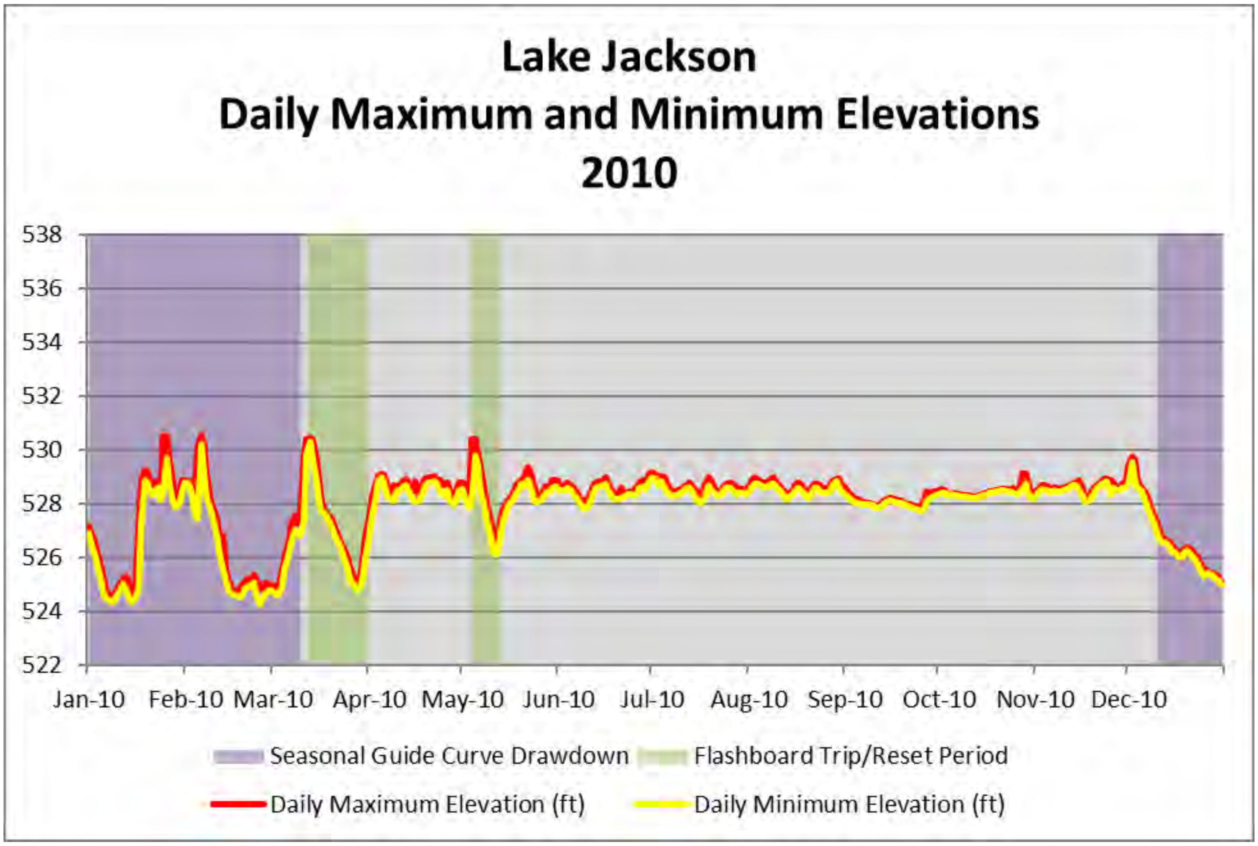
Seasonal Guide Curve Drawdown
Flashboard Trip/Reset Period
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)



Lake Jackson
Daily Maximum and Minimum Elevations
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Jan-10
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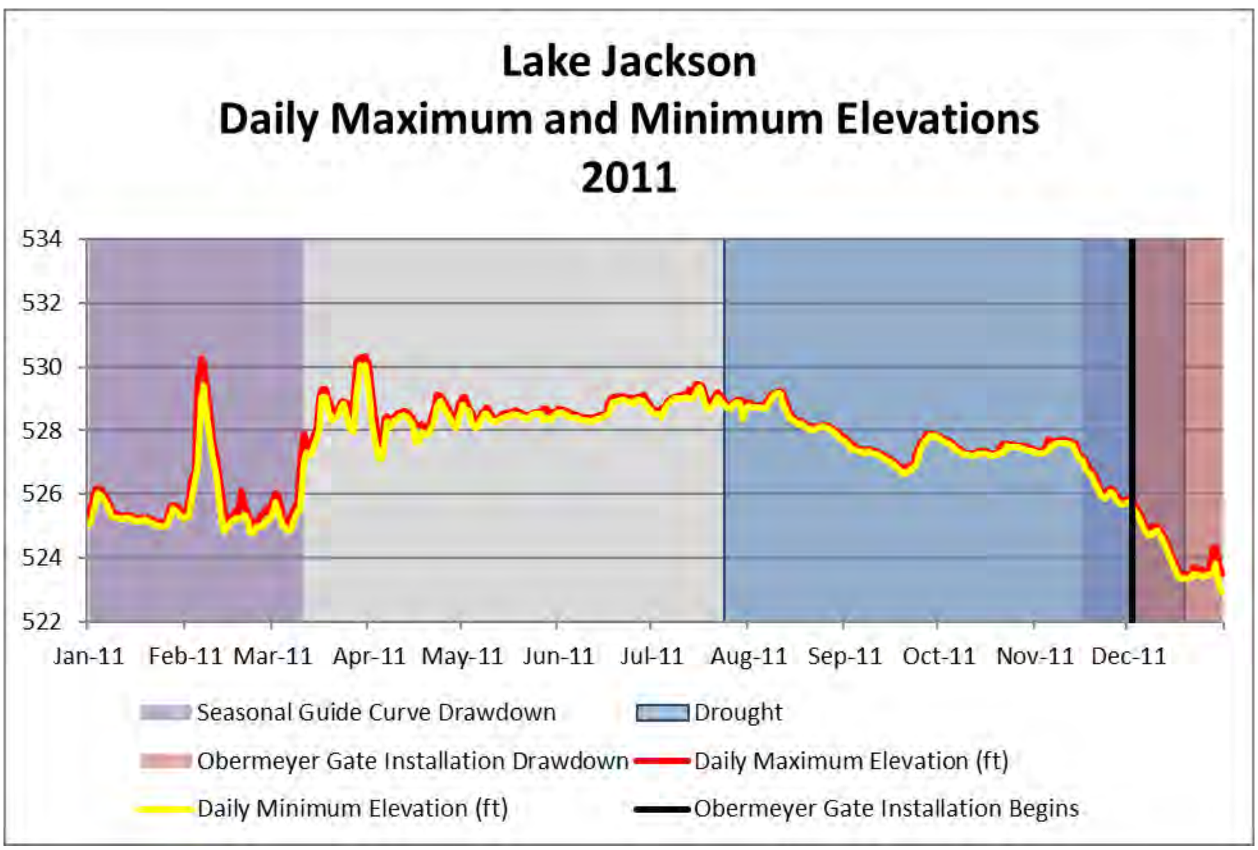
Dec-10
Seasonal Guide Curve Drawdown
Flashboard Trip/Reset Period
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)



Lake Jackson
Daily Maximum and Minimum Elevations
2011
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Jan-11
Feb-11
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Apr-11
May-11
Jun-11
Jul-11
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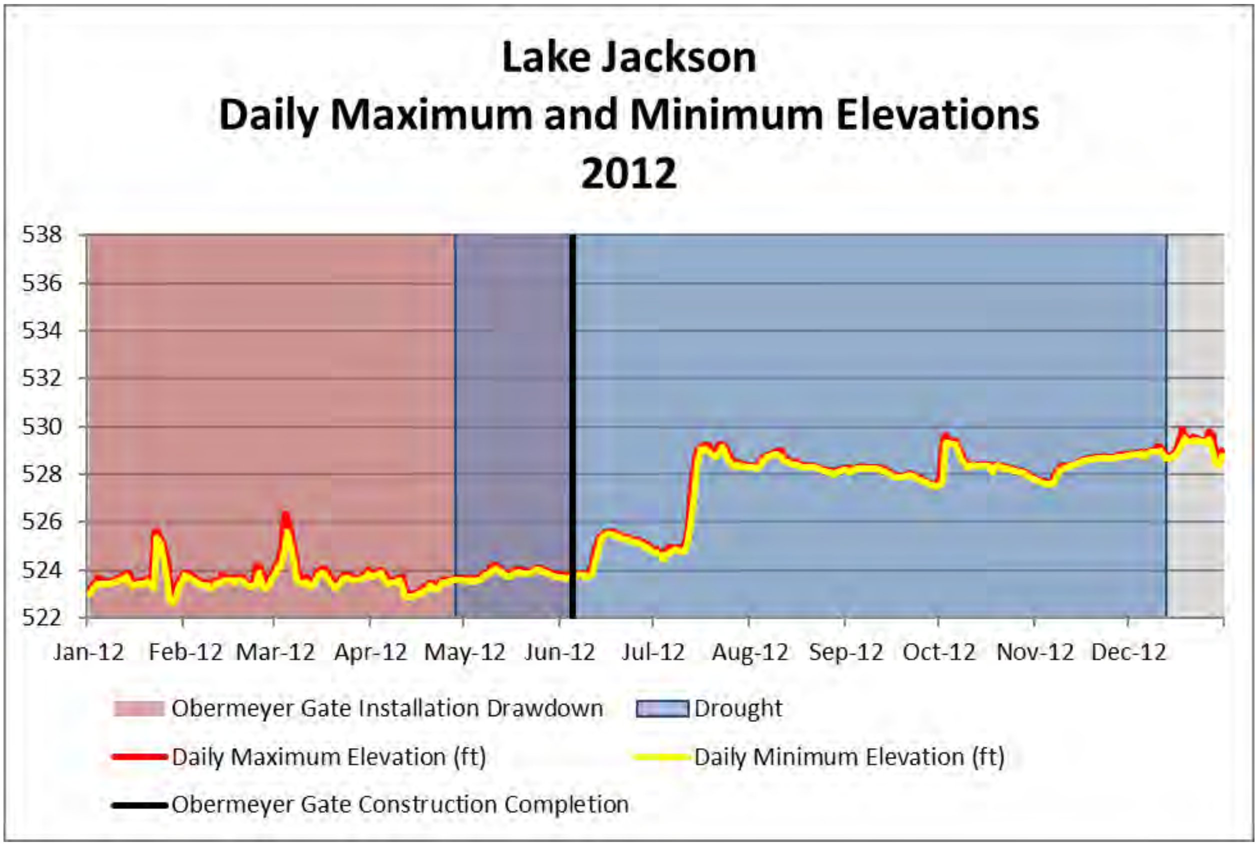
Sep-11
Oct-11
Nov-11
Dec-11
Seasonal Guide Curve Drawdown
Drought
Obermeyer Gate Installation Drawdown
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)
Obermeyer Gate Installation Begins


Lake Jackson
Daily Maximum and Minimum Elevations
2012
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Jan-12
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Sep-12
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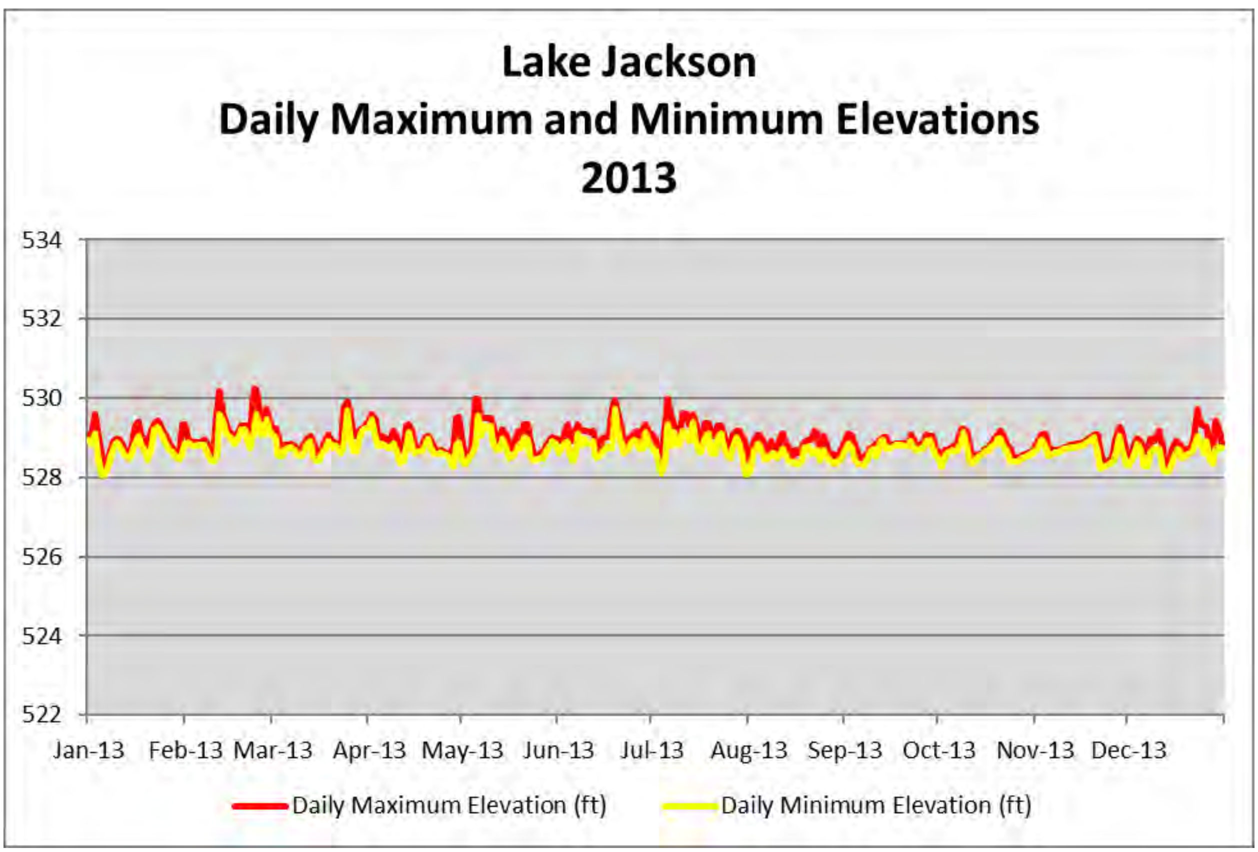
Nov-12
Dec-12
Obermeyer Gate Installation Drawdown
Drought
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)
Obermeyer Gate Construction Completion


Lake Jackson
Daily Maximum and Minimum Elevations
2013
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Jan-13
Feb-13
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Jul-13
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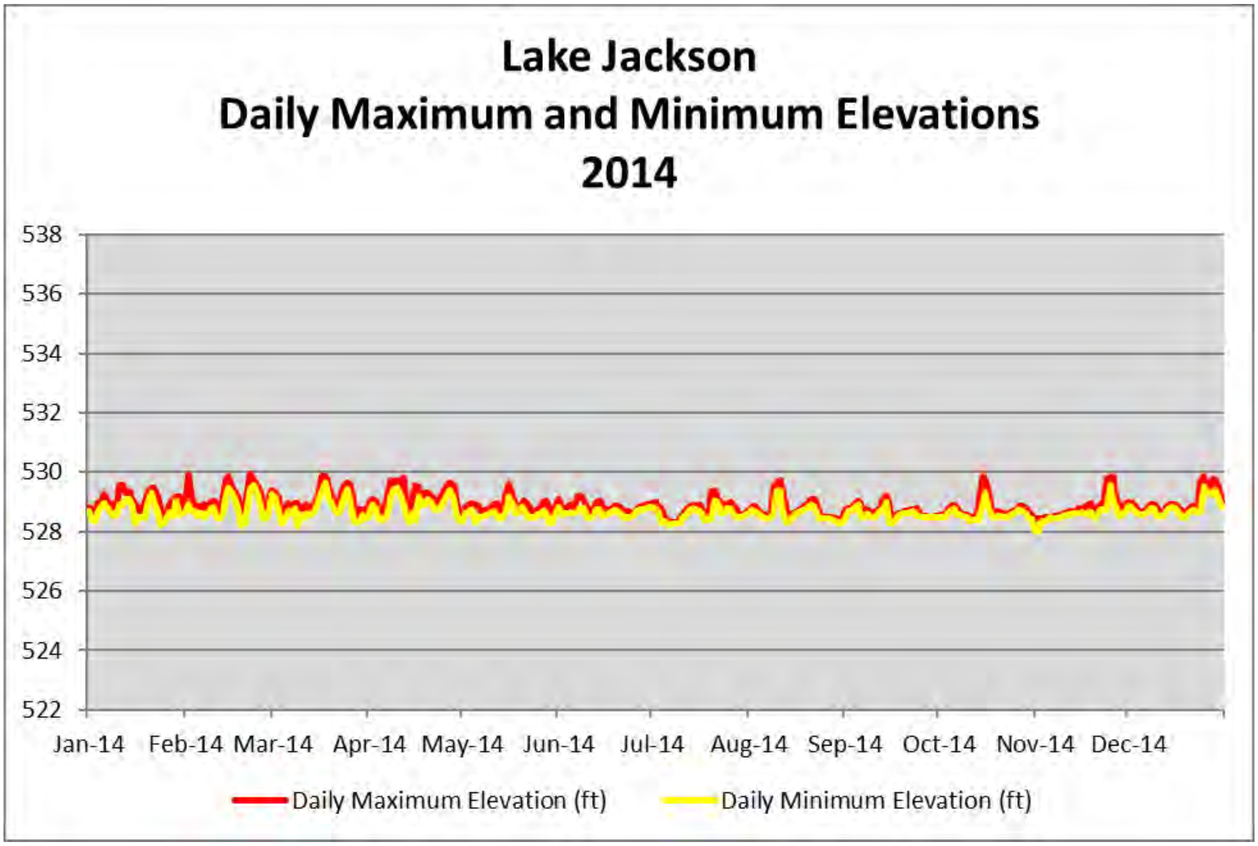
Sep-13
Oct-13
Nov-13
Dec-13
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)



Lake Jackson
Daily Maximum and Minimum Elevations
2014
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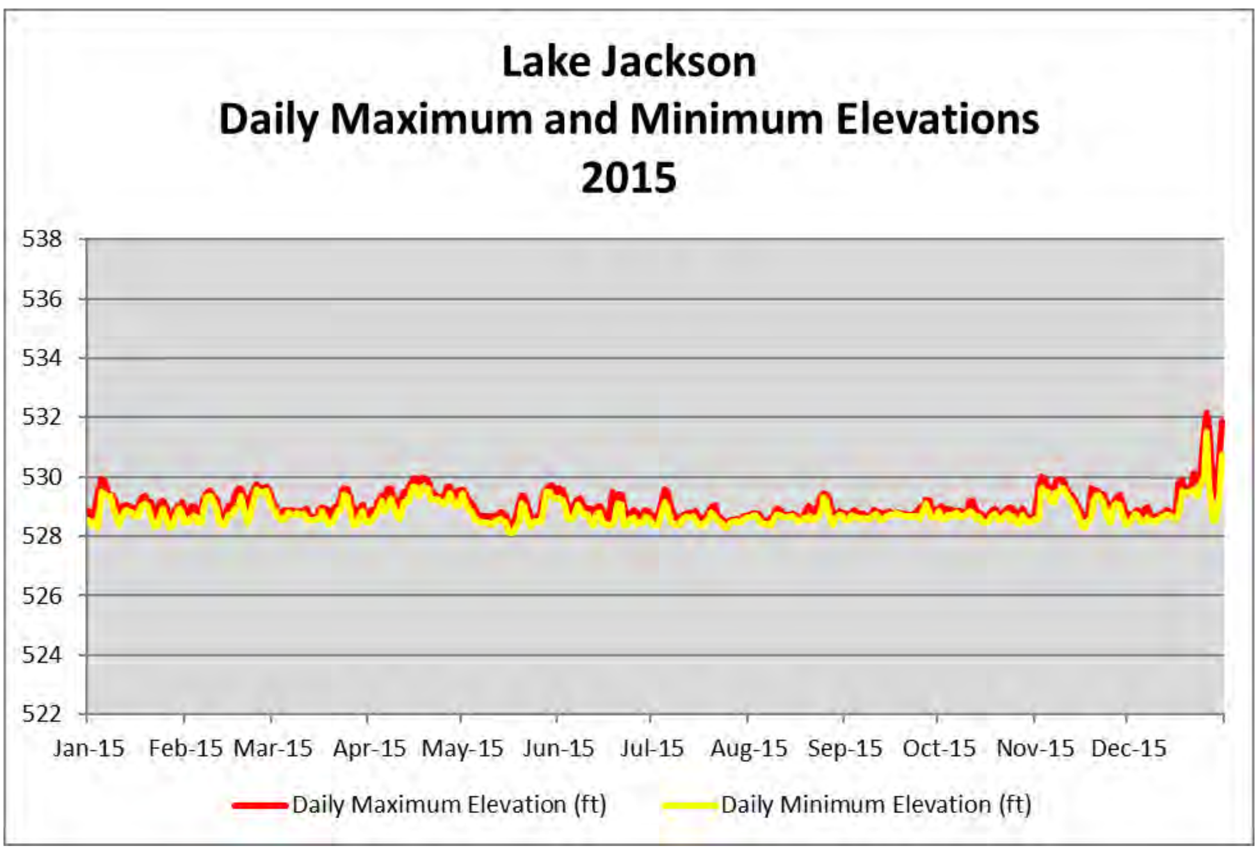
Jan-14 Feb-14 Mar-14 Apr-14 May-14 Jun-14 Jul-14 Aug-14 Sep-14 Oct-14 Nov-14 Dec-14
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)



Lake Jackson
Daily Maximum and Minimum Elevations
2015
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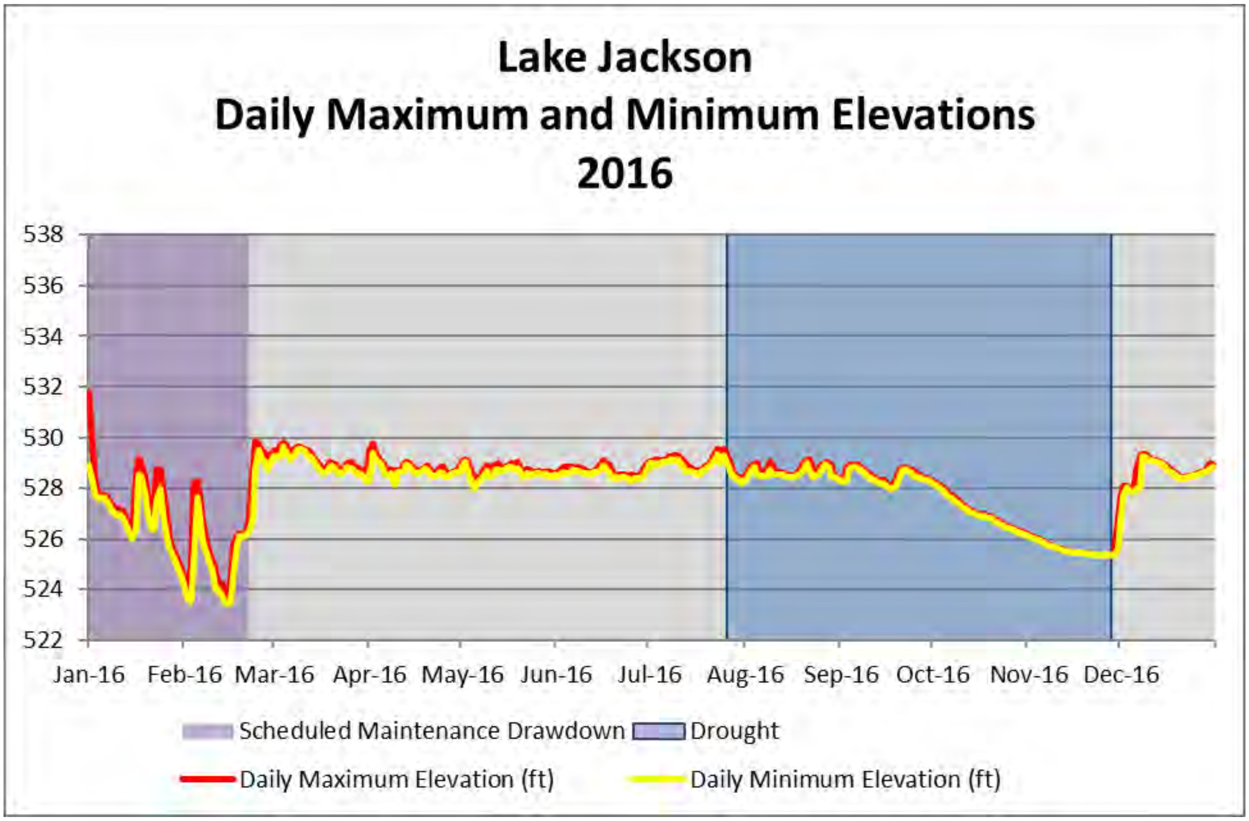
Jan-15 Feb-15 Mar-15 Apr-15 May-15 Jun-15 Jul-15 Aug-15 Sep-15 Oct-15 Nov-15 Dec-15
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)


Lake Jackson
Daily Maximum and Minimum Elevations
2016
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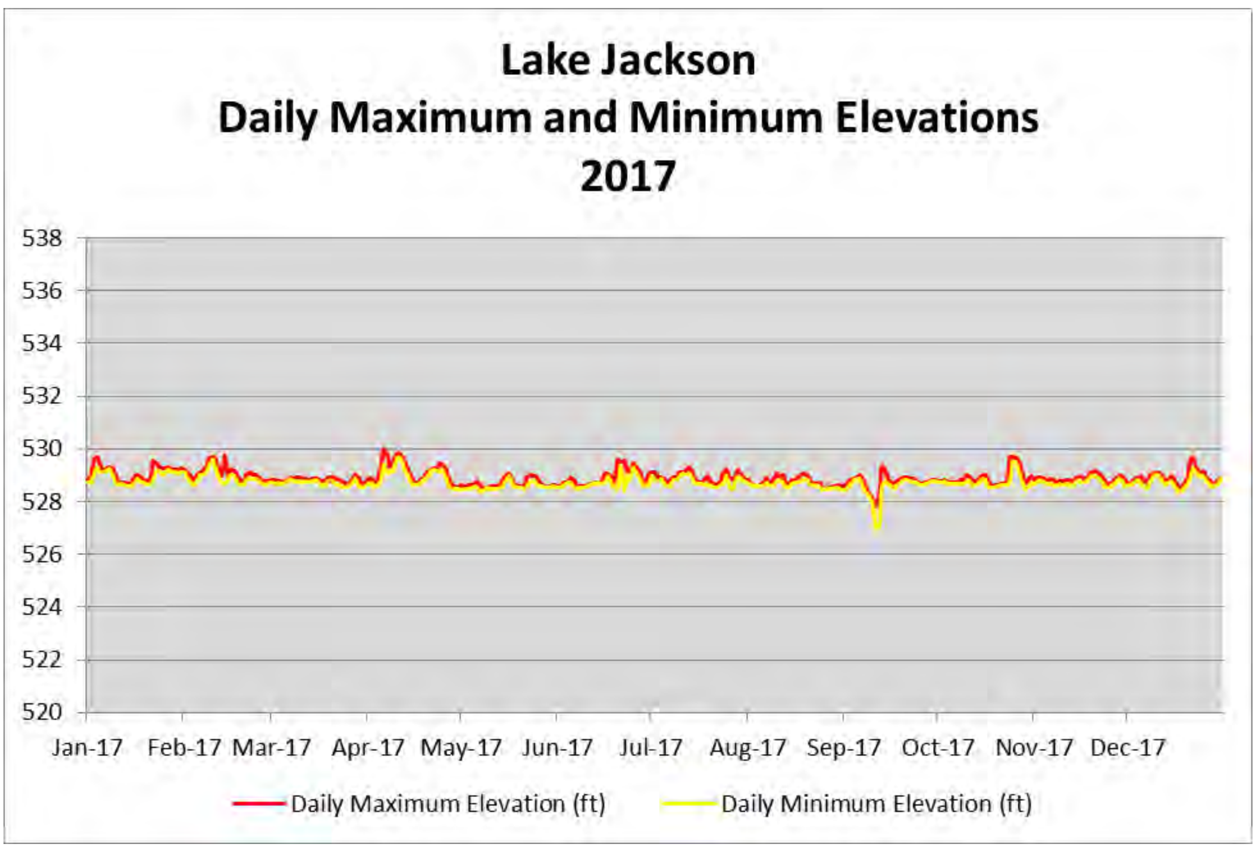
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Scheduled Maintenance Drawdown
Drought
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)


Lake Jackson
Daily Maximum and Minimum Elevations
2017
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Jan-17
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Mar-17
Apr-17
May-17
Jun-17
Jul-17
Aug-17
Sep-17
Oct-17
Nov-17
Dec-17
Daily Maximum Elevation (ft)
Daily Minimum Elevation (ft)

From: Dodd, Anthony Ray
Sent: Sunday, November 18, 2018 8:32 AM
To: Alan Wilson <aew0009@auburn.edu>
Subject: Re:

Thank you, Alan!
I appreciate you taking time to reply during your busy time on the road. I hope you have a safe and happy Thanksgiving!
Safe Travels,
Tony

Get Outlook for iOS

From: Alan Wilson <aew0009@auburn.edu>
Sent: Sunday, November 18, 2018 5:44 AM
To: Dodd, Anthony Ray
Subject: RE:

This email has been sent from an external address. Please use caution when clicking on links or opening attachments.

Hey Tony – Thanks for the note. Here is my recollection regarding the talk we gave to the Jackson Lake Homeowners Association on 22 June 2012. On 6 April 2012, Julia Haar contacted me about giving a talk regarding water quality issues in Jackson Lake after communicating with Elizabeth Booth (see invitation email below). I agreed and contacted you and Tom Broadwell about working together to organize a presentation since it made sense to me to include the group that manages the lake in the presentation. I was excited to team up with you and Tom for this presentation. On 14 June 2012, Tom sent me water quality data for the lake (see email below; data attached). Fred Cox sent me another dataset on 15 June 2012 (attached). I have also attached a copy of our talk. In it, you will see that the talk was structured more informationally on the front end followed by data from the lake. So, no, I haven't conducted any thorough studies on Jackson Lake. I used data made available to me by my colleagues at Georgia Power as well as open access data to show trends in Jackson Lake over time. Hope this helps. If you need more information, just let me know. Alan

---------- Forwarded message ---------
From: **Broadwell, Tom L.** <TLBROADW@southernco.com>
Date: Thu, Jun 14, 2012 at 4:02 PM
Subject: RE: Jackson lake data and meeting with homeowners association June 22
To: wilson@auburn.edu <wilson@auburn.edu>
Cc: Dodd, Anthony Ray <ARDODD@southernco.com>, Cox, Fred L.

<flcox@southernco.com>, O'Mara, Courtenay R. <CROMARA@southernco.com>, Candler, W. Jim <WJCANDLE@southernco.com>

Alan - attached are files of profile data and water chemistry data. There may be some errors in the early profile data (DO, Temp, pH, Spec. cond., etc) -not sure what happened in my download from our database where this data is stored. There is more data, but this is likely plenty.

My take on this data is that there is plenty of nutrients to grow Cyanobacteria and other algae/aquatic plants and that reducing the loading to the reservoir from the surrounding watershed will be the answer to reducing algae blooms, macrophytes, etc. GA EPD is working on this, but it takes time as you know. I think Ms. Haar believes it can happen overnight. I am sure there are plenty of nutrients stored in the bottom sediments throughout the lake that can fuel algae/Cyanobacteria for years, so that is another source also.

In the past, I have asked the Hydro managers to increase frequency of drawdowns for dock maintenance/construction, etc. but they are reluctant to do this due to loss of revenue from hydro operations. I think they are going to 4-5 year intervals - Fred Cox or Courtenay O'Mara can answer this question, and may have input on rationale for these intervals.

Tom Broadwell
GPC
5131 Maner Rd.
Smyrna, GA 30080

404-799-2152

-----Original Message-----
From: Alan Wilson [mailto:aew0009@auburn.edu]
Sent: Wednesday, June 13, 2012 9:45 AM
To: Broadwell, Tom L.; Dodd, Anthony Ray
Subject: jackson lake data

hey guys - how do you want to handle the jackson lake data question? if you have historical water quality data on the lake, i can organize it for our meeting. if you want to do, that is cool too. if you don't want to share past data, that is ok too. i bet i can find some data on STORET or the USGS site. i will send my talk slides to you once i have had a chance to get them done. see you soon.

alan

---------- Forwarded message ---------
From: <jmhaar@msn.com>
Date: Fri, Apr 6, 2012 at 2:37 AM
Subject: Addressing the Jackson Lake Homeowner's Association
To: <wilson@auburn.edu>, <alan.e.wilson@gmail.com>

Hello Dr. Wilson,

Elizabeth Booth, Program Manager of the Watershed Monitoring and Modeling Unit GAEPD, is recommending that I talk with you about the possibility of addressing the Jackson Lake Homeowner's Association with regard to water quality issues. The meeting runs 35-50 in attendance, depending on the time of year. The next meeting is June 22nd.

The topic that I would like to cover may be different than that of the Jackson Lake Board, so perhaps you could give a few topic options for consideration?

My topic preference is mystic cyano bacteria (bluegreen algae), which has been confirmed to be present in our watershed. My questions range from; How prevalent is this in our national and state watersheds? How is it introduced, recognized, and measured? What are the dangers involved? Are there any reconstruction methods that are found to be successful in reversing this condition?

Looking forward to your response,

Julia Haar
Member
Jackson Lake Homeowner's Association

Alan Wilson
Associate Professor - Auburn University
School of Fisheries, Aquaculture, and Aquatic Sciences
www.wilsonlab.com [wilsonlab.com] *- 334.246.1120*

From: Dodd, Anthony Ray <ARDODD@southernco.com>
Sent: Thursday, November 8, 2018 2:46 PM
To: Alan Wilson <aew0009@auburn.edu>
Subject: RE:

Alan,

Thanks again for your interest in addressing this question from FERC for the Jackson Lake hydro relicensing proceedings.
Below this message, please see FERC's exact inquiry seeking clarification in its Additional Information Request (AIR) of 5 Nov 2018.

I very much appreciate your help responding to this. Your response can simply be made back to me in the form of email reply. Please know that your response will become part of the public record. Please let me know if you have any questions.

Safe Travels!
Tony

FERC AIR
FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON, D.C. 20426
November 5, 2018
OFFICE OF ENERGY PROJECTS Project No. 2336-094 Schedule A

...Item Number:

20. During the October 9, 2018, scoping meetings, there was mention of work done in 2012 by Dr. Alan Wilson, an Auburn University Professor, regarding water quality issues (e.g., algal blooms [including cyanobacteria], sedimentation, nutrients, etc.) in Lake Jackson. This work was also referenced by Ms. Julia Haar in her September 25, 2018, filing with the Commission. More specifically, Ms. Haar provided a copy of a presentation given to the Jackson Lake Homeowners Association (Homeowners Association) on June 22, 2012, by Dr. Wilson and two Georgia Power staff members that addressed water quality issues in Lake Jackson. The PAD does not reference Dr. Wilson's work, and it is unclear if the June 22, 2012, presentation to the Homeowners Association is based on a report, or some other work done by Dr. Wilson.[3] To assist us in understanding the issues being raised in the September 25, 2018, filing, and at the October 9, 2018, scoping meeting, please provide a copy of any report(s) that served as the basis for the June 22, 2012, presentation to the Homeowners Association, if available.

______

3. We are aware that Dr. Alan Wilson helped produce a water quality report for Alabama in 2012.

From: Alan Wilson <aew0009@auburn.edu>
Sent: Thursday, November 08, 2018 9:22 AM
To: Dodd, Anthony Ray <ARDODD@southernco.com>
Subject: RE:

Hey Tony – great to hear from you. I am always happy to chat with you. I am driving to NOLA with my family tomorrow. We will be on the road (wife will be driving since I have work to do) from 12-5pm CT. Call my cell 770-722-9075 when you can chat. Alan

---
Alan Wilson
Associate Professor - Auburn University
School of Fisheries, Aquaculture, and Aquatic Sciences
www.wilsonlab.com [wilsonlab.com] - 334.246.1120

From: Dodd, Anthony Ray <ARDODD@southernco.com>
Sent: Tuesday, November 06, 2018 3:04 PM
To: Alan Wilson <aew0009@auburn.edu>
Subject:

Alan,

Hey! I hope all is well with you.
It was good to hear you being involved in GA EPD's HABs kick-off meeting last week.
On a somewhat related note, I'm wondering if I could grab a few minutes of your time by phone to try to recall certain details of
the cyanobacteria presentation you presented for us at Jackson Lake, GA – way back in June of 2012.

I can explain more in conversation.

Might you have an opportunity for brief call from me sometime during Thursday of this week ?

Best Regards,

Tony

Tony Dodd
Natural Resources Specialist
Georgia Power Company
241 Ralph McGill Blvd, NE
Atlanta, GA 30308

Desk: 404-506-5026
Cell: 404-434-9412
ardodd@southernco.com

Georgia Power

Atlantic States Marine Fisheries Commission

Shad & River Herring Management Board

February 19, 2013
2:45 – 4:15 p.m.
Alexandria, Virginia

Draft Agenda

The times listed are approximate; the order in which these items will be taken is subject to change; other items may be added as necessary.

1.	Welcome/Call to Order *(M. Duval)*	2:45 p.m.
2.	Board Consent • Approval of Agenda • Approval of Proceedings from October 22, 2012	2:45 p.m.
3.	Public Comment	2:50 p.m.
4.	Review of NOAA Fisheries Possible Endangered Species Act Listing of River Herring (*K. Taylor)* **Possible Action**	3:00 p.m.
5.	Review of MAFMC Amendment 15 Development (*K. Taylor)*	3:50 p.m.
6.	Consider Georgia proposed American shad stocking plan *(M. Dionne)* **Action**	4:10 p.m.
7.	Other Business/Adjourn	4:15 p.m.

The meeting will be held at the Radisson Plaza Warwick Hotel 220 South 17th Street, Philadelphia, PA (215) 735-6000

MEETING OVERVIEW

Shad & River Herring Management Board Meeting
February 19, 2013
2:45 – 4:15 p.m.
Alexandria, Virginia

Chair: Michelle Duval (NC) Assumed Chairmanship: 02/12	Technical Committee Chair: Mike Dionne (NH)	Law Enforcement Committee Representative: Bridi
Vice Chair: Terry Stockwell (ME)	Advisory Panel Chair: Pam Lyons Gromen	Previous Board Meeting: October 22, 2012
Voting Members: ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, DC, PRFC, VA, NC, SC, GA, FL, NMFS, USFWS (19 votes)		

2. Board Consent

- Approval of Agenda
- Approval of Proceedings from October 22, 2012

3. Public Comment – At the beginning of the meeting public comment will be taken on items not on the agenda. Individuals that wish to speak at this time must sign-in at the beginning of the meeting. For agenda items that have already gone out for public hearing and/or have had a public comment period that has closed, the Board Chair may determine that additional public comment will not provide additional information. In this circumstance the Chair will not allow additional public comment on an issue. For agenda items that the public has not had a chance to provide input, the Board Chair may allow limited opportunity for comment. The Board Chair has the discretion to limit the number of speakers and/or the length of each comment.

4. Review of NOAA Fisheries Possible Endangered Species Act Listing of River Herring (3:00 – 3:50 p.m.)
Background • In August 2011 the National Resources Defense Council petitioned NOAA Fisheries to list alewife and blueback herring (river herring) as threatened under the Endangered Species Act throughout all or a significant portion of its range. Alternatively, the petition requests designation of distinct population segments (DPSs) of alewives and blueback herring and list each DPS as a threatened species. • In November, NOAA Fisheries released a positive 90-day finding on the petition to list river herring under the ESA based on the fact that the petition presents substantial scientific information indicating the petitioned action may be warranted. • In June and July 2012 NOAA Fisheries conducted a series of workshops to gather more information on the status and threats to river herring. The workshops focused on stock structure, extinction risk, and the potential impact of climate change.
Presentations • Update on timeline for ESA status review of river herring by K. Taylor

5. Update Mid-Atlantic Council Amendment 15 Development (3:50-4:10 p.m.)
Background • The MAFMC has initiated the development of Amendment 15 to the SMB FMP to consider adding shad and river herring as a stock in the fishery. **(Briefing CD).**
Presentations • Update on Council Amendments by K. Taylor

6. Consider proposed American shad stocking plan in Georgia (4:10 – 4:15 p.m.)
Background • The state of Georgia has submitted a stocking plan for the Altamaha River. Per Amendment 3 to the FMP, any new stocking programs require TC review and Board approval **(Briefing CD).**
Presentations • Technical Committee Report by M. Dionne
Board actions for consideration • Approve American shad stocking plan for Georiga

7. Other Business/Adjourn

DRAFT PROCEEDINGS OF THE

ATLANTIC STATES MARINE FISHERIES COMMISSION

SHAD AND RIVER HERRING MANAGEMENT BOARD

Radisson Plaza-Warwick Hotel
Philadelphia, Pennsylvania
October 22, 2012

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INDEX OF MOTIONS

1. **Approval of Agenda by Consent** (Page 1)

2. **Approval of Proceedings of August 7, 2012** by Consent (Page 1)

3. **Move to approve the sustainable fishery plans for the states of Massachusetts, Virginia, Rhode Island and Connecticut with the recommendations from the technical committee** (Page 7). Motion by Pat Augustine; second by Bill Adler. Motion carried (Page 7).

4. **Motion to accept the Shad and River Herring FMP Review, the technical committee's recommendations and approve de minimis requests for shad from Massachusetts, New Hampshire and Maine** (Page 8). Motion by Pat Augustine; second by Bill Adler. Motion carried (Page 9).

5. **Move to adjourn by Consent** (Page 10).

ATTENDANCE

Board Members

Terry Stockwell, ME, proxy for P. Keliher (AA)
Steve Train, ME (GA)
Doug Grout, NH (AA)
Dennis Abbott, NH, proxy for Rep. Watters (LA)
G. Ritchie White, NH (GA)
Mike Armstrong, MA, proxy for P. Diodati (AA)
Bill Adler, MA (GA)
Rep. Sarah Peake, MA (LA)
Bob Ballou, RI (AA)
Rick Bellavance, RI, proxy for Rep.Martin (LA)
Bill McElroy, RI (GA)
David Simpson, CT (AA)
Lance Stewart, CT (GA)
Rep. Craig Miner, CT (LA)
James Gilmore, NY (AA)
Brian Culhane, NY, proxy for Sen. Johnson (LA)
Pat Augustine, NY (GA)
Russ Allen, NJ, proxy for D. Chanda (AA)
Tom Fote, NJ (GA)
Loren Lustig, PA (GA)
Mitchell Feigenbaum, PA, proxy for Rep. Vereb (LA)
Leroy Young, PA, proxy for J. Arway (AA)
John Clark, DE, proxy for D. Saveikis (AA)
Bernie Pankowski, DE, proxy for Sen. Venables (LA)
Roy Miller, DE (GA)
Tom O'Connell, MD (AA)
Russell Dize, MD, proxy for Sen. Colburn (LA)
Bill Goldsborough, MD (GA)
Rob O'Reilly, VA, proxy for J. Travelstead (AA)
Kyle Schick, VA, proxy for Sen. Stuart (LA)
Cathy Davenport, VA (GA)
Michelle Duval, NC, proxy for L. Daniel (AA)
Bill Cole, NC (GA)
Ross Self, SC, proxy for R. Boyles (LA)
John Duren, GA (GA)
Patrick Geer, GA, proxy for S. Woodward (AA)
Jim Estes, FL, proxy for J. McCawley (AA)
Wilson Laney, USFWS
A.C. Carpenter, PRFC
Steve Meyers, NMFS

(AA = Administrative Appointee; GA = Governor Appointee; LA = Legislative Appointee)

Ex-Officio Members

Pam Lyons Gromen, Advisory Panel Chair
Larry Miller, Technical Committee Chair

Staff

Bob Beal
Kate Taylor
Mike Waine

Guests

The Shad and River Herring Management Board of the Atlantic States Marine Fisheries Commission convened in the Radisson Plaza-Warwick Hotel, Philadelphia, Pennsylvania, October 22, 2012, and was called to order by Chairman Michelle Duval.

CALL TO ORDER

CHAIRMAN MICHELLE DUVAL: I would like to call the meeting of the Shad and River Herring Management Board to order.

APPROVAL OF AGENDA

CHAIRMAN MICHELLE DUVAL: The first item on the agenda is approval of the agenda. Are there any additions to the agenda? Seeing none, the agenda stands approved.

APPROVAL OF PROCEEDINGS

CHAIRMAN MICHELLE DUVAL: The next item is approval of the proceedings from our August board meeting. Are there any changes to those proceedings? Seeing none, those proceedings stand approved.

PUBLIC COMMENT

CHAIRMAN MICHELLE DUVAL: This is the point in the agenda where we accept public comment from items that are not on the agenda. No one has signed up to provide any public comment. Is there anyone out in the audience who has not signed up to provide public comment that would like to address the board on items not on the agenda? Okay, seeing none, we will move on. Our first major agenda item is review of the possible Endangered Species Act listing for river herring, and Kate is going to give us a brief overview.

REVIEW OF NOAA FISHERIES POSSIBLE ESA LISTING OF RIVER HERRING

MS. KATE TAYLOR: As the board is aware, in August 2011 NMFS received a petition to list alewife and blueback herring on the endangered species list. Last October NMFS published a positive 90-day finding stating that the listing may be warranted. As a result, NMFS initiated three status review workshops in order to develop their proposed rule for the listing.

NMFS will be using the results of the workshops in conjunction with the ASMFC River Herring Benchmark Stock Assessment in the development of the proposed rule. These workshops were held in June and July. Many state agency, technical committee and SAS members along with ASMFC staff were involved in these workshops.

The reports from these workshops were recently published on the NMFS Website, and I am just going to give a brief overview of the results from these three workshops. The first workshop that was held was focused on stock structure of river herring. The main objectives of this workshop were to determine whether there is evidence of stock structure and to provide an expert opinion on the extent of stock structure.

NMFS will use the information from this workshop to assess whether there are discrete and significant populations of alewife and blueback herring, which may warrant separate protections under their DPS policy. For alewives the stock structure hypotheses included a single stock complex for a stock complex as identified in the NRDC petition for a stock complex based on geographic breaks and management differences; a six-stock complex based on genetics; and also an individual river-by-river stock complex.

The hypotheses for blueback herring were similar to that. To assess the strength and weaknesses of each hypothesis, the workshop participants considered all available data including research on genetics, evidence of physiological differences, tagging studies, evidence of strain and homing behavior, growth rates, run timing and abundance of alewife and blueback throughout their range.

As an example of the genetic work that was discussed, participants in the workshop reviewed the preliminary results from Eric Palkovacs' work from Duke University. Many state agencies actually provided Eric with river herring samples for this work. His analysis identified five genetically distinct populations for alewife and blueback herring.

This is an example of the stock structure that was proposed in his research and is included in the stock structure reports. Based on the results of the study, his research suggests that there is substantial population structure at the drainage scale. The preliminary management recommendations from this research suggest that river drainage is the appropriate level for management for both species.

However, the authors noted a number of caveats for their study, including that this is preliminary analysis, hybridization may be occurring between alewife and blueback herring, and a longer time series would be useful in the research. During the workshop, participants also focused other discussions on the genetic diversity in Maine rivers, the influence of stocking, marine migrations, landlocked populations of alewife and also identified major data gaps in the research.

I want to note with regard to the landlocked populations of alewife the petition focuses on anadromous populations and does not address landlocked populations specifically and NMFS has made a determination that the scope of the review pertains only to anadromous populations. The recommendations from the stock structure workshop were that there is evidence of regional stock structure for both alewife and blueback.

However, the exact boundaries of where the stock structure is occurring are difficult to distinguish. Additionally, the ocean phase should be considered a mixed stock, and there is evidence to support regional differences in the migration patterns for both species. The second workshop focused on the extinction risk for alewife and blueback herring.

For each species two hypotheses were examined to look at the extinction risk; a one-stock complex option, coast-wide option; and then also looking at five stock complex options for each species. However, going forward the analysis does allow for the possibility of combining the results of the different DPSs in the future.

No consensus was sought from the participants in the workshop and no results were provided in the report, but rather the report included data that would be used in the analysis and also a recommended methodology for completing the analysis. The report did include an attempted preliminary analysis using the NMFS fall and spring trawl survey data for the coast-wide population, looking at the next hundred years in trying to assess the extinction risk.

However, the analysis did not produce realistic confidence intervals and the model is being modified. I would just like to note this proposed extinction risk analysis is quantitative as opposed to the qualitative analysis that was completed for the sturgeon listing. The third workshop focused on climate change. Again, no consensus was sought by NMFS at the workshop, but rather the invited experts provided their individual opinion on the potential impacts of climate change on river herring.

Some of the results of the workshop were that there are limiting factors that vary across the full distributional range for both species and that conservation of river herring will need to consider numerous factors other than the possible impacts from climate change. All three reports were sent for a peer review.

For the stock structure report the peer reviewers found that the report was based on the best available science. One of the quotes from one of the peer reviewers is that among the data sources the genetic evidence was the most coherent and robust available. For the extinction risk report the peer reviewers generally found that this was based on the best available science.

However, there were noted deficiencies in some areas of the reports and recommendations were made. Two of the peer reviewers also noted and discussed the landlocked populations of alewife and their consideration in the petition. The climate change peer review report has not been published yet; and when it is I will inform you of the results.

The current timeline; the proposed rule was expected on August 6th. The Service filed for and was granted an extension on the proposed rule. Just so the board is aware if the proposed rule does publish in November, the public comment period may not still be open when our February board meeting takes place. It is late in February next year. However, if it publishes after November, if it publishes in December – we have been told to expect it before the end of the year – then it would be open over our February board meeting. Thank you, Madam Chair.

CHAIRMAN DUVAL: Are there any questions for Kate about the workshops? Doug.

MR. DOUGLAS GROUT: Just a little clarification; as you were going through the stock structure you said that one of the options they looked at was a five-stock complex. Yet I also heard something in your report that said that the stocks should be at the river drainage level. There are a lot more river drainages than five, so could you clarify for me what they were trying to say there?

MS. TAYLOR: The work that Eric Palkovacs completed, his management recommendation suggests that the river drainage is the most appropriate level for management. However, the findings of the workshop participants recommended the regional structure as opposed to – or there was evidence of a regional stock structure. No recommendations were made in the report as to which should be used, but the findings of the participants was that there was regional stock structure.

MR. JAMES GILMORE: Kate, when NOAA or the Fisheries Service was here last year when we met with them and we were talking about Atlantic sturgeon, we had asked them about the threats that I guess caused or were the biggest contributing factors to the listing at that point, and the two they said were climate change and population growth.

I think the concern at that point was, well, we'll just about list everything of those two. Now, that was not listed in any of these workshops, so are there other factors that they include in this and is population going to be one of them when they go through doing this analysis. Again, they had climate change listed here, but the one that they had mentioned last time was human population growth.

MS. TAYLOR: There are the five factors for the listing determinations. It includes the present or threatened destruction of habitat, overutilization, disease or predation, the anadromous existing regulatory mechanisms and other natural or manmade factors affecting their continued existence. In developing these workshops, NMFS had consulted with commission staff and technical representation on the data gaps that were not addressed in the stock assessment.

Our terms of reference were very focused. We were operating within the commission stock assessment process. However, for the listing determination the Service is required to provide additional information, including the population by ability analysis and effects of climate change. That is why they focused these workshops on those specific items because they were not addressed in the ASMFC stock assessment.

CHAIRMAN DUVAL: Are there any other questions for Kate on the workshops? Okay, seeing none, we're going to move on to our next item, which is an update on both the New England and Mid-Atlantic Council amendments that pertain to these species.

UPDATE ON NEFMC AMENDMENT 4/5 AND MAFMC AMENDMENT 14

MS. TAYLOR: As the board has been briefed previously, the New England Council's Amendment 5 and the Mid-Atlantic Council's 14, which both include management options to address river herring bycatch, those final EISs have been submitted. At the Atlantic Herring Section this morning, Toni discussed the New England Council's Amendment 4 Federal Court Ruling and postponed the discussion until this board meeting.

I'm going to go through the updates that have occurred under that lawsuit right now. The lawsuit was filed in April of 2011. The claim was that NMFS was in violation of the MSA and the APA by failing to include shad and river herring as a stock in the fishery and to create catch limits for them. They also failed to adequately set up ACLs and AMs for Atlantic herring.

The federal court ruling orders that Amendment 4 was vacated or will be vacated effective one year from now, and the court will retain oversight of the agency's actions in this matter until the Service fully complies with the order. The ruling required NMFS and the New England Council to review the most recent science and consider a full suite of protections for shad and river herring. They gave the Service one year to take action in order to minimize the bycatch of shad and river herring.

This time period will permit the Service to determine whether Amendment 5, which has been approved and submitted by the council, if this minimizes bycatch to the extent practicable. The federal court ruling also orders the Service to consider new approaches for setting allowable catch for sea herring that accounts for its role as a forage species.

The federal court ruling also specifies a specific timeline the Service has to comply. Within one month of the ruling, NMFS was required to provide the court with an explanation of whether the Amendment 4 definition of stock in the fishery complies with the MSA. They have completed this. The Service was also required to send a letter to the New England Council recommending that the council consider shad and river herring as a stock in the fishery based upon the river herring and shad stock assessments and NMFS positive 90-day finding. They also completed this and those letters were included in your briefing material.

In a six months' timeframe NMFS is required to file a report with the court describing the progress on the actions ordered; and at the one-year mark in August NMFS will be required to provide the court with an explanation of whether the Atlantic Herring FMP minimizes bycatch for river herring and also to include a completed NEPA analysis for the specifications and management measures demonstrating that a hard look at the environmental impacts of the remedial actions were taken. Thank you, Madam Chair.

CHAIRMAN DUVAL: Are there any questions for Kate with regard to the status of the New England amendments. I know several folks sitting around the table here sit on the New England Council and there might be questions from some of the other members of the board. All right, if not, we will move on to our update of Mid-Atlantic Council Amendment 15.

REVIEW OF MAFMC AMENDMENT 15 SCOPING DOCUMENT

MS. TAYLOR: The Mid-Atlantic Council has initiated the development of Amendment 15, which will consider the inclusion of shad and river herring as a stock in the fishery to the Squid, Mackerel, Butterfish FMP. The Mid-Atlantic Council could either manage shad and river herring through a new FMP, a separate FMP or could add shad and river herring to the current Squid, Mackerel, Butterfish FMP.

If the council directly managed shad and river herring under an FMP, then the required mandatory and discretionary provisions of the MSA would apply. Potentially blueback herring, alewife, American shad and hickory shad could go into the Squid, Mackerel, Butterfish FMP. The scoping document that was included in your briefing material was provided by council staff.

This is a draft document. It has not gone out for public comment yet although it is expected to be released for public comment very shortly. Council staff has advised that the draft will not change with any significance most likely. The council is requesting input in the scoping document.

They posed specific questions including is the existing management and framework sufficient for shad and river herring; could a federal FMP improve or maintain the condition of river herring stocks; could an FMP resolve competing interests and conflicts among user groups; are current efforts and plan measures by the council sufficient to address bycatch of river herring in federal fisheries; and additionally, what scale should management occur; what management units are appropriate; and if the Mid-Atlantic Council ends up managing shad and river herring, can the council and ASMFC fully accomplish management of river herring throughout its range without doing a joint FMP with the New England Council?

As I mentioned, the amendment was initiated in June. The scoping and public hearings are expected to run some time in the very near future, through the end of November or early December. This lays out the remainder of the timeline for the development of the amendment with the expected final rule effective January 2015.

The public comment period will most likely not occur during an ASMFC board meeting. It is expected obviously to be over before the February board meeting, so the board will need to determine if comments will be submitted to the council when the public comment period does open; and if so, how those comments will be developed if done outside of this meeting. Thank you, Madam Chair.

CHAIRMAN DUVAL: In the past we have used a workgroup approach to develop comments from this board in response to the New England Council Amendment 5 and Mid-Atlantic Council Amendment 14. I guess I would welcome some input from board members with regard to what you all feel might be the most efficient means to provide some comment on the scoping document.

I would think that the board might want to weigh in as to whether or not we would see joint management or complementary management as something that we would prefer should the council decide to move forward with either an amendment to the Squid, Mackerel, Butterfish FMP or a separate FMP for stocks, but I would welcome some input from board members with regards to how you would like to develop some comments on this. Terry.

MR. TERRY STOCKWELL: Madam Chair, I thought the approach you used on Amendment 5 and 14 were very helpful; but just as a point of information for the board, at next week's NRCC meeting the New England Council has forwarded a request for some discussion on the coordination of river herring management, particularly following up on Amendment 15.

The New England Council is at a point of impasse not knowing in what direction to go. It is somewhat reactive to the ongoing litigations, but it is of utmost importance to me and I hope many other members of the board that we have a coordination between the two councils and this board and not have one council take the lead.

CHAIRMAN DUVAL: Thanks for that, Terry. Are there other thoughts or comments around he table? Doug.

MR. GROUT: I would agree with your suggestion of getting some workgroups together in between the two meetings to develop comments for the scoping document and then have those comments approved via an e-mail vote before the comment period is up.

MR. THOMAS FOTE: After dealing with black sea bass, summer flounder and scup for these many years in a joint management plan, I find very little confidence in doing a joint management plan with either one of the councils anymore. I think we should coordinate, we should do things, but I don't want to be put under the restrictions of what the councils are doing; especially like in the case of black sea bass we have a fully recovered fishery that is not being – overfished or overfishing is taking place and yet we're still fishing at the level of a collapsed fishery with this being overfished and overfishing.

We have the summer flounder which is we spent the most money, as NMFS has pointed out many time, on studying summer flounder and yet when the SSCS look at it they still put it as a Tier 3. I'm going to say how much information do we have to get to get a Tier 1. That gives me grave concerns in doing joint management plans anymore because of what goes on in basically dealing with recovered fisheries. Now, we are going to be a long way from recovering river herring but it is just the principle of looking at these joint plans and getting locked into the federal guidelines.

MR. WILLIAM GOLDSBOROUGH: I just want to endorse your thought about having a workgroup work on comments. It seemed to work pretty well last time. Having served on that one, I would volunteer for this one if you go forward that way. One comment to Tom's point; obviously, I think the unifying factor with all these species is that they're all forage species. Having that in common I think there is great value in going down this road; but even having said that, we're going down it already. I think it behooves us to put together some quality comments.

MR. FOTE: River herring was not only a forage species, but it was harvested by a lot of my people to make pickled herring and things like that, and that has been shut down recreationally. It was important to be used for other things. Yes, I understand it is a forage species, but it still is a consumption species also in some ways. I would like to rebuild them to the point that people can go out and catch herring to pickle or use it in any way they want.

DR. WILSON LANEY: To Tom's point, I concur with him entirely. I will just make the point again and I have made it in the past, but river herring is important from an ecological perspective, from an economic perspective and hugely important historically from a cultural perspective, so I think there are three big reasons to try and push this one as a priority for restoration.

MR. MIKE ARMSTRONG: Just a comment; I am concerned the more federal involvement, the more we go that route – there is a problem with bycatch, but the main problems facing river herring occur in the rivers, occur in the headwater, ponds and occur in state waters, and that is the purview of ASMFC. I think our comments should reflect that we're in a better position to solve the really true problems that face river herring as opposed to just the bycatch issue.

CHAIRMAN DUVAL: I think there is agreement on that. If there are no other comments on this issue, this is the point where we start asking for volunteers. Bill Goldsborough has already graciously volunteered to do so. I see Doug Grout. Pam.

MS. PAM LYONS GROMEN: Madam Chair, I just would like to have the opportunity to reach out to the AP members, as before with the other working groups, and allow them to provide some feedback to the working group. Thank you.

CHAIRMAN DUVAL: So noted; I think that would be a good idea and we would do the same thing with the technical committee as well. Back to volunteers; we have Bill, Doug Grout, Terry Stockwell, Russ Allen, and Mitch. That would be five members plus myself plus input from both the technical committee and the advisory panel.

Unless anyone else has a burning desire to participate in that committee, I think that is probably enough cats to try to herd in terms of getting together for a call between now and then. Is everyone good with that approach? I will be getting in touch with those folks to have a call down the road and you should be expecting some e-mail correspondence from us between now and the close of the comment period. The next item on our agenda is review and approval of American Shad and River Herring Sustainable Fishery Plans. I think probably Larry is going to take us through that.

DISCUSSION OF AMERICAN SHAD AND RIVER HERRING SUSTAINABLE FISHERY PLANS

MR. LARRY MILLER: The technical committee received four plans for review and potential approval for sending along to the board. There were three shad plans; one from Massachusetts, one from Connecticut and one from Virginia. For river herring there was one and that came from Rhode Island. Since Kate actually took the better notes and speaks much faster than I do, I will leave it up to Kate go through the particulars for these plans.

MS. TAYLOR: The plan submitted by Massachusetts was a request to close all fisheries outside of the Merrimack River and the Connecticut River. In addition, they would lower the bag limit from six fish per day angler to three fish per day. The technical committee reviewed the plan and would encourage Massachusetts to implement research to document the presence of spawning shad above the Essex Dam. The technical committee recommended that the board consider approval of this plan.

The Connecticut Shad Plan proposed the continuation of the commercial and recreational fisheries in the Connecticut River. In all other systems in Connecticut, they are currently prohibited and will remain prohibited systems. Other than the Connecticut River for recreational fishing would become catch and release only. The technical committee recommended the board consider approval of this plan.

The Virginia Shad Plan is very similar to the bycatch request the board has previously approved from 2006-2011. This is a limited bycatch allowance for American shad through 2017. The technical committee recommended approval of the plan with a modification to lower the permit cap from 50 to 30 and also recommended monitoring the 500 fish harvest cap and adjust as necessary in future seasons.

The Rhode Island River Herring Plan that the board reviewed was for a 5 percent bycatch allowance in the Atlantic herring fishery. There was also a section for a freshwater proposal. However, Rhode Island removed this from the report. It was currently contained in the briefing material, but it has been removed.

The 5 percent bycatch allowance would require mandatory participation by the Atlantic herring fishermen in the current SMAST Monitoring Program. The technical committee had recommended approval of this plan. Thank you, Madam Chair.

CHAIRMAN DUVAL: Are there any questions on any of the plans or comments on the technical committee's report? Rob O'Reilly.

MR. ROB O'REILLY: Madam Chair, I just want to point out on that slide for Virginia the board has approved the bycatch allowance from 2006-2012. I believe the slide said 2011.

CHAIRMAN DUVAL: Thanks for that clarification, Rob. I did just want to give the board a heads up while we're discussing sustainable fishery plans, North Carolina is probably going to, as a result of unfortunate timing, come back to the board for probably a fax poll before the end of the year. The board approved our sustainable fishery plan for shad in May.

That had to go through our state commission's public review and input process. Due to a number of other items that were already in the queue for the July public hearings, this was unable to be reviewed until our September public hearings. There was an advisory committee recommendation from one of our state advisory committees to modify that plan slightly; basically instead of a March start date for the season, move to a February 15th start date for the season in three of the river systems. We want to be proactive and so took that to the technical committee at their recent meeting, and they approved that, but we still have yet to present this to our state marine fisheries commission.

We were just trying to get ahead of the curve and allow some options for our commission. I have no idea what our commission is going to do. It is difficult to predict that. If they stick with the originally proposed opening date in the plan, we are good to go. But if they elect to change that from a March 1 to February 15th start date, we are going to need to come back to this board for approval of that modification.

The reason that is important is because our fisheries by rule in North Carolina open January 1 and run through April 14th. In order for us to issue a proclamation to make that season change, we would need approval prior to the end of the year. I just wanted to give folks a heads up that might be happening. Thank you for your indulgence. Mr. Augustine.

MR. PATRICK AUGUSTINE: Madam Chair, I would move that the board approve –

CHAIRMAN DUVAL: Wait, Pat, I think Bob wanted to make a couple of comments on Rhode Island's Plan, if you don't mind holding up. I'm sorry to interrupt.

MR. ROBERT BALLOU: Dare I jump in when Pat was about to make a motion to approve, but for the board's edification I think it is important with regard to the Rhode Island plan to note that it is more nuance provision than what is up there. The 5 percent bycatch allowance would pertain to landings from federal waters.

However, in state waters what we would enact is a state permitting program through which it would mandate participation in the move-along protocols that are part of the SMAST Program; and in so doing seek to minimize bycatch and maintain our zero tolerance standard. We would not be changing the state standard for state waters. We would be rather implementing a program that would help minimize bycatch in state waters. Thank you.

CHAIRMAN DUVAL: Are there any questions of Bob with regard to Rhode Island's Proposal? Okay, Mr. Augustine, I apologize for the interruption if you would like to continue.

MR. AUGUSTINE: **I move that the board approve the plans as submitted for American shad and river herring sustainable fishery plans for the states of Massachusetts, Connecticut and Virginia and Rhode Island with the recommendations suggested by the technical committee.** I believe they were on Virginia; you had two recommendations.

CHAIRMAN DUVAL: Okay, motion by Mr. Augustine to approve the sustainable fishery plans for the states of Massachusetts, Virginia, Rhode Island and Connecticut with the recommendations from the technical committee.

MR. AUGUSTINE: I want to tie the recommendations from the technical committee directly to Virginia, because Virginia had two recommendations on it. So if that would clarify it; could we move that up, Mike? Is that clear?

CHAIRMAN DUVAL: They have already taken care of that, I believe, so I think it is okay to leave it the way it is.

MR. AUGUSTINE: All right, let's take that off and just say Rhode Island and Connecticut.

CHAIRMAN DUVAL: And a second by Mr. Adler. Is there discussion on the motion? Is there any opposition to the motion? **Seeing none, that motion stands approved.** The next item on our agenda is the Fishery Management Plan Review**,** and I think Kate is going to take us through this.

FISHERY MANAGEMENT PLAN REVIEW AND STATE COMPLIANCE

MS. TAYLOR: The 2012 Fishery Management Plan Review looked at the 2011 fishery. The status of the stocks is where the 2007 benchmark stock assessment found that all stocks are current all-time lows. The status of hickory shad is currently unknown. The 2012 benchmark stock assessment found the stocks to be depleted.

The closure of the Ocean Fishery has lowered the coast-wide landings of American shad. In 2011 coast-wide total landings reported in the compliance reports from the individual states and jurisdictions was at about 650,000 pounds, which is a 14 percent increase from 2010. For hickory shad, in 2011 commercial coast-wide landings were just under 100,000 pounds is a 27 percent decrease from the 2010 landings.

For river herring, in 2011 landings were reported from Maine, New Hampshire, New York, New Jersey, Delaware, Maryland, PRFC, Virginia and North Carolina and South Carolina, totaling 1.2 million pounds, which is a 40 percent decrease from the 2010 numbers with the majority of the landings coming from the state of Maine.

De minimis requests were made from Maine, New Hampshire and Massachusetts. The plan review team found that the provisions of the de minimis standards were met. The plan review team made a number of recommendations; specifically that several states did not report all of the monitoring requirements listed under Amendments 2 and 3. These omissions included variance length frequency, age frequency and degree of repeat spawning.

The plan review team requests that this information be included in the future. The plan review team also requests that all states check with their law enforcement agencies and their freshwater counterparts when reporting poaching, bycatch or other losses. Additionally, the plan review team requests the board task the technical committee with a number of items, including having the technical committee provide a spreadsheet on how to accurately determine the variance; a study on Connecticut sampling methods; a study on the minimum sampling size recommended in the survey design; a consistent definition of a repeat spawner mark; and standardization of the length frequency reporting. That is my report, Madam Chair.

CHAIRMAN DUVAL: And just to clarify in case I missed it, those de minimis requests were for shad?

MS. TAYLOR: For shad.

CHAIRMAN DUVAL: Okay, thank you. Mr. Adler.

MR. WILLIAM A. ADLER: What did you just say?

CHAIRMAN DUVAL: Okay, I was just clarifying that the de minimis requests from Maine was actually for shad as opposed to river herring and Kate confirmed that.

MR. ADLER: Okay, that was my point because we were talking about de minimis from Massachusetts, Maine and everything was for shad and not river herring, right?

CHAIRMAN DUVAL: That is correct. Are there any questions for Kate with regard to the FMP Review? If not, I think I may entertain a motion from the board to task the technical committee with those items that they requested to be tasked with. Mr. Augustine.

MR. AUGUSTINE: How do you want to word the motion? You could rattle it off and Joe could take it down. Let's see how we can do that. I move to accept the technical committee's report. What more detail do you want more than that?

CHAIRMAN DUVAL: **I think it might be move to accept the fishery management plan review.**

MR. AUGUSTINE: **Okay, and that, too.**

CHAIRMAN DUVAL: Second by Bill Adler. Is there any discussion on this motion?

MR. DAVID SIMPSON: I guess just a question about the sort of dual track in assessment and management that we're on now because Amendment 3 is shad, right. Amendment 3 is based on state or regional sustainability plans, which may or may not include some of the elements that – for example, commercial catch characterization and biological sampling for the Connecticut River; we don't use that in our sustainability plan.

But the technical committee is going to spend time reviewing our use of proxy information from the Holyoke, Massachusetts, Dam to characterize our commercial fishery in Connecticut. So what you've got is a detail of stuff that we have done historically that has nothing to do with our sustainability plan and is stuff that we don't do.

It is collected from Massachusetts, if they collect it, and then we use it as best I can. I have made that sound a little more complicated but at what point do we say, look, what are we doing this for, how much technical committee time do you want to spend on it and what is its relevance in management.

CHAIRMAN DUVAL: Dave, I understand what you're getting at. We have directed the states to use the information that they feel is the most appropriate in order to properly manage their fisheries through a sustainable fishery plan. That may or may not include all of the required monitoring elements, so your question is where do these two things converge, more or less.

It is a great question. I don't know if Larry had any input on that. I guess from my perspective I think back to the beginning of Amendment 3 and all of the different monitoring requirements that were put into place and the belief from the plan development team that those were all of the monitoring elements that we ideally would want all the states and jurisdictions to be collecting as the appropriate breadth of information that would be necessary to properly manage these species; recognizing that not all the states and jurisdictions actually have the money to collect some of those and some have been just due to staffing shortages or funding shortages.

Some states have been in a situation where they haven't been able to collect those. There may be a time in the near future where those two things do converge. I think from my perspective the hope is that the sustainable fishery plans are going to continue to be works in progress. I know at least from North Carolina's perspective that as we continue to move down the road and hopefully collect more in-depth and appropriate information, that we may be able to update those sustainability targets that we have chosen and perhaps expand upon them and use more than the two or three that we have chosen for each of the systems.

MR. SIMPSON: I really point it out because it has been, what, five years since we have lost anadromous fish conservation money, so there is no federal support for – this is about managing a state budget and trying to do everything we can to be full partners in the commission process. But we were conscious in our development of the sustainable fishery plan to sort of be parsimonious and pick the most important things that we could develop at the least cost.

Recognizing we are using sportfish restoration money now to run our entire shad project, and you're talking about maybe four or five thousand fish that get caught recreationally and we spend $100,000 just on our monitoring, so it sort of begs the question into the future of we're going to continue to do this as long as we can but you can foresee a day where it might be more difficult.

CHAIRMAN DUVAL: I understand that and can certainly feel that same pain. Are there thoughts from other folks from around the table in response to the comments that Dave had?

MR. MILLER: I think it was pretty much as Dr. Duval had described it. We recognized, when we were working on these different amendments, that each state had a limited amount of resources available and that they were the best entity to determine how to spend that resource in order to achieve what was the ultimate goal, which is the restoration of these fish species.

Also we did recognize that these were works in progress and that there is more than one way to skin a catfish and that maybe we could all learn something from what some other states are doing and that eventually they could adopt some new strategies into their plans in the future after they have reviewed and seen what worked and what hadn't worked.

That was the goal and I think that we're actually achieving that goal. I am seeing some very good plans coming out. A lot of thought, a lot of discussion at the technical committee meetings and a lot of ideas being exchanged, and I think that is exactly what we were hoping would happen.

MR. AUGUSTINE: Madam Chair, do we want to add to that and technical committee report?

CHAIRMAN DUVAL: How about technical committee recommendations?

MR. AUGUSTINE: Excellent; thank you.

CHAIRMAN DUVAL: Okay, the motion reads move to accept the Shad and River Herring FMP – okay, so we need to include de minimis requests in there as well. Okay, the motion now reads move to accept the Shad and River Herring FMP Review and the technical committee's recommendations and approve de minimis requests for shad from Massachusetts, New Hampshire and Maine. Motion by Mr. Augustine; seconded by Mr. Adler. Is there any other discussion on this motion? Is there any objection to this motion**? Seeing none, that motion stands approved.**

At this time I did want to take a couple of minutes since we actually do have a couple of minutes and thank Mr. Miller for his service on the technical committee. He is going to be stepping down as chair, which means that this is his last meeting for us. He was gracious and willing enough to step into that role as the chair of the technical committee when not a lot of other folks had the time or the inclination to do so. I think if everyone could sort of join me in a round of applause for Larry for his efforts. (Applause) Mr. Grout.

MR. GROUT: I had a question for Larry or Kate on the compliance reports. The question is are these items that are listed under each state; are they referred in detail back to the technical committee members so they understand what needs to change here because there are some things that I personally don't quite understand here and even why you're asking for them, like did not report variance on river herring. Well, we get absolute counts at ladders so why would there be a variance on that; but they know what they need to come up with and that is the important thing.

MS. TAYLOR: I inform the states of the compliance issues that were brought up after the FMP Review is accepted and then I also remind them when I send out the compliance report reminder.

OTHER BUSINESS

CHAIRMAN DUVAL: Are there any other questions? If not, I believe that was our last agenda item. Unless there is any other business to come before the board – Wilson.

DR. LANEY: Well, just a quick comment, Madam Chairman, to let the board know that the Fish and Wildlife Service has created a River Herring Team that covers the entire east coast. We can provide a list of who those numbers are. One of the things we're doing as part of the formation of that team is conducting an inventory of all the national wildlife refuges on the east coast with a view toward identifying whether or not they host river herring habitat; and if so, whether there has been any monitoring done.

We do have an expanded inventory and monitoring program for the National Wildlife Refuge System, so there is the possibility that we might be able to allocate some funding toward river herring monitoring on national wildlife refuges. I just wanted to mention that and we can provide details to the technical committee later and to the board, too, if there is more interest in who is serving on that.

CHAIRMAN DUVAL: Thanks for that very much, Wilson. I think a lot of folks would be very interested whenever they hear the word "funding" especially with regard to our anadromous species.

ADJOURNMENT

CHAIRMAN DUVAL: Is there any other business to come before the board? Is there any objection to adjourning? Seeing no objection, the Shad and River Herring Board is adjourned.

(Whereupon, the meeting was adjourned on October 22, 2012.)

Atlantic States Marine Fisheries Commission

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Paul J. Diodati, (MA), Chair *Dr. Louis B. Daniel, III, (NC), Vice-Chair* *Robert E. Beal, Executive Director*

Healthy, self-sustaining populations for all Atlantic coast fish species or successful restoration well in progress by the year 2015

December 5, 2012

Dr. Chris Moore, Executive Director
Mid-Atlantic Fishery Management Council
800 North State Street, Suite 201
Dover, Delaware 19901

Dear Dr. Moore,

Please accept the following comments on behalf of the Atlantic States Marine Fisheries Commission Shad and River Herring (SRH) Management Board regarding the scoping document for Mid-Atlantic Fishery Management Council's (MAFMC) Amendment 15 to the Squid, Mackerel and Butterfish Fisheries Management Plan (SMB FMP).

Given the MAFMC has not yet determined whether it will move forward with Amendment 15 to designate shad and river herring as "stocks in the fishery", it is difficult to provide specific recommendations at this time. The Board is supportive of the development of a draft amendment, insofar as it is important to know what the proposed management alternatives and associated impacts are before a determination is made regarding the necessity of the management document.

In response to the questions posed in the scoping document, the Board offers the following comments and requests:

Effectiveness of Current and Planned Management

The ASMFC has invested a considerable amount of time and resources in the development and implementation of the Amendments 2 and 3 to the ASMFC SRH FMP. These amendments required states to close any state shad and/or river herring fishery that is not determined to be sustainable. To date, six of the seventeen ASMFC managed jurisdictions for river herring and nine of the seventeen ASMFC managed jurisdictions for American shad have sustainable fishing plans in place. The remainder of the jurisdictions will be closed for both species beginning January 1, 2013. It will take, at a minimum, three to five years to begin to evaluate the effect of these management actions.

With regard to the recent actions approved under the New England Fisheries Management Council's (NEFMC) Amendment 5 to the Atlantic Herring FMP and the MAFMC's Amendment 14 to the SMB FMP, ASMFC agrees it is not yet possible to determine the effects of these management actions and it will likely take several years to do so. Both of these amendments require management actions that have the potential to reduce shad and river herring bycatch in the Atlantic herring and squid, mackerel, butterfish fisheries to the full extent possible, while allowing these fisheries to remain operational. ASMFC supported the management actions in both amendments.

Habitat Considerations
Impacts to shad and river herring habitat are of utmost concern for the successful restoration of these species. A determination of shad and river herring as stocks in the fishery would clearly require the designation of essential fish habitat (EFH) for these species. Section 305(b)(3)(B) of the Magnuson-Steven Act obligates councils to provide comment and recommendations to the Secretary and any federal or state agency regarding any activity that is likely to substantially affect the habitat of anadromous species under its authority. ASMFC requests the Council detail how it would address this requirement as well as designation of EFH should it move forward to include these species as stocks in the fishery.

Management Approach
The scoping document details the range of existing complementary and joint management approaches pursued for other Council/ASMFC managed species as potential options. However, the Board believes the unique life history of shad and river herring would require a new approach that acknowledges and preserves the Board's authority to manage in-river state-water fisheries. Similarly, the Board agrees it is the MAFMC's responsibility to control bycatch of these species in federal waters and has consistently appealed to them to do so. As such, the Board requests that the MAFMC address the following concerns should a draft Amendment be developed:

- Clearly detail the process by which Annual Catch Limits (ACLs) and Accountability Measures (AMs) would be set. ASMFC prefers that ACLs and AMs apply only to catch/bycatch in federal waters. If this is not legally possible, ASMFC requests that it be the responsible party for determining any in-river portion of ACLs.
- The impacts of inconsistent federal and state water regulations on existing river-system-specific conservation measures, or regional approaches being considered.
- The potential for an amendment that only addresses federal waters bycatch and EFH designation.

Finally, the Board recommends that the MAFMC bring this issue before the Northeast Regional Coordinating Council should it decide to move forward with Amendment 15. Additionally, ample opportunity should be provided for discussion between the MAFMC, NEFMC, and ASMFC, as well as relevant stakeholder groups.

As always, the ASMFC very much appreciates the opportunity to comment on actions being considered by the MAFMC. We look forward to working with you further on this issue.

Sincerely,

RBeal

Robert Beal

cc: ASMFC Shad and River Herring Management Board

American Shad Stocking Plan for Georgia

Altamaha River

Introduction: Cultured fish have been used successfully in the restoration of depleted American shad populations in several drainages and stocking efforts are now underway in several Atlantic Coast states. Stocking has been especially useful when combined with fish passage programs by re-establishing populations of fish to river segments upstream of recently breached or removed stream obstructions or above facilities where fish passage structures have been constructed (Hendricks and St. Pierre 2002). Segments of the Altamaha Basin have been completely uninhabited by American shad for well over a century due to the lack of fish passage at dams (Evans et al. 2012). The objective of initiating an experimental stocking program is to "jump-start" the recovery effort as a complement to ongoing efforts to obtain fish passage and increase the availability of spawning habitat above dams.

Goal: The long-term restoration goal for the Altamaha River is to re-establish self-sustaining spawning migrations that more closely approximate the historic range in the Altamaha River Basin. This goal will specifically entail the restoration of American shad spawning runs to nearly 6,000 acres of riverine habitat (Tom Litts and Joel Fleming, GADNR, 2007, personal communication) above existing dams. Based on the widely accepted planning level figure of 50 fish/acre as the estimated carrying capacity of restored American shad spawning runs (Hightower and Wong 1997), and complete access to available habitats above dams, the spawning run could eventually increase by approximately 300,000 fish (Evans et al. 2012). It is anticipated that several decades would be required to realize this objective.

Location to be Stocked: Restocking efforts will occur above blockages in the Altamaha basin to "jump start" the rebuilding process for populations within the basin. The number of fry stocked annually would be proportioned among stocking sites based on fry production and the amount and quality of available habitat.

Stocking Rate: Accepting Hendricks and St. Pierre's (2002) recommendation that no more than 25 percent of American shad returns should be of hatchery origin, and calculating the harmonic mean of the Altamaha River census size for the 1982 – 2011 period of record as 134,600 (Don Harrison, GADNR, 2012, personal communication), the number of returning shad of hatchery origin should not exceed 33,600. Applying Hendricks (2006) model of approximately 300 fry stocked per return of one adult American shad, a maximum of 10 million fry could be stocked annually into a combination of sites within the Altamaha Basin. However, due to hatchery limitations, this level of stocking would not likely be feasible, at least in the initial years of the stocking program.

Brood Source: All adult fish will be collected from the Altamaha River during their annual spawning run.

Target Number of Broods: The number of broods to be used will be $\leq$300 adults, maintaining a broodfish sex ratio no greater than 1:3 female/male.

Marking Methods: Fry will be marked with oxytetracycline (OTC) in accordance with ASMFC requirements.

Evaluation: Information gathered during the culture phase will be used to refine and evaluate culture techniques. Sampling for YOY shad will occur in reservoirs and downstream river sections. Otoliths will be removed and examined for OTC marks to evaluate success of stocking efforts and evaluate downstream migration patterns. Data collected from these stocking efforts will provide useful information towards determining the feasibility of stocking above blockages and will be used to guide future shad management efforts in Georgia.

Targeted Start Date: The Georgia Fisheries Management Section will begin experimentation with Shad culture and stocking in the Altamaha River System in 2013.

Literature Cited

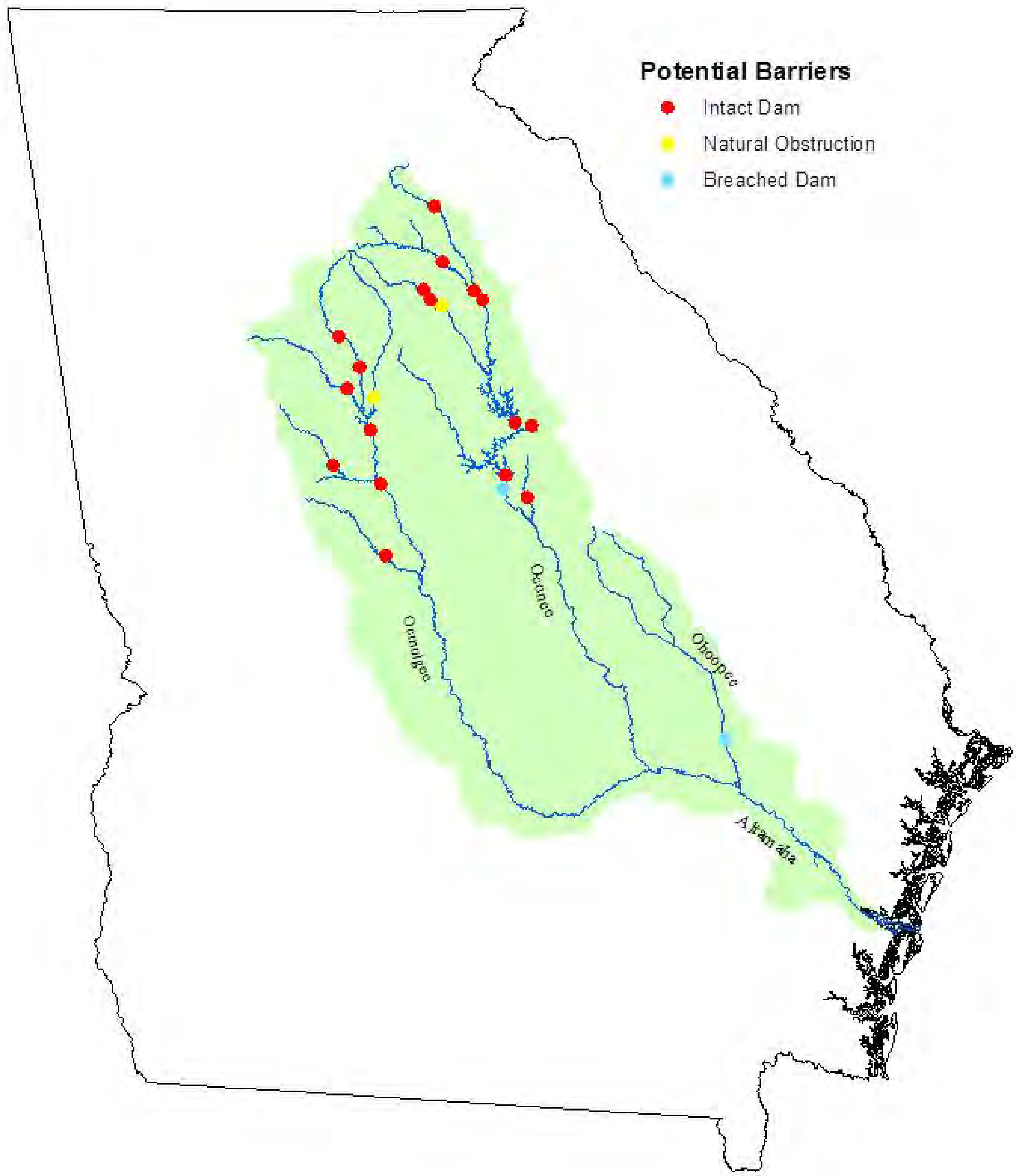
Evans, J et. al. 2012. Priority restoration and management actions for the American shad in the Altamaha River Basin, Georgia. Georgia Department of Natural Resources. 2012. 29 pp.

Hendricks, M. L. and R. A. St. Pierre. 2002. Alosid management and restoration plan for the Susquehanna River Basin. Prepared for the Susquehanna River Anadromous Fish Restoration Cooperative. May 2002. 37 pp.

Hendricks, M. L. 2006. Analysis of adult American shad otoliths, 2005. Restoration of American shad to the Susquehanna River, Annual Progress Report 2005. Susquehanna River Anadromous Fish Restoration Cooperative.

Hightower, J. E. and R. Wong. 1997. Potential benefits to anadromous fishes of providing fish passage within the Roanoke River Basin. Report to the U.S. Fish and Wildlife Service and Virginia Power. 30 pp.

Figure 1. Locations of known possible natural and manmade barriers to potential American shad spawning habitat in the Altamaha River Basin, Georgia.[1]



[1] This map represents the results of a preliminary survey conducted in 2007 and other potential barriers to fish migration may be added in the future.

NEW DISTRIBUTION RECORDS OF GULF SLOPE DRAINAGE FISHES IN THE OCMULGEE RIVER SYSTEM, GEORGIA

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ABSTRACT

Recent fish surveys in the Ocmulgee River system (Altamaha River drainage) in central Georgia by biologists from the Georgia Department of Natural Resources (GDNR) have revealed new distribution records for eight primarily Gulf Slope Drainage species: the eastern blacktail shiner *Cyprinella venusta cercostigma*, blacktip shiner *Lythurus atrapiculus*, silverjaw minnow *N. buccatus*, longnose shiner *N. longirostris*, weed shiner *N. texanus*, flathead catfish *Pylodictus olivaris*, longear sunfish *Lepomis megalotis*, and shoal bass *Micropterus* sp. The five cyprinids are lowland species confined primarily to Coastal Plain streams in the southern portions of their ranges, except in the Chattahoochee and Flint river systems where the species extend significantly above the Fall Line. New records for most of the cyprinids are centered on western tributaries of the Ocmulgee River system in upland, Piedmont portions of the watershed. These western Ocmulgee River tributaries lie in close proximity to eastern tributaries of the upper Flint River, which are suggested as the source of the transfer. Whether the transfer was natural or the result of "bait-bucket" introduction can not be ascertained from available information. Flathead catfish and shoal bass were introduced into the Ocmulgee River in the mid-1970's by GDNR personnel. The source of the population of longear sunfish is unknown. Several of the new record species have close congeners in the Ocmulgee River with which they could conceivably hybridize or compete. Occurrences of a number of native bullhead, sucker and sunfish species are lower in the presence of flathead catfish. We hypothesized that flathead catfish are reducing their populations through direct predation.

INTRODUCTION

Recent fish surveys in the Ocmulgee River system (Altamaha River drainage) in central Georgia (Evans, 1991; Schleiger, in preparation) have revealed new distribution records for eight primarily Gulf Slope Drainage species: the eastern blacktail shiner *Cyprinella venusta cercostigma*, blacktip shiner *Lythrurus atrapiculus*, silverjaw minnow *Notropis buccatus*, longnose shiner *N. longirostris*, weed shiner *N. texanus*, flathead catfish *Pylodictis olivaris*, longear sunfish *Lepomis megalotis*, and shoal bass *Micropterus* sp. The eastern blacktail shiner, blacktip shiner, weed shiner, flathead catfish, longear sunfish and shoal bass were formerly known only from streams draining into the Gulf of Mexico and (in the case of the weed shiner, flathead catfish and longear sunfish) southern tributaries of the Great Lakes. Ocmulgee River system records for these species are the first for an Atlantic Slope drainage basin. Ramsey (1965: Table 1) listed the longnose shiner as occurring in the Altamaha Drainage and is cited by Dahlberg and Scott (1971) and Gilbert and Burgess (1980) who also include the Altamaha River drainage in the longnose shiner's range. No other details on the source of the record are provided. The silverjaw minnow is primarily confined to drainages of the Gulf of Mexico and southern Great Lakes, but also occurs in the lower Susquehanna and upper Rappahannock rivers, Atlantic Slope drainages well to the north of the Altamaha River drainage (Gilbert, 1980).

MATERIALS AND METHODS

The surveys on which the new distribution records are based were conducted between July 1988 and November 1990 by biologists from the Georgia Department of Natural Resources (GDNR), Wildlife Resources Division (JWE, SLS and WC). Fish samples were taken at a total of 149 sites in Piedmont and upper Coastal Plain regions of the Ocmulgee River system between Lake Jackson and the southern limit of the Fall Line Hills physiographic province near Hawkinsville, GA (Fig. 1). Sample gears included seines and three types of electrofishing units: backpack electrofisher, boat electrofisher and a low frequency electrofishing unit (Custom Electronic Design, Model-3A) specially designed for catfish (use of the latter two electrofishing gears was confined to ten sites on the main channel of the Ocmulgee River; Evans, 1991). The collections were sorted and identified by the senior author and student workers (MST and JTH) at the Auburn University Museum Fish Collection. Representative lots of each of the identified species were deposited at the GDNR office at Fort Valley for use as a reference collection. The remainder of the

[1]Present address: Tulane University Museum of Natural History, Belle Chasse LA 70037

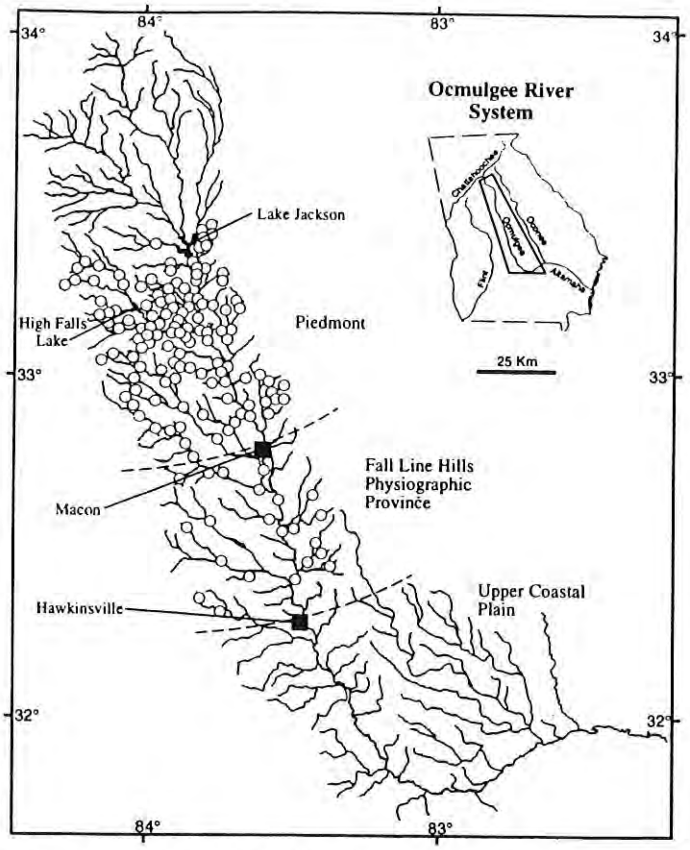

Figure 1. Map of the Ocmulgee River drainage system showing sampling stations for recent GDNR collections (open circles) in relation to physiographic provinces, and the locations of cities and lakes referred to in the text.

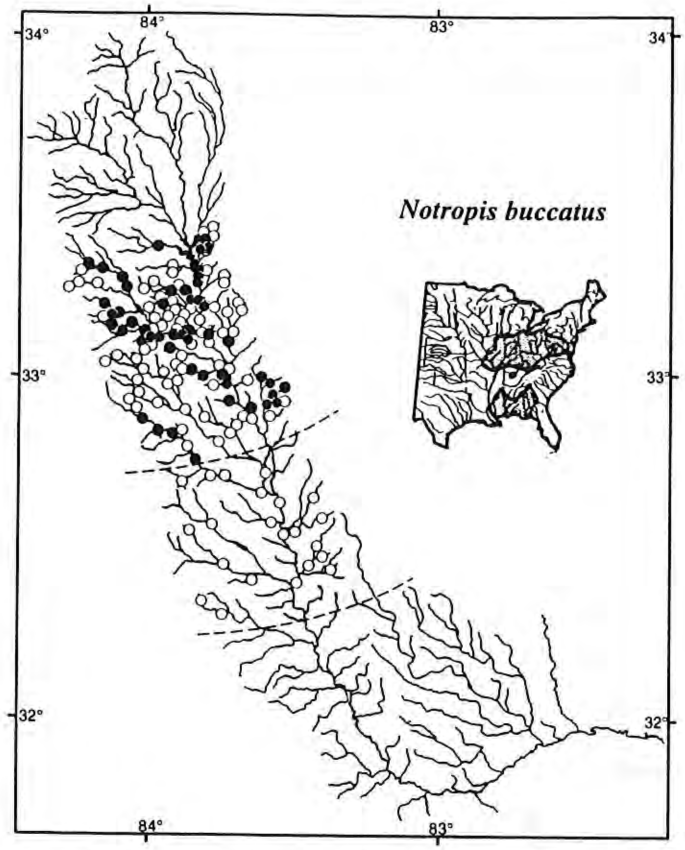

Figure 2. Ocmulgee River system distribution of the silverjaw minnow, *Notropis buccatus* (solid circles) based on recent GDNR collections. Inset map is the species revised overall distribution.

specimens are to be deposited in the University of Georgia, Museum of Natural History Fish Collection for permanent record. Names of species follows Robins et al. (1991).

RESULTS

The silverjaw minnow was the most widespread and abundant of the species reported herein as new to the Ocmulgee River system. The species was represented by a total of 659 specimens from 51 of the 149 sampling sites (Fig. 2). New distribution records for three of the remaining cyprinids (eastern blacktail, blacktip shiner and weed shiners) are centered mainly on the Towaliga River system above High Falls Lake on the western side of the Ocmulgee River watershed. A total of 28 blacktail shiners was collected at two sites: one on the Towaliga River and one on a tributary, Indian Creek, just upstream from its confluence with the Towaliga River (Fig. 3). The blacktip shiner was represented by 16 specimens from the headwaters of the Towaliga River system: two on the Towaliga River proper and one on Troublesome Creek, a small tributary (Fig. 4). The weed shiner was represented by 158 specimens from seven sites. Six of the sites were in the Towaliga River system (all five of the above sites plus Buck Creek, a slightly more southern tributary which also enters High Falls Lake). The seventh site was on Tobesofkee Creek, a direct tributary of the Ocmulgee River well to the south of the Towaliga River (Fig. 5). Six longnose shiners were collected at a single locality on Tussahaw Creek above Lake Jackson (Fig. 6).

Distribution records for the flathead catfish, longear sunfish and shoal bass are centered on the main channel of the Ocmulgee River. Flathead catfish were collected at six Ocmulgee River sites (98 specimens total), and one site on Sabbath Creek (one specimen), a small tributary, near its confluence with the Ocmulgee River (Fig. 6). Longear sunfish were collected at four sites (20 specimens total) in the recent GDNR survey: Tussahaw Creek above Lake Jackson, and three sites on the Ocmulgee River below Lake Jackson (Fig. 4). Additional records in the Auburn University Museum Fish Collection (not shown in Fig. 4) place the species in Lake Jackson as early as 1973 (AUM 18388), in the Ocmulgee River below Lloyd Shoals Dam (south of the GA Hwy 16 crossing) as early as 1977 (AUM 15641), and, more recently, in Falling Creek east of Juliette (AUM 26146). The shoal bass was collected at eight of ten main river sites (81 specimens) plus 17 sites on tributaries of varying sizes (61 specimens, Fig. 7).

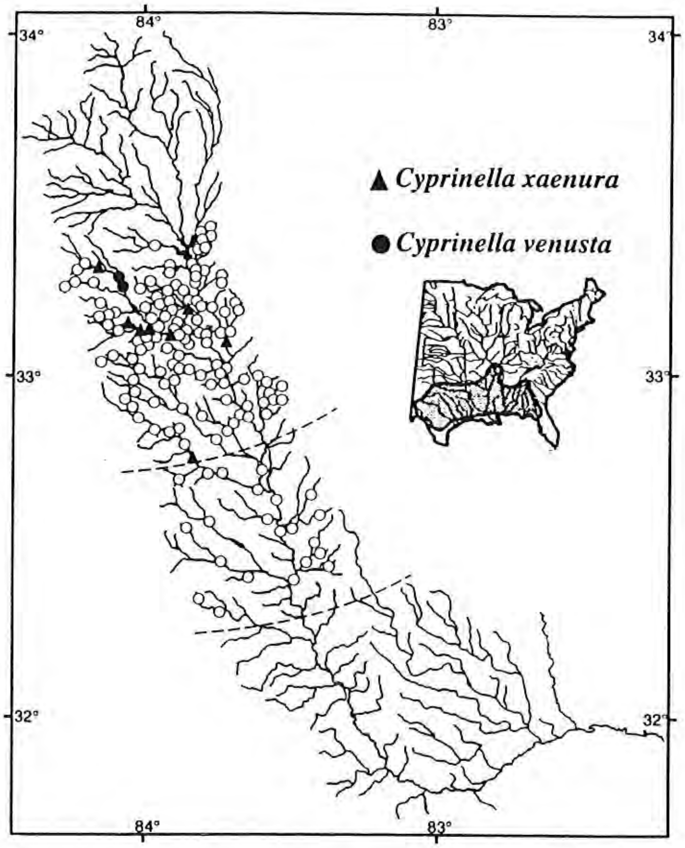

Figure 3. Ocmulgee River system distributions of the blacktail shiner *Cyprinella venusta* (solid circles) and Altamaha shiner *C. xenura* (solid triangles) based on recent GDNR collections. Inset map is revised overall distribution for the blacktail shiner.

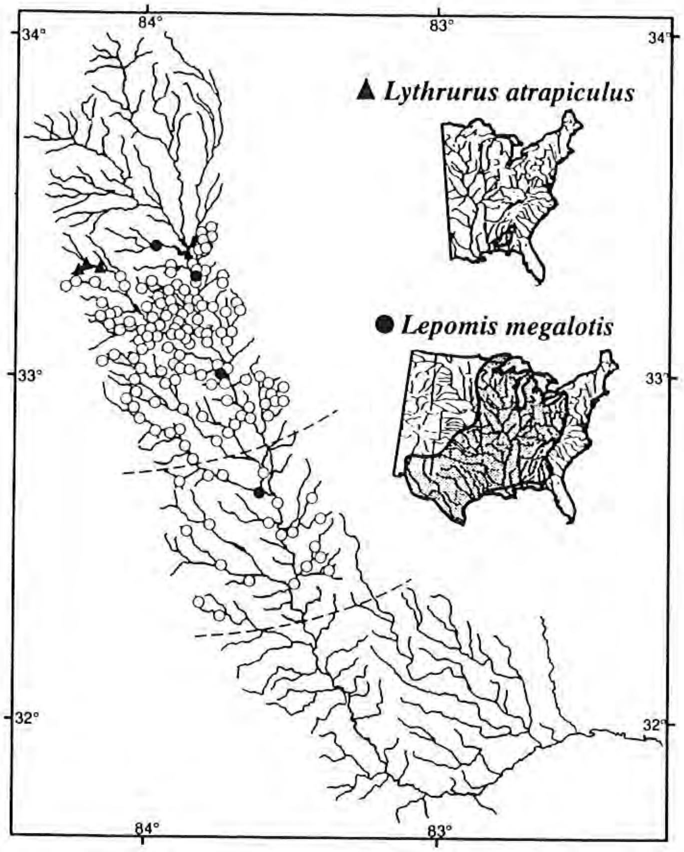

Figure 4. Ocmulgee River system distributions of the blacktip shiner *Lythrurus atrapiculus* (solid triangles) and the longear sunfish *Lepomis megalotis* (solid circles) based on recent GDNR collections and (longear sunfish) records in the Auburn University Museum fish collection. Inset maps are revised overall distribution maps for the two species.

DISCUSSION

The five cyprinid species herein reported as new to the Ocmulgee River system are lowland species that are primarily confined to Coastal Plain streams throughout most of the southern portions of their ranges. However, all of these species extend significantly above the Fall Line into the Piedmont Physiographic Province in the Chattahoochee and Flint river systems (Apalachicola River drainage). The new records are all from upland, Piedmont portions of the Ocmulgee River watershed (i.e., above the upper boundary of the Fall Line Hills Physiographic Province, Figs. 1-6), so the transfer likely involved populations from upland portions of the Chattahoochee and/or Flint river systems. Tributaries of the Chattahoochee and Flint rivers, particularly eastern headwater tributaries of the Flint River, lie in close proximity to western tributaries of the Ocmulgee River (see inset map in Fig. 1). Flint River specimens of the weed shiner differ from more western populations in having deeper bodies and higher numbers of body circumferential scales (Suttkus and Raney, 1955), and Ocmulgee River system specimens exhibit these characteristics.

It is unclear whether the cyprinids entered the Ocmulgee River system at the same or different times, or whether the transfer was natural or the result of "bait-bucket" introduction. The restricted occurrences of two of the species (eastern blacktail and blacktip shiners), and the concentration of collections of a third (the weed shiner), in streams of the Towaliga River system above High Falls Lake suggests that the upper Towaliga River was involved in the transfer of these species into the Ocmulgee River system. The dam that formed High Falls Lake was constructed in 1904 (GDNR, pers. comm.). We consider it most likely that the above cyprinids entered the upper Towaliga River after this time and that High Falls dam is preventing downstream dispersal of two of the species (*Cyprinella venusta* and *Lythurus atrapiculus*). If the above scenario if correct for all three species, then the weed shiner has dispersed downstream across High Falls Reservoir to at least one other part of the Ocmulgee River watershed since its introduction.

A similar scenario, but with much wider subsequent dispersal, could account for the Ocmulgee River distribution of the silverjaw minnow. However, this explanation is com-

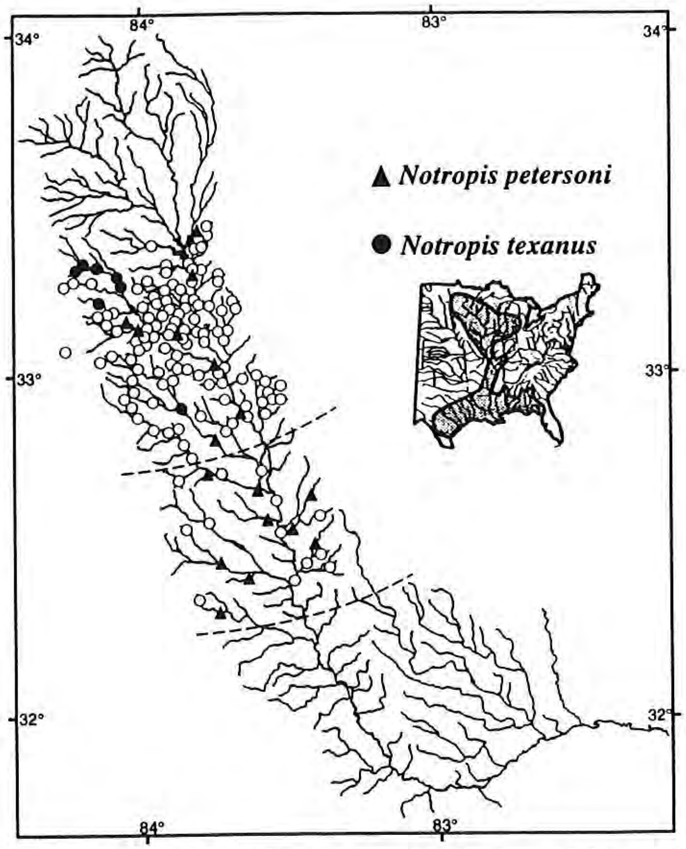

Figure 5. Ocmulgee River system distributions of the weed shiner *Notropis texanus* (solid circles) and coastal shiner *N. petersoni* (solid triangles) based on recent GDNR collections. Inset map is revised overall distribution for the weed shiner.

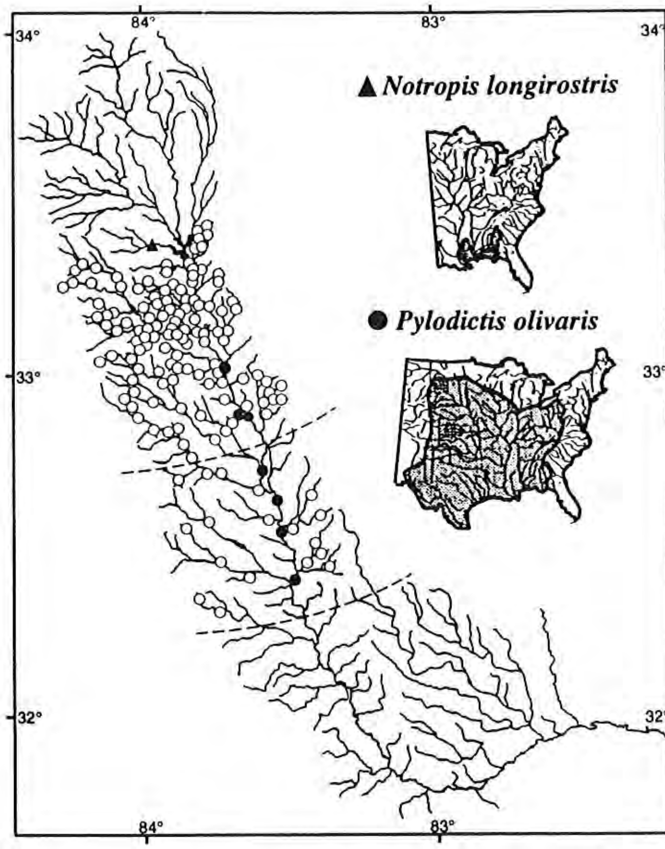

Figure 6. Ocmulgee River system distributions of the longnose shiner *Notropis longirostris* (solid triangles) and the flathead catfish *Pylodictis olivaris* (solid circles) based on recent GDNR collections. Inset maps are revised overall distribution maps for the two species.

plicated by the occurrence of the silverjaw minnow in Tussahaw Creek above Lake Jackson (Fig. 2). Lloyd Shoals Dam which formed Lake Jackson was completed in 1910 and would have posed a barrier to colonization of Tussahaw Creek by direct upstream movement after this time. If the silverjaw minnow entered the Ocmulgee River system prior to 1910, it would have had access to other streams in the upper portion of the watershed above the present Lake Jackson. The species is not listed as occurring anywhere in the Altamaha River system in Dahlberg and Scott's (1971) report on the freshwater fishes of Georgia, which included several collections from the Ocmulgee River system. Moreover, the silverjaw minnow was not recorded in GDNR surveys of the South and Yellow rivers (Hess et al., 1978; 1979), two of the three main Ocmulgee River tributaries above Lake Jackson. We consider it unlikely that previous workers overlooked such a distinctive species. Thus, the most plausible explanations for the silverjaw minnow's present Ocmulgee River system distribution based on available information are: a) entry into the system below Lake Jackson after 1971 with subsequent widespread dispersal to unimpounded sections of the Ocmulgee River system, and independent establishment above Lake Jackson in Tussahaw Creek; or b) entry above Lake Jackson after the late 1970's with widespread dispersal below the lake, and as yet undocumented occurrence above Lake Jackson, except in Tussahaw Creek.

The longnose shiner was taken only in Tussahaw Creek above Lake Jackson. Previous reports of the species' occurrence in the Altamaha River drainage are based on Ramsey's (1965) listing, which apparently is not based on museum records. The species was not reported from the South and Yellow rivers above Lake Jackson by Hess et al. (1978, 1979). Available information suggests that the longnose shiner's point of entry into the Ocmulgee River system was Tussahaw Creek and that Lake Jackson is currently serving as a barrier to its dispersal to other parts of the watershed. Although the silverjaw minnow and the longear sunfish also occur below Lake Jackson, their occurrence in Tussahaw Creek may be related to the longnose shiner's occurrence there.

Flathead catfish and shoal bass were introduced into the Ocmulgee River in the mid-1970's by GDNR personnel. Flathead catfish were introduced into the Ocmulgee River near the GA Hwy 96 bridge in 1973 from previously introduced stock in the upper Flint River (Evans, 1991). The flathead catfish is not native to the Flint River and is believed to have

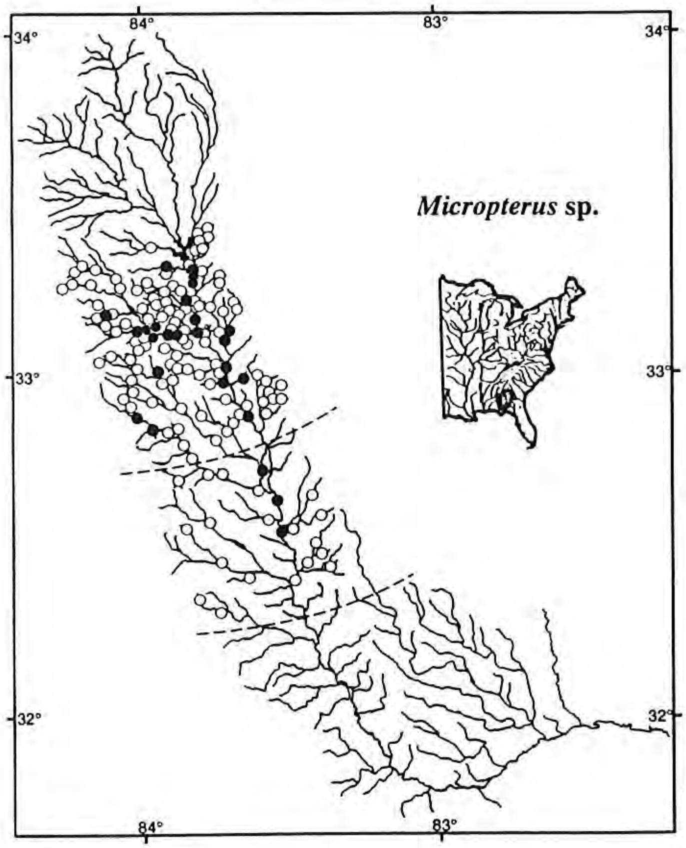

Figure 7. Ocmulgee River system distribution of the shoal bass *Micropterus* sp. (solid circles) based on recent GDNR collections. Inset map is the species' revised overall distribution.

been introduced there by angler stocking in about 1950 (Quinn, 1988). The Ocmulgee River population has since expanded downstream into the lower Altamaha River, and upstream as far as the low head dam at Juliette which is apparently posing a barrier to further upstream movement. The species has also recently been taken in the Oconee River from its confluence with the Ocmulgee River up to the GA Hwy 22 crossing at Milledgeville, GA (Evans, in preparation), and it is known to inhabit High Falls Lake on the Towaliga River, apparently having been independently established there (Evans, 1991). We expect the flathead catfish to eventually extend up the Ocmulgee River as far as Lloyd Shoals Dam below Lake Jackson.

Shoal bass from the upper Flint River were introduced into the upper Ocmulgee River below Lake Jackson in 1975. The species has since spread throughout Piedmont portions of the watershed. The source of the introduced population of longear sunfish in the Ocmulgee River system is unclear. Swift et al. (1986) list the species as "suspected but without museum records or other substantiation" for the Chattahoochee River. There are several records of longear sunfish from the Apalachicola River drainage in the Auburn University Museum Fish Collection, however all are from western tributaries of the Chattahoochee River. We know of no records from eastern tributaries of the Chattahoochee River, the Chattahoochee River proper, or the Flint River, so the transfer (natural or unnatural) likely did not involve nearby streams.

The possibilities of hybridization or competitive displacement are perhaps greatest in cases where the newly recorded species have close congeners with similar ecologies in the Ocmulgee River system. Three congeners of the blacktail shiner, *C. callisema*, *C. leedsi* and *C. xenura*, are native to the Ocmulgee River system. The Altamaha shiner *C. xenura* is endemic to upper reaches of the Oconee and Ocmulgee river systems. The latter species has recently been listed as "endangered" in the state of Georgia. The species was collected at eight sites in the recent survey, all in the upper Piedmont section of the watershed, but none syntopic with *C. venusta*. The Ocmulgee shiner *C. callisema*, a species largely confined to the Altamaha River system, is apparently widespread and abundant in the Ocmulgee River system. A total of 946 individuals was taken from 35 mostly Piedmont sites during the recent survey. The species was syntopic with *C. venusta* at one of two Towaliga River sites. The bannerfin shiner *C. leedsi*, a more widespread species ranging along the lower Coastal Plain from the Ochlocknee and Suwannee river drainages to the lower Savannah River, was taken primarily in the lower main channel of the Ocmulgee River in the recent surveys. Altamaha River drainage populations of all three of the native *Cyprinella* could conceivably be negatively impacted through hybridization or competitive displacement if the blacktail shiner expands below High Falls Reservoir.

The coastal shiner *Notropis petersoni*, a member of the *texanus* species group (Swift 1970), extends well inland onto the Piedmont along the Atlantic Slope. However, over most of the Eastern Gulf Slope, the coastal shiner's distribution is complementary to that of the weed shiner where the two species are sympatric, suggesting the possibility of competitive avoidance. The coastal shiner was common in GDNR collections from both Piedmont and upper Coastal Plain regions of the Ocmulgee River system. The species was collected near sites where weed shiners were collected, but the two species were never collected syntopically. Spread of the weed shiner to other parts of the Ocmulgee River system could restrict coastal shiner populations to lower Coastal Plain portions of the watershed as seen in Gulf Slope drainages to the west.

There is correlative evidence that flathead catfish are negatively impacting populations of several native fish species in the Ocmulgee River. Occurrences and abundances of silver redhorse *Moxostoma anisurum*, smallfin redhorse *M. robustum*, snail bullhead *Ameiurus brunneus*, flat bullhead *A. platycephalus*, and redbreast sunfish *Lepomis auritus*, were negatively correlated with flathead catfish occurrence and abundance (Evans, 1991). The mechanism of interference may be direct predation. Suckers and catfish of a variety of species are common items in the diet of flathead catfish (Minckley and Deacon, 1959; Edmundson, 1974; Davis, 1985). The greatest impact appears to be on snail and flat bullhead. Combined electrofishing catch-per-unit-efforts for these species reached 70 per hour above Juliette Dam but were zero below the dam where flathead catfish were present (Evans, 1991).

There are concerns that shoal bass are hybridizing with redeye bass *Micropterus coosae*, a native bass in the upper Ocmulgee River system. The results of two independent genetic investigations addressing this issue (D. Philipp, Illinois Natural History Survey, personal communication and R. Dunham et al., in preparation) are in conflict. Redeye bass were identified from a total of 29 sites in the upper Ocmulgee River system, including 13 of the 17 sites where shoal bass were taken, with no apparent evidence of hybridization between the two species. The two species occur sympatrically in the Chattahoochee River system, with the redeye bass generally favoring upland streams, and the shoal bass occupying lowland streams and the Fall Line Hills transition area.

The redbreast sunfish *Lepomis auritus*, a species native to the Ocmulgee River system and considered by many to be the Atlantic Slope equivalent of the longear sunfish, occurred syntopically with the longear sunfish at three of the four sites where the latter species was collected. The redbreast sunfish was the numerically dominant sunfish at two of the syntopic sites. The longear sunfish was the dominant sunfish only in Tussahaw Creek. The dollar sunfish *Lepomis marginatus*, another native and closely related sunfish species occurred syntopically with the longear sunfish at one site in the Fall Line Hills transition zone. However, competition should be less of a concern here because the latter two species are ecologically isolated and coexist over a large portion of their native ranges.

ACKNOWLEDGMENTS

We thank Bill Birkhead and Jeremy Knight for reviewing the manuscript and for many helpful editorial suggestions.

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FINAL REPORT

INSTREAM FLOW STUDIES FOR THE NORTH GEORGIA (FERC PROJECT NO. 2354) AND LLOYD SHOALS (FERC PROJECT NO. 2336) HYDROELECTRIC FACILITIES

Commerical and
Financial Information —
Privileged and Confidential

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Sparks, Maryland

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Georgia Power Company (GPC) hereby submits for review the attached Final Report on Instream Flow Incremental Methodology (IFIM) Studies for the North Georgia and Lloyd Shoals hydroelectric projects. GPC acknowledges that there has been substantial criticism of the IFIM methodology, particularly in the Southeast. Two main concerns are: 1) IFIM has not been shown to be a valid predictor of the effect on fish populations from varying stream flows, and 2) IFIM does not evaluate the existing fishery. Accordingly, GPC is continuing to evaluate what impacts changes in stream flows at these projects have on fish populations.

In the most important sense, GPC desires to underscore its fundamental observation that this report or any other similar report should not be viewed in isolation. Section 4(e) of the Federal Power Act sets forth the criteria that need to be considered which include, in addition to the impact on fish and wildlife, power and development purposes, energy conservation, recreational resource needs, and other aspects of environmental quality.

Your review of the enclosed report in light of these considerations will be appreciated.

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1. INTRODUCTION

This report presents the results of Instream Flow Studies performed on the Tallulah, Tugalo, and Ocmulgee rivers. These studies were conducted for Georgia Power Company (GPC) by EA Engineering, Science, and Technology, Inc. as part of the environmental studies for Federal Energy Regulatory Commission (FERC) relicensing of the North Georgia Hydro Group (FERC Project No. 2354) and Lloyd Shoals (FERC Project No. 2336) projects. The purpose was to develop an analytical framework to evaluate the relationship between flow scenarios and the resulting amount of fish habitat, in order to protect fisheries resources in the project tailwaters.

The U.S. Fish and Wildlife Service (FWS) Instream Flow Incremental Methodology (IFIM) (Bovee 1982; Bovee and Milhous 1978) formed the basis of the analyses in this framework. The IFIM is a hierarchical, modular process designed to assess the effects of incremental changes in flow regime on fish habitat. This habitat-based approach quantifies the amount of "potential" fish habitat at various discharges.

The studies described herein were conducted in a logical sequence (Figure 1-1) to yield a basis for evaluation and negotiation of various alternative minimum flow regimes. Project scoping, fish habitat suitability studies, and physical habitat simulation were the core components; the fish survey and temperature monitoring studies were conducted to provide data for scoping and final recommendations.

Project scoping (Section 2) was conducted to delineate the study areas, identify the appropriate fish species for evaluation and the habitat variables of concern, and determine the data sampling locations. Scoping included periodic consultation meetings and contacts with federal and state agencies as required by the FERC application procedures for hydropower licenses (FERC 1985; FERC 1989). The fish survey results (Section 3) provided a basis for selecting species for the overall analysis.

Species included in fish habitat suitability studies were jointly selected by GPC and the agencies on the basis of ecological guilding, existing habitat use information, and the abundance of species in each study area. The habitat preferences of these species were then quantified (Section 4), and habitat suitability criteria were derived for use in physical habitat simulation modeling.

Habitat mapping produced an inventory of riverine habitat types in each study area and provided a basis for selecting habitat/hydraulic sampling locations. Physical habitat simulation modeling (Section 5) integrated the results of fish habitat suitability studies and habitat/hydraulic sampling to yield information on fish habitat versus stream flow dynamics.

In the final phase of the Instream Flow Studies (Figure 1-1), the results of physical habitat modeling for all species were analyzed simultaneously to provide a basis for evaluating flow-habitat relations for the entire fish community. Together with consideration of water availability (stream flow analyses), evaluation of stream temperature regimes (Section 6), and constraints imposed by macrohabitat variables, the results provide a basis for evaluating instream flow regimes producing a range of possible fish habitat-maintenance goals (Section 7).

1.1 PROJECT DESCRIPTION

North Georgia Development

Georgia Power Company's North Georgia Development consists of six dams and hydroelectric generating facilities on the Tallulah, Chattooga, and Tugalo rivers. These rivers are major tributaries of the Savannah River, located in the mountainous regions of northeast Georgia and northwest South Carolina, and are contained within the Blue Ridge Mountains and Southeastern Plains (Piedmont) ecoregions (Omernick 1987). The boundaries of the North Georgia Hydro Development fall within Rabun, Habersham, and Stephens counties, Georgia, and Oconee County, South

Carolina. The development extends over 37.5 mi from the head of Lake Burton to Yonah Dam, and has a total drainage area of 470 mi^2 (Stokes et al. 1987).

Lentic habitats in the North Georgia Hydro Group include six reservoirs--Burton, Nacoochee (Seed), Rabun, Tallulah Falls, Tugalo, and Yonah. Riverine (lotic) habitats directly affected by project operation include the Tallulah River between Lake Rabun and Tallulah Falls Lake, the Tallulah River in Tallulah Gorge, and the Tugalo River between Yonah Lake and Lake Hartwell. The first two of these riverine segments are affected by flow diversion via tunnels to powerhouses at the downstream end of the river segment. Little or no riverine habitat exists between the other reservoirs because downstream reservoir levels back up to the outflow of the upstream reservoir. Major riverine habitats less directly influenced by project operation include the Tallulah River upstream of Burton Lake and the Chattooga River upstream of Tugalo Lake.

Water releases from the North Georgia dams are regulated in an integrated manner for hydroelectric generation to meet peak load demand and for lake-level control for recreation. The existing FERC license for the North Georgia Development has no minimum flow requirement.

Lloyd Shoals

Georgia Power Company's Lloyd Shoals project consists of a single dam and hydroelectic generating plant on the Ocmulgee River near Jackson, Georgia. The boundaries of the Lloyd Shoals project fall within Butts, Jasper, and Newton counties, Georgia. The Ocmulgee River, a major tributary to the Altamaha River, drains south-central Georgia, and is contained within the Southeastern Plains (Piedmont) ecoregion (Omernick 1987). The Lloyd Shoals impoundment, Lake Jackson, extends up the Alcovy River approximately 11 mi, and extends up the Yellow and South rivers lesser distances. The total drainage area for the project is 1,400 mi^2 (Stokes et al. 1987).

Lentic habitat affected by the operation of the Lloyd Shoals project is limited to Lake Jackson. Riverine habitats directly affected by the project are the Ocmulgee River and, to a lesser extent, its principal tributaries, the South, Alcovy, and Yellow rivers.

Water releases from the Lloyd Shoals facility are regulated for hydroelectric generation to meet peak load demand, flow augmentation for cooling water needs for downstream power plants, and for lake-level control for recreation. The existing FERC permit for the Lloyd Shoals facility stipulates a minimum flow of 100 cfs, except when the reservoir level is at or below elevation 518.8 and the inflow to the reservoir is less than 100 cfs; then the outflow will be equal to inflow into the reservoir. During periods of high flow, the facility is operated as a baseload generation facility.

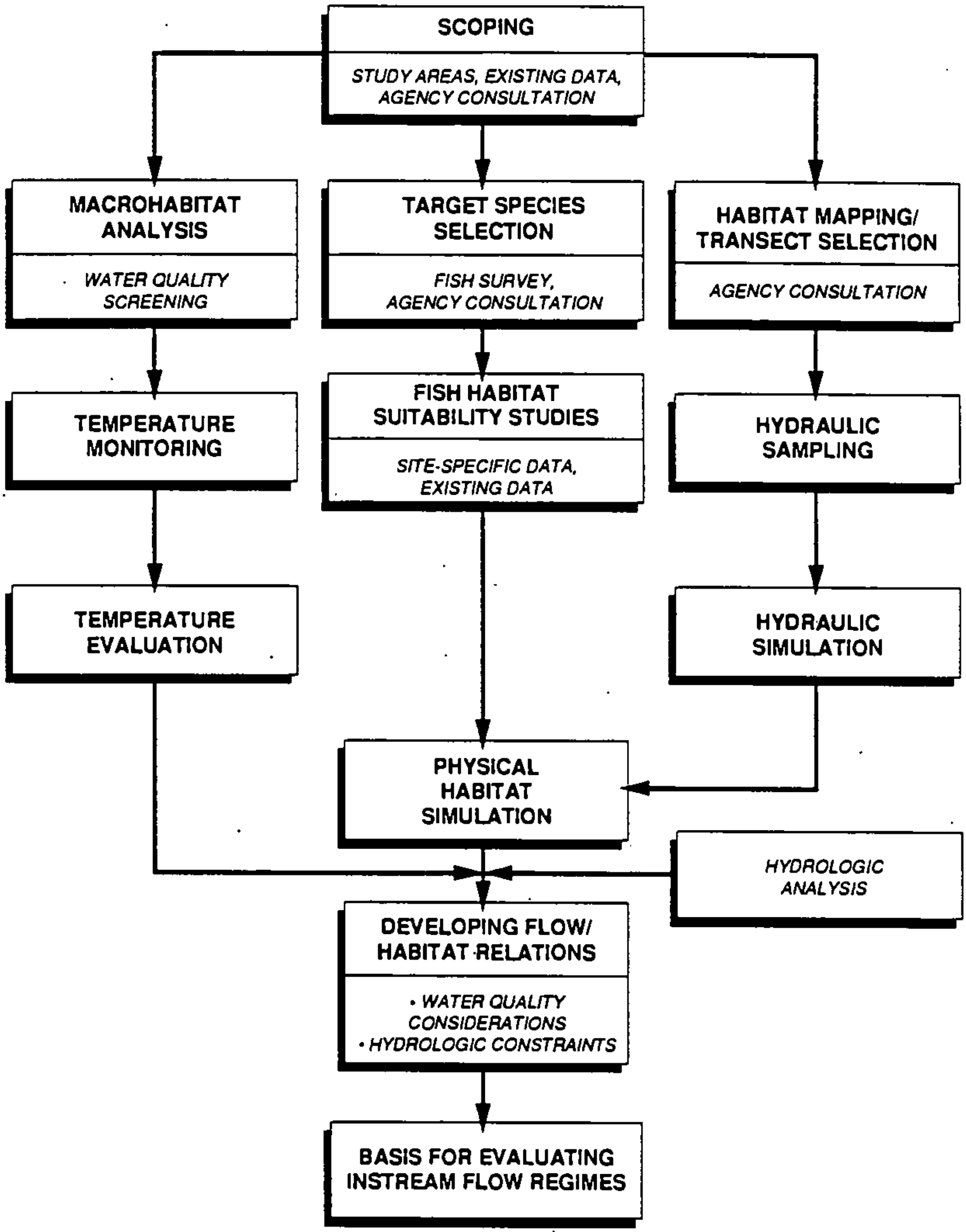

Figure 1-1. Flow chart illustrating sequence of tasks completed for Georgia Power Company's Instream Flow Studies on the Tugalo and Ocmulgee rivers.

2. PROJECT SCOPING

Prior to initiation of Instream Flow Studies, project planning and a predetermination of the various study elements were conducted. Project scoping serves to define the present system and identify variables that must be considered in the analysis. The three scoping tasks were to: (1) define the study area and study sites, (2) identify the flow-dependent variables affecting the habitat potential of the streams, and (3) select the fish species to be included in instream flow analysis and describe their temporal patterns of habitat use.

Completing the scoping process included site visits, analysis of maps and aerial photographs, and a search and review of available water quality and fisheries resource data. Insufficient or lack of existing published or agency file information in several areas triggered two separate study components (e.g. fish survey, temperature monitoring). The results of these studies were integrated as the study progressed. The preliminary results of concurrent studies conducted by Georgia Power Company (GPC) (see Section 2.5) were also used to verify assumptions or decisions made before full information became available.

The scoping process was conducted in consultation with federal and state resource agencies as required by FERC application procedures for hydropower license (FERC 1985; FERC 1989). A chronology of the agency consultation meetings is presented in Section 2.4.

2.1 STUDY AREAS

For the Instream Flow Studies, four study areas were defined by GPC: (1) Tallulah River from Mathis Dam to the Terrora Power House, (2) Tallulah River from Tallulah Falls Dam to Tugalo Lake (Tallulah Gorge), (3) Tugalo River from Yonah Dam to Lake Hartwell, and (4) Ocmulgee River downstream of Lloyd Shoals Dam. The general physical characteristics of each area are presented in Table 2-1 and the habitat characteristics are described in detail in Section 4. Maps of the study areas are presented in Figures 2-1 through 2-4.

Mathis-Terrora Bypass (Figure 2-1)

Flow in the Tallulah River is directed from Lake Rabun into a tunnel at Mathis Dam. The diverted water reenters the Tallulah River channel 5.6 river miles (RM) downstream, after passing through the Terrora Powerhouse located at the headwaters of Tallulah Falls Lake (Figure 2-1). Leakage from Mathis Dam and some ground-water accrual constitute the total flow in the diverted section of the Tallulah River below Mathis Dam to its point of confluence with Tiger Creek; habitat in this section of the old river channel most closely resembles a wetland area. Downstream of the Tiger Creek confluence, the Tallulah River channel appears to have adjusted to the Tiger Creek flow regime during the past 50 years.

In its first-stage consultation document for the North Georgia Hydro Group (GPC 1987a), GPC proposed to conduct no instream flow study in this reach. Several important factors contributed to this decision including the presence of unique wetland and backwater habitats in the old river channel. Additionally, the river channel appears to have equilibrated with the Tiger Creek flow regime, such that no additional flow into the diverted reach is considered to be necessary. Some months later the consulting agencies concurred. During the intervening period, EA completed the scoping, fish survey, temperature monitoring, and habitat mapping study components for this study area. Further study in this area by EA was discontinued in February 1988, by order of GPC's project manager.

Tallulah Gorge (Figure 2-2)

This reach of the Tallulah River is a 1.8 mi length section of deeply incised river channel with precipitous walls and extremely limited and difficult access. Flow is diverted from the Tallulah Falls Lake via a tunnel to the power plant located in the gorge at the river's confluence with Tugalo Reservoir (Figure 2-2). Flow in the diverted reach consists of dam leakage and flow from minor tributaries. The contribution of dam leakage to flow in this reach was reduced considerably during February 1988 after GPC conducted grouting work related to dam safety.

Due to construction work on the Tallulah Falls Dam, field work was delayed in the Tallulah Gorge. Hydraulic sampling in the Tallulah Gorge has begun at the time of this report; the results of the Tallulah Gorge Instream Flow Studies will be presented in an addendum to this report.

Tugalo River (Figure 2-3)

This reach of the Tugalo River extends from Yonah Dam downstream to its point of confluence with Lake Hartwell. This reach can be divided into two segments: riverine habitat and transitional river-reservoir habitat; water depth for the latter is determined by the level of Lake Hartwell. The length of the riverine habitat ranges from 1.2 mi to 2.5 mi, and the downstream boundary of this habitat varies from the downstream island to the U.S. Army Corps of Engineers boat ramp (Figure 2-3), depending on the pool elevation of Lake Hartwell.

Habitat in the riverine portion of the Tugalo River immediately below Yonah Dam consists of riffles and shoals alternating with shallow runs and run/pool habitat; deeper pool habitat is rare or absent in this section. The transitional river-reservoir habitat consists of slow, deeper pool habitat; the depth and current velocity in this transition zone are strongly influenced by the pool elevation of Lake Hartwell.

Two small tributaries contribute flow to this study area. Panther Creek (drainage area 33 mi^2) enters on the west side approximately 0.3 mi downstream of Yonah Dam. Brasstown Creek (drainage area approximately 15 mi^2) enters on the east side approximately 0.7 mi downstream of Yonah Dam.

Ocmulgee River (Figure 2-4)

This study area extends from Lloyd Shoals Dam downstream approximately 16.8 mi to the Highway 83 bridge. Flow in this reach consists of releases from the Lloyd Shoals Dam and numerous small tributaries (i.e., Herds Creek, Yellow Water Creek, Wise Creek, Little Sandy Creek, Long Branch, and Sandy Creek). The combined contribution of the tributaries relative to the flow of the Ocmulgee River at the current minimum flow is very small ($\leq$5 percent).

2.2 FISH RESOURCES

North Georgia

On the basis of a literature search and contacts with the Georgia Department of Natural Resources (GDNR) (England 1987) and with South Carolina Wildlife and Marine Resources Department (SCWMR) (Geddings 1987) regional fish biologists, insufficient information existed to accurately document fish species composition and abundance in any of the study stream areas. Dahlberg and Scott's (1971) checklist of fishes for the Savannah River and scattered university collections (Freeman 1987) were the only sources of information available to obtain species lists.

One notable exception to the dearth of fisheries information was limited data on the use of the Tugalo River by spawning walleye. The Tugalo River is used by walleye, hybrid striped bass, and white bass (Williams 1988). According to reports by SCWMR, walleye were introduced into Hartwell Lake in the early 1960s (SCWMR 1970). Sampling of the Hartwell Dam, Keowee River, and Tugalo River documented the presence of spawning fish in these areas during the period 1971-1973 (SCWMR 1987). Recent information from sampling in February-March 1987 suggests a decline in the abundance of spawning walleye in all three of these areas (SCWMR 1987), but the data are limited and inconclusive. Several possible explanations for this decline have been suggested (e.g., natural mortality, fishing pressure, shift in primary spawning grounds), but no definitive answer is possible at this time. Sampling by EA (see Section 2.5, Concurrent Studies) during February-March of 1988 and 1989 documented a small run of spawning walleye in the Tugalo River.

Based on the available fisheries information, it was clear that a fish survey was needed in the study areas of the North Georgia Development. The objective of the fish survey was to provide an estimate of fish species present and their relative abundance in the study area.

Lloyd Shoals

A literature search and contact with Georgia DNR regional biologists (Ager and Evans 1988) yielded limited historical information from within this study area. Hastings and Frey (1962) reported electrofishing catch from three stations in Jasper, Twigg, and Wilcox counties, Georgia, and Dahlberg and Scott (1971) provided a checklist of freshwater fishes present in the Ocmulgee River. Other studies of fish populations in the Ocmulgee and Altamaha rivers are reported by Coomer and Holder (1980), Frey (1981), Hess et al. (1978), and Hottell et al. (1983), but recent fish species composition data for the Ocmulgee study area considered here are limited to two stations sampled in 1958 and reported by Hastings and Frey (1962). Differences between fish populations in the Ocmulgee River upstream and downstream of the Mill Dam at Juliette, Georgia (Monroe County), are apparent from the historical data, as this dam is a barrier to upstream movement of fish.

Realizing the scarcity of data for the Ocmulgee River, the Georgia DNR has initiated a fish population and sport fishery survey of the upper Ocmulgee River (Evans 1988a) (Lake Jackson to Hawkinsville). Concurrently, GPC has initiated a fish sampling program at four sites on the upper Ocmulgee River. Since these studies had not been initiated prior to April 1988, a preliminary fish survey was deemed necessary to establish a fish species list to provide a basis for selection of species for Instream Flow Studies conducted in 1988.

2.3 HABITAT VARIABLES

Proper application of the Instream Flow Incremental Methodology (IFIM) requires the evaluation of potential biological response at two levels of resolution: macrohabitat and microhabitat. The total habitat available to a species at any flow is a function of macrohabitat and microhabitat conditions. Macrohabitat characteristics are those that are longitudinally distributed more or less uniformly and unidimensionally throughout a stream segment (Bovee 1982; Bartholow and Waddle 1986). Examples of macrohabitat variables affecting the suitability of a stream segment for habitation by aquatic organisms are temperature, dissolved oxygen, nutrients, and dissolved materials.

In contrast, microhabitat characteristics are point-specific conditions that influence the local distribution of fish and other aquatic organisms (Stalnaker 1979). Examples of microhabitat conditions are combinations of depth, velocity, streambed substrate, cover, or other local conditions. Such factors typically vary greatly on a scale of a few feet or less. The quantity and distribution of microhabitat conditions provides an index of the physical habitat quality of a stream segment for a particular species.

The total habitat available to a species at any flow is a function of macrohabitat conditions and microhabitat conditions. Microhabitat conditions are quantified by physical habitat modeling; macrohabitat conditions are considered and incorporated only when they are affecting the habitat potential of the stream (i.e., are outside of the tolerance ranges of the species being evaluated). Where macrohabitat conditions are judged to be affecting the habitat potential of a stream, estimates of total available habitat at any flow must be adjusted or corrected.

This adjustment is typically done on the basis of results from temperature or water quality modeling (Bartholow and Waddle 1986).

Water Quality (Macrohabitat Variables)

The approach to assessment of macrohabitat conditions involved a screening-level review of existing water quality data for the study areas. EA reviewed the summary reports of the available state water quality data (GDNR 1987; GDNR 1988) and water quality data collected by GPC during Water Quality Studies in the study areas during the period 1988 through 1989 (EA 1989 and EA 1990b; see Section 2.5). These data were used to reach conclusions as to the need for incorporating macrohabitat variables in the habitat modeling process.

A wide variety of water quality parameters were examined. The data available from each source varied widely but typically included temperature, pH, conductivity, dissolved oxygen, fecal coliform, and alkalinity. The data set from GPC's Water Quality Studies (EA 1989; EA 1990b) was the most complete data set evaluated; it included monthly and quarterly water quality data. For each study area this data set included one or two sites in the study area and one site in the source reservoir including surface, mid-depth, and bottom samples (profiles). Turbidity, hardness, nutrients, total suspended solids, and a variety of metals were measured. The available temperature data was deemed insufficient for the purposes of this study. A full program of stream temperature monitoring and an evaluation of suitability of the study stream for a variety of fish species was conducted (see Section 6.0).

For each study area, the applicable water quality data was compared to the state standards (South Carolina and/or Georgia, as applicable) for the water classification of that water body. If the state water quality standards were not violated and state/federal reports identified no existing "problems," water quality was deemed to be suitable for maintaining good fish habitat; this conclusion justified dropping water quality from considerations in the physical habitat simulation process. When water quality standards were violated or problems were identified, the parameters, water body, area, and time of year were identified. On the basis of these data, recommendations were formulated as to which study areas had outstanding water quality problems that must be factored into final decisions on instream flow regimes in project tailwaters. These recommendations are outlined in Section 7.1.2.

Microhabitat Variables

The IFIM focuses on microhabitat variables most directly affected by changes in stream flow: water depth, velocity, substrate, and cover. Morphological (Keast and Webb 1966; Gatz 1979), ecological (Mendelson 1975; Gorman and Karr 1978; Shirvel and Dungey 1983), and behavioral (Hartman 1965; Gee 1974; Moyle and Li 1979) evidence suggests that many stream fishes are closely associated with specific microhabitats defined by these variables. Current ecological theory and empirical studies support the hypothesis that microhabitat can limit fish populations, but this limitation does not occur continuously; other factors such as temperature and water quality may be important and must be considered (Orth 1987).

2.4 AGENCY CONSULTATION

Federal Energy Regulatory Commission (FERC) hydropower license application procedures require applicants to consult with the relevant federal and state resource agencies in a three-stage process, to identify environmental issues that must be addressed in the application process (FERC 1985). EA's role in this process included agency consultation meetings, technical support and guidance, and interim reports.

In the first stage of agency consultation, EA attended consultation meetings, provided input to the first-stage consultation document, provided technical advice, and made study plan changes and drafted responses to natural resource agency comments. Table 2-2 provides a chronological listing of the major coordination tasks completed, agency consultation meetings attended, and documents produced by EA in the consultation process.

At the 10 December 1987 first-stage consultation meeting, GDNR requested close interaction with GPC on the "major decision points" of the Instream Flow Studies and notification as to when specific study components would be conducted. Similar requests were made by South Carolina agencies during the 19 January 1988 consultation meeting (Table 2-2). While the U.S. Fish and Wildlife Service (USFWS) was present at the 19 January 1988 consultation meeting, no written responses had been received from the USFWS regarding the first-stage agency consultation document (GPC 1987a). GPC and EA representatives met with a USFWS representative on 2 February 1988 in Charleston, South Carolina to review the Instream Flow Studies Plan and to request formal USFWS comments.

In response to these agency requests regarding the Instream Flow Studies, GPC identified "two major decision points": (1) target species selection for physical habitat and temperature analysis, and (2) review of habitat mapping results and transect selection. EA prepared interim reports for the fish survey and temperature monitoring studies and provided a description and rationale for selection of target species (Appendix A) which were distributed to the agencies for review and comment. Following completion of the habitat mapping process (Section 5.1.1), EA produced documents summarizing the results and proposing instream flow transect locations. These materials were presented by EA in separate agency consultation meetings for the North Georgia and Lloyd Shoals projects (Appendix B).

2.5 CONCURRENT STUDIES

In addition to the Instream Flow Studies, Georgia Power Company is conducting Water Quality and Fisheries Investigations in the North Georgia and Lloyd Shoals project areas. The results of these studies will form the basis of portions of the Exhibit E section of the FERC license applications for these projects.

The Water Quality and Fisheries Investigations are currently ongoing; field work related to these investigations is to be completed during fall 1989 and all final reports are scheduled to be completed during 1990.

Water Quality Investigations (EA 1989; EA 1990b) involved monthly and quarterly laboratory analyses of 23 chemical, physical, and biological parameters at 39 North Georgia and 12 Lloyd Shoals locations during 1988. Monthly in situ profiles of four additional parameters (temperature, dissolved oxygen, pH, and conductivity) were also measured at each location. Sampling locations were chosen to be representative of both reservoir and tailwater areas. The results of these analyses will be used to characterize the existing water quality at the two major study areas and will also be compared to applicable state and federal water quality criteria in order to document any exceedances. Water quality impacts of continued project operations, as well as existing and proposed measures to protect and improve water quality, will also be discussed.

Fisheries Investigations (EA 1990a; EA 1990c) involved the use of various sampling gears (primarily electrofishing and gill nets) at a total of 19 North Georgia reservoir and tailwater locations during the spring and fall of 1988 and 1989. In addition to the general Fisheries Investigations at the North Georgia project area, a 2-year study to assess the effects of the operation of Yonah Dam on walleye spawning in the tailwaters (Tugalo River) was also conducted. At Lloyd Shoals, Ocmulgee River Fisheries Investigations involved quarterly sampling (electrofishing only) during 1988 at four locations in the 12-15 mi reach immediately below Lloyd Shoals Dam. Lake Jackson's fisheries resources will be characterized using data acquired from the GDNR.

The results of the Fisheries Investigations at North Georgia and Lloyd Shoals will be used to describe the existing fisheries resources of the various project waters. Statistics such as relative abundance, relative biomass, and condition factors, as well as diversity indices, will be used for this purpose. Continuing impacts of project operations on fisheries resources will be discussed, as will any measures or facilities that might serve to protect or improve these resources.

The Fisheries and Water Quality Investigations Report will produce information pertinent to the Instream Flow Study results contained herein. The EA reports are not in their final form, but a substantial amount of data is available in its preliminary form. In this report (Instream Flow Studies), the preliminary results of Water Quality Investigations for the study areas are used to identify water quality issues that may need to be addressed when evaluating minimum flows (see Section 2.3). The preliminary results of the Fisheries Investigations are used to verify the results of the Instream Flow Studies fish survey component (Section 3). Any specific reference to these ongoing projects must be viewed as tentative, pending the final report.

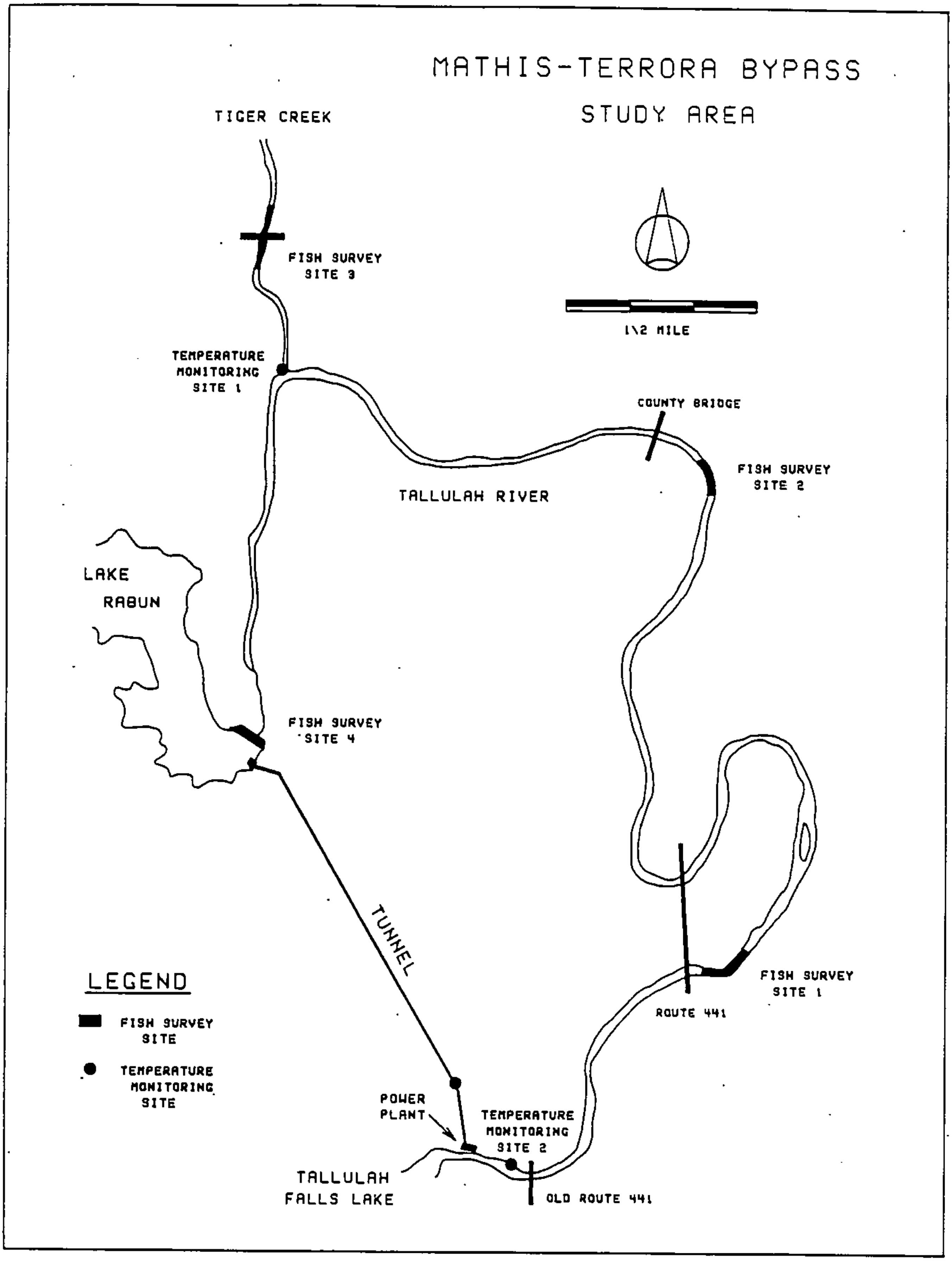

Figure 2-1. Mathis-Terrora Bypass study area map showing temperature monitoring and fish survey site locations.

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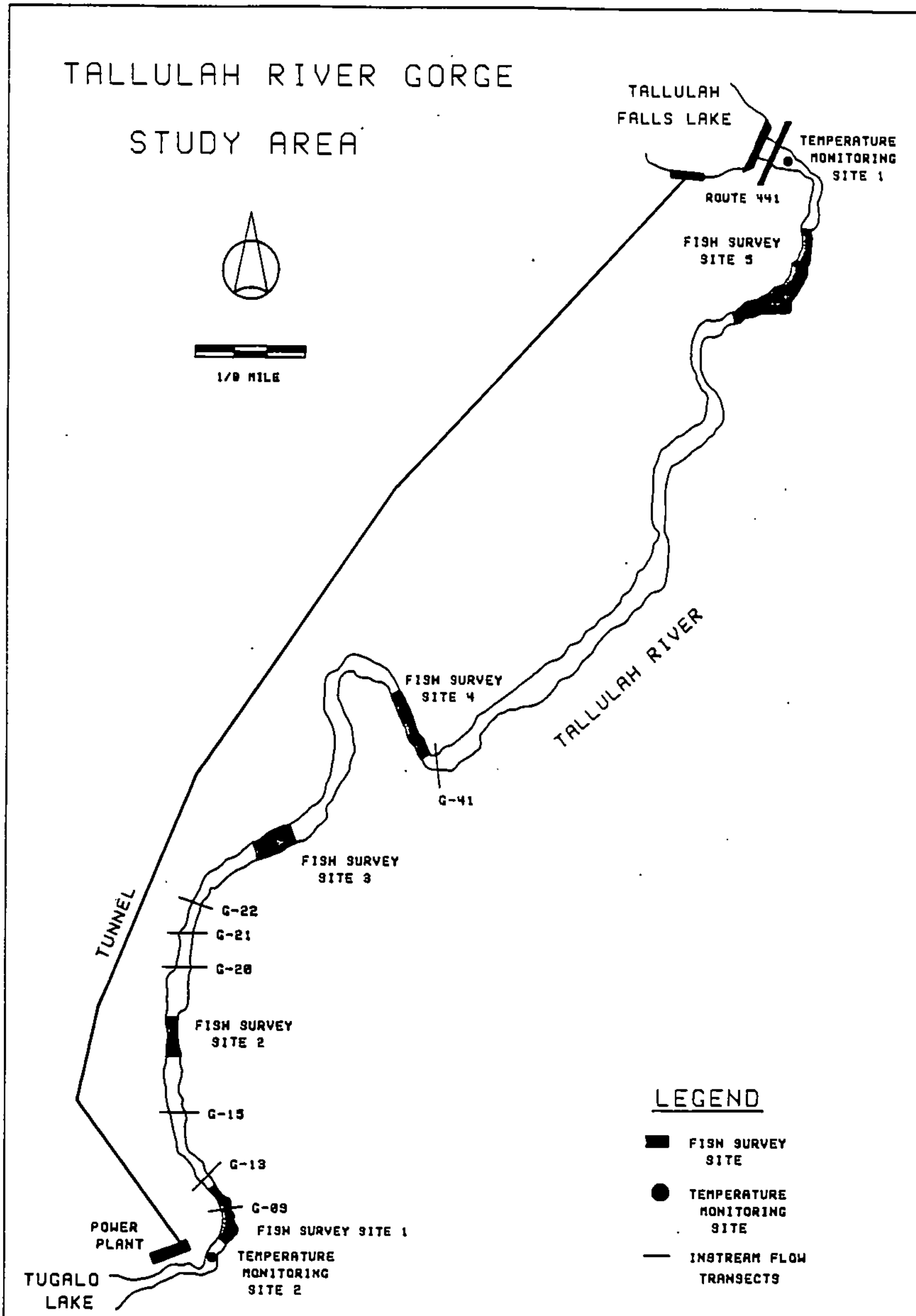


Figure 2-2. Tallulah River Gorge study area map showing temperature monitoring, fish survey sites, and locations of instream flow transects.

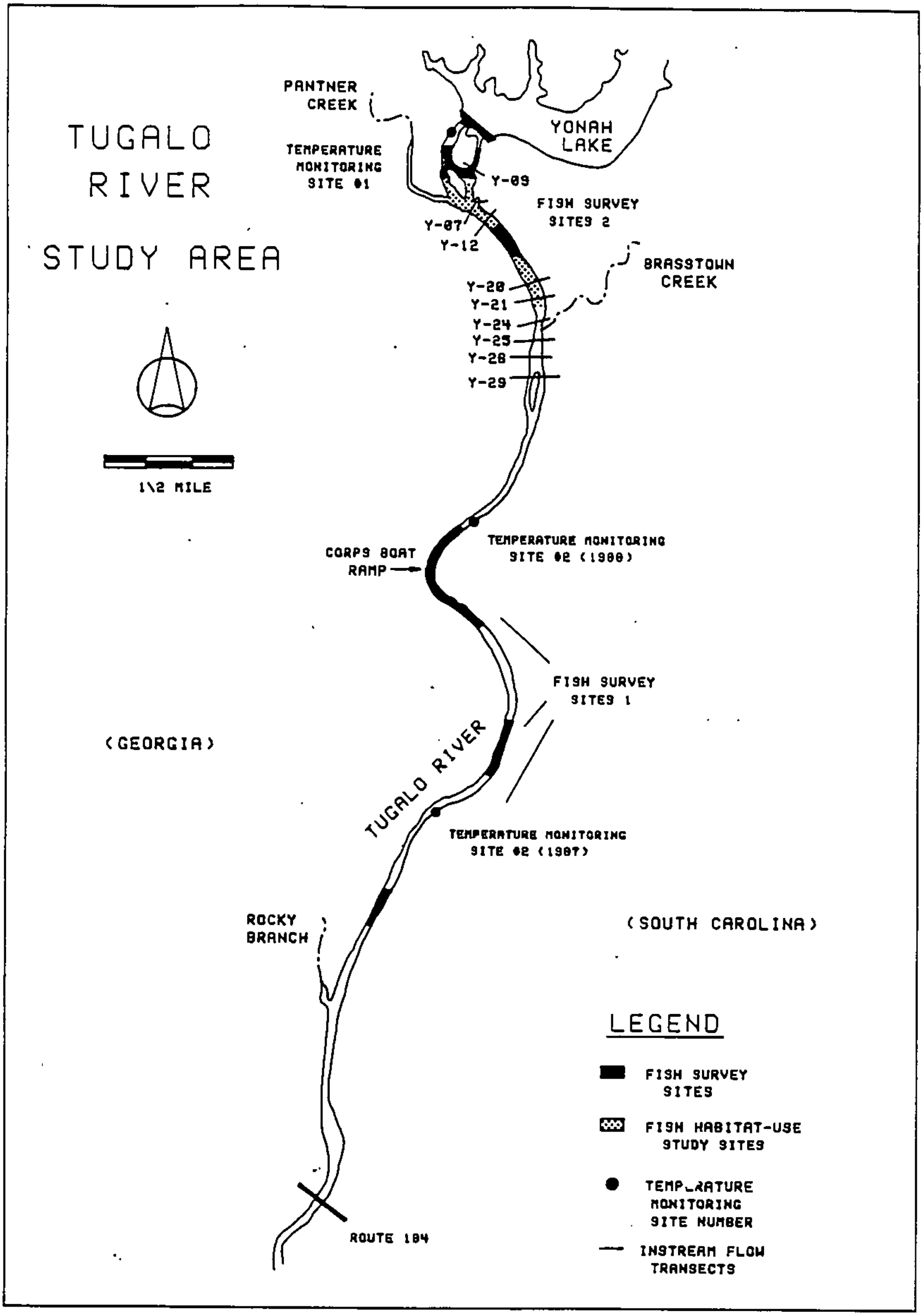


Figure 2-3. Tugalo River study area map showing temperature monitoring, fish survey and fish habitat-use study sites and locations of instream flow transects.

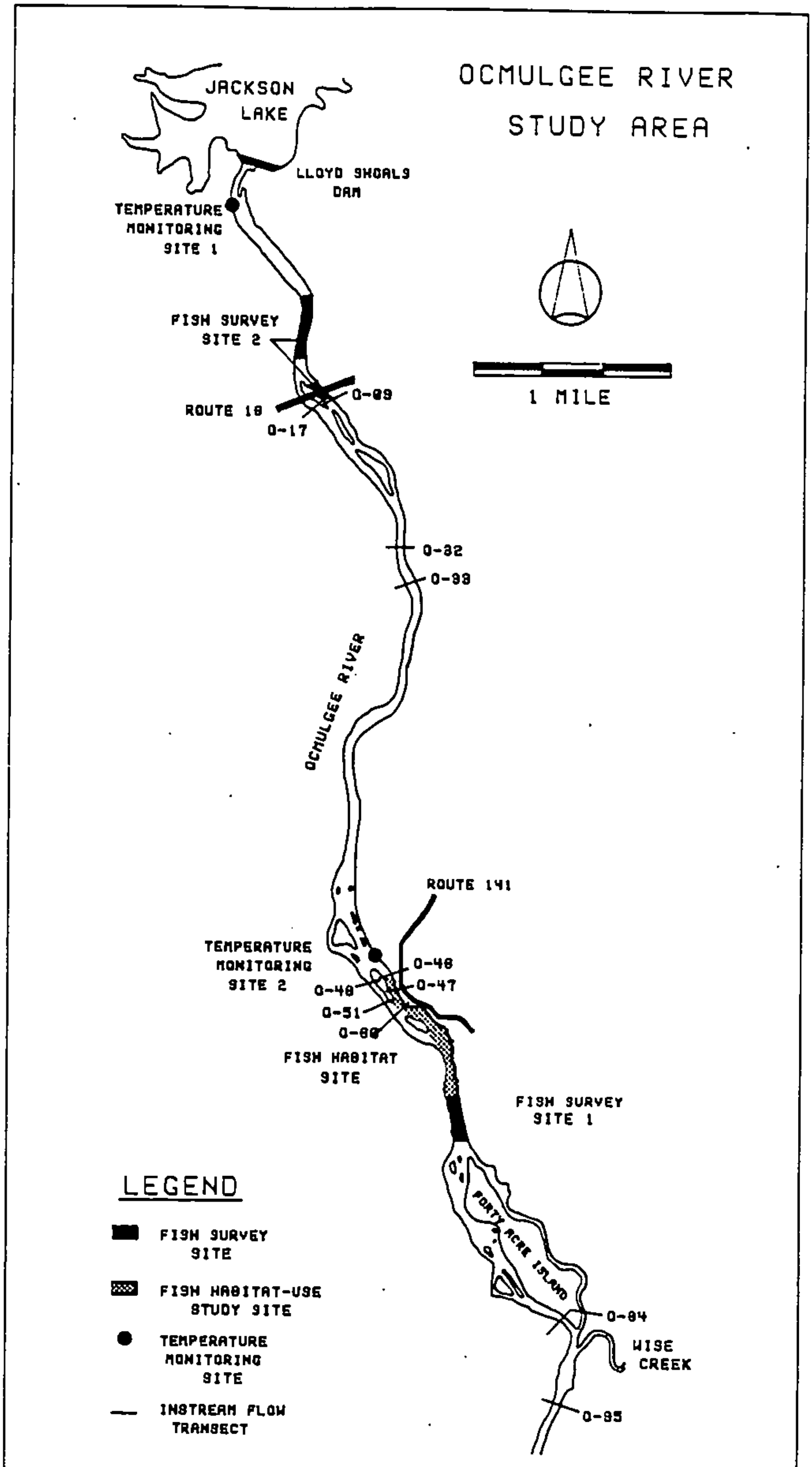


Figure 2-4. Ocmulgee River study area map showing temperature monitoring, fish survey, and fish habitat-use study sites and locations of instream flow transects.

TABLE 2-1 PHYSICAL CHARACTERISTICS AND BOUNDARIES OF THE FOUR INSTREAM FLOW STUDY AREAS

Study Area	Lower Boundary	Upper Boundary	Length (mi)	Drainage Area (mi^2)	Gradient (ft/mi)	Tributaries
Mathis-Terrora Bypass	Tallulah Falls Lake	Tiger Creek	5.6[c]	151[c]	34[b]	Tiger Creek
Tallulah Gorge	Tugalo Lake	Tallulah Falls Dam	1.8[c]	186[c]	288[b]	--
Tugalo River	Hartwell Lake	Yonah Dam	2.08	503[a,c]	4.57	Panther Creek, Brasstown Creek
Ocmulgee River	Route 83 Bridge	Lloyd Shoals Dam	16.8	1,420[c]	3.20	--*

(a) 470 mi^2 at Yonah and 33 mi^2 at Panther Creek.
(b) Based on reservoir pool elevation difference + river distance.
(c) From GPC 1987a, GPC 1987b.

Note: *Herds Creek, Yellow Water Creek, Wise Creek, Little Sandy Creek, Long Branch, and Sandy Creek.

TABLE 2-2 CHRONOLOGICAL SUMMARY OF EA'S INVOLVEMENT IN MAJOR COORDINATION MEETINGS, AGENCY CONSULTATIONS, AND DOCUMENTS (UNDERLINED) ASSOCIATED WITH INSTREAM FLOW STUDIES FOR RELICENSING GEORGIA POWER COMPANY'S NORTH GEORGIA AND LLOYD SHOALS PROJECTS

Dates	
1987	
5-15 Sep	Obtain state agency sampling permits, data, and notify agencies of study initiation and sampling dates
10 Oct - 30 Dec	Review state/federal resource agency comments on first-stage consultation documents; study plan modifications
17 Dec	First-stage consultation meetings with Georgia resource agencies (GDNR: Environmental Protection Division; Water Resources Division, Savannah River Basin Coordinator)
1988	
13 Jan	Submit agency consultation package--Description and Rationale for Selection of Target Species for Instream Flow Studies
19 Jan	First-stage consultation meeting with South Carolina agencies (SCDHEC, SCWMR, SCWRC) and USFWS
21 Jan	First-stage agency consultation meeting with GDNR (Fisheries Division)
25-29 Jan	Clarification of agency comments and preparation of responses
16 Feb	First-stage agency consultation--USFWS (Charleston, SC)
16-20 Feb	Review GDNR and SCWMR comments on target species document
14-15 Apr	Second-stage agency consultation (GDNR, SCDHEC, SCWMR, SCWRC)--habitat mapping/transect selection and progress report for North Georgia
20 Apr	Send Tugalo River Habitat Mapping and Transect Selection summary for agencies to GPC
26 Jul	Second-stage agency consultation meeting with GDNR--habitat mapping/transect selection and progress report for Lloyd Shoals

TABLE 2-2 (Cont.)

Dates	
1988	
4 Aug	Send Ocmulgee River Habitat Mapping and Transect Selection summary for agencies to GPC
19-23 Aug	Study coordination and special-use permits from USFS for Chattooga River work
1989	
17-19 Apr	Federal Energy Regulatory Commission outreach meetings

Note: GPC = Georgia Power Company
GDNR = Georgia Department of Natural Resources
SCDHEC = South Carolina Department of Health and Environmental Control
SCWMR = South Carolina Wildlife and Marine Resources Department
SCWRC = South Carolina Water Resources Commission
USFWS = U.S. Fish and Wildlife Service
USFS = U.S. Forest Service

3. FISH SURVEY

The objective of the fish survey was to obtain an estimate of fish species composition and relative abundance in each of the study areas. The results of these representative fish samples were used in the selection of fish species for habitat preference studies (target species). This fish survey precedes more exhaustive seasonal sampling of the fish populations in the study areas (EA 1990a; EA 1990c) and was not intended to identify all rare or migratory species present.

3.1 METHODS

Fish samples were collected in each of the four study areas during the period 16-23 September 1987. Two to five sites were sampled in each study area (Figures 2-1 to 2-4). In the Mathis-Terrora Bypass reach, four sites were sampled: immediately upstream of the Old Route 441 bridge, immediately downstream of County Bridge near Joy Church, Country Road Bridge at Lakemount, and immediately downstream of Mathis Dam (Figure 2-1); length of stream sampled ranged from 168 ft to 660 ft (Table 3-1). In the Tallulah Gorge, five sites along the length of the Gorge were sampled (Figure 2-2); length of stream sampled ranged from 150 ft to 668 ft (Table 3-1). In the Tugalo River, two sites were sampled: vicinity of Yonah Dam to Corps Boat Ramp and Corps Boat Ramp to Prather Bridge (Figure 2-3). On the Ocmulgee River, two sites were sampled: vicinity of Route 16 bridge and vicinity of Georgia Route 141 near Forty Acre Island (Figure 2-4). At the latter four sites, the entire stream width was not sampled, so sampling effort was only recorded on the basis of time (Table 3-1).

A representative qualitative sample was collected at each site by employing several types of electrofishing gear in a variety of habitat types. For the small river sites (Mathis-Terrora Bypass, Tallulah Gorge), backpack and pram electrofishing gear were used exclusively and the full width of the stream was electrofished at each site. For large river sites (Tugalo River, Ocmulgee River), boat-mounted electrofishing gear was employed in deep pools and runs, and pram and backpack gear were employed in vadable riffle, shoal, and run habitats.

Specifications for electrofishing gear were as follows: (1) boat unit; boat-mounted, Coffelt variable voltage pulsator (VVP-15) powered by 230V alternator and connected to two circular arrays of stainless steel anodes suspended in front of the boat and the boat hull (cathode); (2) pram unit; pram-mounted Coffelt VVP-2C powered by 120V alternator and connected to hand-held electrodes with 50-ft leads; and (3) backpack unit; Coffelt, backpack model BP-1C with hand-held electrodes.

At each location, a three- or four-person crew electrofished in an upstream direction (downstream with boat), netting all stunned fish. Duration of electrofishing and/or length of sample area was recorded. Fish were held alive in water until sampling was completed. Specimens were then identified to species, measured to the nearest millimeter, and weighed to the nearest gram. Some fish were preserved in 10 percent buffered formalin as voucher specimens or for laboratory confirmation of field identification; all other fish were released at the site. For large river sites, boat and pram or backpack electrofishing catches were combined to form a composite sample for that site.

Preserved fish specimens were re-examined in the laboratory to verify that field identifications were correct. Taxonomic references employed were: Moore (1968); Douglas (1974); Eddy and Underhill (1978); and Jenkins and Burkhead (in press). Additionally, keys to the Georgia Centrarchidae and <u>Notropis</u> (provided by Dr. B.J. Freeman, University of Georgia) were used.

Eighty-seven voucher fish specimens representing 19 fish species, were sent to Dr. Byron J. Freeman (University of Georgia) for expert identification. Dr. Freeman was the suggested regional icthyological expert of Georgia fish biologists (Evans 1988b). Any changes in species identifications made by Dr. Freeman were corrected in the fish survey data. These changes are reflected in minor differences between the preliminary fish survey results released to agencies (for target species selection) (Appendix A) and in the final results presented here.

3.2 RESULTS AND DISCUSSION

Fish Community Composition and Relative Abundance

A list of common and scientific names of fishes used throughout the text is presented in Table 3-2.

North Georgia

The combined catch from all sampling sites in the Mathis-Terrora bypass area yielded 444 fish distributed among 14 species within four families (Table 3-3). Seven species--bluehead chub, redbreast sunfish, yellowfin shiner, northern hog sucker, bandfin shiner, whitefin shiner, and margined madtom--constituted 93 percent of the total catch. No other species composed more than 2 percent of the fish collected.

The composition of the fish community was similar at the Mathis-Terrora Sites 1-3, as each of these sites was dominated by the same suite of species (Appendix C). The distribution of the less common species appeared nonuniform, as would be expected due to low probability of capture resulting from their low abundance. Composition of the catch at Site 4 was different largely due to the type of habitat sampled. Site 4 was an emergent wetland area with standing or slow-flowing waters immediately downstream of Mathis Dam; sunfish species dominated the catch at this site.

Fish in the Mathis-Terrora study area exhibited a wide range of sizes (Table 3-3). Most species for which an adequate sample size was obtained had individuals ranging from young-of-the-year (YOY) fish to the expected adult size.

A total of 252 fish distributed among 10 species within four families was collected from the five sites in the Tallulah Gorge (Table 3-4). Bluehead chub, redbreast sunfish, and central stoneroller dominated the catch, together constituting 83 percent of the total catch. Redeye bass and northern hog sucker were the next most abundant species. The average size of fish specimens captured was typically small (Table 3-4) relative to the maximum attainable size for each species, but larger specimens of each species were also collected for most species. Bluehead chubs dominated the catch largely due to the presence of abundant YOY.

The number of species and abundance of fishes was greatest in the middle reaches of the gorge (Sites 2, 3, and 4); sites at the lowermost and uppermost portions of the Tallulah Gorge study area contained very few fishes (exception: bluehead chub YOY) (Appendix C). Overall, the abundance of fish in the Tallulah Gorge was relatively low.

The Tugalo River fish survey yielded a total catch of 473 fish distributed among 22 species within seven families (Table 3-5). Eight species--blackbanded darter, bluegill, margined madtom, redbreast sunfish, snail bullhead, yellow perch, blueback herring, and largemouth bass--constituted 77 percent of the total catch. No other species composed more than 5 percent of the total catch. Although blueback herring ranked high in overall abundance, the total catch of the species was due to one large school of young fish ($\leq$87 mm total length). At Site 1, this same phenomenon was largely true for spottail shiner.

Clear differences exist between fish community composition at Tugalo River Sites 1 and 2 (Appendix C). These differences are largely due to gear type and habitat (Table 3-1). Site 1 is in the upper end of the Tugalo arm of Lake Hartwell (lower end of Tugalo study area), where river stage is determined by the Lake Hartwell pool elevation. This transitional river-reservoir habitat consists of deep pools and runs with moderate to slow velocity. Boat electrofishing was used exclusively due to water depth. Site 1 was dominated by Centrarchid species, pool-dwelling suckers, and midwater planktivores or insectivores (blueback herring, spottail shiner); no darters, madtoms, chubs, and few of the abundant shiners were collected here. In contrast, Site 2 was in the flowing water portion of the Tugalo River study area, which is dominated by riffle, run, and shallow-pool habitat. The fish assemblage at Site 2 was characterized by darters and catfish, Gentrarchids, and a variety of minnow species.

As a result of the fish identification verifications conducted by Dr. B.J. Freeman of the University of Georgia and fish identified by EA (1990c), several corrections were made to the preliminary data released to the agencies in January 1988 (Appendix A). Two bullheads collected in the Tallulah Gorge initially identified as yellow bullhead were changed to brown bullhead. At the Mathis-Terrora site, all brown bullhead (n = 3) were changed to snail bullhead.

The results of the fisheries sampling conducted as part of the ongoing Fisheries Investigations in North Georgia (EA 1990c) yielded fish species composition and abundance data very similar to the results reported here for the Mathis-Terrora bypass and Tugalo River study areas.

During sampling of the Mathis-Terrora bypass area for the Water Quality and Fisheries Investigations, EA (1990c) identified five species not found in this study, including warmouth, smallmouth bass, yellow perch, swamp darter, flat bullhead, and mottled sculpin (Table 3-2). Each of these species was found in relatively low abundance and such differences between surveys would be expected. Difficulties associated with identification of species of flat-headed bullheads (outlined in Section 3.3.2) may account for minor discrepancies for this species. Also, EA (1990c) sampled different areas of Tiger Creek and the Old Tallulah River channel. Otherwise, the results of the two surveys were very similar in terms of species composition and relative abundance.

Species found in Instream Flow Studies fish survey or during underwater observations in the Tugalo River study area but not found during the Fisheries Investigations included blueback herring, common carp, gizzard shad, and striped jumprock. Species collected only by EA (1990c) include redear sunfish, yellowfin shiner, turquoise darter, smallfin redhorse, rosyface chub, and longnose gar (Table 3-2); all of these species were found to be in very low abundance. Yellowfin shiner, longnose gar, and rainbow trout were identified during underwater observations for Instream Flow Studies in the Tugalo River study area.

Overall, the results of the Fisheries Investigations and Instream Flow Studies yielded very similar fish species composition and relative abundance data; the minor differences noted would be expected based on spatial and effort differences. This comparison provides a verification that no important species were overlooked in the initial survey and that the results reported here are similar to those produced in the more extensive survey later conducted by EA (1990c).

Ocmulgee River

A total of 905 fish distributed among 30 species within 10 families were collected from two sampling sites in the Ocmulgee River (Table 3-6). Six species--redbreast sunfish, spottail shiner, snail bullhead, Altamaha shiner, spotted sucker, and American eel--accounted for 75 percent of the total catch. Redbreast sunfish represented nearly one-third of the total catch. No other species composed more than 4 percent.

Redbreast sunfish were the most abundant fish captured at both Site 1 (24.1 percent) and Site 2 (33.8 percent) (Appendix C). A somewhat greater percentage of pool species--gizzard shad, spotted sucker, bluegill, and largemouth bass--were captured at Site 2 below Lloyd Shoals Dam in the vicinity of the Route 16 bridge than at Site 1 off Route 141 in the vicinity of Forty Acre Island. This may have been due to a slightly higher proportion of pool habitat sampled (effort = 90 minutes for Site 2 versus 50 minutes for Site 1) or the increased likelihood of reservoir introductions via Lake Jackson. In addition, gizzard shad relative abundance may be partially inflated when a large school is located and they are more easily collected than at other times. A greater percentage of riffle or shallow water species (spottail shiner, Altamaha shiner) were collected at Site 1 which included more extensive shallow and shoal habitat. At both sites, relatively few species dominated the catch. At Site 1, five species--redbreast sunfish, spottail shiner, Altamaha shiner, snail bullhead, spotted sucker--constituted 80 percent of the total catch. At Site 2, eight species--redbreast sunfish, gizzard shad, American eel, snail bullhead, spotted sucker, bluegill, spottail shiner, largemouth bass--represented 81 percent of the total catch.

As a result of the fish identification verifications conducted by Dr. B.J. Freeman of the University of Georgia and fish identified by EA (1990a), several corrections were made to the preliminary data released to the agencies in January 1989 (Appendix A). Five fish collected in the Ocmulgee River originally reported to be spotted sunfish were changed to redbreast sunfish.

The results of fisheries sampling conducted as part of the ongoing Fisheries Investigations at Lloyd Shoals (EA 1990a) yielded fish species composition and abundance data for the Ocmulgee River study area very similar to the results reported here.

For the Ocmulgee River study area, the electrofishing catch was compared with that of two sites sampled in the Fisheries Investigations on the Ocmulgee River, which were located in the vicinity of the sites reported here. White bass was the only species captured during this study that was not collected by EA (1990a); the likely source of these two specimens was Lake Jackson. Seven species--golden shiner, pugnose minnow, coastal shiner, creek chubsucker, smallfin redhorse, flat bullhead, and mosquitofish--were found only by EA (1990a). All were found in very low abundance, comprising only 48 total individuals out of 4,372 fish collected at two sites over four quarterly samples. Collection of these species was a low probability event (as none were collected in more than half of the samples) and a reflection of the more intensive sampling effort. Golden shiner and mosquitofish were observed underwater during fish habitat-use observations for the Instream Flow Studies. The difficulties in identifying species of flat-headed bullheads and their uncertain distributional status (discussed in Section 3.3.2) may account for minor discrepancies for this species. The presence of Ocmulgee shiner in EA (1990a) collections and absence in this survey is notable, but not exceptional. This schooling species was not collected by EA (1990a) in two of their four surveys. Notwithstanding the above differences, the results of the two surveys yielded remarkably similar species composition and relative abundance data. This comparison provides a verification that no important species were overlooked in the initial survey and that the results reported here are similar to those produced in the more extensive survey later conducted by EA (1990a).

3.3 SPECIAL TAXONOMIC CONSIDERATIONS

Of the fish assemblage encountered in the Tugalo River and Ocmulgee River study areas, two groups of closely related species stand out as having very limited taxonomic and distribution information in the published literature: the *Micropterus coosae* complex and the flat-headed bullheads. One or more species from each of these two groups were suggested by the agencies as target species or were accepted by the agencies as target species for the Instream Flow Studies. Consequently, supplementary discussion of these species groups is provided below.

Data on habitat use by redeye bass (*Micropterus coosae*) and shoal bass (*Micropterus sp.*) were collected as part of the fish habitat suitability criteria studies (Section 4.0). Due to the uncertain distributional status of these species groups in the study areas and potential difficulties in distinguishing among species in these groups, the available literature for applicable information was reviewed prior to field work for habitat suitability criteria studies. The results of the literature reviews, presented below, and experience in the field enabled distinguishing between these species.

3.3.1 *Micropterus coosae* Complex

The two species of concern in this complex are the redeye bass *Micropterus coosae*, first described by Hubbs and Bailey (1940), and the shoal bass *Micropterus sp.*, an undescribed species previously confounded with *M. coosae*. The redeye bass is found above the fall line in small to large streams in the Warrior, Alabama, Chattahoochee, Altamaha, and Savannah drainages (Ramsey 1973; Lee et al. 1980). The shoal bass is an Appalachicola River endemic present only in large Piedmont and Coastal Plain tributaries of the Chipola, Chattahoochee and Flint River drainages (Ramsey 1973; Lee et al. 1980). These species occur sympatrically at several locations (Gilbert 1978; Ramsey 1973).

Historical literature accounts of these species are characterized by some confusion. Ramsey (1975) reported that the redeye bass complex (i.e., redeye and shoal basses) had been the source of considerable taxonomic confusion. During the 1950s and 1960s these basses were considered to be ecologically distinct forms of the same species or "races" (Dahlberg and Scott 1971; Wright 1967). Wright (1967) referred to shoal bass as the "Flint River form" of the redeye bass, and reported its differentiation from the "upland form" of the redeye bass on the basis of several morphological characteristics.

During the period of taxonomic uncertainty, these species were apparently introduced widely (Tatum 1965; Lambert 1980). The Georgia Game and Fish Commission considered transplanting the "Flint River redeye bass" (now thought to be shoal bass) to other rivers in Georgia. The result is that the current distribution of these species is not unequivocally known. Ramsey (1973) considers all records for redeye bass outside of the previously stated distribution to represent introduced populations.

During the Ocmulgee River fish survey reported here, eight individuals of the *Micropterus coosae* complex were collected. Due to the fact that, to date, the shoal bass has not been reported as occurring in the Ocmulgee River, these species were identified as redeye bass. Later contacts with

Georgia DNR fish biologists (Evans 1988b) led us to believe that both species were present in the study area. Some evidence exists that the shoal bass may have been introduced into the upper Ocmulgee River (Evans 1988a).

A literature search was conducted and a list of attributes potentially useful in field identification of these species was compiled (Table 3-7). During preliminary underwater observation of fish for habitat preference studies (Section 4), EA became convinced that both species were present in the Ocmulgee study area. The GDNR is also convinced that both species are present and is now conducting electrophoretic studies of these two species (Evans 1988a). Consequently, the fish habitat utilization data reported in Chapter 4 were based on the assumption that both species are present and EA became adept at identifying these species underwater. The shoal bass appears to be the more abundant species of the _Micropterus coosae_ complex in the upper Ocmulgee River study area.

The status of the _Micropterus coosae_ complex in the upper Ocmulgee River remains undetermined at this time. Current studies by GDNR (Evans 1988a) include objectives to identify the species of the _Micropterus_ complex occurring in the upper Ocmulgee River by expert icthyological identification and electrophoretic analysis (Evans 1988b).

3.3.2 Flat-headed Bullheads of Georgia

Until 1968 only one species of flat-headed bullhead, _Ictalurus platycephalus_, the flat bullhead (Girard) had been recognized. In 1968, Yerger and Relyea redescribed _I. platycephalus_ and identified two additional species, _I. brunneus_, the snail bullhead, and _I. serracanthus_, the spotted bullhead. In Georgia, the flat bullhead is found in Atlantic slope drainages south to the Altamaha River, being absent from the Satilla and St. Mary's rivers. The snail bullhead is found in all three major Georgian drainages, the Savannah, Altamaha, and Apalachicola. The spotted bullhead has a more limited distribution, being confined to the lower Suwanee, Ochlockonee, Appalachicola, and St. Andrews Bay drainage systems of northern Florida, southern Georgia, and southeastern Alabama (Yerger and Relyea 1968; Lee et al. 1980) However, the exact distribution of these three species has not been determined.

Identification of the flat-headed bullheads has been confounded historically since many populations occur sympatrically over their range and because of their variable color patterns; individuals of the three species often appear morphologically similar. Only the flat and snail bullheads, however, occur sympatrically in those drainages examined in this study (the Savannah and Altamaha). While the flat bullhead is reported to prefer slow water habitats with soft mud, muck, or sand bottom, it can also occur over a fairly wide range of ecological conditions (Lee et al. 1980; Yerger and Relyea 1968). Snail bullheads have a strong preference for swifter montane streams with rocky, hard bottoms but may occur in lowland coastal streams where appropriate habitat is available (Lee et al. 1980; Yerger and Relyea 1968; Gilbert 1978); yet, habitat preferences are not sufficient to make species determinations.

The flat bullhead is described as vaguely-to-strongly mottled and golden yellow with brownish ground color. Snail bullheads are reported to be usually solid or uniform and only occasionally mottled or spotted as in the St. John's River population (Florida). Colors are typically olive-green to a brownish or gray-brown ground color (Yerger and Relyea 1968).

Based on the combined results of this survey and the ongoing EA (1990a; 1990c) survey, both the snail bullhead and the flat bullhead are present in the North Georgia and Ocmulgee River study areas. However, snail bullhead collected in both study areas (and identified by Dr. Freeman) were noticeably mottled, a characteristic usually associated with the flat bullhead. The similarity of these two species can make field identification difficult, but it was possible to distinguish between these species after some practice prior to habitat-use studies. However, it is clear from the combined survey results and habitat-use studies (Chapter 4) that snail bullheads are, by a large margin, the dominant flat-headed bullhead in both the North Georgia and Ocmulgee River study areas.

TABLE 3-7 DISTINGUISHING CHARACTERISTICS USED IN THE IDENTIFICATION OF SHOAL BASS AND REDEYE BASS[a]

Shoal Bass (Micropterus sp.)	Redeye Bass (Micropterus coosae)
1. Caudal fin dusky--orange/white frosting absent (Ramsey 1973).	1. Orange/white frosting present dorsally and ventrally on caudal fin (Ramsey 1973).
2. Pattern of horizontal dots less true for larger specimens.	2. Striking pattern of horizontal dots present along ventral half of fish.
3. Vertical bars prominent on fish of all sizes (Wright 1963).	3. Vertical bars prominent only on a few specimens and faded with age (Hubbs and Bailey [1940], Lawrence [1954], Parsons [1954]).
4. Chunky appearance.	4. Slender, elongated head.
5. Dark spot at base of caudal peduncle present on all fish regardless of age (Wright 1963).	5. Dark spot at base of caudal peduncle indistinct on older fish (Hubbs and Bailey [1940], Lawrence [1954], Parsons [1954]).
6. Lighter almost golden coloration especially for larger individuals.	6. Darker body coloration--olivaceous.
7. Red eye evident for only a few specimens (Wright 1963).	7. Bright red eye (Hubbs and Bailey [1940], Lawrence [1954], Parsons [1954]).
8. Generally attain larger size (Ramsey 1973).	8. Average 0.5 lbs (Ramsey 1973).
9. Emargination of dorsal fin greater (Wright 1963).	9. Emargination of dorsal fin less (Wright 1963).

(a) In addition to literature cited below, distinguishing characteristics were provided by J. Evans (GDNR, personal communication) and B.J. Freeman (Univ. of Georgia, personal communication).

4. FISH HABITAT SUITABILITY CRITERIA STUDIES

The biological component of stream habitat simulation is represented by fish species habitat suitability criteria. The habitat suitability criteria (or suitability indices) used in physical habitat simulation modeling define the suitability of habitat variables most closely related to stream hydraulics and channel structure for each major activity or life stage of a given fish species (Bovee 1986; McMahon et al. 1984). These criteria are used in the physical habitat modeling process (Chapter 5) to translate predicted changes in the physical stream environment into predicted changes in usability of a stream area by a species of concern. Habitat suitability criteria define the tolerated and optimum range of selected habitat variables.

The objective of this phase of the Instream Flow Studies is to develop and evaluate habitat suitability criteria for selected fish species for use in physical habitat simulation modeling. The methods used herein for the selection of target species, data collection and analysis, and development of final criteria are consistent with the most recent guidelines and research on this topic (Bovee 1986; Bovee and Zuboy 1988).

Categories of Habitat Suitability Criteria

Several categories of habitat suitability criteria have been designated by the U.S. Fish and Wildlife Service (Edwards et al. 1983; Bovee 1988). The types of criteria are based on the kind of data used to derive the criteria and the method of analysis. Category One criteria are based on literature sources and/or professional experience and judgment. Category Two suitability criteria, typically called utilization criteria, are based on frequency analysis of field data on microhabitat conditions utilized by a species. Category Three criteria are utilization data corrected for bias caused by unequal habitat availability (typically called preference criteria). The category of a criterion does not necessarily imply a difference in quality or accuracy (McMahon et al. 1984).

The concept of Category Three, or preference criteria, was developed primarily for two reasons. First, utilization functions may not always accurately describe a species' preferences because the preferred conditions might be absent or in short supply (i.e., fish forced to use less than ideal habitat), resulting in the need to correct for this environmental bias. This is why Bovee (1986) recommends selecting study sites with a wide variety of microhabitat combinations when developing criteria. Secondly, the high cost of developing habitat suitability criteria led to the need for transferable criteria; the use of criteria in streams that differ from those where the criteria were developed. It has been suggested that this correction for fish habitat suitability leads to a more accurate estimate of true preference, but this contention has met with some criticism (Degraff and Bain 1986; Morhardt and Hanson 1988; Kinzie and Ford 1988). This general topic, determining resource selection from data on use and availability, is currently of central interest in wildlife and fisheries ecology (Strauss 1979; Johnson 1980; Neu et al. 1974; Alldredge and Ratti 1986).

To develop preference criteria for Instream Flow Studies, Bovee (1986) recommends that utilization data be modified by the amount and type of habitat present at the time of sampling (habitat availability data). The form of the modification, based on the work of Voos et al. (1981), Baldridge and Amos (1982), and others, consists of dividing the frequency distribution of fish habitat utilization by that of availability. This proposed correction of habitat utilization data has led to considerable controversy and research on the topic. Some authors contend that true preference cannot be derived from utilization and availability data with this proposed (or several alternative) correction factor (Morhardt and Hanson 1988). When developing habitat preference curves, Hampton (1987) found that small sample sizes at the upper ends of the distributions yielded a misrepresentation of the actual preference of the majority of the population. Hampton (1987) removed the influence of the outliers and the adjusted preference criteria were then in close agreement with the utilization criteria. Kinzie and Ford (1988) reported that preferences for depth, velocity, and substrate were significantly different between streams for a given fish species, casting doubt upon the validity of the correction factor. DeGraff and Bain (1986) tested and rejected the hypothesis that habitat preference is constant in different streams. They concluded that preference curves derived in a single habitat are less useful for wide application, and that habitat-use data that have been gathered locally (i.e., site-specific) and are not corrected for habitat availability are more useful than the preference curves.

In summary, the methods employed for developing habitat preference criteria are equivocal and are still under considerable scrutiny. Currently, the most reasonable approach is to develop site-specific utilization criteria (Category Two) for use in habitat modeling. Conversations with U.S. Fish and Wildlife Service personnel currently working on this topic suggest that this may be the best approach at this time (B. Slauson 1989).

Study Site Selection

When selecting study streams and sites for developing habitat suitability criteria, several stream attributes are desirable (Bovee 1986): (1) habitat diversity: the stream should exhibit a variety of microhabitat conditions (i.e., deep-slow, deep-fast, shallow-slow, shallow-fast, with a variety of substrates and cover types) and should contain some conditions outside the tolerance range of the target species; (2) stream size should be similar to that of the stream to which the criteria will be applied; (3) the fish community composition and abundance should be similar; and (4) water quality and temperature should be within acceptable ranges.

Study sites in the Ocmulgee, Tugalo, and Chattooga rivers were selected to conform as closely as possible to these guidelines. Habitat availability measurements were made at all sites to document the range of microhabitats present. Variable flows at the Tugalo River study area resulted in difficult working conditions and the need for an additional site to study the target fish species. The Chattooga River, a tributary of the Tugalo River, was selected as an additional study site.

Stream size, physical habitat, and fish species composition in the Chattooga River were similar to those of the Tugalo River. A wider range of microhabitat conditions are available in the Chattooga River and water quality is generally excellent (USFS 1971; GDNR 1988). Habitat suitability criteria were developed in the Chattooga River for use in the Tugalo River. For some species, data for criteria development or comparison to Chattooga River data were collected in the Tugalo River.

4.1 METHODS

4.1.1 Selection of Target Species

The fish species to be included in the instream flow analysis were determined during the scoping and first stage agency consultation phase. A proposed suite of candidate species was developed on the basis of the fish survey and selection criteria consistent with U.S. Fish and Wildlife Service guidelines (U.S. Fish and Wildlife Service 1980; Roberts and O'Neil 1985; Bovee 1986) and other published guidelines (Leonard and Orth 1988). The selection process yielded species typical of the stream size and general temperature regime and included representatives of the major habitat, feeding, and breeding guilds (see Appendix A for details).

The proposed list of target species and rationale for selection (Appendix A) was submitted to consulting agencies for comments and approval (Section 2.4). The final selection of target species was consistent with the South Carolina Wildlife and Marine Resources Department comment that "...we recommend the study of at least two redeye bass life stages and one redbreast sunfish life stage. Species and life stage selection of obligate-riffle and pool/slow-current fishes is left to your discretion," and the GDNR comment "...and the walleye and redeye bass [should be] included as target species at this (Tugalo River) site" (Appendix A). The species actually studied are listed in Table 4-1.

Life stages of each species were determined by size [i.e., young-of-the-year (YOY), juvenile, adult] or activity (i.e., spawning). Size range boundaries for each life stage were determined by literature review and results of length-frequency analysis of fish survey data (Table 4-1).

Walleye

Runs of spawning walleye have occurred in the Tugalo River annually since the introduction of this species into Lake Hartwell in 1962 (SCWMR 1970). For reasons that are unclear at this time, the size of the walleye runs in the Tugalo River have apparently declined from the large runs of the 1960s. Concurrently, there appears to be a shift from river spawning to spawning in the reservoir (SCWMR 1987), possibly associated with a change in the strain of walleye stocked from a river-oriented spawning stock to a more lake-oriented spawning stock (SCWMR 1987).

Because of the above-stated reasons, and the status of the walleye as an important sport fish, the walleye is included here as a target species.

4.1.2 Microhabitat Data Collection

Collecting fish microhabitat-use data consisted of selecting study sites, sampling by direct observation within habitats in approximately the same proportion that those habitats occurred in the stream, measuring physical habitat at fish locations, and quantifying the available microhabitat by stratified-random sampling.

Preliminary testing of field methods was conducted in the fall of 1987 and spring of 1988. All personnel were certified scuba divers trained in underwater methods and fish identification. Training sessions were conducted to ensure consistency in data collection among observers. The same four people conducted all fish microhabitat data collection.

Three primary study sites were used: (1) Chattooga River near the Highway 76 bridge; (2) Tugalo River near Yonah Dam (Figure 2-3); and (3) Ocmulgee River near Forty Acre Island (Figure 2-4). A complete description of these study areas and their habitat characteristics are included in the results section.

Collection of species microhabitat data was completed during the period March through November 1988. Table 4-2 presents the species observed and the dates of observation for all study sites. A limited number of observations of spawning walleye in the Tugalo River were collected in March 1988. Observations on spawning, larval, and early young-of-the-year (YOY) fishes were collected primarily during June 1988.

Fish Observation Methods

During the study, several methods of observing fish were used and evaluated. A description of each method and a discussion of its application are described below. For most species life stages, the most favored (Bovee 1986) approach, direct observation of fish by surface observation and underwater observation by snorkeling and scuba, was used (Table 4-2).

Underwater Observation

Underwater observation was the most effective method for habitat-utilization data collection and had the fewest limitations as to which habitats could be sampled. Snorkeling and scuba are used extensively in fish habitat studies and allow reliable species identification and size and abundance estimates (Goldstein 1978; Helfman 1981; Northcote and Wilke 1963; Bovee 1986; Moore and Gregory 1988; Leonard and Orth 1988, Hankin and Reeves 1988).

Underwater observations of fish microhabitat use were typically made between 1000 and 1600 hours (optimal light conditions) in a full range of habitats. Water visibility was estimated, and in all cases exceeded the minimum standards suggested by Hickman and Saylor (1984). Snorkeling was generally limited to water less than 5 ft deep; scuba was employed in water with depth greater than 5 ft or where velocities were too high for effective snorkeling.

Two to three divers moved slowly upstream observing fish in assigned "lanes". The entire area of the stream segment was viewed. Observers utilized cover objects as viewing vantage points whenever possible to avoid startling fish. Undisturbed fish were observed for a time period sufficient to determine and record focal point of habitat use, species, size class (life stage), number of fish, activity, position in water column, and whether or not cover was being utilized (Table 4-3). These data were recorded underwater on waterproof paper. A weighted and numbered location marker was placed to identify the focal point. Upon completion of underwater observations, microhabitat variables and marker number were recorded for each location marker as described in Section 4.1.3.

For schooling fish, one or more markers was used, depending on school size and number of distinct focal points being used. For small schools (<30 fish) using a single microhabitat, a single marker was placed. For large schools, or where focal points were in different microhabitats, a marker was placed for each 30 fish and/or focal point. These situations accounted for less than 5 percent of all fish observations.

Surface Observations

Surface observation refers to viewing fish and determining their microhabitat use from out-of-water vantage points including banks, blinds, or wading. This approach has been successfully applied in determining fish microhabitat use (Bachman 1984; Leonard et al. 1986; Moore and Gregory 1988) and is especially useful for spawning, fry, and YOY fish that inhabit shallow, slow, stream-margin habitats (Moore and Gregory 1988).

This technique consisted of walking or wading quietly in an upstream direction and observing undisturbed fish or identifying the location of nests, and measuring physical microhabitat at these locations as previously described. Positive identification of species was by direct observation of an adult guarding a nest or, for larvae and YOY, by capturing a specimen with a net. Whenever the surface observation technique was employed, underwater observations were collected concurrently for those same species life stages, in habitats not observable by surface observation, to avoid sampling method bias. Limits imposed by the netting technique precluded collection of data on activity, position in water column, and whether or not cover was being utilized.

Electrofishing

Electrofishing is a technique with limited applicability as a sampling tool for fish habitat utilization studies. The reasons for these limitations are described by Bovee (1986), but the single most important is "fright bias", the tendency for fish to flee from samplers or to be caught in areas that the fish were not originally inhabiting. Fright bias is commonly noted in clear waters when sampling is directed at highly mobile fishes (Bain 1988).

The margined madtom is a small, highly cover-oriented, interstitial-dwelling, benthic fish species. Underwater observation of this species is difficult, especially in shallow (<1 ft) water. We found backpack electrofishing to be ideally suited for sampling this species, since this species does not flee upon approach of a sampler and typically moves less than 1-2 ft when "stunned." Bain (1988) found this technique to be suitable for small, cover-oriented fish when a predetermined sampling design is employed.

To determine the microhabitat use of margined madtom, we combined electrofishing (in habitats <3 ft in depth) and underwater observation techniques to adequately sample all habitat types. In order to pool observations from these two methods, we corrected for their unequal relative yields, as suggested by Bovee (1986), on the basis of catch per unit area.

We sampled margined madtoms along randomly selected transects in the Tugalo River in a manner similar to Bain (1988). The Tugalo River study area was stratified into 100-ft segments on an aerial photograph and each 100-ft segment was assigned a habitat type. A sampling location was randomly placed within each 100 ft of strata. From the pool of possible locations, 10 locations were selected at random until the percentage of habitat types represented by the locations equaled the percentage of habitat types in the study area.

At each location, we established two transects perpendicular to the channel, 3 ft in width, separated by a distance of 20 ft. The upstream transect was sampled by an underwater observer overturning all rocks within the "lane." The downstream transect "lane" was sampled by back-pack electrofishing (three person crew). Each fish "capture" location was marked and physical microhabitat measurements were collected. For transects in water depths greater than 3 ft, only underwater observations were conducted. The relationship between yield (catch-per-unit-area) for electrofishing and underwater observations was plotted and regressed by the least squares method (Montgomery and Peck 1982). Using a rationale similar to that of Petering and Van Den Avyle (1988), the slope of this relationship was the correction factor used to weigh the results of one method relative to the other prior to data pooling.

Habitat Availability

Habitat available to fish at the time of fish observations was quantified for each study area at the same (within 0.1 ft stage) discharge. The study area was divided into 100-ft segments. Within each 100-ft segment, a transect was randomly located and established perpendicular to flow. Habitat measurements were made at predetermined intervals (7.0 ft, Chattooga River; 10.0 ft, Tugalo and Ocmulgee rivers) along the transect line, starting alternately, at water's edge and 3 ft out from water's edge.

4.1.3 Physical Microhabitat Measurements

Methods used to measure microhabitat conditions were identical for fish habitat utilization, habitat availability, and transect measurements for physical habitat modeling. For each point of interest in the stream (i.e., fish location, transect vertical), depth was measured to the nearest 0.05 ft with a 4-ft, 7-ft, or 10-ft wading rod, and water velocities were measured to the nearest 0.01 fps with a Marsh McBirney analog or digital current meter. Mean column velocity was measured at 0.6 of the depth down from the surface. If depth exceeded 3.0 ft, or if complex flow was evident, two readings (at 0.2 and 0.8 of the depth from surface) were taken and averaged.

Substrate and cover were visually estimated (Bovee 1986; Bain et al. 1985) within a 3-ft-radius circle around the point of interest. Dominant, subdominant, and percent dominant substrate or cover were classified according to a modified Wentworth scale (Bain et al. 1985) and a cover type description, respectively, and given a numerical code (Table 4-3).

Additional miscellaneous data collected at some locations included bottom velocity, vegetation (no vegetation, rooted, attached), vegetation density (absent, sparse, moderate, heavy), and substrate embeddedness. See Table 4-3 for complete descriptions.

4.1.4 Data Analysis

Habitat suitability index curves (Bovee 1986) were developed for each life stage of each species for depth, mean column velocity, dominant substrate, and dominant cover. Each focal point observation was treated as a single sample regardless of the number of fish at that location. In the analysis phase, each observation was weighted by the square root of the number of fish present at that focal point.

Prior to development of habitat suitability criteria, descriptive univariate statistics for each variable for all species and life stages for each river (SAS 1988) were calculated. For continuous variables, these included: mean, minimum, and maximum values; standard deviation and variance; and median, lower quartile (25th percentile), and upper quartile (75th percentile) values.

For the continuous variables, depth and mean column velocity, the basic approach to developing suitability index curves included: development of frequency histograms, decreasing histogram irregularities through the use of optimal interval size (Slauson 1988) and smoothing algorithms (Velleman 1980), and drawing frequency polygons (Zar 1974). A generic example of these analyses are presented in Figure 4-1. A more detailed description of these methods is presented below and is based on methods presented by Bovee (1986), Slauson (1988), and Cheslak and Garcia (1988).

The first step in frequency analysis of the continuous variables was the selection of interval size. We used Sturges' formula as modified by Cheslak and Garcia (1988) to determine optimal interval size: optimal interval size = $r/(1 + 3.332 * \log_{10}n)$ where r = the range of the variable (max-min) and n = the number of observations. The utility of this approach in the context of suitability index criteria has been demonstrated by Cheslak and Garcia (1988).

Frequency histograms of depth and mean column velocity constructed using the optimal bin size were then normalized to a range of zero to one (Figure 4-1). At this point, the histograms were examined by two biologists and decisions were made regarding: (1) the need for smoothing to reduce local irregularities in the frequency histogram (Slauson 1988; Cheslak and Garcia 1988); the possible solutions were no smoothing, one pass, or two passes of a three-point running-means procedure; (2) methods for calculating running-means results for the first histogram interval; options were two-point and three-point running-means for the first interval; and (3) objective methods for drawing the final endpoints of the frequency polygons.

For the second and third decision points outlined above, the overriding considerations in final calculations were the inherent shape of the original histogram, the variable, and the biology of the species life stage being considered. For the variable depth, suitability at zero depth was always set to zero for all species. The suitability of near-zero depths was determined by the data under the constraint that depth less than one to two times the body height of the species life stage under consideration was unsuitable. A three-point running mean was typically used for the first histogram interval for depth. Zero and near-zero velocities are preferred by some species and avoided by other species. For slow-water inhabitants frequently using zero velocity, a two-point running mean was used for the first histogram interval; for species life stages avoiding slow water, a three-point running mean was used in the first histogram interval. These adjustments ensured that the shape and relative values of the original histogram were retained after smoothing. After any histogram smoothing, the histograms were re-normalized (Figure 4-1).

In the final step, suitability criteria curves were developed by connecting the midpoints of each histogram interval with a straight line (frequency polygon) (Figure 4-1). A suitability of one (optimum) was assigned to the range of values occurring under the highest interval (not fully illustrated in Figure 4-1). The endpoints of the frequency polygons were drawn under the following constraints: (1) if the minimum observed value was zero, the midpoint of the first bin was connected to the y-axis with a horizontal line; (2) if the minimum observed value was 0.01-0.05, the midpoint of the first bin was connected to the origin; (3) if the minimum observed value was less than the midpoint of the first bin, then the midpoint of the first bin was connected to the minimum value; otherwise, the midpoint of the second bin was connected to the minimum value.

For the discrete variables, dominant substrate and dominant cover, normalized frequency histograms were constructed (Figure 4-2) and the resulting suitability values for each substrate or cover type were determined.

Statistical Analysis

The question of whether a species is using habitat selectively or non-selectively (i.e. in proportion to its relative abundance in the environment) is of interest when interpreting habitat use and availability data (Johnson 1980; Alldredge and Ratti 1986). Selection of specific ranges or classes of variables were tested for by comparing each species habitat utilization pattern with that of available habitat.

For continuous variables, we used the Kruskal-Wallis and two sample Kolmogorov-Smirnov criteria to test for location and distribution differences, respectively, between utilization and availability under the null hypothesis of no difference (Conover 1971). For discrete variables, the chi-square test of equality of proportions (Zar 1974) in each class was employed and in all cases the alpha level was set at 0.05.

Exploratory descriptive multivariate analysis was conducted to develop a simple fish/habitat model that simultaneously described habitat use by all fish species relative to the available habitat. Principal components analysis (Pielou 1984) was used to reduce the number of habitat variables (by creating new synthetic habitat variables) and remove correlations among variables. This approach provides an objective format for interpreting species habitat utilization patterns (Rotenberry and Wiens 1978; Carnes and Slade 1982). Groups of species utilizing similar habitats were identified using average distance cluster analysis (Nie et al. 1975) of habitat space centroids (mean principal component scores). These analyses, similar to those conducted by Leonard and Orth (1988) and Bain et al. (1988), were performed only to provide a characterization of the range and types of microhabitats used by the species studied.

4.2 RESULTS AND DISCUSSION

4.2.1 Study Sites and Habitat Availability

Chattooga River

Fish habitat use and habitat availability data were collected in the Chattooga River from a point approximately 250 ft downstream of the Route 76 bridge, Rabun County, Georgia, and extending upstream 1,700 ft to a waterfall (Bull Sluice). Habitats in this study area were dominated by run and riffle, with lesser amounts of cascade, run/ pool, and pool (Table 4-4). Substrate was dominated by bedrock, boulders, and sand/ small gravel although all other substrate types were present. Cover was generally in low abundance, consisting primarily of boulders and bedrock ledges (Table 4-4). Chattooga River discharges during these studies ranged from 155 cfs to 350 cfs (McFarlane 1989).

Measurements of habitat availability (n = 350) were taken along 18 transects. The results showed that for the range of discharges encountered, depths ranged from a maximum of 3 ft in riffles to 8 ft in pool habitats. Average mean column velocities were lowest in pool (0.35 fps) and highest in cascades (1.1 fps) and ranged from 0.0 to 4.32 fps for the site (Table 4-4).

Tugalo River

Habitat data were collected from a 1,300-ft segment of the Tugalo River (Figure 2-3). Habitats in this area were dominated by run habitat; the remaining area consisted of nearly equal proportions of riffle, riffle/ run, and run/pool habitats (Table 4-4). Habitat measurements along 13 transects (n = 244) indicate a lesser range of available microhabitats than the Chattooga River for the discharge at the time of measurements.

Depths ranged from 0.0 to 6.8 ft and velocities ranged from 0.0 to 2.32 fps for the site. Substrate was dominated by cobbles and boulders, with nearly equal proportions of the less common substrates, bedrock, gravel, and sand. The abundance and type of cover was similar to the Chattooga (i.e. dominated by no cover, boulder, and ledge), but logs and log complexes were more abundant. Discharges during these studies ranged from approximately 120 to 160 cfs.

Ocmulgee River

Fish habitat use and availability data were collected from a 1,400-ft segment of the Ocmulgee River in the vicinity of Forty Acre Island (Figure 2-4). This was an area of divided channels (i.e., islands) and only a portion (one-half) of the full channel width was sampled in some areas. Habitat at this site was dominated by pool and shoal habitat, with lesser proportions of run/pool and run habitat (Table 4-4). Other habitat types--cascade, riffle, chute, and backwater--were present within the larger habitat groupings. Substrate consisted primarily of bedrock, boulders and sand; gravel and cobble were least abundant. A variety of cover types were present, but most common were no cover, boulder, and ledge, with lesser amounts of rooted plants and logs and limited amounts of overhang and undercut banks. Discharges in the Ocmulgee River during these studies ranged from approximately 250-600 cfs.

Based on 351 habitat measurements along 14 transects, a wide range of depths and velocities were present for the range of flows encountered (Table 4-4). Depths ranged from a maximum of 4.0 ft in runs to 13.8 ft in pools. Average mean column velocities were slowest in pools (0.23 fps) and greatest in shoals (1.09 fps), and mean column velocities as high as 5.58 fps were encountered.

4.2.2 Fish Habitat Use Observations

Chattooga River

During the study period, measurements were collected at 1,518 fish habitat-use focal points, representing the habitat use of 2,576 fish (Table 4-5); these data were collected as a result of 83.4 observer-hours in the Chattooga River. The number of measurements (sample size) collected by species and life stage are presented in Table 4-5.

The largest sample sizes obtained were for redeye bass, northern hog sucker, whitefin shiner, silver redhorse, and redbreast sunfish. Moderate sample sizes were obtained for striped jumprock, bandfin shiner, margined madtom and snail bullhead. The reliability of descriptions of habitat use and generalizations outlined below are related to the sample sizes reported.

Fishes of the Chattooga River used a wide range of habitats and overlapped in habitat use among species. Data were collected for species life stages representative of shallow-fast, shallow-slow, deep-fast and deep-slow habitats over a variety of substrates. The relationship between available habitat and use of habitat by fishes is illustrated by the results of principal components analysis (Figure 4-3) and the summary of microhabitat variables measured at fish locations for each species and life stage (Table 4-5).

The results of principal components analysis (Figure 4-3; Table 4-6) simultaneously illustrates the use of five habitat variables by fish with respect to the habitat types sampled. The first two principal components (PC), explained 58 percent of the variability of all habitat measurements collected. The interpretations of PC1 and PC2 are illustrated on Figure 4-3). For example, available habitats range from shallow-fast-coarse substrate habitats (cascade, riffle habitats) in the upper left quadrant to deep-slow-fine substrate in the lower right quadrant (pool habitat). Mean principal component scores (plotted on

Figure 4-3) and the original microhabitat measurements were used to place the species life stages into groups that used similar habitats (i.e., guilds). Generalizations below are based on 25 and 75 percent quartiles.

Margined madtoms and adult striped jumprock used the faster and shallower habitats (typically >0.7 fps velocity and <2.5 ft depth) with coarse substrate; northern hog sucker juveniles and adults used similar but somewhat deeper and slower (typically <3.5 ft depth and >0.5 fps velocity) habitats. Both of these groups characteristically used riffles, cascades, and runs (Figure 4-3). Adults of redeye bass, redbreast sunfish, snail bullhead, and silver redhorse primarily used moderate to deeper water with moderate velocities (typically >3 ft depth and <1.0 fps velocity). Although all four of these species life stages used a variety of substrate types, they appeared to preferentially use irregular bedrock and boulders, and hence were typically associated with boulder and ledge cover (less so for silver redhorse). Habitat for these species are characterized as run, run/pool, and pool (Figure 4-3).

Three species life stages were characterized as inhabiting shallow, slow-water habitats--northern hog sucker YOY, redeye bass YOY, and spawning redbreast sunfish (Figure 4-3). Most observations for this group were collected by surface observations in shallow habitats along the margins of runs and pools, typically less than 2.5 ft depth and velocities slower than 0.5 fps (Table 4-2). Northern hog sucker YOY and spawning redbreast sunfish showed a decided preference for sand and small gravel substrates; redeye bass YOY used a variety of substrate types but used disproportionately more small boulder substrate.

Adult whitefin shiner, bandfin shiner, and juvenile redeye bass are best characterized as habitat generalists. These species life stages used a wide range of both depths and velocities and showed no apparent strong preference for specific substrate types.

Tugalo River

A total of 883 fish habitat-use observations were made during the study period on the Tugalo River, representing the habitat use of 1,856 fish (Table 4-7); these data were produced as a result of 78.8 observer hours. Most observer hours expended in the Tugalo River were directed at specialized observations for margined madtom and bluehead chub. The number of focal point habitat measurements collected for each species and life stage are presented in Table 4-7.

The largest sample sizes were obtained for juvenile and adult margined madtom, spawning bluehead chub and redbreast sunfish, adult redeye bass and blackbanded darter, and YOY bluehead chub. Moderate-to-small sample sizes were obtained for juvenile and adult whitefin shiner and YOY northern hog suckers. Most observations were collected during two specific time periods: during the late May to early June period, most spawning and YOY observations were collected along with general habitat observations; the madtom habitat-use study occurred in mid-September and also yielded data on snail bullheads (Table 4-2).

The relationship between available habitat and habitat use by fishes in the Tugalo River is illustrated by the results of principal components and cluster analysis (Figure 4-4; Table 4-6). The summary of microhabitat variables measured at fish locations for each species and life stage are presented in Table 4-7. The first two principal components explained 63 percent of the variability of all habitat measurements collected; the interpretation of these axes are illustrated in Figure 4-4. Groups of fish using similar habitat as determined by cluster analysis are indicated.

Representatives of shallow-slow habitats were small YOY bluehead chub and northern hog sucker. Although these species did not cluster together (Figure 4-4), both used similar habitats with depths shallower than 1.8 ft and velocities typically less than 0.4 fps; northern hog sucker

YOY appeared capable of using slightly faster habitats. Both were typically found along the stream margins in riffles and runs. Northern hog sucker YOY used open cobble areas with fines and gravels and avoided bedrock areas. Chub YOY were often associated with sandy (fines) areas with no cover or logs as typically found in the Tugalo River margins.

A group of species using shallow habitats with moderate-to-fast velocities included juvenile and adult margined madtom, adult blackbanded darter, spawning bluehead chub and adult whitefin shiner. These species life stages used riffle, riffle/run and to a lesser extent, run habitat and were usually found in water shallower than 1.4 ft and faster than 0.5 fps (Table 4-7). Bluehead chubs selected areas of small and large cobbles with interspersed gravels (nests were constructed of gravel) and used areas of no cover, along the edge of boulders, or within log complexes. Margined madtoms used substrates which provided interstitial spaces (cobbles, small boulders) and avoided fine substrates and bedrock; cover appeared unimportant. Blackbanded darters used most substrate types frequently but avoided organic and preferred fines and small gravel.

Residents of the deeper habitats were adult snail bullhead and redeye bass (Figure 4-4) and other species life stages not shown in Figure 4-4 because of small sample size, including: adults of silver redhorse, largemouth bass, and redbreast sunfish. These species life stages were found in run and run/pool habitats with depths greater than 2.0 ft and velocities less than 0.5 fps (Table 4-7). Both adult redeye bass and snail bullhead were moderately to strongly associated with cover, typically using boulders, ledges, or logs in proportions greater than the available habitat. Snail bullhead adults preferred coarser substrates and avoided organic, fines, and smooth bedrock; adult redeye bass did not exhibit a consistent substrate preference.

Spawning redbreast sunfish constructed nests in very slow velocity water of shallow-to-moderate depth. Although organic and fine substrate types were uncommon in the Tugalo River study area, redbreast sunfish selected areas of mixed cobbles and fines/organics to construct their nests; areas with logs or log complexes were used preferentially.

Walleye

Because of the importance of this target species, specific efforts were made to collect spawning microhabitat data during February, March, and April of 1988 and 1989. In both years, the abundance of adult walleye was monitored with hoop nets and gill nets (EA 1990c; see Section 2.5) until running ripe males and females were present in the river; attempts to locate walleye spawning locations were then initiated. Observations were made by surface observation and underwater observation.

Approximately 20 observer-hours were expended in attempting to locate spawning walleye in the Tugalo River study area during the period 11 March to 1 April 1988. Very few occurrences of spawning walleye were recorded, due to low walleye abundance (EA 1990c) and poor water clarity.

On 11 March 1988, Walleye were observed spawning in run habitat approximately 1,000 ft downstream of transect Y-29. Several pairs of walleye were observed splashing and breaking water while moving together; actual spawning was verified by collecting freshly spawned eggs in those locations. Sixteen microhabitat measurements were collected within three separate, but adjacent, spawning areas.

Walleye were observed spawning in depths of 1.2-1.7 ft, 0.6-1.5 mean column velocity, over cobble/gravel substrates.

Panther Creek

Panther Creek is a tributary that joins the Tugalo River approximately 1,000 ft downstream of Yonah Dam. Portions of Panther Creek were included in a survey of chub nest locations conducted on the Tugalo River during the week of 31 May 1988 (Table 4-2). Habitat measurements were taken at 22 chub spawning (nest) locations. Chubs spawning in Panther Creek used shallow (typically 1-2 ft) habitats with slow to moderate velocities and substrates composed of interspersed gravels and cobbles (Table 4-7).

Ocmulgee River

A total of 910 fish habitat-use observations were made during the study period representing the habitat use of 3,645 fish (Table 4-8); these data were produced from 80.7 observer hours in the Ocmulgee River. The number of focal point measurements collected by species and life stage are presented in Table 4-8.

The largest sample sizes were obtained for adult life stages of shoal bass, striped jumprock and Altamaha shiners; juveniles of shoal bass and striped jumprock; and spawning redbreast sunfish (Table 4-8). Moderate sample sizes were obtained for adult snail bullhead, redeye bass, and silver redhorse, and juvenile Altamaha shiner. Most observations for spawning and YOY life stages were collected during 2 weeks in late June 1988; the remaining observations were collected in early November 1988 (Table 4-2).

The relationship between available habitat and habitat use by fishes in the Ocmulgee River is illustrated by the results of principal components and cluster analysis (Figure 4-5; Table 4-6). The summary of microhabitat variables measured at fish locations for each species and life stage are presented in Table 4-8. The first two principal components explained 59 percent of the variability of all habitat measurements collected; the interpretation of these axes are illustrated in Figure 4-5. Groups of fish using similar habitat as determined by cluster analysis are indicated.

The fish species life stages studied used a wide range of habitats and overlapped in habitat use. Representatives of shallow-slow habitats were small YOY shoal bass and striped jumprock; although difficult to interpret from Figure 4-5, these areas were largely in shallow, shoal or stream margin habitats. These two species life stages used habitats shallower than 2 ft and slower than 0.5 fps almost exclusively (Table 4-8). Both were found over a variety of substrates but used gravels preferentially and avoided smooth bedrock; areas of no cover, ledges, and vegetation were used most frequently.

Representatives of relatively faster, shallow-to-moderate depth habitats typical of shoals and runs were adult striped jumprock and Altamaha shiner. Both typically used depths shallower than 3 ft and moderate velocities (striped jumprock used substantially faster water); both used a variety of substrate and cover types, but were most frequently associated with irregular bedrock and ledges (Table 4-8).

Residents of the deepest water were adult shoal bass and silver redhorse. These species life stages were typically found in run, run/pool, and pool habitat with depths greater than 3 ft and slow velocities (<0.8 fps); these were the only target fish species observed in the deeper pool areas (8-14 ft) (Table 4-8). Adult snail bullhead and redeye bass used slightly shallower habitats, but with similar water velocities, and tended to be associated with coarse substrates. Snail bullhead were always strongly associated with cover such as boulders and logs.

Spawning redbreast sunfish constructed nests in slow habitats with shallow-to-moderate depths and having fine substrate types. This species life stage appeared to prefer cover such as ledges or rooted vegetation, but these were not requisites, as open water was frequently used. This species use of coarse substrate types for spawning always appeared to be predicated upon the presence of some fine substrate.

4.2.3 Final Habitat Suitability Criteria

In this report section, the derivation of the final habitat suitability criteria to be used in physical habitat modeling is described and the final results are presented. The quality of the habitat suitability criteria and their applicability to one or more of the study rivers are then evaluated.

Derivation of Suitability Criteria Coordinates

As described in Section 4.1.4, several methods of translating field data into more or less smooth monotonic or unimodal functions (Slauson 1988) suitable for use in physical habitat simulation were used, including: optimal bin-size frequency analysis, curve smoothing, and construction of frequency polygons. For some species (e.g., bluehead chub YOY, margined madtom adults and YOY) constructing histograms based on an optimal bin size was sufficient to produce a smooth function, and no further smoothing was necessary. Other species (e.g., northern hog sucker juvenile) required up to two passes of a running-means procedure to gain acceptable smoothness. Two-bin running means for the end bins were sometimes required for some species and variables to retain the original histogram shape through the smoothing process.

For each species and life stage, Appendix D contains graphic illustration of the field data, the normalized raw data, and the histogram and frequency polygon resulting from curve smoothing (if any). No smoothing of cover or substrate values was conducted.

The x-y coordinates were taken directly from the frequency polygons (Appendix D) and input directly into computer files for physical habitat modeling; these coordinates are presented in Appendix E. Optimal habitat (i.e., suitability = 1.0) for a species and variable was defined as the range of that variable under the tallest bin, and was assigned a suitability of 1.0. The endpoints and endpoint line segments were drawn as described in Section 4.1.4.

Quality Review and Verification

For species life stages with large sample sizes (greater than 50-100 observations, depending on species) the analysis was considered complete at this point and the final habitat suitability criteria were used for physical habitat modeling in the river from which the data originated. In some cases, literature data or published habitat suitability criteria for that species were provided as a comparison and to support the data from the study rivers.

For species life stages having small-to-moderate sample sizes, several approaches were used to verify that basing the final habitat suitability criteria on the observed sample sizes was justified. The first approach was similar to a "verification study" as described by Bovee (1986). The data collected in this study were compared with existing criteria from literature sources. Strong agreement to minor disagreement of these two sources is considered to be a confirmation of the criteria.

A similar situation existed where small sample sizes were available from one study river and large sample sizes were available from another study river (e.g., redbreast sunfish: Ocmulgee River, n = 184; Tugalo River, n = 70) and the final habitat suitability criteria were to be applied to both rivers. In this situation, the smaller data set was used to verify the applicability of habitat suitability criteria developed from the study area with a large sample size to the study area with the smaller sample size.

Finally, some very limited modifications of the final habitat suitability criteria were made on the basis of the professional judgment of fisheries biologists involved in the fieldwork and data analysis. Criteria modification is a recognized and accepted method for making changes to improve the accuracy of habitat suitability criteria (Bovee 1986). The limited modifications (e.g. depth criteria for adult silver redhorse, depth criteria for margined madtom) are explicitly described below.

Terminology

In the sections below, the microhabitat use patterns of each species and life stage are described in detail. Several terms are used frequently in these descriptions; these terms are defined here for clarity: "Range" refers to the interval between the minimum and maximum value of a variable; "optimum suitability" refers to the interval under the tallest histogram bin (or bins when two or more bins are subequal); and "typical" or "most frequently" refers to the interval between the first quartile (25%) to the third quartile (75 percentile) values of a variable (Tables 4-5, 4-7, and 4-8).

Bluehead Chub

Microhabitat use data collected in the Tugalo River for spawning bluehead chub were in close agreement with the data based on limited sample sizes collected in the other streams (Panther Creek, Chattooga and Ocmulgee rivers) (Tables 4-5, 4-7, and 4-8; Appendix D) and with previously published suitability criteria (Miller 1964; Leonard et al. 1986; Lobb and Orth 1988). All of these data suggest that spawning chubs use a very narrow range of habitat conditions: shallow water (0.3-3.0 ft), moderate velocity (0.2-1.5 fps), gravel and cobble substrates, and are associated with, but not dependent upon, cover objects.

Based on our analyses of a moderate sample size (n = 72) and agreement with published data, the quality of the habitat suitability criteria for spawning chub (Appendix D) are good to excellent. Numerous species are reported to spawn on chub mounds (Raney 1947; Leonard et al. 1986), and the importance of chub mounds in this respect must be emphasized. Lachner (1952) suggested that the use of chub nests by other cyprinids for breeding purposes may be important in the maintenance of a large supply of forage minnows for piscivores.

The microhabitat data for bluehead chub YOY represent the habitat use of fish less than 1.0 in.; these fish were early YOY, probably best referred to as prejuveniles (Snyder 1983). Bluehead chub YOY in the Tugalo River used shallow (<1.80 ft) and slow velocity (<0.38 fps) habitats with fines and cobble substrates. These data are in close agreement with YOY chub habitat use in the Cowpasture River, Virginia, reported by Goudreau

(1989) (n = 46; number of fish = 336): range of depths 0.6-2.5 ft; range of velocities 0.0-0.27 fps; fines and cobble substrates most frequently used. Although based on a moderate sample size, the well-defined depth and velocity distributions of bluehead chub YOY from the Tugalo River and their agreement with existing data suggest that the quality of the final criteria for YOY bluehead chub are fair to good.

Final habitat suitability criteria for both life stages of bluehead chub (Appendix D) were derived from data originating in this study and were not modified on the basis of literature data. These criteria were used in habitat simulation of the Tugalo River only.

Redbreast Sunfish

The U.S. Fish and Wildlife Service has published habitat suitability criteria for redbreast sunfish based on professional opinion from a 4-round delphi exercise with 11 expert panelists (Crance 1988). The published criteria apply to two life stages: (1) spawning, incubation, and larvae, and (2) juvenile and adults, and are used below for comparison to the data collected in this study.

A large sample size (n = 184) was obtained for spawning redbreast sunfish (nests) in the Ocmulgee River; smaller sample sizes were collected in the Tugalo and Chattooga rivers (Tables 4-5, 4-7, and 4-8). The Ocmulgee River data represent data collected from a wider range of habitats, as observations taken in the Tugalo and Chattooga rivers were collected from a limited number of concentrated spawning areas. Notwithstanding this difference, spawning microhabitats for redbreast sunfish were similar among the study rivers: shallow-to-moderate depth (1-3 ft), slow water (<0.5 fps), with fines/gravel substrate and some cover. The range of microhabitats used by spawning redbreast sunfish in the Ocmulgee River encompassed the range of microhabitats used by spawning redbreast sunfish in the Tugalo and Chattooga rivers.

The final habitat suitability criteria for spawning redbreast sunfish in the Ocmulgee River (Appendix D) are in very close agreement with those published by Crance (1988) who reported: optimum depths 1-3 ft; optimum velocities 0.1-0.4 fps; sand and gravel substrates optimum. Mean column velocities at redbreast sunfish nests in the Chattooga and Tugalo rivers (Tables 4-5 and 4-7) were substantially slower, but were similar to the only published field data for redbreast sunfish spawning (Leonard et al. 1986).

The large sample size, range of habitats, and agreement with published data substantiates the use of the final habitat suitability criteria for spawning redbreast sunfish based on the Ocmulgee River data set (Appendix D), and indicates that the criteria are of good quality. Agreement among rivers suggests that these criteria can be applied to both the Tugalo and Ocmulgee river habitat modeling.

Data collected in this study for adult redbreast sunfish in the Chattooga River (n = 52; 97 fish) were compared to Crance's (1988) criteria for adult/juveniles. Crance (1988) reported optimal depths from 2.0 to 7.0 ft, decreasing to a suitability of 0.5 at 20 ft; the Chattooga data show near-optimal depths in the 2.0-5.0 ft range, declining to zero suitability near 10 ft (Appendix D). Crance (1988) reported substantial disagreement among panelists as to suitability of depths greater than 3 ft; in light of this, the Chattooga depth data appear reasonable. For velocity, Crance (1988) reported optimal velocities of 0.1-0.7 fps, declining to zero suitability at 3.0 fps; data for the Chattooga show near-optimal velocities from 0.0-0.5 fps, declining to zero suitability at about 2.0 fps (Appendix D). Crance (1988) did not provide substrate criteria for redbreast sunfish adults, but reported highest suitabilities for the cover types logs/brush/snags, cobble/boulders, and rock overhangs. In the Chattooga River, cover types most frequently used by adult redbreast sunfish included no cover, boulders, ledges, and logs (Appendix D).

Considering the different nature of Crance's (1988) expert opinion-based criteria and the site-specific criteria presented in Appendix D, the two sets of criteria are fairly similar. Based on the above results and a moderate sample size, the final criteria for adult redbreast sunfish (Appendix D) from the Chattooga River were used in both the Tugalo and Ocmulgee river habitat simulations.

<u>Northern Hog Sucker</u>

Moderate-to-large sample sizes were collected for YOY, juvenile, and adult northern hog suckers in the Chattooga River study area (Table 4-5). Habitat suitability data for YOY and adult northern hog sucker developed by Leonard et al. (1986) (n = 24) for Virginia streams, and microhabitat use data from Illinois streams (Larimore and Garrels 1982) and a West Virginia river (Lobb 1986) were available for comparison.

All available data sources and the final suitability criteria (Appendix D) for northern hog suckers show that YOY typically use very shallow (<1.5 ft), slow water (<1.0 fps), most commonly over cobble and sand substrates with no cover. Lobb (1986) classified YOY northern hog suckers as part of the shallow edge-pool guild. Leonard et al.'s (1986) velocity criteria have a wider optimum range (0.0-0.7 fps) as compared to the criteria based on Chattooga River data (0.0-0.2 fps) but have an identical range (0.0-1.0 fps).

Leonard et al. (1986) developed criteria for the adult northern hog sucker on the basis of small sample sizes and literature accounts (Larimore and Garrels 1982; Scott and Crossman 1973). Leonard et al. (1986) reported depth suitability increasing from zero at 0.28 ft to optimal at depths greater than 1.30 ft; the data collected in the present study show a similar rapid increase in suitability at depths from 0.9 to 2.2 ft, optimal depths of 2.2-3.3 ft, and declining suitability to zero at about 9.4 ft. Depths exceeding 4-6 ft were not available in the Leonard et al.

(1986) and Larimore and Garrels (1982) study areas, so declining suitability of depths beyond this range would not be shown as in the present study (Appendix D).

Velocity suitability criteria for the adult northern hog sucker in the present study (Appendix D) are similar to the final velocity criteria reported by Leonard et al. (1986) (Appendix D). Both show rapid increases in suitability of velocities from 0.0 to 0.8 fps, optimal or near-optimal velocities from 0.8 to 1.6 fps, and low or no suitability beyond 3.0 fps. However, substantial differences in suitability occur in the velocity range 1.6-2.5 fps between the two criteria. Agreement between the two velocity criteria at the high velocity end is not necessarily expected, as Leonard et al. (1986) criteria are based on few samples in this velocity range, and their criteria were intentionally drawn in a conservative manner to ensure that criteria encompassed the upper optimal range (Orth 1989).

Substantial differences existed between the substrate criteria in this study (Appendix D) and those of Leonard et al. (1986); most of these can be attributed to differences in predominant available substrates at the study sites, as the reported optimum substrate in both cases was also the most abundant substrate. Other literature suggests that adult northern hog suckers use a wide variety of substrates (Becker 1983) but select hard substrates over soft/fine substrates (Jenkins and Burkhead, in press). The use of substrates by juvenile and adult northern hog suckers in the present study was non-selective ($X^2 = 7.468$, $p = 0.487$; $X^2 = 13.485$, $p = 0.096$ for juveniles and adults, respectively).

No previously published criteria or specific habitat use information were available for the juvenile northern hog sucker. Juveniles used habitats almost identically to adults (Table 4-5; Appendix D) and these life stages were frequently observed together.

Based on the large sample sizes and similarity to published habitat suitability criteria, the final YOY, juvenile, and adult northern hog sucker criteria were used without modification (Appendix D) in the Tugalo River habitat simulations.

Whitefin Shiner

Data on habitat use by whitefin shiner from the Chattooga and Tugalo rivers include a large sample size for adults, small sample sizes for YOY, and a few miscellaneous measurements at spawning locations (Tables 4-5 and 4-7). Data for YOY and spawning whitefin shiner were insufficient to develop habitat suitability criteria. Based on measurements at spawning locations and miscellaneous underwater observations, spawning occurs in the crevices of logs, boulders, and bedrock in typical adult habitats.

No published data on the habitat of this species are available; however, published data on the habitats used by other similar Notropis species are available for general comparison (Leonard et al. 1986; Lobb 1986).

Based on a large sample from the Chattooga River (n = 239; 566 fish), adult whitefin shiners used a wide range of habitats but primarily used moderate depths (1.3-3.5 ft) and slow-to-moderate velocities (0.35-1.10 ft) over a variety of substrate types (Table 4-5). Boulders and ledges were frequently used as velocity barriers (i.e., feeding stations), but no cover type was preferred (Appendix D).

The final habitat suitability criteria for adult whitefin shiner are remarkably similar to the criteria for rosefin shiner (Notropis ardens) reported by Leonard et al. (1986). Data for rosefin shiner habitat use indicated the range of utilized depths as 0.43-9.32 ft with optimum suitability at 1.6-2.7 ft, and the range of utilized velocities as 0.07-1.84 fps with optimal suitability at 0.21-1.15 fps; no cover preference was indicated. Lobb (1986) grouped a suite of Notropis species as members of the riffle-habitat guild but added that these species frequently used a variety of habitat types, commonly including run habitat. Our data for adult whitefin shiners suggest that they are habitat generalists, most frequently using riffle and run habitat.

Final habitat suitability criteria were developed only for the adult whitefin shiner (Appendix D) and these criteria were used in habitat simulation on the Tugalo River only. Based on the large sample size and general agreement with habitat data for other ecologically similar Notropis species, the final criteria are reasonable and of good quality.

Striped Jumprock

Data on microhabitat use of YOY striped jumprock were collected in the Ocmulgee River (n = 72; 230 fish) during June 1988 (Table 4-8). At this time, these fish were approximately 1-2 in. in size, and were found occupying bedrock shoals, often congregating behind velocity shelters created by bedrock outcrops. Striped jumprock YOY typically occupied shallow (0.8-1.7 ft) water with slow current (0.01-0.23 fps) (Table 4-8); optimum depths were found to be 0.62-0.92 ft and optimum velocities were found to be 0.0-0.12 fps (Appendix D). In addition to irregular bedrock, striped jumprock YOY used gravels, smooth bedrock and fines; areas of no cover were preferred, but some association with ledges and attached vegetation was observed.

No published data exist about habitat use by YOY striped jumprock, but it is noteworthy that the habitat use by YOY striped jumprock is quite similar to that of the YOY northern hog sucker (Tables 4-5 and 4-8; Appendix D).

Microhabitat use data for adult striped jumprock were collected primarily in the Ocmulgee River (n = 100; 174 fish), but smaller sample sizes were also collected from the Chattooga (n = 15; 16 fish) and Tugalo (n = 4; 6 fish) rivers. Striped jumprock adults occupied shallow-to-moderate depths (range 0.4-3.6 ft) and a wide range of velocities (0.02-2.85 ft; Table 4-8); optimal depths were 1.68-2.51 ft and optimal velocities were 0.38-0.75 fps (Appendix D). Adult striped jumprock were observed in small schools occupying bedrock shoal areas and often using swift chute areas to graze on the surface of bedrock and boulders. Substrate use was dominated by irregular and smooth bedrock, but large gravel, small boulders, and cobble substrate were also used.

Microhabitat use data for adult striped jumprock in the Chattooga River, although based on a small sample size, are in very close agreement with the data for the Ocmulgee River (Tables 4-5 and 4-8). Adult striped jumprock in the Chattooga were most often found in depths of 1.70-2.70 ft, and velocities of 0.65-1.25 fps, over bedrock substrates. These data suggest that adult striped jumprock use similar habitat in both rivers. Leonard et al. (1986) reported that an ecologically similar and closely-related sucker species, the black jumprock (Moxostoma cervinum), was also a shallow, fast-water inhabitant (riffle guild); the following were reported for black jumprock: optimum depths 1.7-2.4 ft; optimum velocities 1.0-2.0 fps; cobbles and bedrock preferred; and, no preference for cover. Except for inhabiting slightly slower velocities, the habitat suitability criteria for adult striped jumprock are quite similar to those for adult black jumprock.

Final habitat suitability criteria for YOY and adult striped jumprock are presented in Appendix D. These criteria are judged to be of good quality, based on moderate sample sizes and general agreement with data for ecologically similar species. The final criteria, based on data from the Ocmulgee River, were used in habitat modeling in the Ocmulgee and Tugalo rivers.

Silver Redhorse

Data on the microhabitat use by adult silver redhorse were obtained primarily from the Chattooga River (n = 102; 282 fish). Smaller sample sizes were available from the Tugalo (n = 9; 29 fish) and Ocmulgee (n = 26; 202 fish) rivers for comparison (Tables 4-7 and 4-8). Data for YOY and juveniles were insufficient to develop habitat suitability criteria.

Based on a small sample size (n = 26; 202 fish), habitat use by silver redhorse in the Ocmulgee River was similar to habitat use in the Chattooga River. Optimum suitability for depth was 3.81-4.76 ft in the Chattooga, while in the Ocmulgee optimum depth was reached at about 5 ft. In the Chattooga, suitability dropped to zero when depths increased to 9.52 ft, while silver redhorse in the Ocmulgee were observed in up to 14 ft of water. The lack of available deep-water habitat in the Chattooga River (i.e., >8 ft) was the reason for this difference. The range of observed velocities were quite similar with values in the range 0.05-2.06 fps for the Chattooga and 0.05-2.45 fps for the Ocmulgee. Optimum velocity suitability was slightly lower for the Ocmulgee (0.42-0.84 fps) than the Chattooga (0.79-1.05 fps) and was probably a direct result of the deeper, slower pools available in the Ocmulgee River (Appendix D, Tables 4-5 and 4-8).

Substrate use by adult silver redhorse was very similar in the two rivers. Fines were used most often, followed by gravel (either small or large) and irregular bedrock. Groups of silver redhorse were often observed cruising or feeding over sandy bottomed pools or in sandy depressions in run and cascade habitat. Silver redhorse were usually observed in open water (no cover) in both rivers. In the Ocmulgee they were occasionally found in association with log complexes, boulders, and ledges, the dominant available cover types. Chattooga River fish were also found associated with ledges and boulders (Appendix D, Tables 4-5 and 4-8).

The sample size of adult silver redhorse (n = 9) from the Tugalo River was too small to make any comparison with data from the Chattooga and Ocmulgee rivers.

Final habitat suitability criteria for adult silver redhorse are presented in Appendix D. The final criteria were based on data from the Chattooga River (larger sample size), and the similarity of habitat use by this species life stage in two rivers provides a justification for using these final criteria in the Tugalo and Ocmulgee rivers. The final depth criterion, derived from the Chattooga River data, was modified on the basis of the known suitability of deeper water based on data from the Ocmulgee River. Depths in excess of 3.80 ft were assigned a suitability value of 1.0.

Redeye Bass

Microhabitat use data for redeye bass were collected primarily in the Chattooga River and included large sample sizes for three life stages: YOY (n = 180; 189 fish), juveniles (n = 174; 184 fish), and adults (n = 199; 224 fish) (Table 4-5). Smaller sample sizes for adults were collected from the Tugalo River (n = 43; 51 fish) and the Ocmulgee River (n = 34; 38 fish); these data provide a basis for comparing adult redeye bass habitat use among three rivers (Tables 4-7 and 4-8). No quantitative data on the habitat use of redeye bass are available in the literature, so a brief comparison is made with the habitat used by a closely related and ecologically similar species--the smallmouth bass (*Micropterus dolomieui*).

Redeye bass YOY in the Chattooga River were observed most often in water of shallow depth (optimum suitability 0.8-1.6 ft) (Appendix D; Table 4-5) although occasionally were found in deeper water (up to 7 ft). Redeye bass YOY utilized a wide range of velocities (range 0.00-2.24 fps) but preferred slower water (optimum suitability 0.00-0.27 fps). Dominant substrates utilized by redeye bass YOY included small boulders, fines, small gravels, and to a lesser extent irregular bedrock; no cover, boulders, and ledges were the cover types most frequently utilized.

Juvenile redeye bass were found in somewhat deeper water than YOY (range 0.75-7.50 ft; optimum suitability 1.60-3.20 ft) (Appendix D; Table 4-5), but utilized almost identical current velocities (range 0.01-2.25 fps; optimal suitability 0.00-0.27 fps). Juvenile redeye bass used substrates non-selectively (i.e., in direct proportion to availability; χ^2 = 8.605;

p = 3.77). Juveniles typically occupied open water, but were also found in association with boulder and ledge cover types.

Adult redeye bass utilized deeper waters (range 1.20-9.30 ft; optimum suitability 2.81-3.75 ft) with slow to moderate current velocity (range 0.04-2.80 fps; optimum suitability 0.32-0.96 fps) (Appendix D; Table 4-5). Substrate and cover use for adults was very similar to that previously described for juveniles.

Habitat use by adult redeye bass was very similar in the Chattooga and Ocmulgee rivers: most observations were within the depth range 2.5-5.0 ft and within the current velocity range 0.4-1.2 fps for both rivers; substrate types utilized included small boulders and irregular bedrock; no cover, boulders, and ledges were among the most frequently used cover types (Table 4-5). In the Tugalo River adult redeye bass used similar but slightly shallower and slower water (Table 4-7). This appears to be due to the low-abundance, deeper, moderate-velocity habitats available in the Tugalo River, resulting in a bias of the data from the Tugalo River for this species. However, in all three rivers, adult redeye bass typically used run and run/pool habitat and deeper areas of shoals.

Not unexpectedly, habitat use by redeye bass is quite similar to that of smallmouth bass, an ecologically similar riverine species. Adult and juvenile smallmouth bass have been classified as habitat generalists (Leonard et al. 1986; Lobb 1986; Bain et al. 1988) and this description applies as well to the adult and juvenile redeye bass, which herein are shown to use a wide variety of depths, velocities, and substrate types. Leonard et al. (1986), whose data are also based on underwater observations, reported optimum habitat for juvenile and adult smallmouth bass as: depths greater than 2-3 ft; velocities in the range 0.2-0.8 fps; coarse substrates (cobble, boulder, bedrock), and instream object/undercut bank cover types.

Smallmouth bass are known to use depths of 1.2-4.8 ft (Probst et al. 1984), velocities less than 0.6 fps (Probst et al. 1984; Rankin 1986), and to prefer substrates ranging from gravel to boulders (Munther 1970; Rankin 1986) with selection for larger particle sizes (Larimore and Garrels 1982; Sechnick et al. 1986). Other accounts of habitat use by smallmouth bass indicate a preference for depths of 0.50-3.75 ft, velocities less than 1.60 fps, and substrates ranging from sand to rocks (Larimore and Garrels 1982). These accounts of habitat use agree closely with the habitat used by redeye bass: intermediate depths, slow to moderate current speed, coarse substrate types, and moderate cover.

Final habitat suitability criteria for YOY, juvenile, and adult redeye bass, presented in Appendix D, were based on data from the Chattooga River. These criteria were used in habitat simulations of the Ocmulgee and Tugalo rivers. Based on the large sample sizes, agreement between rivers, and similarity to habitat use of an ecologically similar species, these criteria are judged to be of good-to-excellent quality.

Shoal Bass

Data on the microhabitat use of the shoal bass collected from the Ocmulgee River were sufficient to develop habitat suitability criteria for YOY based on a large sample size (n = 127; 337 fish) and for adults based on a moderate sample size (n = 83; 86 fish); an insufficient number of observations were obtained for juveniles (n = 11; 11 fish) (Table 4-8). The shoal bass is an undescribed species (Section 3.3) for which no published habitat suitability information exists.

Shoal bass YOY were observed in June 1988; at this time YOY were approximately 1-2 in. They typically used shallow depths (range 0.30-3.20 ft; optimum suitability 1.09-1.45 ft), areas of very slow current velocity (range 0.0-1.1; optimum 0.0-0.14 fps), over a wide variety of substrates including irregular and smooth bedrock, gravel, and fines. Although frequently found in open water, YOY utilized rooted and attached vegetation and ledge cover types (Appendix D; Table 4-8).

Shoal bass adults also used a wide range of habitats but were observed primarily in moderate to deep water (range 1.65-13.00 ft; optimum suitability 3.08-4.62 ft) with slow-to-moderate velocities (range 0.0-1.88 fps; optimum suitability 0.51-0.77 fps) (Appendix D; Table 4-8). Adult shoal bass used substrates in nearly direct proportion to substrate availability ($\chi^2 = 17.569$; $p = 0.041$). Shoal bass were observed occupying open water nearly as frequently as they were observed in the vicinity of boulders. Other cover objects used by adults included bedrock ledges and log complexes.

In the Ocmulgee River, shoal bass adults used habitat similar to the redeye bass adults; the two species were frequently observed together. Both shoal bass and redeye bass have similar optimum ranges for depth (approximately 2.80-4.60 ft) and velocity (approximately 0.35-0.96 fps), and both used a wide range of similar substrates and cover types (Table 4-8). However, shoal bass also utilized the deeper pools not frequently occupied by redeye bass; the maximum depth used by redeye bass in the Ocmulgee River was 9.3 ft, versus 13.0 ft for shoal bass.

Final habitat suitability criteria for YOY and adult shoal bass, presented in Appendix D, were used in habitat simulation of the Ocmulgee River only. Based on the moderate-to-large sample sizes and similarity of habitat use with other riverine Micropterus species, the quality of the criteria is judged to be good.

Altamaha Shiner

Data on habitat use by the Altamaha shiner were obtained solely from observations made on the Ocmulgee River and include a moderate sample size of YOY fish (n = 42; 592 fish) and a large sample size of adults (n = 171; 1,665 fish). Data for YOY and adults were sufficient to develop habitat suitability criteria. No published data on the habitat of this species are available.

Altamaha shiner YOY used a wide range of depth and flow conditions inhabiting moderate depths (range 0.95-4.20 ft; optimum suitability 2.04-2.55 ft) and slow to moderate velocities (0.05-1.45 fps; optimum suitability 0.22-0.44 fps) (Appendix D; Table 4-8). YOY shiners were often observed in mid-column over irregular bedrock substrates interspersed with gravels or small boulders. Ledges and boulders provided velocity shelter for feeding stations and cover, but no cover was used most frequently.

Adult Altamaha shiners were observed occupying depths from 0.80 to 3.80 ft with optimum suitability in the range 1.43-1.78 ft, and velocities from 0.02 to 3.50 fps with optimum suitability of 0.42-0.83 fps (Appendix D; Table 4-8). These values are quite similar to criteria previously reported for whitefin shiner from the Chattooga River, and similar to rosefin shiner criteria reported by Leonard et al. (1986), although the ranges of depth and velocity for Altamaha shiner were narrower than those of whitefin shiner. As with whitefin shiner, our data suggest that Altamaha shiner are typically riffle-run (shoal) inhabitants but tend to utilize a fairly wide range of depths and velocities within their preferred habitat.

The final habitat suitability criteria for both life stages of Altamaha shiner, presented in Appendix D, were derived from data originating in the Ocmulgee River and were used in habitat simulation only in the Ocmulgee River. However, based on the relatively large sample sizes obtained during this study, similarities with published data on the habitat used by other *Notropis* species, and information obtained for whitefin shiners during this study, the habitat suitability criteria for Altamaha shiners is believed to be of good quality.

Margined Madtom

As described in Section 4.1.2, an independent study was conducted to determine the habitat use of margined madtom, a highly cover-oriented, benthic fish species. Thirteen paired transect locations in the Tugalo

River, stratified by habitat type, were sampled; six locations were sampled by both electrofishing and snorkeling, three locations were sampled only by electrofishing, and four locations were sampled only by snorkeling (Table 4-9). A total of 325 margined madtoms were collected (three miscellaneous observations from other snorkeling efforts were later added). The "catch" of madtoms by snorkeling (C_s) was regressed against the catch of madtoms by electrofishing (C_e) and yielded the equation $C_s = 2.39\ C_e + 7.36$ ($r = .911$). The interpretation of this equation is that snorkeling an equal area of habitat yields 2.39 times more observations than electrofishing. The data sets produced by the two methods were pooled by weighting the electrofishing observations by 2.4.

Data on microhabitat use of margined madtom in the Tugalo River were sufficient to develop habitat suitability for YOY ($n = 154$; 251 fish) and adults ($n = 174$; 309 fish) (Table 4-7). Smaller sample sizes for YOY ($n = 14$; 14 fish) and adults ($n = 36$; 36 fish) were also collected in the Chattooga River for comparison (Table 4-5). However, the Chattooga River madtom data are thought to be somewhat biased due to the fact that a systematic sampling was not completed in all habitats for this species and electrofishing techniques necessary to sample shallow water (<1.0 ft) were not used.

Margined madtom YOY used riffle and run areas with shallow depths (range 0.10-1.90 ft; optimum suitability 0.44-0.65 ft) and a wide range of current velocities (range 0.01-2.48 fps), but preferred moderate velocities (optimum suitability 0.60-0.90 fps). Substrates used by margined madtom YOY were largely restricted to the intermediate particle sizes, large gravel to small boulders (Appendix D; Table 4-7).

Adult margined madtoms were found in habitats similar to YOY, with slightly deeper water (range 0.10-5.40 ft; optimum suitability 0.63-1.26 ft), nearly identical current velocities (Appendix D; Table 4-7), and similar substrate sizes.

Because margined madtoms are secretive, interstitial dwellers, the cover types recognized in this section are probably not meaningful to this species. In fact, use of cover by adults was in direct proportion to availability ($X^2 = 7.491$; $p = 0.187$) suggesting that this species is indifferent to cover as defined in this study. Based on these data, all cover types were assigned a suitability of 1.0 for habitat modeling of both life stages of this species.

Adult margined madtoms in the Chattooga River appeared to use slightly deeper and faster habitats, but similar substrate types, than their Tugalo River counterparts (Table 4-5). Caution should be used when making these comparisons, due to potential bias in Chattooga River samples previously outlined. Habitat for this species is generally considered to be cobble and gravel areas of moderate-to-swift riffles and runs (Lee et al. 1980), which is in close agreement with our findings.

Final habitat suitability criteria for YOY and adult margined madtoms, presented in Appendix D, are based solely on the Tugalo River data and were used for physical habitat simulation for the Tugalo River only. Based on the large sample size and agreement with general literature descriptions of habitat use by this species, the final criteria are judged to be good.

Walleye

Data collected at walleye spawning locations in the Tugalo River ($n = 16$) were insufficient to develop habitat suitability criteria. Consequently, it was necessary to rely on habitat suitability criteria from existing literature. A full literature search was conducted to obtain data on the microhabitat preferences of spawning walleye. The search yielded many references on spawning walleye and general descriptive accounts of walleye spawning habitats, but few reports containing actual physical microhabitat measurements at walleye spawning locations.

The most important references found were McMahon et al. (1984), Gaboury (1985), and Bechtel (1986). McMahon et al. (1984) is the habitat suitability index model or "Blue Book" for the walleye, and includes Category Two suitability criteria for depth and velocity based on frequency analysis of raw data collected in the Yellowstone River (Graham, unpublished data) and by Kallemeyn and Novotny (1977), and Category One criteria for substrate based on information from Graham (unpublished data), Kallemeyn and Novotny (1977), and Newburg (1975). Habitat suitability criteria for incubation are identical to the spawning criteria (McMahon et al. 1984).

The Gaboury (1985) study included walleye egg survival and instream flow/habitat modeling components. Habitat suitability criteria for depth, velocity, and substrate were developed for spawning walleye based on measurements from eight spawning areas in the Valley River, Manitoba, (total sample size not reported) and for egg incubation based on egg survival studies in the Valley River.

The Bechtel (1986) study was an assessment of instream flow needs for walleye spawning habitat below the Sheldon Springs Hydroelectric Project on the Missisquoi River, Vermont. Development of the walleye spawning habitat suitability criteria in this study used "...a combined approach of developing preliminary curves based on empirical data, followed by agency review and (subsequent) modification of the curves to their final form" (Bechtel 1986). Because no data were available on walleye spawning in Vermont, the initial habitat suitability criteria were developed from information collected in Wisconsin. The data consisted of 89 measurements collected by the Wisconsin Cooperative Fishery Research Unit (under contract to the U.S. Fish and Wildlife Service) from seven streams in Wisconsin. The curves were developed from the raw data by frequency analysis and smoothing, and transmitted to Vermont state and federal resource agencies for review and comment; changes suggested by these agencies were incorporated into the final curves.

The final habitat suitability criteria for the three studies outlined above are presented together in Figure 4-6. The substrate suitability criteria are nearly identical for all of the studies; gravel and cobble are the most suitable substrates (Figure 4-6). The range of suitable velocities is nearly identical, but the optimum range is substantially slower for the Bechtel (1986) data, and slightly lower for the Gaboury (1985) data. All three data sets yielded depth criteria with ascending limbs in a similar range, but both the Bechtel (1986) and Gaboury (1985) data show a narrower range and shallower optimum depths (Figure 4-6).

In deciding which set of spawning walleye habitat suitability criteria to use for habitat simulation of the Tugalo River, the origin and comprehensiveness of the data and the similarity to the spawning walleye microhabitat use data (n = 16) collected in the Tugalo River were considered. The Bechtel (1986) curves were judged to be most applicable to the Tugalo River because: (1) the data were collected in a variety of streams by experienced U.S. Fish and Wildlife Service personnel specifically for habitat suitability criteria development; (2) the criteria were developed using methods similar to methods used in this study (e.g., frequency analysis and smoothing); and, (3) the final criteria include formal review and modification by state and federal resource agencies (i.e., U.S. Fish and Wildlife Service, Vermont Department of Fish and Wildlife). Additionally, the microhabitat data collected at walleye spawning locations in the Tugalo River are in closest agreement with the criteria of Bechtel (1986). Computer files containing the habitat suitability criteria coordinates for spawning walleye are presented in Appendix E.

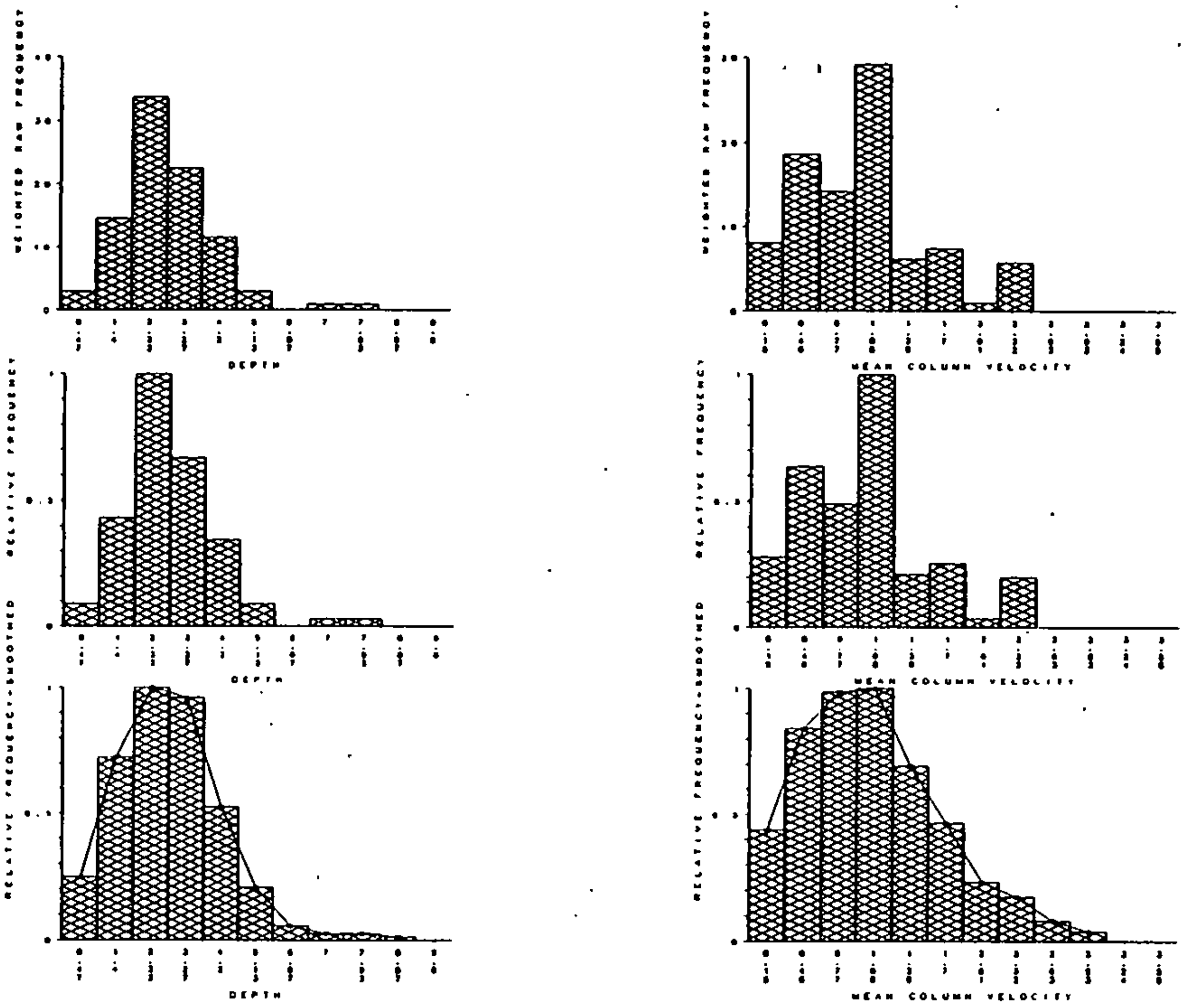


Figure 4-1. Example of development of depth and velocity suitability criteria for juvenile northern hog sucker from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons). One pass of a three-point running mean was used in the above example. (See text for complete explanation.)

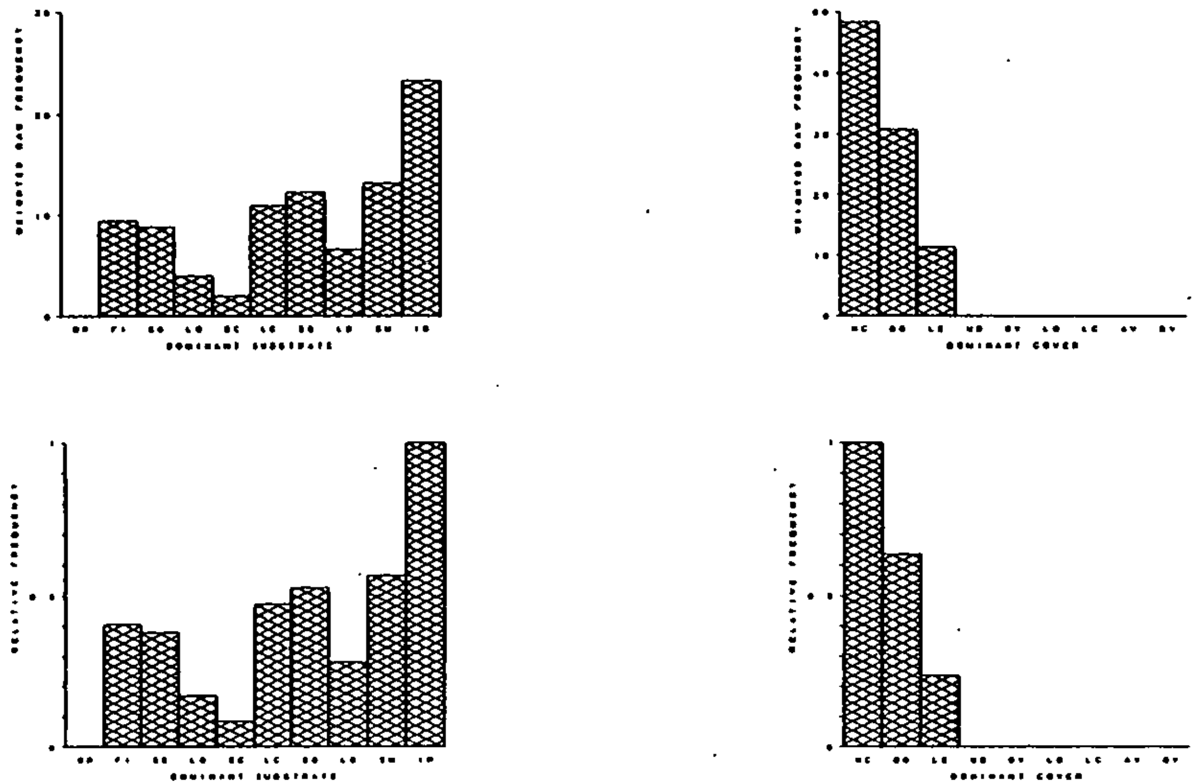
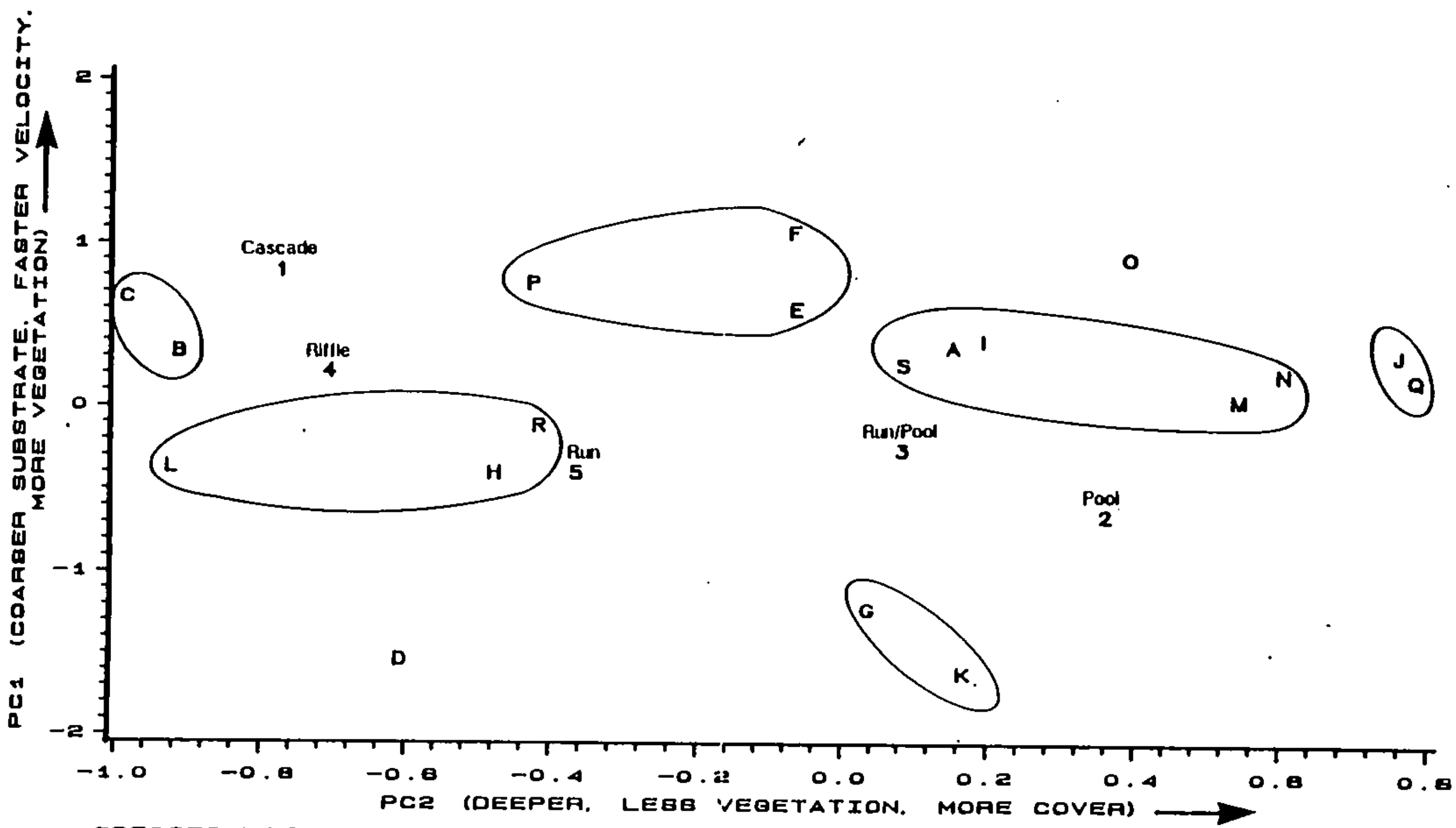


Figure 4-2. Example of development of substrate and cover suitability criteria for juvenile northern hog sucker from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria. (See text for complete explanation.)

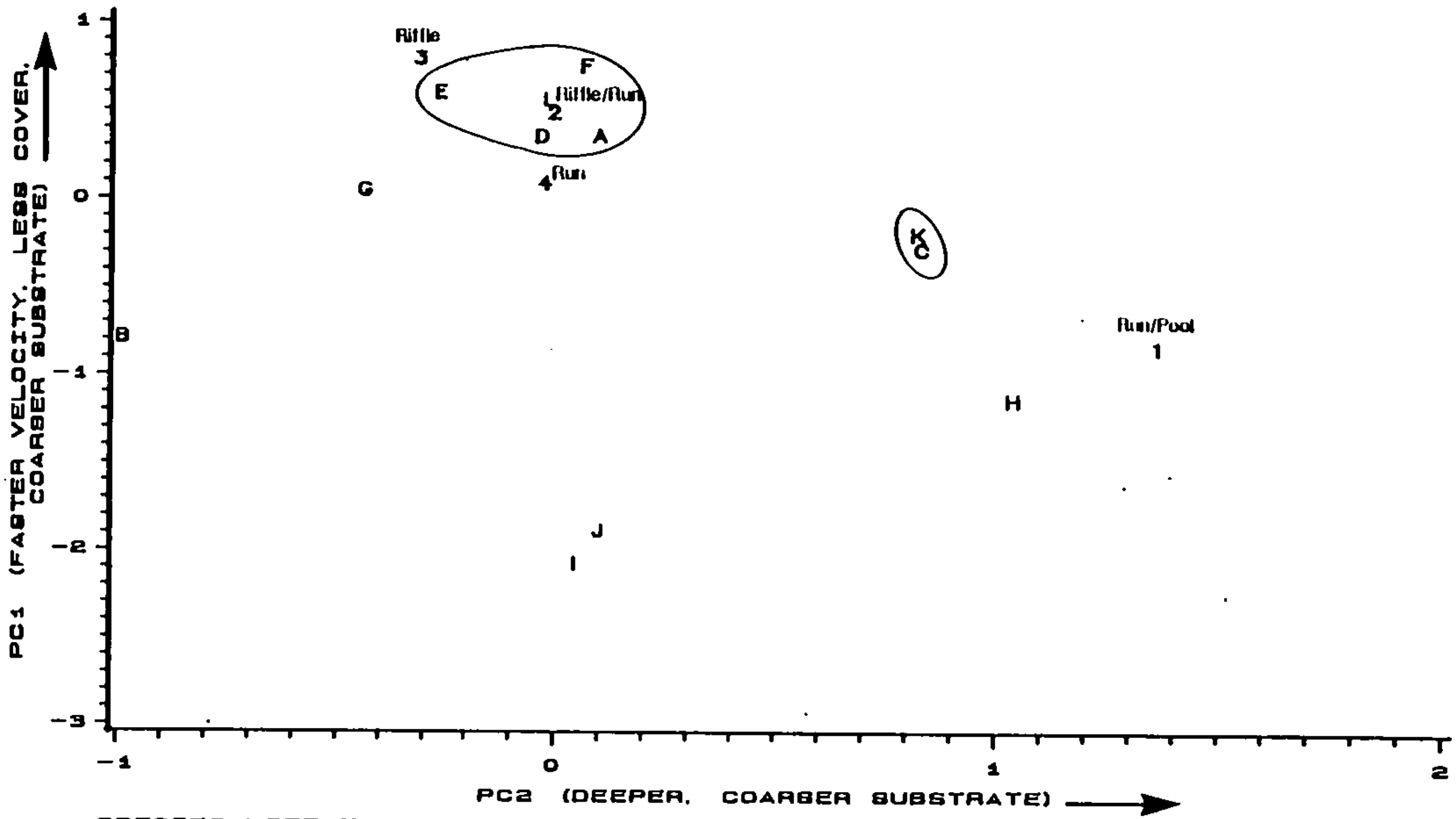


SPECIES LIFESTAGE LABEL

(See Table 4-1)

A	BS4	1	CAS	B	MM2	C	MM4
D	NH2	E	NH3	F	NH4	2	PUL
3	R/P	G	RB1	H	RB2	I	RB3
J	RB4	4	RIF	K	RS1	L	RS2
M	RS3	N	RS4	5	RUN	O	SB4
P	SJ4	Q	SR4	R	WS2	S	WS4

Figure 4-3. Characterization of microhabitat use by eighteen fish species life stages within the total available Chattooga River habitat. Plotted points are mean scores (centroids) for each species life stage (letters) and habitat type (numbers) derived from principal components analysis of microhabitat measurements. Axes labels, determined from Table 4-6, are superimposed to assist in interpretation. Species life stages identified by cluster analysis as using similar microhabitat are enclosed by a solid line. Species codes are listed in Table 4-1; life stage codes are 1 = spawning, 2 = young-of-the-year, 3 = juvenile, and 4 = adult. Because three principal component scores were used in cluster analysis, the relative proximity of centroids is not fully shown in this figure.



SPECIES LIFESTAGE LABEL

(See Table 4-1)

A	BC1	B	BC2	C	BD2	D	BD4
E	MM2	F	MM4	G	NH2	1	R/P
2	R/R	H	RB4	3	RIF	I	RS1
J	RS4	4	RUN	K	SB4	L	WB4

Figure 4-4. Characterization of microhabitat use by twelve fish species life stages within the total available Tugalo River habitat. Plotted points are mean scores (centroids) for each species life stage (letters) and habitat type (numbers) derived from principal components analysis of microhabitat measurements. Axes labels, determined from Table 4-6, are superimposed to assist in interpretation. Species life stages identified by cluster analysis as using similar microhabitat are enclosed by a solid line. Species codes are listed in Table 4-1; life stage codes are 1 = spawning, 2 = young-of-the-year, 3 = juvenile, and 4 = adult. Because three principal component scores were used in cluster analysis, the relative proximity of centroids is not fully shown in this figure.

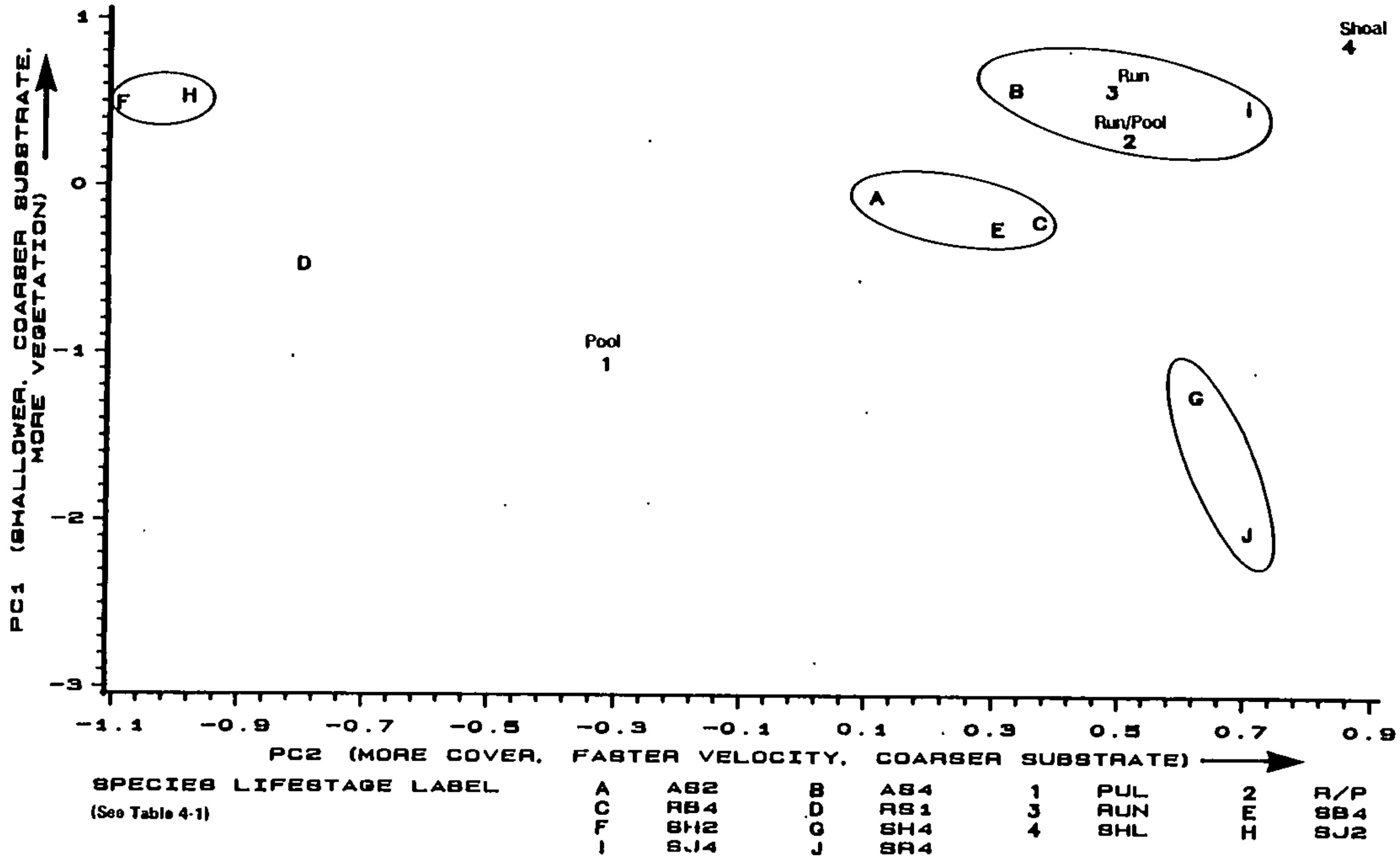


Figure 4-5. Characterization of microhabitat use by ten fish species life stages within the total available Ocmulgee River habitat. Plotted points are mean scores for each species life stage (letters) and habitat type (numbers) derived from principal components analysis of microhabitat measurements. Axes labels, determined from Table 4-6, are superimposed to assist in interpretation. Species life stages identified by cluster analysis as using similar microhabitat are enclosed by a solid line. Species codes are listed in Table 4-1; life stage codes are 1 = spawning, 2 = young-of-the-year, 3 = juvenile, and 4 = adult. Because three principal component scores were used in cluster analysis, the relative proximity of centroids is not fully shown in this figure.

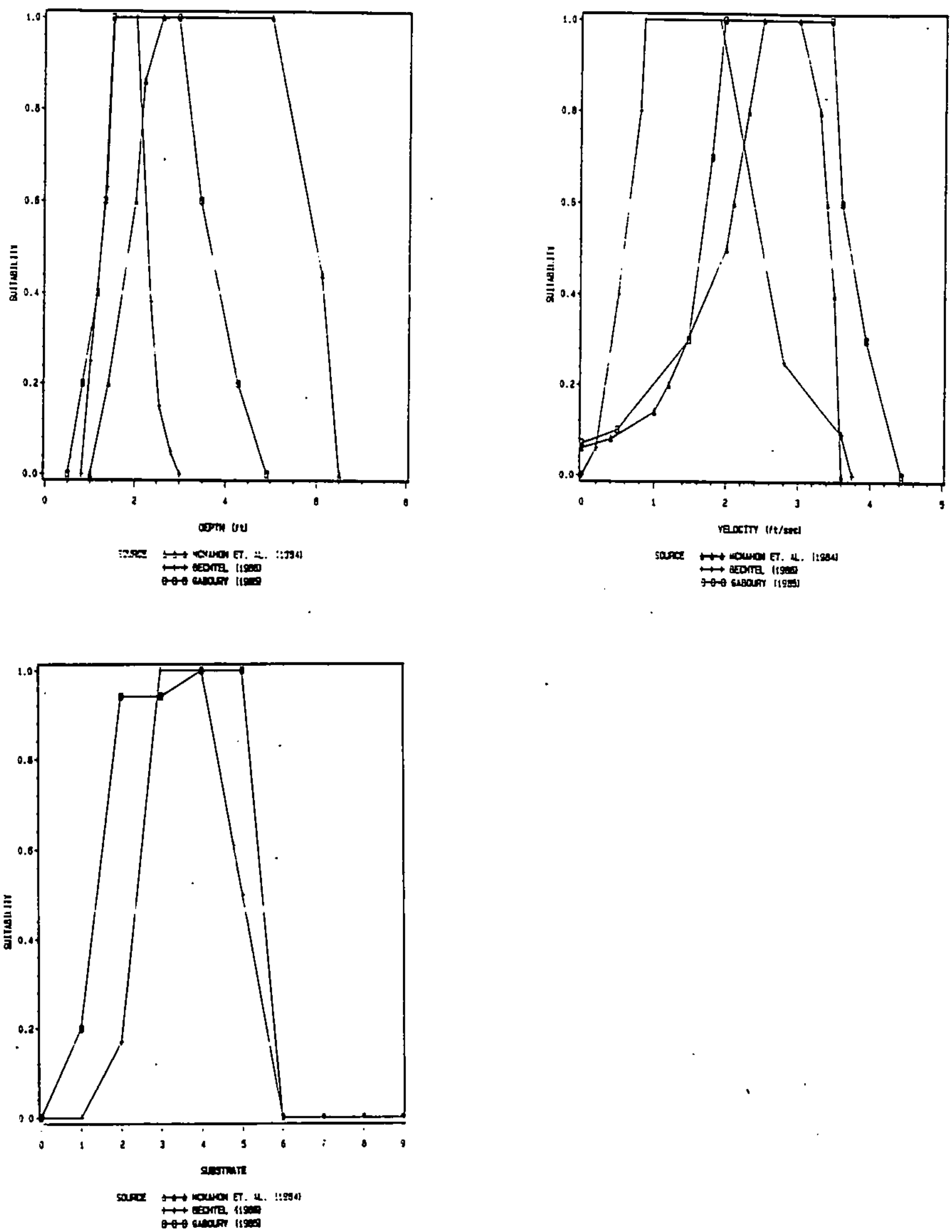


Figure 4-6. Depth, velocity, and substrate suitability criteria for spawning walleye from three independent sources; McMahon et al. (1984), Bechtel (1986), and Gaboury (1985).

TABLE 4-1 TARGET SPECIES AND SIZE RANGES FOR EACH LIFE STAGE OBSERVED IN THE TUGALO, CHATTOOGA, AND OCMULGEE RIVERS DURING HABITAT SUITABILITY STUDIES

Species			Life Stage (Size, Range, mm)		
Scientific Name	Common Name	Code	YOY	Juvenile	Adult
Cyprinidae					
Nocomis leptocephalus	Bluehead chub	BC	≤50	51-100	>100
Notropis hudsonius	Spottail shiner	SS	≤50	--	>50
Notropis lutipinnis	Yellowfin shiner	YS	≤50	--	>50
Netropis niveus[a]	Whitefin shiner	WS	≤50	--	>50
Notropis xaenurus	Altamaha shiner	AS	≤50	--	>50
Notropis zonistius	Bandfin shiner	BS	≤50	--	>50
Catostomidae					
Hypentelium nigricans	Northern hog sucker	NH	≤100	101-150	>150
Moxostoma anisurum[a]	Silver redhorse	SR	≤100	101-200	>200
Moxostoma rupiscartes	Striped jumprock	SJ	≤50	51-100	>100
Ictaluridae					
Ictalurus brunneus	Snail bullhead	SB	≤50	51-100	>100
Noturus insignis[a]	Margined madtom	MM	≤50	--	>50
Centrarchidae					
Lepomis auritus[a]	Redbreast sunfish	RS	≤50	51-100	>100
Micropterus coosae[a]	Redeye bass	RB	≤100	101-150	>150
Micropterus sp.	Shoal bass	SH	≤100	101-150	>150
Micropterus salmoides	Largemouth bass	LB	≤100	101-150	>150
Percidae					
Percina nigrofasciata[a]	Blackbanded darter	BD	≤50	--	>50
Stizostedion v. vitreum[a]	Walleye	WE		adults only	

(a) Suggested target species: South Carolina Wildlife and Marine Resources Department.

TABLE 4-2 SUMMARY OF LOCATION, DATE, AND METHODS FOR COLLECTION OF FISH MICROHABITAT USE DATA ON THE CHATTOOGA, TUGALO (INCLUDING PANTHER CREEK), AND OCMULGEE RIVERS

Species	Lifestage	Method of Data Collection: Underwater Observation	Surface Observation	Electrofishing	Dates Sampled At Each River Site: MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Altamaha shiner	YOY	O											O
	Adult	O											O
Bandfin shiner	YOY	C									C		
	Adult	C								C	C		
Blackbanded darter	Spawn	T					T	T					
	YOY	O,T						O,T					
	Adult	T						T					
Bluegill	Juvenile	T						T					
	Adult	T					T	T					
Bluehead chub	Spawn		C,O,P,T				P,T	O,T	C				
	YOY		T				T	T					
	Juvenile	T						T					
	Adult	T						T					
Largemouth bass	Spawn	O,T						O,T					
	YOY	O						O					
	Juvenile	T						T					
	Adult	T						T					
Margined madtom	YOY	C,T		T				T			C,T		
	Adult	C,T		T				T			C,T		
Northern hog sucker	YOY	C	C,T				T	T	C,T		C		
	Juvenile	C,T	C				T	T	C	C	C		
	Adult	C,T					T	T	C	C	C		
Rainbow trout	Adult	T						T					
Redbreast sunfish	Spawn	C,O,T	C,O,T					O,T	C,T	C			
	YOY	C,O,T						O,T			C		
	Juvenile	C,O,T						O,T			C		
	Adult	C,O,T						O,T			C		
Redeye bass	Spawn	C,O,T	C					O,T	C				
	YOY	C,T	C					T	C	C	C		
	Juvenile	C,O,T	C					O,T	C	C	C		
	Adult	C,O,T					T	O,T	C	C	C		O

Note: C = Chattooga River; O = Ocmulgee River; P = Panther Creek; T = Tugalo River.

TABLE 4-2 (Cont.)

Species	Lifestage	Method of Data Collection: Underwater Observation	Surface Observation	Electrofishing	Dates Sampled At Each River Site: MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Shoal bass	YOY	O						O					O
	Juvenile	O											O
	Adult	O											O
Silver redhorse	YOY	C							C		C		
	Juvenile	C,O							C	C	C		O
	Adult	C,O,T					T	T	C,O	C	C		O
Snail bullhead	Spawn	T						T					
	YOY	C,T		T				T			C,T		
	Juvenile	C,T		T					C	C	C,T		
	Adult	C,O,T		T			T	O,T			C,T		O
Spottail shiner	Adult	T						T					
Striped jumprock	YOY	C,O						O	C				
	Juvenile	C,O						O	C	C			
	Adult	C,O,T					T	O,T	C	C	C		O
Walleye	Spawn		T		T								
	Adult	T	T		T	T							
Warmouth	Adult	T						T					
White bass	Adult	T						T					
Whitefin shiner	Spawn	C,T						T	C	C			
	YOY	C,T						T			C		
	Adult	C,T					T	T		C	C		

TABLE 4-3 DESCRIPTION, CLASSIFICATION, AND CODING OF HABITAT AND FISH BEHAVIOR ATTRIBUTES MEASURED OR ESTIMATED AT FISH LOCATIONS DURING HABITAT SUITABILITY STUDIES ON THE CHATTOOGA, TUGALO, AND OCMULGEE RIVERS

Code	Classification	Description	
SUBSTRATE			
0	Organic	Organic Debris/Detritus	
1	Fines	<2 mm	<0.08 in.
2	Small Gravel	2-16 mm	0.1-0.6 in.
3	Large Gravel	16-64 mm	0.6-2.5 in.
4	Small Cobble	64-128 mm	2.5-5.0 in.
5	Large Cobble	128-256 mm	5.0-10.1 in.
6	Small Boulder	256-1,000 mm	10.1-39.4 in.
7	Large Boulder	>1,000 mm	>39.4 in.
8	Plain Bedrock	surface irregularities <150 mm	<6 in.
9	Irregular Bedrock	surface irregularities >150 mm	>6 in.
COVER			
0	No Cover	Open water	
1	Boulders	Rocks >256 mm (10.1 in.)	
2	Ledges	Bedrock irregularities >256 mm (10.1 in.)	
3	Undercut	Streambank undercut >256 mm (10.1 in.)	
4	Overhang	Objects suspended within 91 mm (3 ft)	
5	Log	Log (>150 mm [6 in.] dia.) on bottom	
6	Log Complex/ Root Wad	Aggregates of Logs/Root Systems	
7	Attached Vegetation	Aquatic Veg. Attached to Rocks	
8	Rooted Vegetation	Aquatic Veg. Rooted in Substrate	
EMBEDDEDNESS			
1	≤25% embedded	Gravel, cobble, and boulder particles have less than 25% of their surface embedded by fines.	
2	50% embedded	Gravel, cobble, and boulder particles have between 25 and 50% of their surface embedded by fines.	
3	75% embedded	Gravel, cobble, and boulder particles have between 50 and 90% of their surface embedded by fines.	
4	90-100% embedded	Gravel, cobble, and boulder particles have more than 90% of their surface embedded by fines.	

Code	Classification	Description
VEGETATION TYPE		
0	No vegetation	
7	Attached vegetation	
8	Rooted vegetation	
VEGETATION DENSITY		
0	No vegetation	No vegetation present
1	Sparse	≤25% coverage
2	Moderate	25-75% coverage
3	Heavy	75-100% coverage
FISH SIZE CLASS		
1	Spawning	
2	Young-of-the-year	
3	Juveniles	
4	Adults	
FISH ACTIVITY		
FF	Foraging and feeding	
RH	Resting and holding	
RS	Random swimming	
SN	Spawning	
SS	Stationary swimming	
FISH POSITION IN WATER COLUMN		
0	In contact with the bottom	
1	Near bottom but not in contact with	
2	Lower one-third	
3	Mid column	
4	Upper one-third	
5	On or near surface	
FISH USE OF COVER		
0	Not using cover	
1	Using cover	

TABLE 4-4 PHYSICAL CHARACTERISTICS OF THE THREE FISH MICROHABITAT STUDY SITES

	Tugalo River			Chattooga River			Ocmulgee River		
Drainage Area	470 mi^2			207 mi^2			1,450 mi^2		
Discharge Range	150 cfs			155-350 cfs			250-600 cfs		
Length of Site	1,300 ft			1,700 ft			1,400 ft		
Average Wetted Width	189 ft			129 ft			255 ft		
No. of Availability Transects	13			18			14		
Total Measurements (N)	244			350			351		
	%(a)	Mean Depth	Mean Velocity(b)	%(c)	Mean Depth	Mean Velocity	%(d)	Mean Depth	Mean Velocity
HABITAT TYPE									
Riffle	24	0.5	0.8	26	1.1	1.0			
Riffle/Run	19	0.7	0.7						
Run	34	0.9	0.5	42	1.6	0.6	4	1.9	0.7
Run/Pool	23	2.7	0.2	9	2.2	0.5	17	2.6	0.8
Pool				9	2.6	0.4	39	5.1	0.2
Shoal							40	1.6	1.1
Cascade				14	1.1	1.1			

(a) Percentages based on total wetted widths of availability transects for each habitat type.
(b) Mean velocity refers to average mean column velocity for habitat type.
(c) Percentages based on total wetted widths of availability transects for each habitat type.
(d) Percentages based on habitat mapping.
(e) Percent dominant substrate obtained from point measurements made along availability transects.
(f) Percent dominant cover type obtained from point measurements made along availability transects.

TABLE 4-4 (Cont.)

	Tugalo River %	Chattooga River %	Ocmulgee River %
SUBSTRATE COMPOSITION[e]			
Organic	0.0	0.0	0.3
Fines	4.5	18.3	14.5
Small Gravel	9.0	12.0	5.1
Large Gravel	5.7	3.1	7.1
Small Cobble	34.0	2.6	2.8
Large Cobble	15.2	6.0	2.3
Small Boulder	19.3	13.1	10.8
Large Boulder	1.2	8.3	7.7
Smooth Bedrock	4.5	13.4	21.1
Irregular Bedrock	6.6	23.1	28.2
COVER[f]			
No Cover	73.0	61.1	49.3
Boulder	20.5	23.4	17.9
Ledge	2.5	14.3	16.0
Undercut	0.0	0.0	1.1
Overhang	0.8	0.9	1.7
Log	1.2	0.0	4.8
Log Complex/Root Wad	2.0	0.3	1.4
Attached Plants	0.0	0.0	0.0
Rooted Plants	0.0	0.0	7.7

TABLE 4-5 SUMMARY OF MICROHABITAT MEASUREMENTS TAKEN AT FISH LOCATIONS ON THE CHATTOOGA RIVER FROM JULY-SEPTEMBER 1988

	N[a]	N(W)[a]	Depth (ft)						Mean Column Velocity (fps)					
SPECIES--LIFE STAGE			Mean	Min	Max	Q1[b]	Median	Q3[b]	Mean	Min	Max	Q1[b]	Median	Q3[b]
Bluehead chub-spawn	1	1	1.00	1.00	1.00	1.00	1.00	1.00	1.18	1.18	1.18	1.18	1.18	1.18
Bandfin shiner-yoy	1	10	1.85	1.85	1.85	1.85	1.85	1.85	0.50	0.50	0.50	0.50	0.50	0.50
Bandfin shiner-adult	27	60	3.31	1.10	8.40	1.50	2.50	3.70	0.74	0.10	1.88	0.44	0.60	1.06
Margined madtom-yoy	14	14	1.37	0.90	1.95	1.00	1.35	1.60	1.29	0.28	2.80	0.88	1.14	1.70
Margined madtom-adult	36	36	1.07	0.20	2.40	0.63	1.00	1.37	1.63	0.23	3.15	1.00	1.73	2.19
Northern hog sucker-yoy	153	405	0.66	0.20	3.00	0.50	0.60	0.70	0.19	0.00	0.77	0.05	0.15	0.30
Northern hog sucker-juvenile	78	111	2.80	0.70	7.50	1.95	2.70	3.30	0.99	0.15	2.40	0.56	0.94	1.23
Northern hog sucker-adult	99	115	2.88	0.90	9.40	2.05	2.60	3.40	1.21	0.05	3.12	0.65	1.07	1.67
Redeye bass-spawn	14	14	1.30	0.80	1.75	1.00	1.35	1.60	0.11	0.01	0.36	0.04	0.06	0.15
Redeye bass-yoy	180	189	1.22	0.20	7.00	0.70	1.00	1.47	0.36	0.00	2.24	0.08	0.25	0.52
Redeye bass-juvenile	174	184	2.92	0.75	7.50	1.80	2.62	3.80	0.77	0.01	2.25	0.34	0.72	1.12
Redeye bass-adult	199	224	3.94	1.20	9.30	2.50	3.50	5.05	0.84	0.04	2.80	0.47	0.75	1.15
Redbreast sunfish-spawn	26	26	1.53	0.70	2.95	1.00	1.50	2.10	0.07	0.00	0.25	0.02	0.05	0.08
Redbreast sunfish-yoy	11	11	1.19	0.70	1.90	0.80	1.25	1.50	0.14	0.00	0.65	0.02	0.05	0.15
Redbreast sunfish-juvenile	27	39	3.26	1.10	6.50	2.05	3.15	4.20	0.52	0.08	1.73	0.15	0.47	0.83
Redbreast sunfish-adult	52	97	3.69	1.25	9.30	2.33	3.50	4.37	0.58	0.03	1.70	0.22	0.40	0.86
Snail bullhead-yoy	4	4	1.43	1.20	1.65	1.22	1.42	1.62	1.09	0.62	1.50	0.85	1.11	1.32
Snail bullhead-juvenile	4	4	2.05	1.40	2.60	1.70	2.10	2.40	0.73	0.58	0.85	0.61	0.74	0.84
Snail bullhead-adult	15	16	3.22	1.40	5.40	2.10	3.20	4.10	0.56	0.07	1.50	0.22	0.41	0.93
Striped jumprock-yoy	2	4	0.93	0.60	1.25	0.60	0.93	1.25	2.37	0.55	4.20	0.55	2.37	4.20
Striped jumprock-juvenile	7	8	0.93	0.50	1.80	0.70	0.80	1.00	0.72	0.05	2.10	0.15	0.40	1.65
Striped jumprock-adult	15	16	2.11	1.05	3.10	1.70	2.00	2.70	1.08	0.20	3.00	0.65	1.00	1.25
Silver redhorse-yoy	2	8	2.75	0.85	3.70	0.85	2.27	3.70	1.05	0.35	1.40	0.35	0.88	1.40
Silver redhorse-juvenile	8	14	2.44	1.20	4.60	1.52	2.15	3.05	0.78	0.10	1.25	0.44	0.77	1.13
Silver redhorse-adult	102	282	4.37	1.50	8.80	3.35	3.90	4.70	0.87	0.05	2.06	0.68	0.94	1.15
Whitefin shiner-spawn	2	2	3.47	1.95	5.00	1.95	3.47	5.00	0.75	0.63	0.86	0.63	0.75	0.86
Whitefin shiner-yoy	26	116	2.04	0.55	6.10	0.75	1.05	3.40	0.46	0.04	1.08	0.28	0.49	0.85
Whitefin shiner-adult	239	566	2.78	0.60	9.30	1.30	1.80	3.45	0.78	0.02	3.20	0.35	0.75	1.11

a N = total number of points at which fish were observed and microhabitat measurements were taken (i.e., sample size); N(W) = N weighted by the number of fish observed at that location

b Q1 = first quartile (25th percentile); Q3 = third quartile (75th percentile)

TABLE 4-5 (Cont.)

	Dominant Substrate (percent of observations)									
SPECIES-LIFE STAGE	Organic	Fines	Sm Gravel	Lg Gravel	Sm Cobble	Lg Cobble	Sm Boulder	Lg Boulder	Smh Bedrock	Irr Bedrock
Bluehead chub-spawn	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Bandfin shiner-yoy	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
Bandfin shiner-adult	0.00	7.41	18.52	3.70	0.00	7.41	25.93	3.70	14.81	18.52
Margined madtom-yoy	0.00	14.29	0.00	7.14	35.71	35.71	0.00	0.00	7.14	0.00
Margined madtom-adult	0.00	0.00	0.00	25.00	33.33	25.00	11.11	2.78	0.00	2.78
Northern hog sucker-yoy	0.00	45.75	32.68	3.27	3.27	3.27	5.88	0.00	4.58	1.31
Northern hog sucker-juvenile	0.00	11.54	10.26	5.13	2.56	11.54	12.82	6.41	12.82	26.92
Northern hog sucker-adult	0.00	9.09	7.07	3.03	3.03	5.05	14.14	8.08	12.12	38.38
Redeye bass-spawn	0.00	7.14	14.29	21.43	0.00	14.29	21.43	7.14	0.00	14.29
Redeye bass-yoy	0.00	21.67	16.11	1.67	3.89	6.11	22.78	7.78	8.89	11.11
Redeye bass-juvenile	0.00	18.97	9.77	2.30	2.87	6.32	20.11	6.90	8.05	24.71
Redeye bass-adult	0.00	19.10	15.58	5.53	3.02	2.01	22.61	6.03	9.05	17.09
Redbreast sunfish-spawn	0.00	30.77	34.62	26.92	0.00	0.00	7.69	0.00	0.00	0.00
Redbreast sunfish-yoy	0.00	36.36	0.00	0.00	0.00	9.09	18.18	36.36	0.00	0.00
Redbreast sunfish-juvenile	0.00	29.63	3.70	0.00	3.70	0.00	11.11	14.81	25.93	11.11
Redbreast sunfish-adult	0.00	30.77	3.85	0.00	1.92	7.69	3.85	13.46	17.31	21.15
Snail bullhead-yoy	0.00	50.00	0.00	0.00	0.00	0.00	25.00	0.00	25.00	0.00
Snail bullhead-juvenile	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Snail bullhead-adult	0.00	6.67	0.00	0.00	0.00	0.00	0.00	26.67	0.00	66.67
Striped jumprock-yoy	0.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	50.00
Striped jumprock-juvenile	0.00	14.29	14.29	0.00	28.57	28.57	14.29	0.00	0.00	0.00
Striped jumprock-adult	0.00	6.67	0.00	6.67	0.00	6.67	6.67	20.00	13.33	40.00
Silver redhorse-yoy	0.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	50.00	0.00
Silver redhorse-juvenile	0.00	25.00	0.00	25.00	0.00	0.00	0.00	12.50	37.50	0.00
Silver redhorse-adult	0.00	30.39	20.59	4.90	1.96	0.98	10.78	1.96	12.75	15.69
Whitefin shiner-spawn	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00
Whitefin shiner-yoy	0.00	30.77	7.69	3.85	0.00	11.54	3.85	19.23	7.69	15.38
Whitefin shiner-adult	0.00	17.57	9.21	2.93	5.02	6.28	18.83	3.35	15.48	21.34

TABLE 4-5 (Cont.)

SPECIES-LIFE STAGE	Dominant Cover (percent of observations) No Cover	Boulder	Ledge	Undercut	Overhang	Log	Log Com/Roots	Attached Veg	Rooted Veg
Bluehead chub-spawn	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bandfin shiner-yoy	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bandfin shiner-adult	48.15	29.63	22.22	0.00	0.00	0.00	0.00	0.00	0.00
Margined madtom-yoy	71.43	28.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Margined madtom-adult	58.33	41.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern hog sucker-yoy	86.93	9.80	1.96	0.00	0.00	0.00	0.00	1.31	0.00
Northern hog sucker-juvenile	52.56	33.33	14.10	0.00	0.00	0.00	0.00	0.00	0.00
Northern hog sucker-adult	44.44	31.31	24.24	0.00	0.00	0.00	0.00	0.00	0.00
Redeye bass-spawn	64.29	28.57	7.14	0.00	0.00	0.00	0.00	0.00	0.00
Redeye bass-yoy	45.00	33.89	16.67	0.00	2.22	1.67	0.56	0.00	0.00
Redeye bass-juvenile	37.93	35.06	24.14	0.00	0.57	1.72	0.57	0.00	0.00
Redeye bass-adult	41.71	35.18	21.61	0.00	0.50	1.01	0.00	0.00	0.00
Redbrea t sunfish-spawn	65.38	23.08	3.85	0.00	3.85	3.85	0.00	0.00	0.00
Redbreast sunfish-yoy	27.27	72.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Redbreast sunfish-juvenile	33.33	37.04	29.63	0.00	0.00	0.00	0.00	0.00	0.00
Redbreast sunfish-adult	46.15	23.08	28.85	0.00	0.00	1.92	0.00	0.00	0.00
Snail bullhead-yoy	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Snail bullhead-juvenile	25.00	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Snail bullhead-adult	6.67	53.33	40.00	0.00	0.00	0.00	0.00	0.00	0.00
Striped jumprock-yoy	50.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00
Striped jumprock-juvenile	71.43	14.29	14.29	0.00	0.00	0.00	0.00	0.00	0.00
Striped jumprock-adult	73.33	13.33	13.33	0.00	0.00	0.00	0.00	0.00	0.00
Silver redhorse-yoy	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Silver redhorse-juvenile	75.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Silver redhorse-adult	64.71	16.67	18.63	0.00	0.00	0.00	0.00	0.00	0.00
Whitefin shiner-spawn	50.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00
Whitefin shiner-yoy	61.54	26.92	11.54	0.00	0.00	0.00	0.00	0.00	0.00
Whitefin shiner-adult	49.37	29.29	20.50	0.00	0.42	0.00	0.00	0.00	0.42

TABLE 4-6 FACTOR LOADINGS, EIGENVALUES, AND PROPORTION OF VARIANCE ACCOUNTED FOR FROM PRINCIPAL COMPONENTS ANALYSIS OF MICROHABITAT VARIABLES MEASURED AT FISH LOCATIONS AND HABITAT AVAILABILITY TRANSECTS IN THE CHATTOOGA, TUGALO, AND OCMULGEE RIVERS. ONLY THE FIRST TWO PRINCIPAL COMPONENTS (PC) ARE PRESENTED.

Chattooga River:

Factor Loadings	PC 1	PC 2
Depth	0.226	0.792
Mean Column Velocity	0.484	0.027
Dominant Substrate	0.595	0.003
Dominant Cover	0.380	0.200
Vegetation	0.465	-0.577
Eigenvalue	1.764	1.148
Proportion Variance Explained	0.352	0.582
Cumulative Variance Explained	0.352	0.786

Tugalo River:

Factor Loadings	PC 1	PC 2
Depth	-0.366	0.766
Mean Column Velocity	0.610	-0.021
Dominant Substrate	0.457	0.642
Dominant Cover	-0.535	0.001
Eigenvalue	1.467	1.036
Proportion Variance Explained	0.367	0.259
Cumulative Variance Explained	0.367	0.626

Ocmulgee River:

Factor Loadings	PC 1	PC 2
Depth	-0.595	0.184
Mean Column Velocity	0.194	0.593
Dominant Substrate	0.508	0.322
Dominant Cover	0.004	-0.647
Vegetation	0.592	-0.291
Eigenvalue	1.595	1.363
Proportion Variance Explained	0.319	0.273
Cumulative Variance Explained	0.319	0.592

TABLE 4-7 SUMMARY OF MICROHABITAT MEASUREMENTS TAKEN AT FISH LOCATIONS ON THE TUGALO RIVER AND PANTHER CREEK FROM MAY-SEPTEMBER 1988

SPECIES - LIFE STAGE	N[a]	N(W)[a]	Depth (ft)						Mean Column Velocity (fps)					
			Mean	Min	Max	Q1[b]	Median	Q3[b]	Mean	Min	Max	Q1[b]	Median	Q3[b]
Tugalo River														
Bluehead chub-spawn	72	72	1.18	0.50	2.10	0.93	1.10	1.42	0.94	0.13	2.20	0.70	0.92	1.12
Bluehead chub-yoy	43	358	0.40	0.10	1.80	0.20	0.30	0.40	0.09	0.00	0.38	0.03	0.08	0.13
Bluehead chub-juvenile	5	8	1.14	0.80	1.35	1.00	1.10	1.25	0.79	0.25	1.25	0.70	0.84	0.98
Bluehead chub-adult	9	25	1.26	0.60	2.50	0.90	1.00	1.40	0.83	0.05	2.00	0.35	0.60	1.20
Blackbanded darter-spawn	14	14	1.19	0.55	1.85	0.90	1.20	1.40	0.74	0.10	2.45	0.33	0.45	1.30
Blackbanded darter-yoy	19	26	1.84	0.60	6.30	0.90	1.15	1.50	0.58	0.13	1.80	0.25	0.43	0.82
Blackbanded darter-adult	68	105	1.18	0.40	5.30	0.80	1.00	1.40	0.93	0.10	2.38	0.49	0.84	1.33
Bluegill-juvenile	1	8	1.20	1.20	1.20	1.20	1.20	1.20	0.10	0.10	0.10	0.10	0.10	0.10
Bluegill-adult	1	4	1.45	1.45	1.45	1.45	1.45	1.45	0.10	0.10	0.10	0.10	0.10	0.10
Largemouth bass-spawn	2	2	2.41	2.17	2.66	2.17	2.41	2.66	0.00	0.00	0.00	0.00	0.00	0.00
Largemouth bass-juvenile	1	1	1.20	1.20	1.20	1.20	1.20	1.20	0.10	0.10	0.10	0.10	0.10	0.10
Largemouth bass-adult	3	4	1.53	1.50	1.60	1.50	1.50	1.60	0.80	0.80	0.80	0.80	0.80	0.80
Margined madtom-yoy	154	251	0.70	0.10	1.90	0.45	0.60	0.90	0.79	0.01	2.48	0.52	0.76	1.01
Margined madtom-adult	174	309	0.84	0.10	5.40	0.50	0.78	1.00	0.87	0.00	2.70	0.42	0.88	1.11
Northern hog sucker-yoy	20	160	0.54	0.15	1.55	0.28	0.40	0.82	0.45	0.01	1.80	0.07	0.17	0.35
Northern hog sucker-juvenile	2	6	1.87	1.00	2.30	1.00	1.65	2.30	0.71	0.50	0.82	0.50	0.66	0.82
Northern hog sucker-adult	8	18	1.92	1.40	2.30	1.50	1.80	2.15	0.62	0.14	0.95	0.36	0.57	0.82
Redeye bass-spawn	5	5	2.50	2.10	3.30	2.10	2.50	2.50	0.10	0.08	0.15	0.08	0.08	0.10
Redeye bass-yoy	7	57	2.88	1.05	3.90	1.20	1.60	2.65	0.09	0.01	0.48	0.02	0.05	0.35
Redeye bass-juvenile	13	15	1.54	0.90	2.85	1.20	1.50	1.60	0.40	0.02	1.40	0.15	0.26	0.45
Redeye bass-adult	43	51	2.53	1.20	6.50	1.60	2.20	2.85	0.34	0.00	1.40	0.14	0.30	0.39
Redbreast sunfish-spawn	70	70	2.16	0.85	3.50	1.70	2.05	2.53	0.01	0.00	0.09	0.00	0.00	0.00
Redbreast sunfish-yoy	1	3	0.80	0.80	0.80	0.80	0.80	0.80	0.12	0.12	0.12	0.12	0.12	0.12
Redbreast sunfish-juvenile	13	30	1.16	0.70	1.50	0.95	1.30	1.40	0.26	0.04	0.45	0.16	0.20	0.37
Redbreast sunfish-adult	24	32	1.42	0.95	2.15	1.15	1.30	1.72	0.24	0.00	0.65	0.05	0.16	0.39
Rainbow trout-adult	1	1	5.90	5.90	5.90	5.90	5.90	5.90	0.33	0.33	0.33	0.33	0.33	0.33
Snail bullhead-spawn	1	1	0.90	0.90	0.90	0.90	0.90	0.90	0.30	0.30	0.30	0.30	0.30	0.30
Snail bullhead-yoy	10	10	0.99	0.25	2.75	0.30	0.80	1.45	0.27	0.02	0.88	0.05	0.18	0.27
Snail bullhead-juvenile	11	11	0.93	0.50	1.65	0.60	0.90	1.15	0.29	0.02	0.63	0.14	0.25	0.52
Snail bullhead-adult	35	36	1.53	0.50	5.60	0.95	1.15	1.50	0.53	0.03	2.45	0.14	0.31	0.86
Striped jumprock-adult	4	6	2.15	1.80	2.80	1.85	2.00	2.45	0.76	0.22	1.40	0.32	0.70	1.20
Silver redhorse-adult	9	29	3.67	1.45	7.20	2.00	3.80	5.50	0.19	0.01	0.75	0.08	0.11	0.26
Spottail shiner-adult	7	26	1.20	0.90	1.70	1.00	1.05	1.50	0.55	0.08	1.47	0.14	0.42	0.83
White bass-adult	2	14	5.12	4.60	5.90	4.60	5.25	5.90	0.26	0.25	0.26	0.25	0.26	0.26
Warmouth-adult	3	3	1.62	1.35	2.15	1.35	1.35	2.15	0.28	0.05	0.40	0.05	0.40	0.40
Whitefin shiner-spawn	3	3	1.28	0.90	1.90	0.90	1.05	1.90	0.72	0.40	1.05	0.40	0.70	1.05
Whitefin shiner-yoy	2	2	1.00	0.90	1.10	0.90	1.00	1.10	0.74	0.70	0.78	0.70	0.74	0.78
Whitefin shiner-adult	23	81	1.15	0.60	1.80	0.90	1.10	1.30	0.92	0.40	1.40	0.70	0.84	1.18
Panther Creek														
Bluehead chub-spawn	22	22	1.12	0.60	2.20	0.90	1.00	1.20	0.64	0.20	1.30	0.50	0.61	0.75

a N = total number of points at which fish were observed and microhabitat measurements were taken (i.e., sample size); N(W) = N weighted by the number of fish observed at that location

b Q1 = first quartile (25th percentile); Q3 = third quartile (75th percentile)

TABLE 4-7 (Cont.)

SPECIES-LIFE STAGE	Organic	Fines	Sm Gravel	Lg Gravel	Sm Cobble	Lg Cobble	Sm Boulder	Lg Boulder	Smh Bedrock	Irr Bedrock
	Dominant Substrate (percent of observations)									
Tugalo River										
Bluehead chub-spawn	0.00	2.78	16.67	8.33	27.78	27.78	6.94	2.78	1.39	5.56
Bluehead chub-yoy	2.33	53.49	2.33	2.33	4.65	18.60	11.63	2.33	2.33	0.00
Bluehead chub-juvenile	0.00	0.00	20.00	0.00	60.00	20.00	0.00	0.00	0.00	0.00
Bluehead chub-adult	0.00	11.11	22.22	0.00	44.44	22.22	0.00	0.00	0.00	0.00
Blackbanded darter-spawn	0.00	0.00	35.71	0.00	21.43	21.43	0.00	7.14	14.29	0.00
Blackbanded darter-yoy	0.00	5.26	15.79	5.26	21.05	26.32	10.53	0.00	5.26	10.53
Blackbanded darter-adult	0.00	13.24	23.53	7.35	14.71	16.18	14.71	2.94	1.47	5.88
Bluegill-juvenile	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
Bluegill-adult	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Largemouth bass-spawn	0.00	50.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00
Largemouth bass-juvenile	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
Largemouth bass-adult	0.00	0.00	0.00	0.00	66.67	0.00	33.33	0.00	0.00	0.00
Margined madtom-yoy	0.00	0.00	3.25	8.44	58.44	18.18	6.49	0.00	3.90	1.30
Margined madtom-adult	0.00	0.00	3.45	2.30	39.08	17.24	27.59	1.15	3.45	5.75
Northern hog sucker-yoy	0.00	5.00	10.00	10.00	35.00	25.00	15.00	0.00	0.00	0.00
Northern hog sucker-juvenile	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
Northern hog sucker-adult	0.00	25.00	12.50	0.00	37.50	12.50	12.50	0.00	0.00	0.00
Redeye bass-spawn	0.00	0.00	20.00	0.00	40.00	40.00	0.00	0.00	0.00	0.00
Redeye bass-yoy	0.00	14.29	0.00	0.00	28.57	28.57	14.29	0.00	0.00	14.29
Redeye bass-juvenile	0.00	7.69	23.08	7.69	7.69	30.77	7.69	0.00	0.00	15.38
Redeye bass-adult	2.33	23.26	20.93	2.33	9.30	18.60	4.65	6.98	0.00	11.63
Redbreast sunfish-spawn	0.00	64.29	21.43	10.00	0.00	2.86	1.43	0.00	0.00	0.00
Redbreast sunfish-yoy	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00
Redbreast sunfish-juvenile	0.00	15.38	15.38	0.00	15.38	46.15	0.00	0.00	7.69	0.00
Redbreast sunfish-adult	12.50	16.67	4.17	0.00	16.67	41.67	4.17	0.00	4.17	0.00
Rainbow trout-adult	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Snail bullhead-spawn	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
Snail bullhead-yoy	10.00	0.00	0.00	10.00	40.00	30.00	10.00	0.00	0.00	0.00
Snail bullhead-juvenile	0.00	0.00	0.00	0.00	36.36	9.09	45.45	0.00	9.09	0.00
Snail bullhead-adult	0.00	0.00	8.57	2.86	14.29	8.57	42.86	8.57	2.86	11.43
Striped jumprock-adult	0.00	0.00	25.00	0.00	0.00	75.00	0.00	0.00	0.00	0.00
Silver redhorse-adult	0.00	44.44	22.22	0.00	11.11	22.22	0.00	0.00	0.00	0.00
Spottail shiner-adult	0.00	0.00	57.14	0.00	28.57	14.29	0.00	0.00	0.00	0.00
White bass-adult	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Warmouth-adult	33.33	0.00	0.00	66.67	0.00	0.00	0.00	0.00	0.00	0.00
Whitefin shiner-spawn	0.00	33.33	0.00	0.00	33.33	33.33	0.00	0.00	0.00	0.00
Whitefin shiner-yoy	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00
Whitefin shiner-adult	0.00	0.00	17.39	4.35	30.43	47.83	0.00	0.00	0.00	0.00
Panther Creek										
Bluehead chub-spawn	4.55	18.18	27.27	0.00	9.09	18.52	9.09	0.00	0.00	9.09

TABLE 4-7 (Cont.)

SPECIES-LIFE STAGE	No Cover	Boulder	Ledge	Undercut	Overhang	Log	Log Com/Roots	Attached Veg	Rooted Veg
	Dominant Cover (percent of observations)								
Tugalo River									
Bluehead chub-spawn	68.06	16.67	2.78	0.00	0.00	1.39	11.11	0.00	0.00
Bluehead chub-yoy	65.12	13.95	0.00	0.00	0.00	9.30	9.30	0.00	2.33
Bluehead chub-juvenile	80.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00
Bluehead chub-adult	77.78	0.00	0.00	0.00	0.00	0.00	22.22	0.00	0.00
Blackbanded darter-spawn	50.00	7.14	14.29	0.00	0.00	0.00	28.57	0.00	0.00
Blackbanded darter-yoy	63.16	15.79	10.53	0.00	0.00	5.26	5.26	0.00	0.00
Blackbanded darter-adult	66.18	26.47	0.00	0.00	0.00	5.88	1.47	0.00	0.00
Bluegill-juvenile	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
Bluegill-adult	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Largemouth bass-spawn	0.00	50.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00
Largemouth bass-juvenile	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
Largemouth bass-adult	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Margined madtom-yoy	85.06	11.69	1.95	0.00	0.00	0.65	0.65	0.00	0.00
Margined madtom-adult	68.97	27.59	2.30	0.00	0.00	0.00	1.15	0.00	0.00
Northern hog sucker-yoy	80.00	15.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00
Northern hog sucker-juvenile	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern hog sucker-adult	37.50	0.00	0.00	0.00	0.00	12.50	50.00	0.00	0.00
Redeye bass-spawn	20.00	40.00	20.00	0.00	0.00	20.00	0.00	0.00	0.00
Redeye bass-yoy	14.29	28.57	0.00	0.00	0.00	14.29	42.86	0.00	0.00
Redeye bas.-juvenile	30.77	23.08	7.69	7.69	0.00	15.38	15.38	0.00	0.00
Redeye bass-adult	39.53	27.91	13.95	0.00	4.65	6.98	6.98	0.00	0.00
Redbreast sunfish-spawn	60.00	2.86	0.00	0.00	0.00	15.71	21.43	0.00	0.00
Redbreast sunfish-yoy	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
Redbreast sunfish-juvenile	0.00	7.69	0.00	0.00	0.00	23.08	69.23	0.00	0.00
Redbreast sunfish-adult	12.50	4.17	0.00	0.00	0.00	45.83	37.50	0.00	0.00
Rainbow trout-adult	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Snail bullhead-spawn	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
Snail bullhead-yoy	80.00	10.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00
Snail bullhead-juvenile	27.27	54.55	0.00	0.00	0.00	9.09	9.09	0.00	0.00
Snail bullhead-adult	11.43	60.00	14.29	0.00	0.00	2.86	11.43	0.00	0.00
Striped jumprock-adult	75.00	0.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00
Silver redhorse-adult	22.22	0.00	11.11	0.00	0.00	22.22	44.44	0.00	0.00
Spottail shiner-adult	85.71	14.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White bass-adult	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Warmouth-adult	0.00	0.00	0.00	0.00	0.00	66.67	33.33	0.00	0.00
Whitefin shiner-spawn	33.33	33.33	0.00	0.00	0.00	33.33	0.00	0.00	0.00
Whitefin shiner-yoy	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Whitefin shiner-adult	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Panther Creek									
Bluehead chub-spawn	54.55	13.64	0.00	0.00	27.27	4.55	0.00	0.00	0.00

TABLE 4-8 SUMMARY OF MICROHABITAT MEASUREMENTS TAKEN AT FISH LOCATIONS ON THE OCMULGEE RIVER FROM JUNE-NOVEMBER 1988

SPECIES-LIFE STAGE	N[a]	N(W)[a]	Depth (ft) Mean	Depth (ft) Min	Depth (ft) Max	Depth (ft) Q1[b]	Depth (ft) Median	Depth (ft) Q3[b]	Mean Column Velocity (fps) Mean	Mean Column Velocity (fps) Min	Mean Column Velocity (fps) Max	Mean Column Velocity (fps) Q1[b]	Mean Column Velocity (fps) Median	Mean Column Velocity (fps) Q3[b]
Altamaha shiner-yoy	42	592	2.33	0.95	4.20	1.60	2.15	2.70	0.44	0.05	1.45	0.20	0.32	0.55
Altamaha shiner-adult	171	1665	1.92	0.80	3.80	1.40	1.75	2.10	0.59	0.02	3.50	0.25	0.52	0.85
Bluehead chub-spawn	4	4	1.31	0.70	2.10	0.95	1.22	1.67	0.66	0.32	0.88	0.48	0.72	0.83
Blackbanded darter-yoy	1	1	1.70	1.70	1.70	1.70	1.70	1.70	0.02	0.02	0.02	0.02	0.02	0.02
Largemoutb bass-spawn	2	2	3.15	3.10	3.20	3.10	3.15	3.20	0.14	0.08	0.20	0.08	0.14	0.20
Largemouth bass-yoy	1	1	0.60	0.60	0.60	0.60	0.60	0.60	0.15	0.15	0.15	0.15	0.15	0.15
Redeye bass-spawn	1	1	1.65	1.65	1.65	1.65	1.65	1.65	0.00	0.00	0.00	0.00	0.00	0.00
Redeye bass-juvenile	2	2	2.42	2.05	2.80	2.05	2.42	2.80	1.54	1.29	1.78	1.29	1.54	1.78
Redeye bass-adult	34	38	3.59	0.40	7.00	2.70	3.50	4.40	0.56	0.01	1.40	0.35	0.53	0.85
Redbreast sunfish-spawn	184	184	1.83	0.40	4.30	1.00	1.65	2.60	0.18	0.00	3.05	0.01	0.04	0.19
Redbreast sunfish-yoy	10	69	0.64	0.50	1.20	0.50	0.55	1.00	0.03	0.00	0.08	0.00	0.02	0.05
Redbreast sunfish-juvenile	1	2	0.65	0.65	0.65	0.65	0.65	0.65	0.01	0.01	0.01	0.01	0.01	0.01
Redbreast sunfisb-adult	1	1	1.10	1.10	1.10	1.10	1.10	1.10	0.08	0.08	0.08	0.08	0.08	0.08
Snail bullhead-adult	30	30	3.78	1.30	6.50	2.90	3.50	4.70	0.38	0.00	0.85	0.20	0.35	0.55
Shoal bass-yoy	127	337	1.35	0.30	3.20	0.80	1.20	1.70	0.19	0.00	1.10	0.04	0.12	0.29
Shoal bass-juvenile	11	11	2.30	1.10	3.30	1.55	2.30	3.10	0.58	0.03	1.15	0.15	0.65	0.98
Shoal bass-adult	83	86	5.25	1.65	13.00	3.25	4.20	6.90	0.56	0.00	1.88	0.35	0.52	0.70
Striped jumprock-yoy	72	230	0.99	0.25	2.45	0.50	0.70	1.15	0.17	0.00	0.87	0.01	0.05	0.23
Striped jumprock-juvenile	5	9	1.51	0.60	2.40	1.00	1.20	1.45	0.39	0.01	0.90	0.07	0.09	0.62
Striped jumprock-adult	100	174	2.13	0.40	3.60	1.75	2.00	2.50	1.02	0.02	2.85	0.53	0.90	1.40
Silver redborse-juvenile	2	4	3.85	3.70	4.00	3.70	3.85	4.00	0.23	0.12	0.33	0.12	0.23	0.33
Silver redhorse-adult	26	202	8.65	2.30	14.00	4.00	6.35	13.00	0.52	0.05	2.45	0.12	0.47	0.82

a N = total number of points at which fish were observed and microhabitat measurements were taken (i.e., sample size);
  N(W) = N weighted by the number of fish observed at that location

b Q1 = first quartile (25th percentile); Q3 = third quartile (75th percentile)

TABLE 4-8 (Cont.)

	Dominant Substrate (percent of observations)									
	Organic	Fines	Sm Gravel	Lg Gravel	Sm Cobble	Lg Cobble	Sm Boulder	Lg Boulder	Smh Bedrock	Irr Bedrock
SPECIES-LIFE STAGE										
Altamaha shiner-yoy	2.38	4.76	14.29	7.14	0.00	7.14	16.67	0.00	4.76	42.86
Altamaha shiner-adult	1.17	1.75	5.85	5.26	0.00	7.60	5.26	2.92	14.04	56.14
Bluehead chub-spawn	0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	75.00
Blackbanded darter-yoy	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Largemouth bass-spawn	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Largemouth bass-yoy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Redeye bass-spawn	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Redeye bass-juvenile	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	50.00
Redeye bass-adult	0.00	0.00	2.94	2.94	8.82	5.88	29.41	11.76	14.71	23.53
Redbreast sunfish-spawn	2.17	28.26	52.72	3.26	0.00	1.09	1.09	0.00	2.17	9.24
Redbreast sunfish-yoy	0.00	10.00	10.00	0.00	0.00	0.00	0.00	0.00	20.00	60.00
Redbreast sunfish-juvenile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Redbreast sunfish-adult	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Snail bullhead-adult	0.00	0.00	0.00	0.00	3.33	0.00	20.00	40.00	6.67	30.00
Shoal bass-yoy	2.36	7.09	16.54	9.45	0.00	3.15	3.15	1.57	18.90	37.80
Shoal bass-juvenile	0.00	0.00	0.00	0.00	9.09	9.09	9.09	9.09	9.09	54.55
Shoal bass-adult	0.00	10.84	6.02	15.66	4.82	2.41	9.64	16.87	12.05	21.69
Striped jumprock-yoy	2.78	8.33	18.06	8.33	0.00	0.00	2.78	0.00	13.89	45.83
Striped jumprock-juvenile	0.00	20.00	40.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00
Striped jumprock-adult	0.00	2.00	4.00	14.00	1.00	7.00	8.00	3.00	19.00	42.00
Silver redhorse-juvenile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	50.00
Silver redhorse-adult	0.00	42.31	7.69	15.38	3.85	0.00	15.38	0.00	0.00	15.38

TABLE 4-8 (Cont.)

SPECIES-LIFE STAGE	Dominant Cover (percent of observations)								
	No Cover	Boulder	Ledge	Undercut	Overhang	Log	Log Com/Roots	Attached Veg	Rooted Veg
Altamaha shiner-yoy	38.10	23.81	26.19	0.00	0.00	4.76	4.76	0.00	2.38
Altamaha shiner-adult	38.01	16.37	35.67	0.00	0.00	5.85	4.09	0.00	0.00
Bluehead chub-spawn	25.00	25.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00
Blackbanded darter-yoy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Largemouth bass-spawn	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Largemouth bass-yoy	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Redeye bass-spawn	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Redeye bass-juvenile	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Redeye bass-adult	20.59	52.94	14.71	0.00	2.94	2.94	2.94	0.00	2.94
Redbreast sunfish-spawn	52.17	12.50	10.33	1.09	0.54	2.72	3.26	0.00	17.39
Redbreast sunfish-yoy	40.00	0.00	30.00	0.00	0.00	0.00	0.00	20.00	10.00
Redbreast sunfish-juvenile	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Redbreast sunfish-adult	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Snail bullhead-adult	3.33	70.00	23.33	0.00	0.00	0.00	0.00	0.00	3.33
Shoal bass-yoy	23.62	4.72	22.05	0.00	0.00	3.15	1.57	15.75	29.13
Shoal bass-juvenile	27.27	36.36	36.36	0.00	0.00	0.00	0.00	0.00	0.00
Shoal bass-adult	37.35	36.14	9.64	0.00	2.41	3.61	10.84	0.00	0.00
Striped jumprock-yoy	30.56	2.78	25.00	0.00	1.39	1.39	4.17	20.83	13.89
Striped jumprock-juvenile	80.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
Striped jumprock-adult	45.00	16.00	27.00	0.00	4.00	1.00	3.00	1.00	3.00
Silver redhorse-juvenile	50.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Silver redhorse-adult	73.08	7.69	3.85	0.00	0.00	3.85	11.54	0.00	0.00

TABLE 4-9 SUMMARY OF RESULTS OF MARGINED MADTOM HABITAT-USE STUDY BASED ON COMBINED ELECTROFISHING AND SNORKELING OF PAIRED TRANSECTS IN THE TUGALO RIVER STUDY AREA

Paired Transect Location	Habitat	Wetted Width (ft)	Electrofishing Effort (hours)	Electrofishing Madtoms Collected	Electrofishing Catch per Hour	Snorkeling Effort (Hours)	Snorkeling Madtoms Observed	Snorkeling Catch per Hour	Approximate Location
1	Run	177.2	0.25	15	60.0	1.78	47	26.4	First run below island
2	Run	206.7	0.18	3	16.7	1.30	24	18.5	First run below island
5	Riffle	96.8	0.30	22	73.3				Left channel, island
7	Riffle/run	110.2	0.32	20	62.5				Left channel, near Transect Y29
10	Run/pool	229.7	0.23	1	4.3	0.75	4	5.3	NR Transect Y26
13	Riffle	210.6	0.32	13	40.6	1.33	37	27.8	NR Transect Y25
15	Riffle/run	211.5	0.38	10	26.3	1.03	25	24.3	NR Transect Y24
19	Run	226.0	0.27	9	33.3	1.48	29	19.6	NR Transect Y21
29	Riffle	291.7	0.40	35	87.5				NR Transect Y19
41	Riffle/run	133.0	--	--	--	0.88	21	23.9	NR Transect Y12
43	Run	240.3	--	--	--	0.70	6	8.6	NR Transect Y12
48	Run/pool	238.8	--	--	--	1.00	2	2.0	NR Transect Y7
54	Run/pool	103.6	--	--	--	0.50	2	4.0	NR GPC Park

5. PHYSICAL HABITAT SIMULATION

Application of physical habitat simulation requires the use of a collection of computer programs to simulate physical habitat in a stream in relation to flow regime. Various elements of fish habitat preferences and open channel hydraulics are simulated to describe the relationship between stream discharge and the amount of habitat available to fish. The three major components of physical habitat simulation are the hydraulic model programs (physical component), species habitat suitability criteria (biological component), and the habitat model programs.

In this study, application of physical habitat simulation consisted of several independent steps including:

- Delineation of the location, type, and amount of stream habitat types within each study area and selection of representative sampling sites (habitat mapping, transect selection).
- Placement of cross-sectional transects within each representative habitat type and collection of measurements to characterize channel characteristics, habitat, and hydraulic conditions (transect sampling).
- Development of habitat suitability criteria for represented fish species from site-specific data (Section 4).
- Integration of the above components by hydraulic and habitat simulation to produce an index of habitat available for each species life stage and discharge of interest (hydraulic and habitat simulation).

The output variable of the physical habitat simulation--weighted usable area (WUA)--is an index of available habitat expressed as square feet of habitat per 1,000 ft of stream (Bovee 1982; Milhous et al. 1984). The output of the habitat model defines the relationship between weighted usable area and discharge for each species life stage.

5.1 METHODS

5.1.1 Habitat Mapping and Transect Placement

Habitat mapping is a technique for determining the location, type, and amount of habitats found in a stream segment (Morhardt et al. 1983). This includes mapping the habitat in a stream prior to determining where to take measurements, stratifying the entire segment into various habitat types, and placing data-collection transects in the most representative areas of the stream segment. The results of habitat mapping are used to extrapolate the results of habitat modeling to the whole stream segment; each transect is weighted in direct proportion to the amount of the habitat in the segment. This procedure maximizes the accuracy of extrapolating the hydraulic/habitat characteristics of a collection of transects to the entire stream segment. It represents an improvement over the traditional method for transect placement (Bovee 1982) and is now taught as the standard method by the FWS.

The length of river within each of the study areas was mapped with a combination of aerial photography and ground survey. High-quality aerial photographs of each river segment were enlarged to an appropriate scale (1 in. = 200-400 ft), photocopied, and laminated. Mylar overlays showing the river margins were produced for drawing habitat boundaries in the field. All stream segments were mapped by two fisheries biologists during on-foot or boat surveys. Each homogenous habitat area (e.g., riffle, pool, cascade) was marked on the overlay in the field and assigned a unique number. Habitat attributes such as channel shape, substrate type, length, gradient, or bank condition were measured or estimated and recorded on field data forms. Ground-level photographs of each habitat area were taken, labeled with the unique habitat number, and compiled in notebooks.

Following field data collection, each habitat area was classified into mutually exclusive habitat types (Appendix B), and its length (or area) was calculated with an electronic planimeter. A database of the habitat areas and their attributes was developed and analyzed with the Statistical Analysis System (SAS 1988) to show summary statistics for all attributes and total area of each habitat type.

On the basis of the above analyses, the locations of several representative transects were selected for each habitat type. A summary of the above analyses was prepared for agency review (Appendix B). Agency consultation meetings for transect selection were conducted, during which all materials described above were presented (Section 2-4). In coordination with FWS, SCDHEC, SCWRC, and GDNR, the above materials were reviewed, examined in the field, and approved.

5.1.2 Transect Sampling

All transects were sampled using the same methods, similar to methods outlined by Trihey and Wegner (1983). Two permanent headstakes (rebar rods) were established, one on each bank, to define a cross-sectional transect line perpendicular to stream flow. Sampling stations along each transect were established at intervals necessary to describe the cross-sectional profile of the channel, distribution of substrate and cover, water velocities, and to obtain an accurate discharge measurement. Between 17 and 64 stations (mean = 40 stations) were sampled at every transect and less than 10 percent of the total stream discharge passed between any two stations at any flow.

A benchmark was established at each transect and arbitrarily defined as an elevation of 100 ft. The elevations of the headstakes and each station were measured, using standard surveying equipment and techniques, to the nearest 0.01 ft.

For a minimum of three discharge rates, water surface elevation was measured at each transect. Where water surface elevations were not uniform (within 0.05 ft) across the entire transect, segments of the transect with uniform water surface elevations were identified and measured separately and their endpoints were recorded.

Stream depth and velocity were measured at each station for at least two discharge rates at each transect. Velocity was measured with instruments and techniques as previously described in Section 4.1.3. Depth was determined indirectly for each station by subtracting the known streambed elevation for each station from the elevation of the water surface at that discharge.

At each sampling station along a transect, a rectangular cell within the stream was visualized, its width being half the distance to adjacent stations and extending upstream and downstream 10 ft. Within each cell, streambed substrate and cover types were visually estimated as described in Section 4.1.3 and illustrated in Table 4-3.

At each transect, a staff gauge was established. For each period of stream flow measurement, the staff gauge was periodically monitored to document any change in stream discharge for each measurement period; discharge for a transect was calculated from measured depths and velocities as described by Trihey and Wegner (1983).

5.1.3 Physical Habitat Simulation

The two basic components of stream habitat simulation are hydraulic simulation and habitat simulation. Hydraulic simulation is used to describe the area of a stream having various combinations of depth, velocity, substrate, and cover as a function of discharge. Habitat simulation converts the predicted hydraulic parameters and known substrate and cover conditions into equivalent habitat units, using habitat suitability criteria, and predicts the amount of habitat as a function of flow for any species and life stage of interest. The theory and details of these methods are discussed in detail by Bovee and Milhous (1978), Stalnaker (1979), Bovee (1982), and Milhous et al. (1984).

Hydraulic Simulation

The hydraulic simulation model used herein is EA's equivalent version of the single-velocity application of the IFG4 program of the U.S. Fish and Wildlife Service National Ecology Research Center (NERC) (Milhous et al. 1984). The primary feature of this hydraulic simulation model is its ability to simulate a broad range of flow conditions for each transect with a single set of velocity data. The two major elements of the hydraulic simulation model are the stage/discharge relationship and the prediction of velocities at each transect station (or cell).

The stage/discharge relationship, representing the change in stage (or water surface elevation) at each transect as a function of stream flow, can be defined in the model in one of two ways: (1) by invoking an energy balance, step-backwater algorithm [the WSP, or water surface profile model (Bovee and Milhous 1978)], or (2) by applying the log stage-log discharge linear regression model. For all simulations, the regression technique was used because of the potential limitation of the WSP model in hydraulically complex rivers (Bovee and Milhous 1978).

One requirement of the single-velocity IFG-4 model is a uniform water surface elevation across the transect. Many of the transects in this study had non-uniform water surfaces across the transect due to the complex nature of the streams, locally steep gradients, and frequent ledges and boulders. This problem was resolved by collecting data as described in Section 5.2.2 and independently simulating the stage/discharge relationship for each transect segment which exhibited a uniform water surface elevation. Thus, any single transect could have up to seven independent stage/discharge relationships.

The second major function of the single-velocity IFG-4 model, prediction of mean column velocity at each station, is accomplished by invoking a modified version of the Manning equation:

$$v = 1.49/n * d^{2/3} * s^{1/2} \qquad \text{(Equation 5-1)}$$

where

n = roughness coefficient of transect cell, dimensionless

v = mean column velocity for transect cell, ft/second

d = mean depth for transect cell, ft

s = slope of the energy gradient.

Cell-specific velocities measured at calibration discharge rates are applied to the Manning equation to predict n, the roughness coefficient. During simulation, the roughness coefficient and velocity term in the equation are interchanged, and velocity is predicted over a range of stream flows as mean depth, d, increases and roughness is held constant. This permits independent simulations of velocity for each set of field-measured calibration velocities. Calibration velocity sets were measured at two or more discharge rates for each study area.

One of the difficulties encountered in using the single-velocity IFG-4 model is the assignment of roughness coefficients to transect cells that were not underwater at the calibration discharge rate. Generally, this includes transect cells on the banks of the stream, on islands or exposed shoals, bars, or boulders in the main channel. When the model predicts high water surface elevations at the upper range of simulated discharge rates, the roughness coefficients that are assigned to these cells may have a significant effect on predictions of fish habitat. Unless values for the roughness coefficient for these cells are supplied during model simulation, the default feature of the single-velocity model is to use a nearest neighbor value for any out-of-the-water cells. This means that roughness coefficients are used to assign roughness values for cells on the stream bank.

The problem that often arises in this situation is that the cells on the edge of the stream often exhibit low velocities, due more to an edge effect than to the roughness characteristic of the cell itself. These low velocities, often coupled with shallow depth, result in unreasonably high roughness values for the edge cells, which then become projected to the out-of-the-water cells on the stream bank.

To avoid this occurrence in simulations on the Tugalo and Ocmulgee rivers, an average roughness coefficient, calculated from all wetted-cell roughness coefficients, was used in the place of the default edge cell values for out-of-the-water cells. Such adjustments were made to less than 5 percent of the total number of cells. In addition to these adjustments, a "cap" of 5.0 was placed on n values. However, high roughness values that could be identified from field notes as resulting from either substrate roughness, upstream velocity breaks, or downstream controls were not adjusted. Both of the above adjustments to cell roughness values are accepted procedures in "calibrating" a transect data set for hydraulic modeling with the IFG-4 program. The use of an average n value or placing a cap on n values can be found in Milhous et al. (1984).

Transects on the Ocmulgee River which were placed in divided channel habitat included by definition only one-half of the stream channel. In the hydraulic simulation phase, such transects were combined with a transect crossing the remaining portion of the channel to form a "composite" transect. This was done to permit accurate hydraulic simulation of the entire river flow simultaneously. During the habitat modeling process, the results for the two transects constituting each "composite" transect were separated and expressed independently.

<u>Hydraulic Model Diagnostics</u>

In this phase, a quality control check of the hydraulic field data was conducted and the reliability and range of flow over which accurate simulations could be expected were determined. Figure 5-1 illustrates the steps which were followed to examine the data, using EA's Pascal programs and the diagnostic outputs produced.

Each transect data set was examined in several ways. First, the cross-sectional profile of the channel was plotted using EA's BEDPLOT program and examined for accuracy and potential errors. Second, the distribution of velocities and calculated roughness values at stations along a transect were displayed, using EA's NVELDIST program (Figure 5-2); patterns of velocity and roughness were related to known channel features during calibration. Third, the stage/discharge data were plotted (EA's SQPLOT program) and examined for log-linearity; regression diagnostics for the stage/discharge relationship were printed by the SQSTAT program (Figure 5-3). Factors evaluated for each transect segment included slope, intercept, mean percent error, and the ratio of measured to predicted discharge.

For each velocity data set, hydraulic model simulations were performed over a wide range of stream flows. The reasonableness of predicted velocity values for each transect was evaluated by examining the transect Froude number and Velocity Adjustment Factor (VAF). The VAF is the correction factor used to force the simulated velocities to reproduce the discharge determined from the stage/discharge relationship (Milhous et al. 1984). The VAF should be close to one (1.0) when the simulated discharge is equal to the calibration discharge, and less than one when the simulated discharge is less than the calibration discharge.

The Froude number is a measure of general flow characteristics of the stream, and is based on depth and velocity of the stream. Stream sections with Froude numbers less than one exhibit subcritical flow. Subcritical flow is typical of most natural streams, which exhibit velocity ranging from 0.5 to 3.0 ft/second and depth greater than 1.0 ft. Depth and velocity values for a given transect tha* result in a Froude number that is less than one represent reasonable values. Predicted depth and velocity values that result in a Froude number that is greater than one are not reasonable, as a Froude number greater than one represents a stream of supercritical flow.

In the context of evaluating the reasonableness of predicted depth and velocity values of a PHABSIM simulation, the Froude number is of primary use in examining the higher discharge rates. The discharge rate at which the Froude number reaches a value of 1.0 represents the limit of extrapolation. The Froude number was calculated for each transect over the range of simulated discharge rates as

$$F_j = V_j \;/\; (g*D_j)^{1/2} \qquad \text{(Equation 5-2)}$$

where

F_j = Froude number at discharge rate j
V_j = average transect velocity at discharge rate j, in fps
D_j = average transect depth at discharge rate j, in feet
g = gravitational constant

Average velocity and depth for each discharge rate were calculated as

$$V_j = \sum_{i=a_j}^{b_j} V_{ij} \;/\; \sum_{i=a_j}^{b_j} W_i \qquad \text{(Equation 5-3)}$$

$$D_j = \sum_{i=a_j}^{b_j} D_{ij} \;/\; \sum_{i=a_j}^{b_j} W_i \qquad \text{(Equation 5-4)}$$

where

V_{ij} = velocity predicted at transect cell i, discharge rate j, in ft/second
D_{ij} = depth predicted at transect cell i, discharge rate j, in ft
W_i = width of transect cell i
a_j = number of first cell wetted at discharge rate j
b_j = number of last cell wetted at discharge rate j.

Based on the predicted Froude numbers and velocity adjustment factors for each transect, the results reported herein were considered reasonable extrapolations of the data. Computed Froude numbers and velocity adjustment factors for each transect are provided in Appendix F.

Habitat Simulation

In this phase, the hydraulic simulation results are translated into a measure of habitat available for any species life stage as a function of stream flow. In EA's microhabitat simulation program, HABSIM, the suitability of each cell along a transect is calculated from the habitat suitability criteria in a fashion identical to the FWS HABTAT Model (Milhous et al. 1984).

The output of the habitat program consists of a function defining the relationship between weighted usable area (WUA) per 1,000 ft of stream and stream flow. Independent WUA vs. stream flow functions are produced for each life stage and transect, and are summed for the stream reach of interest.

The WUA for each species and transect was calculated as

$$WUA(Q)_{transect} = \sum_{i=1}^{n} (S_d \times S_v \times S_s \times S_c)^{1/4} \; (A_i) \qquad \text{(Equation 5-5)}$$

where

S = suitability of depth (S_d), velocity (S_v), substrate (S_s), and cover (S_c) of cell i for species i

A_i = area of cell i

n = number of cells for that transect

WUA(Q) = weighted usable area for the transect, species, and flow of interest

Suitability weighting factors were obtained from the habitat suitability criteria (Chapter 4; Appendix D). Computer files containing the habitat suitability criteria coordinates are presented in Appendix E.

Weighted usable area for the stream reach (study area) was calculated as:

$$WUA(Q)_{reach} = \sum_{j=1}^{n} T_j \; WUA(Q)_{transect} \qquad \text{(Equation 5-6)}$$

where

T_j = transect weighting factor for transect j

n = number of transects in reach

$WUA(Q)_{reach}$ = the weighted usable area for the reach and flow of interest

The transect weighting factor is the extrapolation factor described in Section 5.2.1.

5.2 RESULTS AND DISCUSSION

5.2.1 Habitat Mapping and Transect Weighting

A summary of the results of habitat mapping presented to the agencies during transect selection meetings is presented in Appendix B. The final transects used in hydraulic and habitat data collection are listed in Table 5-1.

Tugalo River

In the Tugalo River, two transects were placed in each of the major habitat types (riffle, riffle-run, run, and run-pool) and one transect was placed in a backwater area for a total of nine final transects. Each major habi`at was then categorized as being most similar to one of the two transects representing that habitat type, and transect weighting factors were calculated as the proportion of the total stream length represented by that transect. Computations for calculation of the relative contribution of each habitat type and the transect weighting factors are shown in Table 5-1; these computations are based on habitat in the riverine portion of the Tugalo River (Section 2.1).

Ocmulgee River

In the Ocmulgee River, 11 final transects were selected. One transect was established for each combination of primary habitat types (shoal, run-pool, run, and pool) and channel types. Two transects were placed in other habitat types of limited distribution. Two of the final transects included secondary or side channels, characterizing the occurrence of these habitat types in the Ocmulgee River study area.

Due to the high variability of river widths in the Ocmulgee River, it was necessary to calculate transect weighting factors from the relative contribution of the habitat based on the area of the habitat (versus length of the habitat). The computations for transect weighting factors are shown in Table 5-1 (based on habitats from Lloyd Shoals Dam to the vicinity of Nelson Island). The transect weighting factors (WF) for the Ocmulgee River were calculated as:

$$WF_i = \sum_{i=1}^{n} \frac{L_i}{\Sigma L_i} \qquad \text{(Equation 5-7)}$$

where

L_i = the total area (ft²) of habitat type i divided by the average width of habitat type i (termed length factor) and n = number of areas classified as habitat type i.

These variables were computed by electronic planimetry from aerial photographs. When multiple transects were used to describe a habitat type (i.e., divided-channel shoal habitat; Table 5-1), each transect was assigned an equal weighting factor totaling the weighting factor for the habitat represented.

5.2.2 Hydraulic Sampling and Simulation Diagnostics

The results of transect sampling, cross-sectional profiles of the stream channel, measured velocities, calculated roughness values, stage-discharge relationships, and diagnostic statistics are presented in Appendix F.

Tugalo River

Hydraulic sampling of all nine Tugalo River transects was conducted 2-6 May 1988 during controlled flows provided by GPC. Stage and discharge measurements were collected at four stream flow rates (Appendix F). Velocities were measured at all transect stations at all flows, providing four sets of measurements for calibrating the hydraulic model. During 2-3 May 1988, a U.S. Geologic Survey (USGS) team was present to measure flows in the Yonah tailwater and in Panther Creek; these data provided a cross-check of discharge estimates. All USGS data were within 0-10 percent difference of the discharge estimates reported herein; the discharge for Panther Creek, as calculated by USGS on 3 May 1988, was 28 cfs. The discharge of Brasstown Creek on 3 May 1988 was 23 cfs. The best estimates of discharge for the four calibration flows were derived from transect discharge estimates and USGS discharge estimates, corrected for tributary flows.

The diagnostics of the hydraulic simulations for the Tugalo River (Appendix F) indicate that the results are of good quality: the mean percent errors (MPE) of the transect segment stage-discharge relationships were 43 percent excellent (<5 MPE), 40 percent good (5.1-10 MPE), 14.3 percent fair (10.1-25 MPE), and 3 percent poor (>25 MPE). The range of velocity adjustment factors encountered were reasonable and trends in velocity adjustment factors were as expected; velocity adjustment factors were typically within the range 0.90-1.10 when calibration flows equaled the simulated flows (Appendix F). All transect Froude numbers assumed reasonable values for the flow range simulated; pools had low Froude numbers; and riffles had moderate, but subcritical values (Appendix F).

The range of flows simulated for the Tugalo River was 20-3,000 cfs. The low end of this range is equivalent to the approximate flow that would occur if the Yonah facility was discharging zero flow (i.e., only tributary flow) and the high end is equivalent to the maximum flow that can be output from the Yonah facility under full power production at the most efficient gate setting.

Ocmulgee River

Hydraulic sampling of 11 Ocmulgee River transects was conducted during the periods 29 August - 2 September 1988, 10-11 October 1988, and 15-18 October 1988, during controlled flows provided by GPC. Stage and discharge measurements were collected at four stream flow rates (Appendix F). Velocities were measured at all transect stations at two flows, providing two sets of measurements for calibrating the hydraulic model. The best estimates of discharge for the calibration flows were derived from comparison of transect discharge estimates and the Lloyd Shoals facility tailwater rating curve.

Diagnosis of the hydraulic simulations for the Ocmulgee River (Appendix F) indicate that the results are of good quality. MPEs of the transect segment stage-discharge relationships were: 54.6 percent excellent (<5 MPE), 27.3 percent good (5-10 MPE), 13.6 percent fair (10-25 MPE), and 4.5 percent poor (>25 MPE) (Appendix F). The range of velocity adjustment factors were reasonable for the range of flows simulated and trends in velocity adjustment factors were as expected; velocity adjustment factors were typically within the range 0.90-1.10 when the calibration flow equaled the simulated flow (Appendix F).

All transect Froude numbers assumed reasonable values for the flows simulated.

The range of flows simulated for the Ocmulgee River was 50-3,500 cfs. This range of flows is approximately equivalent to zero power generation with some dam leakage to the maximum capacity of the Lloyd Shoals facility under full power production at the most efficient gate setting.

5.2.3 Habitat Simulation Output

A separate habitat simulation output (WUA versus discharge) was produced for each of the separate calibration flows (sets of velocity measurements). Depending on the quality of the data and hydraulic characteristics of the stream, the WUA versus discharge functions can be somewhat different for each calibration flow. In terms of evaluating the simulation output, and in anticipation of using the habitat-discharge functions in further analyses, a decision must be made as to the function which most accurately depicts the habitat-discharge dynamics of the stream. Two alternatives are possible: (1) selecting output of habitat simulation based on the best and most complete calibration data set, and (2) producing hybrid habitat-discharge functions by combining output from habitat simulations of separate discharge ranges for each calibration flow. These alternatives were evaluated by comparing and contrasting the results of each calibration flow in light of hydraulic considerations.

Figures 5-4 and 5-5 illustrate the habitat-discharge functions produced with two independent calibration data sets for the Tugalo and Ocmulgee rivers. A summary of these data are presented in Tables 5-2 and 5-3. Inspection of Figure 5-4 shows that estimates of WUA for the Tugalo River are nearly identical regardless of the calibration data set used. For the Ocmulgee River, estimates of WUA from the two calibration flows are nearly identical at flows less than 500 cfs and are similar at flows greater than 500 cfs (Figure 5-5).

Based upon the above comparison, it was decided to base the final habitat simulations on the 575 cfs calibration flow for the Tugalo River and the 1,960 cfs calibration flow for the Ocmulgee River. The reasoning behind this decision was twofold:

1. For both rivers, the lower stream flows at which velocity measurements were taken were quite low. Consequently, the hydraulic simulation is based on fewer data, because fewer cells are underwater and exhibit measurable velocity. Thus, many of the transect roughness coefficients have to be assigned either from water's edge cells or averages from the wetted cells. In contrast, hydraulic simulations performed on velocity data sets collected at intermediate flows (i.e., 575 cfs at Tugalo River and 1,960 cfs at Ocmulgee River) benefit from larger amounts of data and are more accurate in simulating velocity distributions over a broad range of discharges.

2. Inspection of the habitat-discharge functions shows that at the lower range of stream flows, WUA is predicted to be nearly identical, regardless of the data set. Therefore, there is apparently no need to combine results of habitat simulations of different flow ranges based on separate calibration data sets.

Based on the above arguments, final habitat-discharge functions were generated for the Tugalo River based on the 575 cfs calibration flow and for the Ocmulgee River based on the 1,960 cfs calibration flow (Figure 5-4 and 5-5); these functions represent the most accurate habitat versus discharge functions simulated for each study stream.

5.2.4 Habitat-Discharge Relations

Plots of the relationship between available habitat (WUA) and stream discharge for each species life stage are presented in Figure 5-6 for the Tugalo River and in Figure 5-7 for the Ocmulgee River. A summary of these data in tabular form are presented in Tables 5-2, 5-3, and Appendix G.

Three general types of habitat-discharge relations were observed in the Tugalo and Ocmulgee rivers. In the Type-I relations, WUA was near zero at low flow, increased at a moderate rate, exhibited a broad peak, and then gradually declined with increasing discharge (e.g., adult silver redhorse, adult redeye bass) (Figure 5-6). In Type-II relations, WUA increased rapidly from a low or moderate value at low flow, exhibited a narrower peak, and declined rapidly (e.g., spawning redbreast sunfish, margined madtoms, spawning bluehead chubs) (Figure 5-6). In Type-III relations, WUA peaked at low flows and decreased with increasing discharge. These patterns are similar to those reported by Leonard and Orth (1988), and their terminology is adopted here. The assignment of species life stages to these patterns is not exact since the habitat-discharge relations of some species are intermediate.

The shape of the habitat-discharge response curve is a function of the species life stage habitat preferences and reflects the interaction between hydraulic variables and channel structure with increasing discharge: (1) rapid increase in wetted stream bottom area (depth to a lesser extent) especially in riffle areas; (2) increases in velocity; and (3) inundation of areas of variable substrate and cover types. Velocity is affected more by a given change in flow than other hydraulic variables (Kraft 1972; Williams and Winget 1979). As a result, the maximum habitat range of a species life stage is often closely associated with its velocity preference (Leonard and Orth 1988).

Species life stages that use similar microhabitats (habitat-use guilds) typically exhibit similar habitat-discharge relations (Leonard and Orth 1988). This was found to be true of the species life stages included in habitat modeling on the Tugalo and Ocmulgee rivers (Figures 5-6 and 5-7), and some generalizations are outlined below.

Species life stages inhabiting shallow-slow habitats (e.g., YOY of northern hog sucker, striped jumprock, redeye bass) typically exhibit Type-III habitat discharge relations. At low flows, both the Ocmulgee and Tugalo rivers retain a substantial proportion of their total surface area, and shallow-slow habitats are abundant throughout the channel, yielding high WUA values for these species. As discharge increases, WUA values decrease due to increasing depths and velocities above the preferred or tolerated ranges of these small YOY fishes. Habitat for this group of species is maximized at near-zero flows. Some species exhibiting a Type-III response may exhibit a unimodal peak in WUA at very low flows not shown in our data due to extrapolation limits on hydraulic simulations.

Species life stages inhabiting shallow to moderate depths and with moderate to fast water velocity preferences (e.g., spawning bluehead chub, adult margined madtoms, juvenile Altamaha shiners), typically exhibited a Type-II habitat-discharge relation (Figures 5-6 and 5-7). At low flow, substantial amounts of shallow to moderate depth habitat is available, but velocity is often too slow. With increasing discharge, WUA rapidly increases as velocities increase and the channel is wetted; soon velocities enter unsuitable ranges and WUA drops off rapidly. The slope of the ascending limb of the curve and the location and width of its peak closely reflect the velocity preferences of the species life stage; species with moderate velocity preferences have steeper ascending portions of the curve and peak at lower flows than species with higher or wider velocity preferences. For some species life stages with narrow depth tolerances, depth may be a more limiting habitat variable.

Those species preferring deeper runs and pool habitat and/or having wide velocity tolerances (e.g., adults and juveniles of redeye bass, shoal bass, whitefin shiners, Altamaha shiners, silver redhorse, striped jumprock, redbreast sunfish) generally exhibited Type I habitat-discharge relations. Although pools and runs maintain some of their depth and surface areas at low flows, velocities are usually too low. As discharge increases, velocities enter suitable ranges and new areas of suitable depth are created. Habitat is maximized at moderate flows, and due to wide velocity preferences, WUA does not decline as rapidly with additional flow, resulting in broad peaks on the WUA curve for some species.

The habitat versus discharge plots for some species exhibit irregularities (i.e., stair-step patterns or secondary peaks). These patterns relate to irregularities in the stream channel and the location of areas with suitable/preferred substrate or cover. As discharge in the stream increases, areas of the channel are inundated and depths and velocities increase at different rates and often in a nonlinear fashion. Local areas of the stream channels may shift alternately between highly suitable and unsuitable, creating the observed patterns.

PHYSICAL HABITAT SIMULATION FLOW CHART

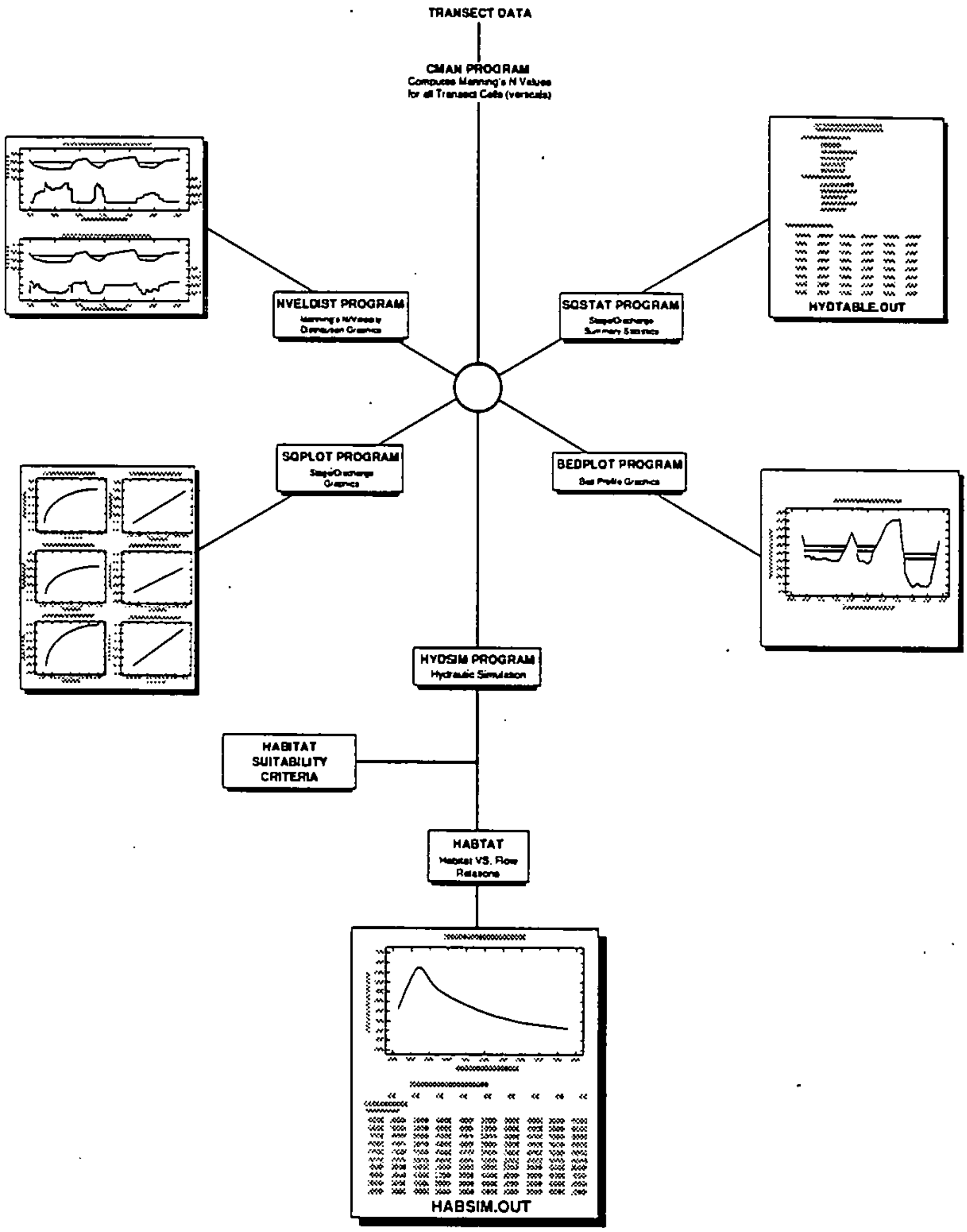


Figure 5-1. Diagram of steps in process of physical habitat simulation illustrating Pascal programs and diagnostics.

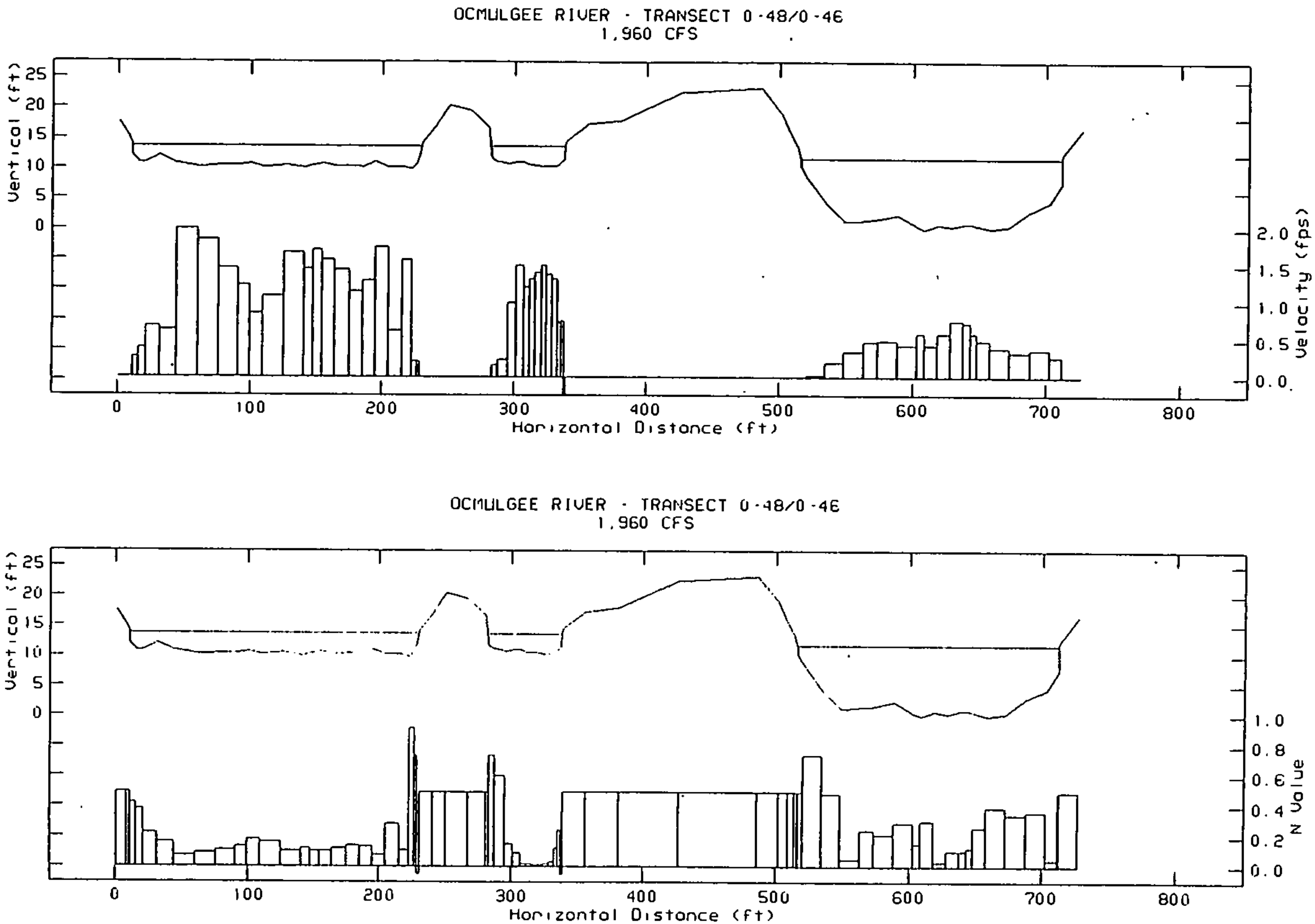


Figure 5-2. Example output of EA's NVELDIST program showing transect cross sectional profile and distribution of velocities and computed Manning's n values. Ocmulgee River transect 0-48/0-46 at a flow of 1,960 cfs is illustrated.

OCMULGEE RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT O-51 AND O-47; DIVIDED CHANNEL RUN/POOL AND DIVIDED CHANNEL SHOAL HABITATS

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 0.4 TO 261.1 FEET

STAGE OF ZERO FLOW (SZF)= 88.60

INTERCEPT (LN(A)) = -0.3756
SLOPE (B) = 0.2271

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	3021.179	0.943
1960.000	1843.542	1.063
650.000	630.224	1.031
375.000	387.901	0.967

MEAN % ERROR	4.61
VARIANCE	2.52
STANDARD DEVIATION	1.59
SAMPLE SIZE	4

TRANSECT SECTION : 302.1 TO 406.0 FEET

STAGE OF ZERO FLOW (SZF)= 88.78

INTERCEPT (LN(A)) = -1.2924
SLOPE (B) = 0.3296

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2826.585	1.008
1960.000	1939.768	1.010
650.000	691.309	0.940
375.000	359.221	1.044

MEAN % ERROR	3.10
VARIANCE	7.10
STANDARD DEVIATION	2.66
SAMPLE SIZE	4

TRANSECT SECTION : 418.0 TO 563.4 FEET

STAGE OF ZERO FLOW (SZF)= 88.78

INTERCEPT (LN(A)) = -1.4324
SLOPE (B) = 0.3436

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2799.033	1.018
1960.000	1961.065	0.999
650.000	693.586	0.937
375.000	357.639	1.049

Figure 5-3. Example output of EA's SQSTAT program illustrating stage-discharge and hydraulic simulation diagnostics.

MEAN % ERROR	3.29
VARIANCE	8.73
STANDARD DEVIATION	2.95
SAMPLE SIZE	4

HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR	
					1960 CFS DATA SET	375 CFS DATA SET
50	320.4	2.1	0.07	0.009	0.080	0.254
100	382.5	1.9	0.13	0.017	0.143	0.438
150	402.0	2.0	0.19	0.024	0.195	0.592
200	408.1	2.1	0.23	0.028	0.237	0.714
250	410.2	2.2	0.28	0.033	0.275	0.821
300	412.0	2.3	0.32	0.037	0.310	0.917
350	413.5	2.4	0.36	0.041	0.343	1.004
400	414.9	2.5	0.39	0.044	0.373	1.085
500	423.3	2.6	0.46	0.051	0.429	1.231
700	418.5	2.8	0.60	0.063	0.528	1.491
900	418.9	3.0	0.72	0.073	0.612	1.707
1100	419.3	3.2	0.83	0.082	0.688	1.897
1300	419.7	3.3	0.94	0.091	0.756	2.069
1500	420.1	3.4	1.04	0.099	0.820	2.226
2000	420.9	3.7	1.29	0.118	0.961	2.575
2400	421.8	3.9	1.47	0.132	1.061	2.819
2800	422.5	4.0	1.64	0.144	1.153	3.042
3200	423.2	4.2	1.81	0.156	1.238	3.248
3600	424.0	4.3	1.97	0.167	1.317	3.439
4000	424.7	4.4	2.13	0.178	1.392	3.619

Figure 5-3 (Cont.)

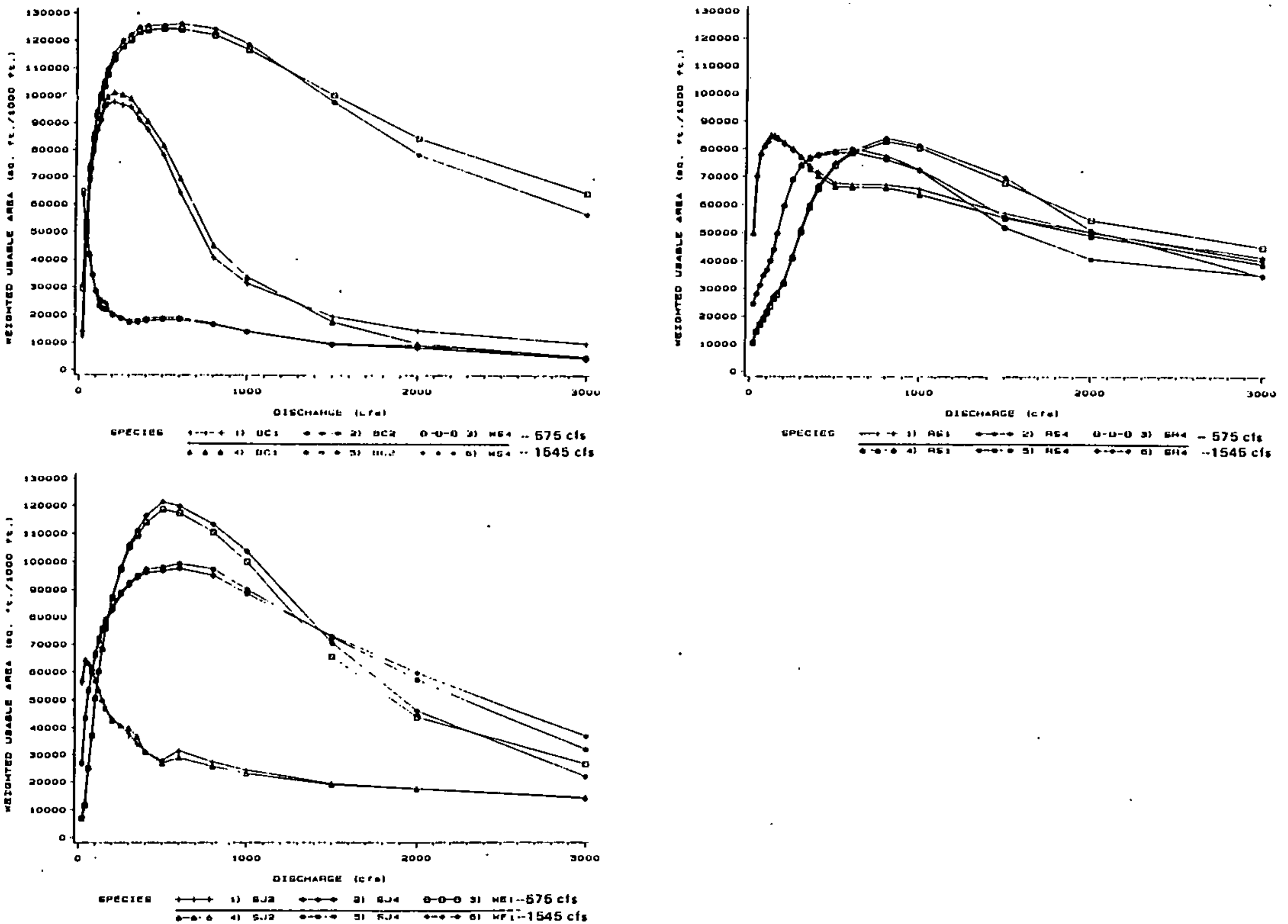


Figure 5-4. Comparison of weighted usable area versus discharge relations produced by separate calibration flows (575 cfs, 1,545 cfs) for selected species on the Tugalo River. Species abbreviations are listed in Table 4-1; life stage codes are 1 = spawning, 2 = young-of-the-year, 3 = juvenile, and 4 = adult.

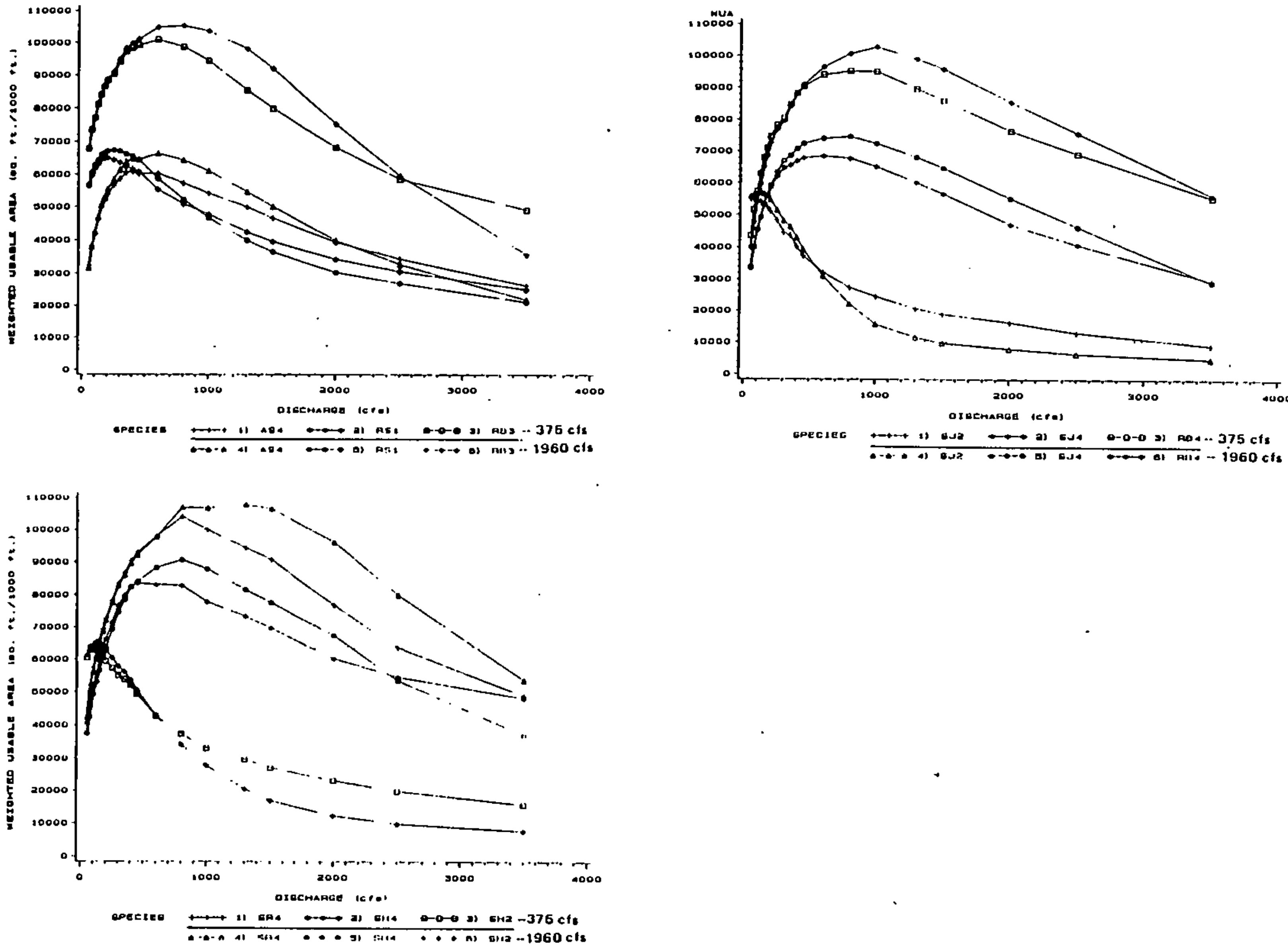


Figure 5-5. Comparison of weighted usable area versus discharge relations produced by separate calibration flows (375 cfs, 1,960 cfs) for selected species on the Ocmulgee River. Species abbreviations are listed in Table 4-1; life stage codes are 1 = spawning, 2 = young-of-the-year, 3 = juvenile, and 4 = adult.

TABLE 3-1 FISH SAMPLING GEAR, EFFORT[(a)], AND HABITATS SAMPLED AT EACH SITE IN THE MATHIS-TERRORA BYPASS, TALLULAH GORGE, TUGALO RIVER, AND OCMULGEE RIVER DURING 16-23 SEPTEMBER 1987

Study Area	Site[(b)]	Fish Sampling Gear Type/Effort[(a)]/Habitat
Mathis-Terrora Bypass	1	Backpack and pram; 83 min; 660 ft, pool, riffle, run
	2	Backpack; 30 min; 255 ft pool, riffle, run
	3	Backpack; 20 min; 168 ft, pool riffle, run, backwater
	4	Backpack; 20 min; 100 ft, pool, emergent vegetation
Tallulah Gorge	1	Backpack; 30 min; 150 ft, pools, runs
	2	Backpack; 20 min; 165 ft, cascade, run
	3	Backpack; 27 min; 183 ft, pool, cascade, run
	4	Backpack; 30 min; 200 ft, chutes, cascade, run
	5	Backpack; 45 min; 668 ft, pools, run, cascade, chutes
Tugalo River	1	Boat; 17 min; pool, run Boat; 50 min; pool
	2	Backpack and pram; 90 min; riffle, run, shallow pool Backpack; 85 min; riffle, run, backwater
Ocmulgee River	1	Backpack and pram; 60 min; shoal, riffle, shallow run Boat; 50 min; pool, deep and shallow run, backwater
	2	Backpack and pram; 55 min; shoal, riffle, shallow run Boat; 90 min; pool, run

(a) Effort = Measure of time (minutes) or distance of stream reach over which sampling occurred.
(b) See Figures 2-1 through 2-4 for locations of sampling sites.

TABLE 3-2 COMMON AND SCIENTIFIC NAMES OF FISH SPECIES FOUND IN THE MATHIS-TERRORA BYPASS, TALLULAH GORGE, TUGALO RIVER, AND OCMULGEE RIVER STUDY AREAS

Common Name	Scientific Name
LEPISOSTEIDAE	
Longnose gar	Lepisosteus osseus
AMIIDAE	
Bowfin	Amia calva[c]
ANGUILLIDAE	
American eel	Anguilla rostrata
CLUPEIDAE	
Blueback herring	Alosa aestivalis[a]
Gizzard shad	Dorosoma cepedianum
SALMONIDAE	
Rainbow trout	Oncorhynchus mykiss
ESOCIDAE	
Chain pickerel	Esox niger
CYPRINIDAE	
Central stoneroller	Campostoma anomalum
Common carp	Cyprinus carpio
Rosyface chub	Hybopsis rubrifrons[b]
Bluehead chub	Nocomis leptocephalus[a]
Golden shiner	Notemigonus crysoleucas[c]
Ocmulgee shiner	Notropis callisema(c)
Pugnose minnow	Notropis emiliae(c)
Spottail shiner	Notropis hudsonius(a)
Yellowfin shiner	Notropis lutipinnis(a)
Whitefin shiner	Notropis niveus(a)
Coastal shiner	Notropis petersoni(c)
Altamaha shiner	Notropis xaenurus(a)
Bandfin shiner	Notropis zonistius(a)
CATOSTOMIDAE	
Creek chubsucker	Erimyzon oblongus[c]
Northern hog sucker	Hypentelium nigricans[a]
Spotted sucker	Minytrema melanops
Silver redhorse	Moxostoma anisurum
Smallfin redhorse	Moxostoma robustum[b,c]
Striped jumprock	Moxostoma rupiscartes
ICTALURIDAE	
Snail bullhead	Ictalurus brunneus[a]
White catfish	Ictalurus catus
Brown bullhead	Ictalurus nebulosus[a]
Flat bullhead	Ictalurus platycephalus[b,c]
Channel catfish	Ictalurus punctatus
Margined madtom	Noturus insignis(a)
Flathead catfish	Pylodictis olivaris(c)
POECILIIDAE	
Mosquitofish	Gambusia affinis
ATHERINIDAE	
Brook silverside	Labidesthes sicculus[c]
PERCICHTHYIDAE	
White bass	Morone chrysops
CENTRARCHIDAE	
Redbreast sunfish	Lepomis auritus[a]
Green sunfish	Lepomis cyanellus
Bluegill	Lepomis macrochirus
Dollar sunfish	Lepomis marginatus
Redear sunfish	Lepomis microlophus[a,b]
Redeye bass	Micropterus coosae(a)
Smallmouth bass	Micropterus dolomieui(b)
Largemouth bass	Micropterus salmoides
Shoal bass	Micropterus sp.
Black crappie	Pomoxis nigromaculatus
PERCIDAE	
Swamp darter	Etheostoma fusiforme[b]
Turquoise darter	Etheostoma insciptum[a,b]
Tessellated darter	Etheostoma olmstedi(c)
Yellow perch	Perca flavescens
Blackbanded darter	Percina nigrofasciata[a]
Walleye	Stizostedion vitreum vitreum
MUGILIDAE	
Striped mullet	Mugil cephalus[c]
COTTIDAE	
Mottled sculpin	Cottus bairdi[b]

(a) ID verified by Freeman.
(b) Collected by EA (in progress) in North Georgia study area (not collected during this study).
(c) Collected by EA (in progress) in Ocmulgee River (not collected during this study)

TABLE 3-3 FISH SPECIES COMPOSITION AND LENGTH DATA FOR ALL MATHIS-TERRORA BYPASS SAMPLING SITES COMBINED; COLLECTION PERIOD 16-23 SEPTEMBER 1987

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Bluehead chub	88	19.8	78.0	33	153	26.8
Redbreast sunfish	75	16.9	98.0	50	186	33.3
Yellowfin shiner	74	16.7	57.8	31	80	9.0
Northern hog sucker	62	14.0	127.3	46	256	53.0
Bandfin shiner	40	9.0	85.5	60	106	12.4
Whitefin shiner	39	8.8	61.4	31	88	12.1
Margined madtom	33	7.4	98.5	30	146	22.4
Redeye bass	8	1.8	125.5	59	211	48.6
Stoneroller	8	1.8	93.5	77	125	14.8
Striped jumprock	7	1.6	197.3	165	252	33.2
Largemouth bass	3	0.7	132.3	41	236	98.1
Green sunfish	3	0.7	155.0	136	171	17.7
Snail bullhead	3	0.7	101.7	98	105	3.5
Bluegill	1	0.2	75.0	75	75	.
All	444	100.0	89.7	30	256	40.3

TABLE 3-4 FISH SPECIES COMPOSITION AND LENGTH DATA FOR ALL TALLULAH GORGE SAMPLING SITES COMBINED; COLLECTION PERIOD 16-23 SEPTEMBER 1987

			Length (mm)			
Species	Number	Percent	Mean	Minimum	Maximum	Standard Deviation
Bluehead chub	129	51.2	52.0	30	163	25.8
Redbreast sunfish	48	19.0	63.8	29	180	46.6
Stoneroller	32	12.7	64.9	38	127	26.9
Redeye bass	17	6.7	112.6	76	290	56.4
Northern hog sucker	10	4.0	84.6	72	100	10.6
Snail bullhead	7	2.8	201.4	170	230	22.1
Yellowfin shiner	5	2.0	41.8	38	47	3.9
Brown bullhead	2	0.8	69.5	68	71	2.1
Striped jumprock	1	0.4	193.0	193	193	.
Margined madtom	1	0.4	54.0	54	54	.
All	252	100.0	65.9	29	290	43.7

TABLE 3-5 FISH SPECIES COMPOSITION AND LENGTH DATA FOR ALL TUGALO RIVER SAMPLING SITES COMBINED; COLLECTION PERIOD 16-23 SEPTEMBER 1987

			Length (mm)			
Species	Number	Percent	Mean	Minimum	Maximum	Standard Deviation
Blackbanded darter	74	15.6	78.2	46	101	11.2
Bluegill	65	13.7	112.8	51	193	26.3
Margined madtom	57	12.1	89.6	44	128	15.5
Redbreast sunfish	50	10.6	134.4	46	195	37.5
Yellow perch	31	6.6	105.2	60	162	31.0
Snail bullhead	28	5.9	162.6	100	240	43.7
Largemouth bass	26	5.5	157.0	41	450	112.5
Blueback herring	26	5.5	80.5	73	87	3.4
Spottail shiner	20	4.2	92.4	58	114	13.2
Bluehead chub	17	3.6	128.4	85	200	28.6
Whitefin shiner	16	3.4	79.5	68	95	9.0
Silver redhorse	13	2.7	398.4	303	466	41.6
Redeye bass	11	2.3	172.4	64	301	98.0
Green sunfish	9	1.9	105.9	78	132	19.6
Brown bullhead	7	1.5	162.0	130	200	29.1
Northern hog sucker	6	1.3	158.8	140	194	20.7
Carp	6	1.3	489.2	433	530	44.5
Warmouth	4	0.8	171.8	139	195	26.7
White bass	2	0.4	380.5	361	400	27.6
Striped jumprock	2	0.4	146.0	141	151	7.1
Gizzard shad	2	0.4	300.0	290	310	14.1
Channel catfish	1	0.2	310.0	310	310	.
All	473	100.0	126.7	41	530	81.9

TABLE 3-6 FISH SPECIES COMPOSITION AND LENGTH DATA FOR ALL OCMULGEE RIVER SAMPLING SITES COMBINED; COLLECTION PERIOD 16-23 SEPTEMBER 1987

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Redbreast sunfish	275	30.4	116.6	27	195	30.4
Spottail shiner	152	16.8	83.3	63	117	13.1
Snail bullhead	69	7.6	177.3	45	347	67.1
Altamaha shiner	69	7.6	60.4	38	93	12.5
Spotted sucker	63	7.0	352.2	100	505	92.8
American eel	51	5.6	295.2	190	610	78.6
Largemouth bass	35	3.9	184.4	70	387	88.2
Gizzard shad	32	3.5	322.2	243	386	34.9
Bluegill	30	3.3	150.2	56	220	43.8
Brown bullhead	24	2.7	225.4	86	345	51.0
Silver redhorse	21	2.3	338.6	205	445	86.5
Turquoise darter	16	1.8	48.8	40	71	7.3
Redeye bass	8	0.9	205.6	73	340	84.1
Blackbanded darter	8	0.9	72.9	59	100	15.9
Redear sunfish	8	0.9	193.9	145	300	63.6
Yellowfin shiner	8	0.9	48.3	40	54	5.8
Bluehead chub	7	0.8	120.4	72	155	27.3
Striped jumprock	6	0.7	179.3	160	204	17.0
Yellow perch	5	0.6	196.8	102	285	72.8
White catfish	4	0.4	196.5	68	280	90.5
Longnose gar	3	0.3	553.0	376	790	213.4
White bass	2	0.2	465.0	460	470	7.1
Carp	2	0.2	575.0	470	680	148.5
Dollar sunfish	1	0.1	135.0	135	135	.
Margined madtom	1	0.1	90.0	90	90	.
Stoneroller	1	0.1	125.0	125	125	.
Chain pickeral	1	0.1	402.0	402	402	.
Black crappie	1	0.1	.	.	.	.
Warmouth	1	0.1	150.0	150	150	.
Green sunfish	1	0.1	124.0	124	124	.
All	905	100.0	161.0	27	790	109.0

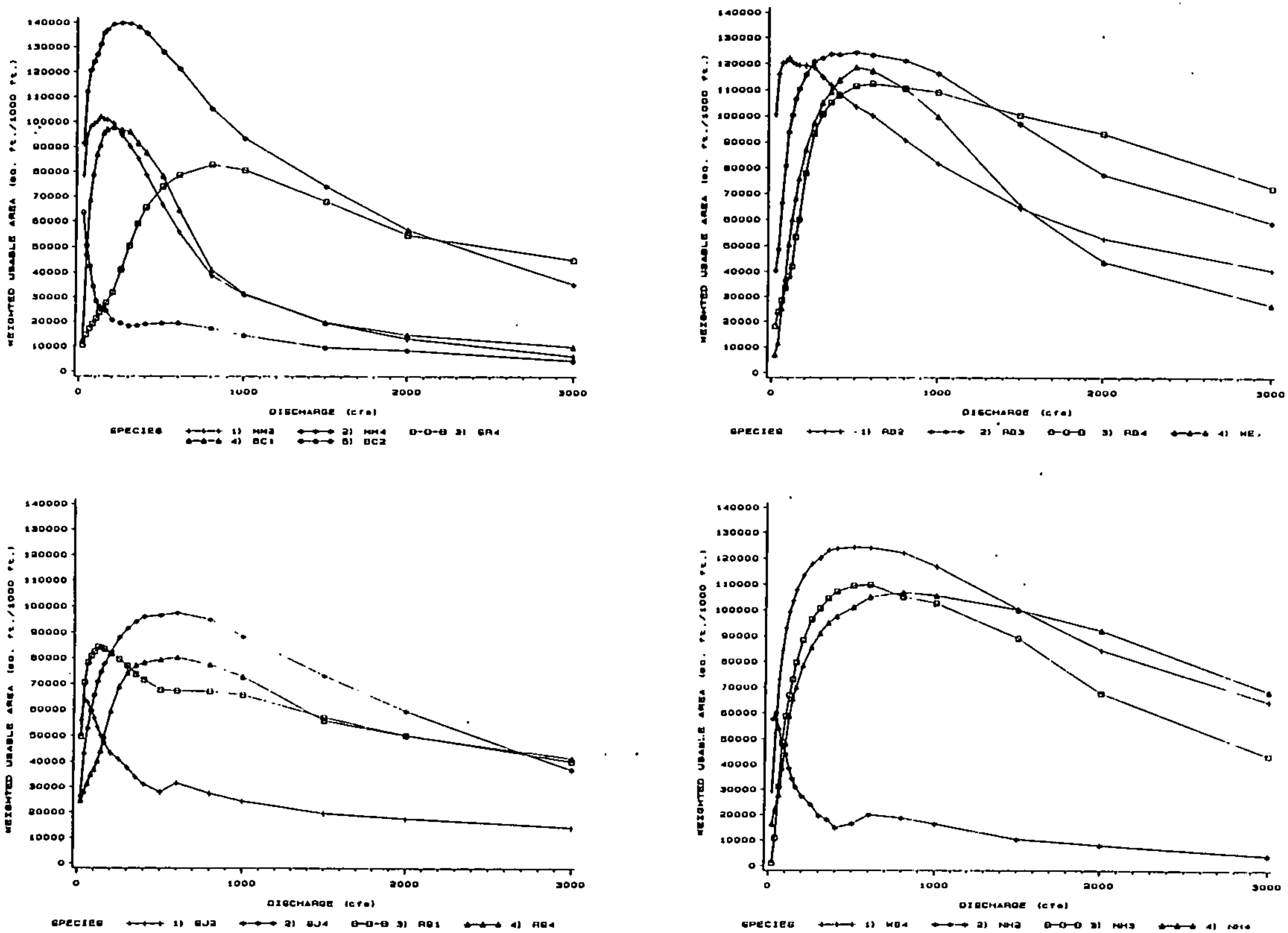


Figure 5-6. Final weighted usable area versus discharge relations for all species life stages in the Tugalo River study area. Species abbreviations are listed in Table 4-1; life stage codes are 1 = spawning, 2 = young-of-the-year, 3 = juvenile, and 4 = adult.

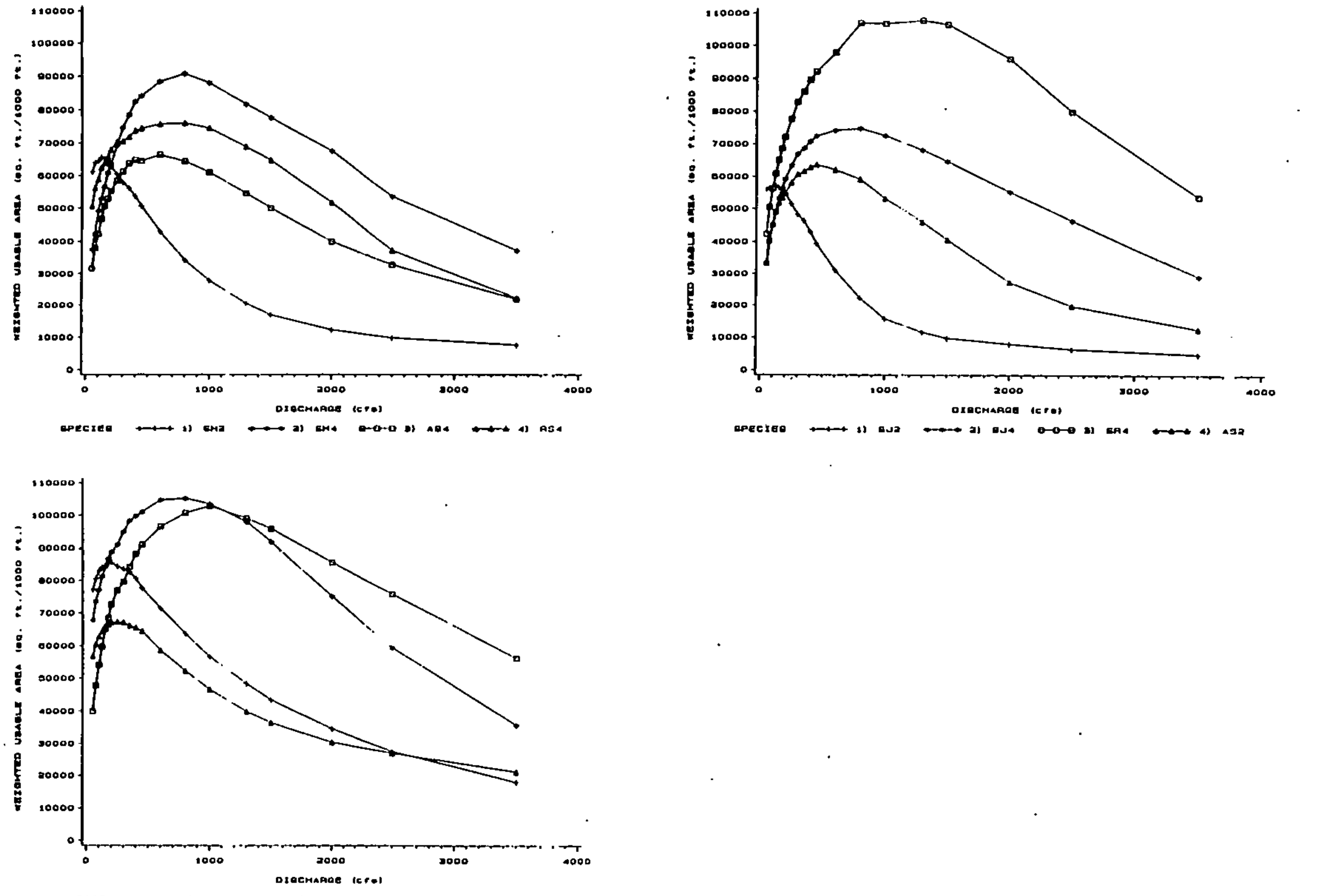


Figure 5-7. Final weighted usable area versus discharge relations for all species life stages in the Ocmulgee River study area. Species abbreviations are listed in Table 4-1; life stage codes are 1 = spawning, 2 = young-of-the-year, 3 = juvenile, and 4 = adult.

TABLE 5-1 SUMMARY OF HYDRAULIC/HABITAT SIMULATION TRANSECT ATTRIBUTES AND COMPUTATION OF TRANSECT WEIGHTING FACTORS[a]

TUGALO RIVER

Transect Number	Habitat Type	Total Length of Habitat Represented (ft)	Percent of Total Reach Length	Weighting Factor
Y-7	Run/Pool	1,324	10.1	0.101
Y-9	Backwater	1,236	9.4	0.094
Y-12	Run	774	5.9	0.059
Y-20	Run	3,622	27.5	0.275
Y-21	Riffle/Run	625	4.8	0.048
Y-24	Riffle/Run	1,794	13.6	0.136
Y-25	Riffle	466	3.5	0.035
Y-26	Run/Pool	1,379	10.5	0.105
Y-29	Riffle	1,940	14.7	0.147
TOTAL		13,160	100.0	1.000

OCMULGEE RIVER

Transect Number	Channel and Habitat Type	Total Area of Habitat Represented (acres)	Average Width (W) of Habitat (ft)	Length Factor (L) (ft) (area/width)	Weighting Factor ($L_i/\Sigma L_i$)
O-9	Divided Channel Shoal	9.2	161	2,489	0.053
O-17	Divided Channel Shoal	9.2	161	2,489	0.053
O-32	Single Channel Run/Pool	36.0	213	7,362	0.157
O-33	Single Channel Pool	55.4	204	11,830	0.252
O-46	Divided Channel Pool	10.8	149	3,157	0.067
O-47	Divided Channel Shoal	9.2	161	2,489	0.053
O-48	Divided Channel Run	10.8	95	4,952	0.106
O-51	Divided Channel Run/Pool	8.4	100	3,659	0.078
O-60	Single Channel Shoal	32.0	356	3,916	0.084
O-84	Single Channel Gravel Run	6.0	140	1,867	0.040
O-95	Single Channel Sandy Run/Pool	10.8	178	2,643	0.056
TOTAL				46,853	1.000

(a) See text for explanation.

TABLE 5-2 SUMMARY OF AVAILABLE HABITAT, EXPRESSED AS WEIGHTED USABLE AREA (WUA) (SQ. FT./1,000 FT.), FOR EACH SPECIES LIFE STAGE AND DISCHARGE IN THE TUGALO RIVER STUDY AREA. RESULTS DERIVED FROM PHYSICAL HABITAT SIMULATION.

SPECIES-LIFE STAGE	DISCHARGE (CFS)									
	20	40	60	80	100	120	140	160	200	250
Bluehead chub-spawn	12621	47411	68478	79085	86983	90597	95540	96811	97746	96574
Bluehead chub-yoy	63395	50502	42296	34292	28312	25767	24924	24253	20540	19214
Margined madtom-yoy	78581	94525	97961	99184	100167	102004	101045	100875	99168	94714
Margined madtom-adult	91333	112089	120624	124096	126999	131038	135653	137045	139313	139679
Northern hog sucker-yoy	57580	59884	53751	47784	44033	38449	34247	30923	27077	23979
Northern hog sucker-juvenile	997	10886	31313	48652	58716	66864	73164	79739	88326	96364
Northern hog sucker-adult	16378	22201	27769	38442	48263	58695	65479	69969	78511	85564
Redeye bass-yoy	100523	115940	120182	120779	122189	120407	119670	119352	119142	118490
Redeye bass-juvenile	40243	48521	66251	80817	93660	100321	106451	110299	115745	120792
Redeye bass-adult	18048	23791	28404	33388	38052	41986	53297	59939	77916	93191
Redbreast sunfish-spawn	49770	70463	78269	80896	82554	84481	84191	83447	81636	79520
Redbreast sunfish-adult	24520	28081	31246	34879	36865	40198	44165	49828	59443	68801
Striped jumprock-yoy	56012	63977	62671	59897	56829	53291	50020	47380	43335	40893
Striped jumprock-adult	26403	43069	52767	59590	65629	70829	74630	77742	82335	88021
Silver redhorse-adult	10446	14501	17041	18979	21134	23513	26319	27738	31828	41034
Walleye-spawn	6955	11560	24975	36969	50558	60013	68045	75828	87041	97213
Whitefin shiner-adult	29398	52323	72972	84212	92939	99251	103422	107732	113321	117950
	300	350	400	500	600	800	1000	1500	2000	3000
Bluehead chub-spawn	95915	91370	87564	78155	64330	40789	31365	19613	14497	9800
Bluehead chuh-yoy	18084	18275	18836	19181	19249	17118	14189	9438	8269	4283
Margined madtom-yoy	90121	85167	78531	66456	55706	38606	30853	19369	12992	6082
Margined madtom-adult	139501	138054	135477	128001	121134	105014	93264	73874	56402	35128
Northern hog sucker-yoy	19530	18004	14815	16342	19866	18553	16261	10296	7923	3866
Northern hog suck :-juvenile	100616	104563	107109	109398	109790	105057	102552	89045	67597	43185
Northern hog sucker-adult	90942	95000	97510	101003	105035	106826	105543	100070	91993	68118
Redeye bass-yoy	114812	111824	108358	103588	100130	90674	81646	64291	52658	40371
Redeye bass-juvenile	122103	123624	123439	124268	123210	121041	116205	96926	77295	58646
Redeye bass-adult	100617	105114	107895	111410	112313	110646	109097	100304	93173	72045
Redbreast sunfish-spawn	76999	73624	71488	67589	67176	66941	65583	56954	50209	40051
Redbreast sunfish-adult	74183	77193	78257	79397	80243	77378	72697	55732	49981	41278
Striped jumprock-yoy	37614	33963	31038	27766	31470	27214	24132	19366	17360	13877
Striped jumprock-adult	91505	94162	96067	96599	97496	94920	88368	73008	59343	36703
Silver redhorse-adult	50327	58936	65497	73964	78533	82753	80466	67773	54435	44834
Walleye-spawn	105065	109166	113723	118501	117125	110281	99770	65262	43734	26377
Whitefin shiner-adult	120247	123167	123839	124368	124116	122052	116785	100303	84418	64140

TABLE 5-3 SUMMARY OF AVAILABLE HABITAT, EXPRESSED AS WEIGHTED USABLE AREA (WUA) (SQ. FT./1,000 FT.), FOR EACH SPECIES LIFE STAGE AND DISCHARGE IN THE OCMULGEE RIVER STUDY AREA. RESULTS DERIVED FROM PHYSICAL HABITAT SIMULATION.

SPECIES-LIFE STAGE	DISCHARGE (CFS)									
	50	75	100	125	150	175	200	250	300	350
Altamaha shiner-yoy	33324	41084	45184	49075	51793	53388	54938	58120	60707	61618
Altamaha shiner-adult	31627	37985	42240	46746	50570	52890	55291	58410	61234	63686
Redeye bass-yoy	77151	80581	83032	84186	84646	85411	85567	84413	83611	82549
Redeye bass-juvenile	67861	73532	77053	81258	84134	86749	88741	90952	94887	98286
Redeye bass-adult	39953	47795	54088	59716	65047	68559	72650	76974	79562	84237
Redbreast sunfish-spawn	56725	60466	62913	64310	66021	66482	67059	67306	67084	66153
Redbreast sunfish-adult	50536	56180	58862	62435	63775	65801	67927	70267	70484	71834
Shoal bass-yoy	61134	63989	64465	65600	65162	64537	62777	60472	57887	56130
Shoal bass-adult	37510	42285	49171	52929	56592	60820	63501	69204	74690	78471
Striped jumprock-yoy	56035	56612	56821	57203	56608	55934	54721	51472	48177	46330
Striped jumprock-adult	33540	39885	45234	49179	53260	56316	59293	63399	66946	68703
Silver redhorse-adult	42343	50495	56227	60964	65161	68645	72166	77696	82936	86041

SPECIES-LIFE STAGE	400	450	600	800	1000	1300	1500	2000	2500	3500
Altamaha shiner-yoy	62875	63672	62058	59135	53085	45919	40551	27245	19695	12438
Altamaha shiner-adult	64764	64459	66323	64272	60897	54517	49928	39815	32686	21722
Redeye bass-yoy	80695	77674	71441	63684	56613	48328	43404	34544	27411	17853
Redeye bass-juvenile	99794	101029	104667	105110	103388	97928	91818	75147	59409	35622
Redeye bass-adult	88159	90983	96539	100692	102799	99016	95839	85569	75810	56128
Redbreast sunfish-spawn	65515	64463	58597	52195	46548	39830	36354	30239	26841	21019
Redbreast sunfish-adult	73749	74446	75701	75966	74412	68683	64573	51561	37154	22076
Shoal bass-yoy	53639	50595	42904	34186	27771	20447	16821	12185	9703	7542
Shoal bass-adult	82388	84073	88323	90658	87913	81571	77554	67401	53413	37077
Striped jumprock yoy	43007	39352	31045	22199	15656	11540	9700	7950	6391	4787
Striped jumprock-adult	70868	72464	74144	74716	72518	68165	64728	55215	46356	29048
Silver redhorse-adult	89575	92095	97810	106935	106712	107736	106480	96043	79974	53629

6. STREAM TEMPERATURE STUDY

Temperature is one of the most important environmental parameters that affects the biota of an aquatic system (Macan 1961; Hubbs 1972; Coutant 1983) and is a major component that determines the suitability of stream habitats for various fish species (Armour 1988). Impounding running waters results in a modification of the downstream thermal regime (Ward and Stanford 1979; Walburg et al. 1983); the magnitude of this modification depends primarily on release depth, thermal stratification of the reservoir, hydraulic residence time, and dam operation.

From the perspective of maintaining suitable instream flows downstream of GPC hydro facilities, the most important question is: Do tailwater temperatures remain suitable for the survival and propagation of resident fish species during low flows associated with periods of non-generation? Detailed historical temperature data necessary to make this determination for the Tallulah Gorge, Tugalo River, and Ocmulgee River were found to be lacking. In order to evaluate this question, a detailed temperature monitoring and evaluation study was conducted for each study area.

The objective of the temperature monitoring study was to determine if stream temperatures in the study areas are suitable for the propagation (spawning, growth, survival) of resident fish species under existing flow regimes. This study was designed as a component of the scoping process (Chapter 2) to determine whether temperature must be incorporated into the physical habitat simulation process.

Thermal Classification of Study Streams

Stream and river classifications are often generalized with respect to temperature into two categories: warmwater and coldwater. Temperatures between 20 C and 26 C are usually cited as the threshold value separating warmwater and coldwater streams (Embody 1921; Ricker 1934; Moyle and Chech 1982; Ohio EPA 1987). Based on this criterion and the physical, chemical, and biological attributes characterizing warmwater and coldwater streams outlined by Winger (1980), each of the study streams would be classified as a warmwater stream.

"Warmwater streams" range from relatively cool, small headwater streams with turbulent flow, stable rubble-gravel substrates, and inhabited by smallmouth bass, to the comparatively warmer lowland floodplain systems with quiet flow, sand-mud substrates, and inhabited by largemouth bass (Winger 1980). This range of warmwater stream types is represented in the four study areas from the Tallulah River to the Ocmulgee River.

Notwithstanding the above discussion, GDNR commented that "The Tugalo River should be considered a coolwater not a warmwater habitat, and the walleye and redeye bass included as study species at this site" (Appendix A). Some "coolwater" fish species are present at the Tugalo River study area (e.g., bluehead chub, walleye, yellow perch). In recognition of this fact, the fish species selected for temperature analysis included coolwater fish species (Table 6-1) and was therefore consistent with GDNR's request.

Rationale and Approach

To date, little guidance has been available for evaluating thermal regimes downstream of hydroelectric facilities. Much of the available information on the thermal requirements and tolerance of fishes was developed to evaluate the discharge of heated waters from power plants (Coutant 1977). Most recently, the U.S. Fish and Wildlife Service (FWS) has presented guidelines to aid biologists in analyzing stream temperature regimes and preparing recommendations for fish protection (Armour 1988); the options presented are to base evaluations on: (1) experimental temperature tolerance results, (2) suitability of a temperature regime for key life stages, or (3) population statistics and predicted responses to simulated temperatures.

The approach used herein is considered sound, as it incorporates aspects of each of the three approaches to temperature evaluation proposed by Armour (1988). Our reasoning follows that of Brungs and Jones (1977) and Nestler et al. (1986) that temperature regimes should protect appropriate and desirable species, but should not be unnecessarily restrictive to project operations. The stream temperature evaluation study herein consisted of four components. First, ambient stream temperatures were continuously monitored in each study stream. Second, experimental temperature response data and temperature requirements were compiled from the literature for target species and life stages. The rationale and criteria used in selecting target species life stages were presented to and reviewed by natural resource agencies (see Section 2.4 and Appendix A). Third, the temperature criteria for these fish species were compared to existing stream temperatures to evaluate for potential impacts on spawning, growth, and survival. Time periods for evaluation of each life stage and activity were determined from species phenologies (Figure 6-1) (e.g. critical spawning period, summer growth). Fourth, ambient temperatures of the study streams were qualitatively compared to the thermal regimes of adjacent or nearby unregulated streams.

6.1 METHODS

6.1.1 Stream Temperature Monitoring

Stream temperatures were monitored from July 1987 through October 1988 at half hour intervals at upstream (dam tailrace) and downstream sites in each of the four study areas (Figures 2-1 through 2-4). At each site, a Ryan Model RTM-1 continuous recording thermograph (range -32C to +70 C, resolution 0.1 C, accuracy ±0.3 C; Ryan Instruments, Inc.) was permanently installed instream in a submersible waterproof case. Each installation point was selected to ensure that water circulated around the instrument at all discharges and that the instrument was not in direct sunlight. Thermographs were visited every 90 days throughout the operational period to retrieve stored data and to ensure that they were functioning properly.

Thermographs were originally proposed to be operational during the warmer months (May-October of 1987). The actual period of record varied for each thermograph. In the Tugalo and Ocmulgee rivers, the monitoring period was substantially longer than proposed, and included up to a full year of data at some sites. Gaps in the data were the result of both intentional removal during winter periods and loss of instruments. Instruments were removed temporarily during fall and winter periods at the Tugalo and Ocmulgee River sites. At Tiger Creek, thermographs at the upstream and downstream sites were removed permanently on 26 June 1988 and 20 September 1987, respectively. Two thermographs were lost at the Tallulah Gorge downstream site. One thermograph was dislodged and lost between 2 December 1987 and 31 March 1988. An additional thermograph was lost sometime between July and October 1988 as a result of unanticipated flow in the Gorge bypass area; it was later recovered, but was damaged beyond repair.

Upon retrieval of the instruments from the stream, the accumulated temperature data were downloaded to a computer for analysis. Two types of analysis were performed: (1) determination of weekly mean, minimum, and maximum temperatures; and (2) determination of the frequency and duration of time intervals during which stream temperature exceeded specific thermal criteria for key species. Weekly mean, minimum, and maximum temperatures were calculated on the basis of a 7-day period arbitrarily defined as 0000 hours Sunday to 2400 hours Saturday. Therefore, full-week periods consisted of 336 temperature measurements, and some partial weeks were created. For each time interval during which the stream temperature exceeded a biological temperature criterion, the following was determined: start date and time, end date and time, duration of time interval (hours), and maximum temperature during the time interval.

A literature review was conducted to obtain information on spawning, growth, and survival temperature requirements for each species and life stage selected (Table 6-1). Although a variety of temperature criteria have been used to assess temperature regimes, none are consistently available in the literature. In decreasing preference, thermal data used as spawning criteria included maximum temperature for embryo survival (MTES), upper limit of optimum range for spawning (ULS), and preferred spawning temperature. Criteria used for growth included maximum weekly average temperature (MWAT), optimum growth temperature, and final preferendum (FP). Criteria used for survival included ultimate upper incipient lethal temperature (UUILT), upper incipient lethal temperature (UILT), projected upper lethal threshold, and upper avoidance temperature (UA). Definitions and further discussion concerning these temperature criteria can be found in Brungs and Jones (1977), EPA (1986), and Armour (1988).

The suitability of the existing temperature regime was evaluated in each area by comparing ambient stream temperatures with the appropriate spawning, growth, and survival temperature criteria. Each comparison was made only for the period during which a life stage was present or activity (e.g. spawning) was occurring. When a species temperature criterion was exceeded, the frequency and duration of periods during which they were exceeded were examined to evaluate the magnitude or severity of the temperature effect.

In the final step in the temperature analysis, maximum temperatures in each study area were compared with maximum temperatures in nearby unregulated rivers. This component of the analysis was constrained by available data, typically from USGS gauging stations.

6.1.2 Fish Temperature Criteria

A temperature evaluation for spawning, growth, and survival functions was performed for 11 species of fish including warmwater and coolwater representatives (Table 6-1). Temperature criteria were evaluated for warmwater species in the Ocmulgee River. For two species, silver redhorse and walleye, only spawning requirements were evaluated.

An attempt was made to select appropriate temperature criteria which most accurately depicted the upper temperature limits for spawning, growth, and survival of each species and life stage. Criteria derived experimentally were favored and were preferentially selected, when available, over criteria derived from field observations. For evaluation of spawning, the maximum temperature for embryo survival (MTES) was preferred, but the ULS was also used. For evaluation of growth, the MWAT was the preferred criterion. When MWAT data were not available, the FP and optimum growth (OG) criteria (Jobling 1981) were used; both are conservative estimates of the upper temperature limit for growth. For evaluation of survival, the UUILT criterion was preferred, since this criterion is independent of acclimation temperature. When UUILT data were absent, UILT and UA criteria were substituted and acclimation temperatures were cited for reference conditions (Table 6-1). UILT and UA are conservative estimates of the upper temperature limit for survival.

In most cases, temperature criteria were available for the species being evaluated. In two cases, temperature criteria for surrogate species were substituted. Smallmouth bass criteria were used in the evaluation of redeye bass growth and survival. Support for this substitution was based on the premise that smallmouth bass, representing a more northern species with coolwater temperature criteria, would lead to a conservative evaluation. In the second case, river redhorse (*Moxostoma carinatum*) spawning criteria were substituted for silver redhorse spawning criteria due to a paucity of data for the latter.

In one instance, temperature criteria for one species were intended to apply to all members of a genus for which temperature data were otherwise lacking. Temperature criteria for spottail shiner were used to represent *Notropis* species in both North Georgia and Ocmulgee River sites for several reasons. Of the five most commonly observed shiner species--whitefin, Altamaha, spottail, yellowfin, and bandfin--temperature criteria data for spawning, growth, and survival were available only for spottail shiner. Second, yellowfin shiner survival criteria (UILT = 33 C) were similar to spottail shiner survival criteria (UILT = 34 C). Spottail shiner can be considered a more northerly species, and, therefore, temperature criteria are likely to be more conservative in relation to the remaining species.

Finally, temperature criteria should not be viewed as absolutes, since they could be expected to vary geographically, seasonally (i.e. with acclimation), with life stage as well as with the physiological condition of the fish (Armour 1988). However, the criteria used here were considered best estimates available to predict possible temperature problems and were usually conservative.

6.2 RESULTS AND DISCUSSION

6.2.1 Hydrologic and Meteorologic Conditions

Any conclusions regarding the results of the stream temperature monitoring and evaluation study must be qualified by a statement of the conditions during the monitoring period. These conditions provide a basis for determining the representativeness of the data and the reasonable range of extrapolation of the results.

In order to characterize the meteorologic and hydrologic conditions during the stream temperature monitoring period, NOAA air temperature and precipitation records, USGS flow records, and plant generating records were examined. This permitted a determination of whether the stream temperature monitoring period was warmer/cooler and drier/wetter than average. Air temperature, precipitation, and stream flow data were used because consistent data and calculated "normals" were available and because stream temperatures are sensitive to these variables (Bartholow 1989).

Mean monthly air temperatures for selected North Georgia and Central Georgia cities for the summer months (June, July, August) during 1987 and 1988 are presented in Table 6-2. For the most part, mean monthly temperatures during June, July, and August, for both 1987 and 1988, were above normal, especially during August of both years. One exception was that mean monthly temperatures at Macon in 1988 were slightly cooler than normal for the months of June and July. For all other stations examined, mean monthly temperatures ranged from 0.2-3.6 F above normal for those three months in 1987 and from 0.1-2.8 F above normal for the same period in 1988.

Precipitation records and GPC plant operating records both indicated that 1987 and 1988 were drier than average years. Monthly precipitation records indicated that summer rainfall was less than normal for both 1987 and 1988 (NOAA 1987, 1988). Monthly mean runoff was below normal in both north and central Georgia during the summer months of 1987 and 1988 and both years had below normal runoff for both the 1987 and 1988 water years (Stokes et al. 1988, 1989).

Stream discharge in the Tugalo River study area ranged from approximately 120 to 3,500 cfs during the temperature monitoring period. Low flows of extended duration (periods longer than 48 hours with no generation at Yonah Plant) occurred during the summer periods of 1987 and 1988; the lowest discharges during these periods were estimated to be approximately 120 cfs. Including the flow from Panther Creek and Brasstown Creek, the extended duration low flow estimate at the Tugalo River monitoring station is approximately 120-166 cfs.

Stream discharge in the Ocmulgee River study area ranged from approximately 250 cfs to 3,000 cfs during the temperature monitoring period. Low flows of extended duration (periods longer than 48 hours with no generation at Lloyd Shoals Plant) occurred during the summer periods of 1987 and 1988; the lowest discharge that occurred during these periods was approximately 250 cfs.

Based on the above data, both 1987 and 1988 can be characterized as warm, dry years. During both years the Tugalo and Ocmulgee rivers experienced multiple periods of extended-duration low flows. The results of the temperature monitoring can then be interpreted as representing a near worst-case scenario in terms of maximum stream temperatures under existing flow regimes.

6.2.2 Suitability of Thermal Regime for Key Fish Species

Tugalo River

Stream temperatures in the Tugalo River below Yonah Dam during the period of temperature monitoring ranged from a minimum of 4.9 C to a maximum of 31.3 C (Tables 6-3 and 6-4; Figures 6-2 and 6-3). Temperatures were lowest during January and highest during July and August (Figures 6-2 and 6-3). Mean weekly temperatures ranged from a high of 26 C to a low of 5.3 C (Tables 6-3 and 6-4). Overall temperature patterns exhibited a distinct sine shape. Maximum summer temperatures were similar between years 1987 and 1988 (Figures 6-2 and 6-3).

Water temperatures at site 2 were typically warmer and exhibited greater daily or weekly variation than temperatures at site 1 located immediately below Yonah Dam. Temperatures at site 1 are more uniform due to the proximity to the release of mid-depth water from Yonah Lake. Being further downstream, water reaching site 2 is subject to greater variation in solar radiation and meteorological conditions and thus exhibits greater temperature extremes.

Mean weekly water temperatures in the Tugalo River were within the optimum range for spawning and did not exceed the spawning criterion during the reported spawning period for most species at both sites (Figures 6-2 and 6-3; Table 6-1). Two exceptions were redeye bass and spottail shiner. Mean weekly temperatures exceeded their upper temperature limit for spawning during the latter portion of their reported spawning periods. This is not believed to impact spawning, as temperatures suitable for spawning were available earlier than the reported spawning period for a time period exceeding 5 weeks during April and May. Underwater observations during spring spawning periods provide support for this conclusion. Nests actively guarded by redeye bass, spawning activity by whitefin shiners, and many YOY fish were observed in June 1988.

Maximum weekly water temperatures in the Tugalo River, exceeded spawning criteria at some point over the course of the spawning period for a number of species (Figures 6-2 and 6-3). However, in cases where maximum stream temperatures rose above upper spawning limits, appropriate spawning temperatures were available for at least 5 weeks sometime during the spring and summer. For example, maximum weekly temperatures exceeded the upper limit for optimum spawning of northern hog sucker (23 C) during the last 2 weeks of their reported spawning period (May) at site 2. However, aside from the last 2 weeks in May, temperatures were suitable for spawning for at least 4-6 weeks prior to that time. This observation applies to the other species for which spawning criteria were exceeded--spottail shiner, redeye bass, and brown bullhead. For all other species, maximum weekly temperatures stayed within the bounds for the range of optimum spawning temperatures over the reported spawning periods.

Thermal criteria for growth ranged from 28 C for northern hog sucker to 33 C for redeye bass. At site 1 near Yonah Dam, maximum weekly or mean weekly temperatures never exceeded the criteria for optimum growth for any species evaluated (Figure 6-2). Maximum temperatures peaked at 28 C while mean weekly temperatures reached only 27 C. At site 2, maximum weekly temperatures exceeded growth criteria for several species--redbreast sunfish, brown bullhead, and northern hog sucker (Figure 6-3). The optimum growth criteria for brown bullhead (optimum growth = 31 C) and for redbreast sunfish (final preferendum = 31 C) was met or exceeded on two occasions (for 1.0 and 1.5 hours on 17 and 18 August, respectively) by no more than 0.3 C.

With an optimum growth criterion of 28 C (FP), northern hog sucker is generally considered to be a coolwater species. Ambient stream temperatures exceeded this criterion 19 times between 31 July and 27 August in 1987 for durations ranging from 0.5 hours to 5.0 hours. Ambient stream temperatures during the period reached 30.8 C (2.8 C above the criterion). During 1988, ambient stream temperatures exceeded this criterion on 40 occasions between 16 July and 14 September for durations ranging from 0.5 hours to 6.5 hours. Maximum stream temperature during the period was 31.3 C (3.3 C above the optimum growth criterion). Since temperatures exceeded the optimum growth criterion for northern hog sucker for a maximum of 6.5 hours, this leaves more than 17 hours each day where temperatures will be within the range allowing optimum growth. Furthermore, as noted by the National Academy of Sciences and National Academy of Engineering (1973), "Optimum temperatures (such as those producing fastest growth rates) are not generally necessary at all times to maintain thriving populations and are often exceeded in nature during summer months."

The lowest survival criterion for all species examined (34 C for three species--northern hog sucker, yellow perch, spottail shiner) was nearly 3 C greater than maximum weekly temperatures observed at site 2 and approximately 8 C higher than the maximum weekly temperatures observed at site 1. Maximum stream temperatures in the Tugalo river for 1987-1988 were well below lethal limits for the species evaluated. Therefore, survival of the species evaluated would be assured within the study areas even during summer maximum temperatures.

Ocmulgee River

Stream temperatures in the Ocmulgee River study area during the period of temperature monitoring ranged from a minimum of 4.9 C to a maximum of 31.3 C (Tables 6-5 and 6-6; Figures 6-4 and 6-5). Minimum temperatures occurred in January and maximum temperatures occurred in July or August. Average weekly temperatures ranged from a high of 28.6 C to a low of 6.1 C (Tables 6-5 and 6-6). Overall temperature patterns exhibited a typical sine-shaped form, with the coldest water temperatures occurring in December and January, and the warmest water temperatures occurring in July and August (Figures 6-4 and 6-5). Temperature changes between seasons were gradual.

Summer water temperatures during 1987 were warmer than the corresponding period in 1988 at both sites (Figures 6-4 and 6-5); this was a difference of approximately 1-2 C in mean weekly temperature.

Water temperatures at site 2 were typically warmer and characterized by greater daily or weekly temperature variability than site 1. Water discharged from Lloyd Shoals Dam was a relatively uniform temperature on a daily or weekly basis, as would be expected of water discharged from mid-depth of a large reservoir (Walburg et al. 1983). Water reaching site 2 had been subject to variable solar radiation and meteorological conditions, so it is typically warmer and exhibits greater diurnal variability.

Mean weekly water temperatures in the Ocmulgee River were within the optimum range for spawning and did not exceed the upper limit of optimum spawning temperatures during the reported spawning period for most species at both sites (Figures 6-4 and 6-5; Table 6-1). Two exceptions were largemouth bass and spottail shiners. For these species, mean weekly temperatures exceeded their upper temperature limit for spawning during the later portion of their spawning periods at both temperature monitoring sites. This result is not considered to indicate a negative effect on spawning of these species as stream temperatures were within optimal spawning temperature ranges for greater than four weeks for both species during April and May. Information from underwater observations of fish (Section 4) during the summer spawning period supports this conclusion. Nests of largemouth and shoal bass, spawning activity by Altamaha shiner and spottail shiner, and many YOY fish of all three species were observed in June 1988. Further, many shiners are known to be fractional spawners (Scott and Crossman 1973), and it is likely that such species would spawn again in the fall as temperatures passed through their optimal spawning temperature range.

Maximum weekly water temperatures did exceed the upper spawning temperature criteria during some interval of the spawning period for most of the species evaluated. However, in cases where maximum stream temperatures climbed above optimum spawning limits, appropriate spawning temperatures were available for at a minimum of 5 weeks sometime prior to the reported spawning period. Again, this is not considered to indicate a negative effect on spawning since fish are known to exhibit biological plasticity, being able to adjust to different thermal regimes by altering timing for spawning (Hokanson and Biesinger 1989). Also, since spawning periods were based on literature accounts as well as on our observations from both North Georgia sites and the Ocmulgee River, the actual limits of the spawning period are flexible.

Growth criteria for species evaluated for the Ocmulgee River ranged from 30 C for spottail shiner to 33 C for redeye bass (Table 6-1). At site 1 (just downstream from the Lloyd Shoals Dam), maximum weekly and mean weekly temperatures never exceeded criteria for optimum growth for the species evaluated. Maximum weekly temperatures were generally at 2 C below the lowest growth criterion (Figure 6-4). Downstream at site 2, maximum weekly temperatures briefly exceeded growth criteria for two species--redbreast sunfish and brown bullhead (Figure 6-5). The criterion for optimum growth for brown bullhead (31 C) was met and exceeded only once for 0.5 hour on 1 August 1988. The same also applies for the redbreast sunfish optimum growth criterion (final preferendum = 31 C). Therefore, for the majority of the summer periods, stream temperatures at both sites in the Ocmulgee River seldom exceeded the upper limit for optimum growth for any of the species evaluated.

Ambient stream temperatures in the Ocmulgee River never exceeded the survival criterion for any of the species evaluated (Figures 6-4 and 6-5; Table 6-1). Survival temperature criteria ranged from 34 C for spottail shiner to 37 C for redeye bass. The maximum stream temperature was 31.3 C during 1987 and 1988, which is 3C lower than the lowest survival criterion at site 2. At site 1, the lowest survival criterion (34 C) was approximately 6 C higher than the maximum stream temperatures. Since survival criteria usually carry with them a safety factor of 2 C (Brungs and Jones 1977), temperatures in the Ocmulgee River during the summers of

1987 and 1988 never threatened the survival (by reaching lethal limits) of any of the species evaluated.

6.2.3 Comparison with Unregulated Stream Temperatures

Tugalo River

With the assistance of the United States Geological Survey (USGS) (McFarlane, 1989) the Conasauga River was identified as an unregulated stream with a similar drainage basin area (687 mi^2) and geographic location to the Tugalo River, and having a continuous (hourly) temperature record. For the period of record 1968 to 1988 the extreme temperatures for the Conasauga River at Tilton, Georgia (USGS gauge 02387000) were: maximum 33 C (July 1986) and minimum 0 C (December 1981). Summer temperatures in the Conasauga River (June, July, August) typically range from the lower 20s to the lower 30s and are characterized by diurnal temperature variation of 2-6 C (Stokes et al. 1986, 1987). During 1986 and 1987 the highest observed temperatures occurred during the lowest flows (less than 50 cfs). Minimum stream temperatures in the Conasauga River typically occur in December through February and are typically in the range of 3-6 C, although temperatures as low as 0 C have been recorded.

Typical maximum stream temperatures observed in the Tugalo River below Yonah Dam were similar to, but somewhat (1-3 C) lower than those of the Conasauga River. Some diurnal and weekly temperature variations in the Tugalo River at site 2 were generally 2-4 C greater than those of the Conasauga River. This was largely due to the lower minimum temperatures observed in the Tugalo River, which typically occurred during periods of generation at Yonah Dam. Diurnal temperature variations in the Tugalo River immediately below Yonah Dam were typically less than 2 C, more similar to the diurnal temperature variations in the unregulated Conasauga River.

Ocmulgee River

A review of the available data yielded no suitable continuous temperature records for unregulated rivers in Georgia with a drainage basin and location similar to the Ocmulgee River (McFarlane 1989). Most mid-size rivers in south-central Georgia are influenced by impoundments or waste heat discharges (Dyar and Stokes 1973). Consequently, comparison of stream temperatures in the Ocmulgee River study area with those of nearby unregulated streams of similar size was difficult.

Clearly, the temperature regime in the Ocmulgee River is modified by the Lloyd Shoals Dam, but the observed summer temperature range and maximum summer temperatures are not out of the range expected for this geographic region and stream size. A review of existing stream temperature data (Dyar and Stokes 1973; Stokes et al. 1989) show that most larger streams in Georgia (e.g. Flint River near Montezuma, Ogeechee River near Mount Oliver, Ohoopee River near Reidsville) all have typical summer temperatures (June, July, August) in the 20-29 C range and attain maximum temperatures near or exceeding 30-35 C. These attributes also characterize the Ocmulgee River at site 2, and to a lesser extent, site 1. Stream temperatures immediately downstream of the Lloyd Shoals Dam appear somewhat depressed relative to unregulated stream temperatures. However, this lowering of the temperature regime is slight relative to that occurring below deep reservoirs with hypolimnetic releases in this geographical region (e.g., Lake Sidney Lanier, Chattahoochee River).

6.2.4 General Conclusions

The primary conclusion of this temperature monitoring and evaluation study is that temperature regimes in the study areas of the Tugalo and Ocmulgee rivers are suitable for the reproduction, growth, and survival of fish species representative of the resident fish assemblages. This conclusion is based on analysis of the suitability of the ambient temperature regimes for key species life stages conducted in a manner consistent with accepted methods (Brungs and Jones 1977; Armour 1988). The study was conducted during two drier-than-average water years and included warmer-than-average summer periods and low-flow periods of extended duration in both study areas. Therefore, the conclusion that the study stream temperature regimes are suitable is applicable to other years when conditions are similar to or wetter/cooler than 1987 and 1988, for low flows of the magnitude encountered.

Analysis of the temperature regimes in the Tugalo and Ocmulgee river study areas indicates that survival of the fish species is never threatened. Maximum temperatures never exceeded the survival criteria of any species examined. Temperatures suitable for spawning occurred for periods sufficient to allow successful reproduction by all species considered in the spring or summer in both rivers. These periods of suitable spawning temperatures did not always fall within the reported spawning dates for some species. This is not considered to be particularly significant as fish are known to adjust spawning periods to thermal regimes (Hokanson and Beisinger 1989). Observations of spawning and/or presence of YOY (cited previously) of most species provides further support for this conclusion.

Temperature regimes in the Tugalo and Ocmulgee rivers rarely exceed the optimum growth criteria of any of the species examined. The optimum growth criteria that were exceeded--those for northern hog sucker, brown bullhead, and redbreast sunfish--were very conservative estimates of the upper limit for growth (i.e., final preferendum and optimum growth). When these criteria were exceeded by small margins, the most accurate interpretation is that the stream attained temperatures slightly higher than were optimum for growth. Optimum temperatures (such as those producing the fastest growth rates) are not generally necessary at all times to maintain thriving populations, and are often exceeded in nature during summer (NAS/NAE 1973). In fact, summer temperature regimes in the Tugalo and Ocmulgee rivers were generally slightly lower than the upper limits for optimum growth of warmwater fishes (based on laboratory studies). Further, it appears that due to the thermal modification by the project impoundment, temperatures in the Tugalo and Ocmulgee rivers are somewhat lower than nearby or adjacent unregulated rivers; the reasons for this are discussed below in Section 6.2.5.

The conclusion that the Tugalo River and Ocmulgee River thermal regimes are suitable for the survival and propagation of coolwater and warmwater fish species is supported by other rationale. Hokanson and Biesinger (1989) developed composite annual temperature envelopes for the protection of cold-, cool-, and warm-water fish guilds of the United States. These composite annual temperature envelopes included a temperature regime that supports reproductive activity, growth, and survival of each of the guilds, based on the 5, 50, and 95 percentile values of weekly mean stream temperatures where a guild of fishes was present in U.S. streams. Comparing temperatures in the Tugalo and Ocmulgee rivers with the composite annual temperature envelopes for coolwater and warmwater guilds, respectively, showed that mean weekly temperatures always fell within the range providing sufficient environmental protection (i.e. thermal regime) for the fish assemblages.

Hokanson and Biesinger (1989) also present generalized temperature requirements for temperate climate thermal guilds as follows:

Summary of Temperature Requirements (C) for Temperate Thermal Guilds

	Coolwater			Warmwater		
	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range
UUILT	33.6	0.8	32.5-34.3	38.9	0.8	38.2-40.2
Physiological optimum	23.9	2.2	20.6-27.5	29.0	3.8	20.5-32.5
Upper net biomass gain	29.9	1.3	28.0-32.1	35.3	0.4	35.0-36.0
Upper spawning threshold	21.2	3.1	18.2-25.8	27.6	3.1	21.1-35.4
Lower spawning threshold	7.8	4.7	4.4-16.4	16.8	3.6	11.6-23.1

Examination of temperature monitoring data (Figures 6-2, 6-3, 6-4, and 6-5) clearly shows that these criteria are met in the Tugalo (coolwater) and Ocmulgee (warmwater) rivers.

6.2.5 Thermal Modification Due To Impoundment

The extent to which impoundments modify the downstream temperature regime depends primarily upon the release depth, the thermal stratification patterns of the reservoir, and dam operation (Ward and Stanford 1979). Both Yonah Dam and Lloyd Shoals Dam have mid-depth releases (Yonah Dam intake is at 30-40 ft depth in an area of 60-80 ft total depth; Lloyd Shoals Dam intake is at 25-35 ft in an area of approximately 90-100 ft total depth). Intermediate-level outlets provide releases of water at a temperature that is dependent upon the relative depth and stability of the thermocline and the occurrence of density flows (Petts 1984).

Lake Jackson exhibits moderate to strong thermal stratification during May-September with the depth of the thermocline typically occurring at 20-40 ft (EA 1989). The intake of the Lloyd Shoals facility is typically at or above the thermocline. Yonah Lake is a small storage reservoir with a low retention time, thereby exhibiting only weak to moderate stratification and is often nearly isothermal during some summer months (EA 1990b). Temperatures in Yonah Lake most strongly reflect the temperature of waters released from the dam immediately upstream, Tugalo Dam. Tugalo Lake stratifies strongly during the summer months (EA 1990b) but release depths are intermediate (intake at 25-35 ft in an area of approximately 150 ft depth) and typically at or above the thermocline). These attributes result in both Yonah and Lloyd Shoals dams yielding outflow temperature intermediate to the cold waters of deep-release dams and warm waters of surface-release dams.

Waters released from Yonah and Lloyd Shoals dams are below equilibrium temperatures for those streams during the summer months, and warming occurs in the downstream direction, but this warming is not enough to result in levels stressful to fish within the study areas at the observed minimum flow levels.

6.2.6 Other Considerations

In addition to comparison of ambient stream temperatures with the thermal criteria of fishes, other important temperature conditions should be considered. Brungs and Jones (1977) list three such conditions: (1) the seasonal (temperature) cycle should be retained, (2) the changes in temperature should be gradual, and (3) the temperature should not be so high or so low as to alter the composition of the desired population. Clearly these conditions are met in the Tugalo and Ocmulgee River study areas; temperatures show the typical harmonic (sinusoidal) seasonal temperature change pattern and gradual seasonal changes are apparent on a weekly and monthly time scale (Figures 6-2, 6-3, 6-4, and 6-5). Data presented in this report and EA (1990a; 1990c) indicate the presence of healthy, reproducing populations of desirable game and non-game fishes in both study areas.

6.2.7 Implications for Physical Habitat Modeling

Based on the analysis of stream temperature monitoring data and comparison with fish temperature tolerance criteria and thermal regimes of similar unregulated streams, the temperature regimes of the Tugalo and Ocmulgee rivers are suitable for the survival and propagation of fish species representative of the resident fish assemblages. Therefore, temperature does not need to be explicitly considered and factored into the analysis of flow-habitat relations (physical habitat simulation) for the range of low flows and seasonal conditions encountered during the period of monitoring.

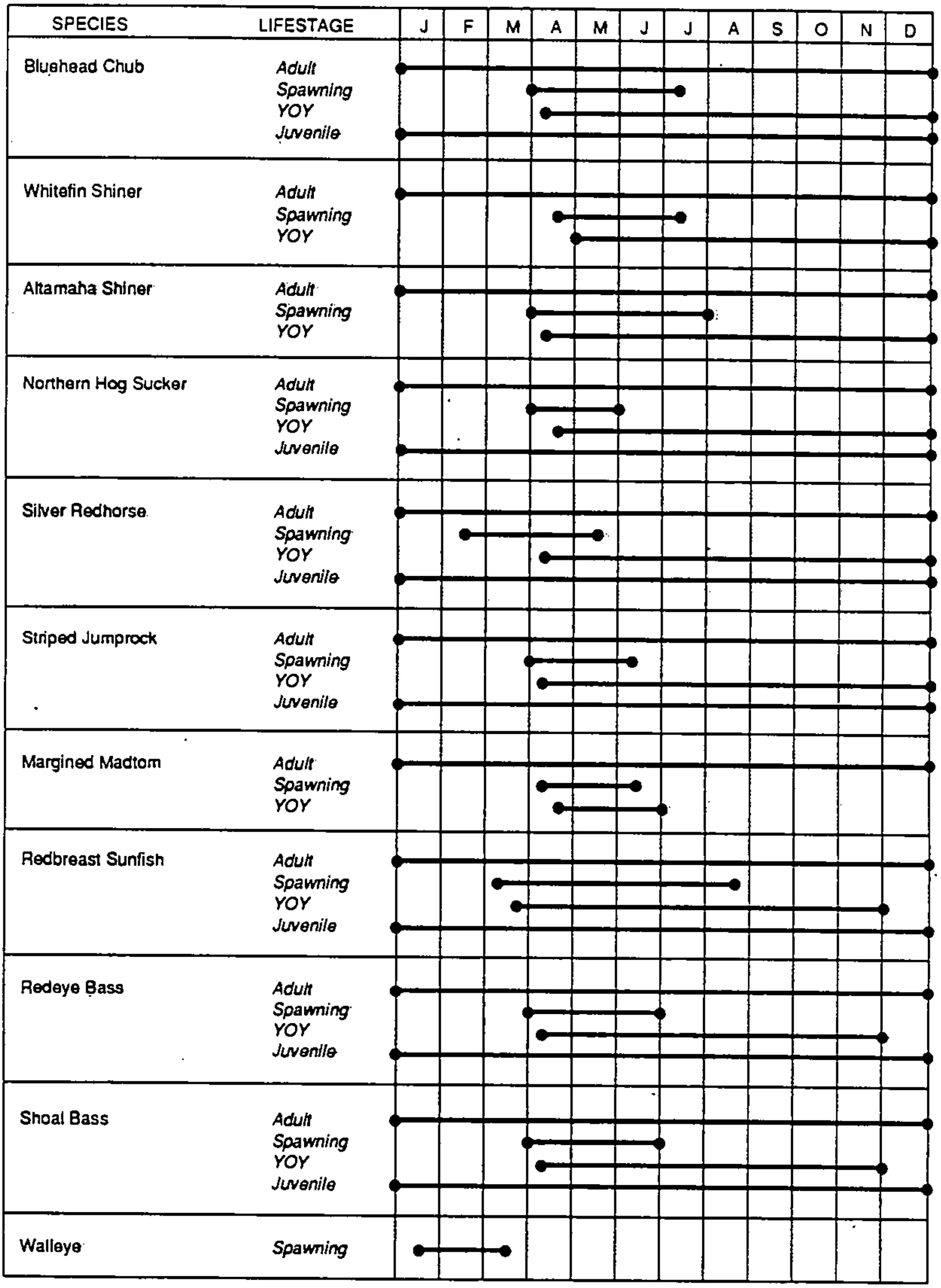


Figure 6-1. Seasonal occurrence of target species life stages based on literature accounts and field observations during instream flow studies in the Tugalo and Ocmulgee river study areas.

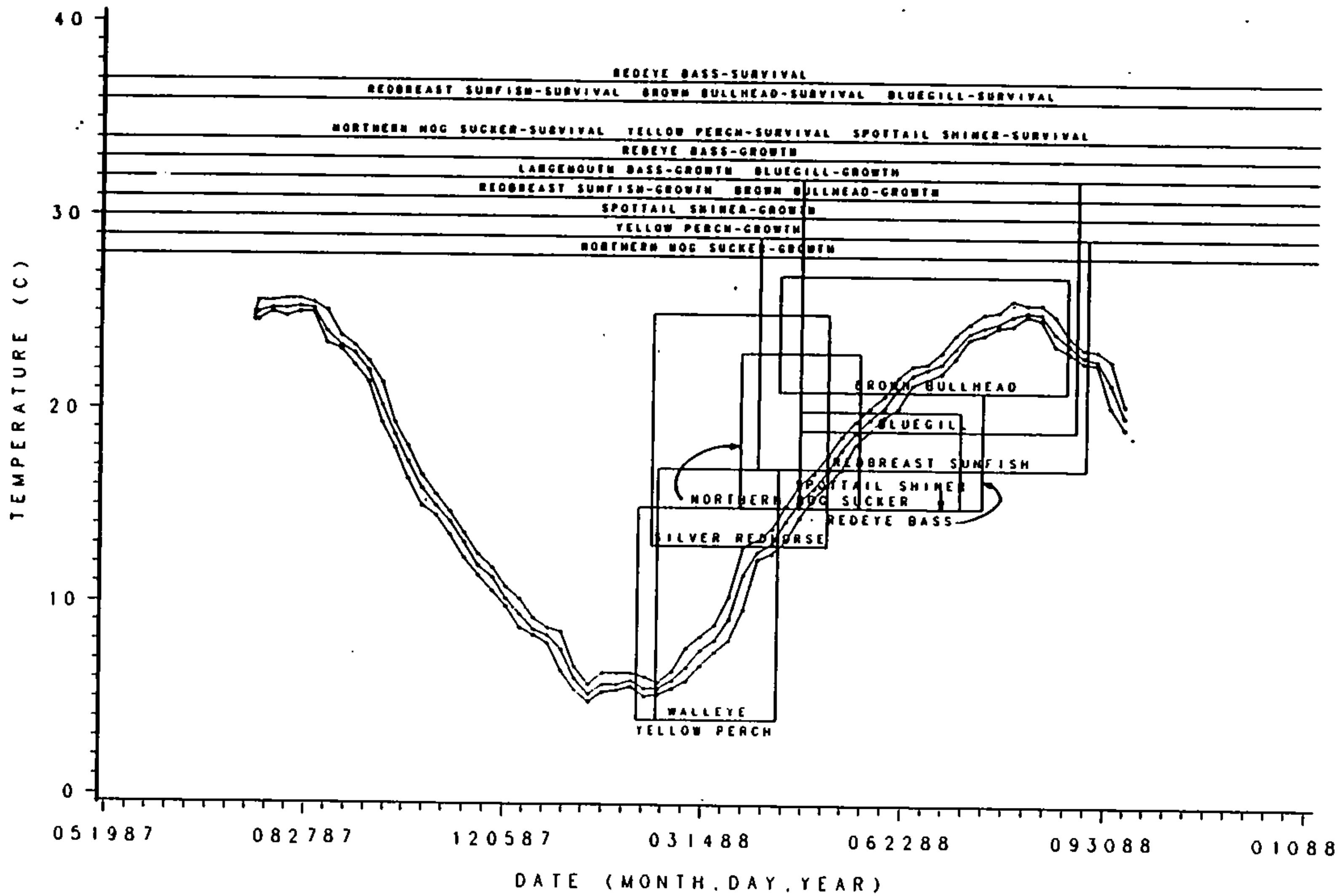


Figure 6-2. Weekly minimum, mean, and maximum stream temperatures in the Tugalo River at temperature monitoring site 1. Temperature criteria for growth and survival of representative fish species are illustrated as horizontal lines (see Table 6-1). Boxes indicate the optimum temperature range for spawning over the duration of the known spawning period.

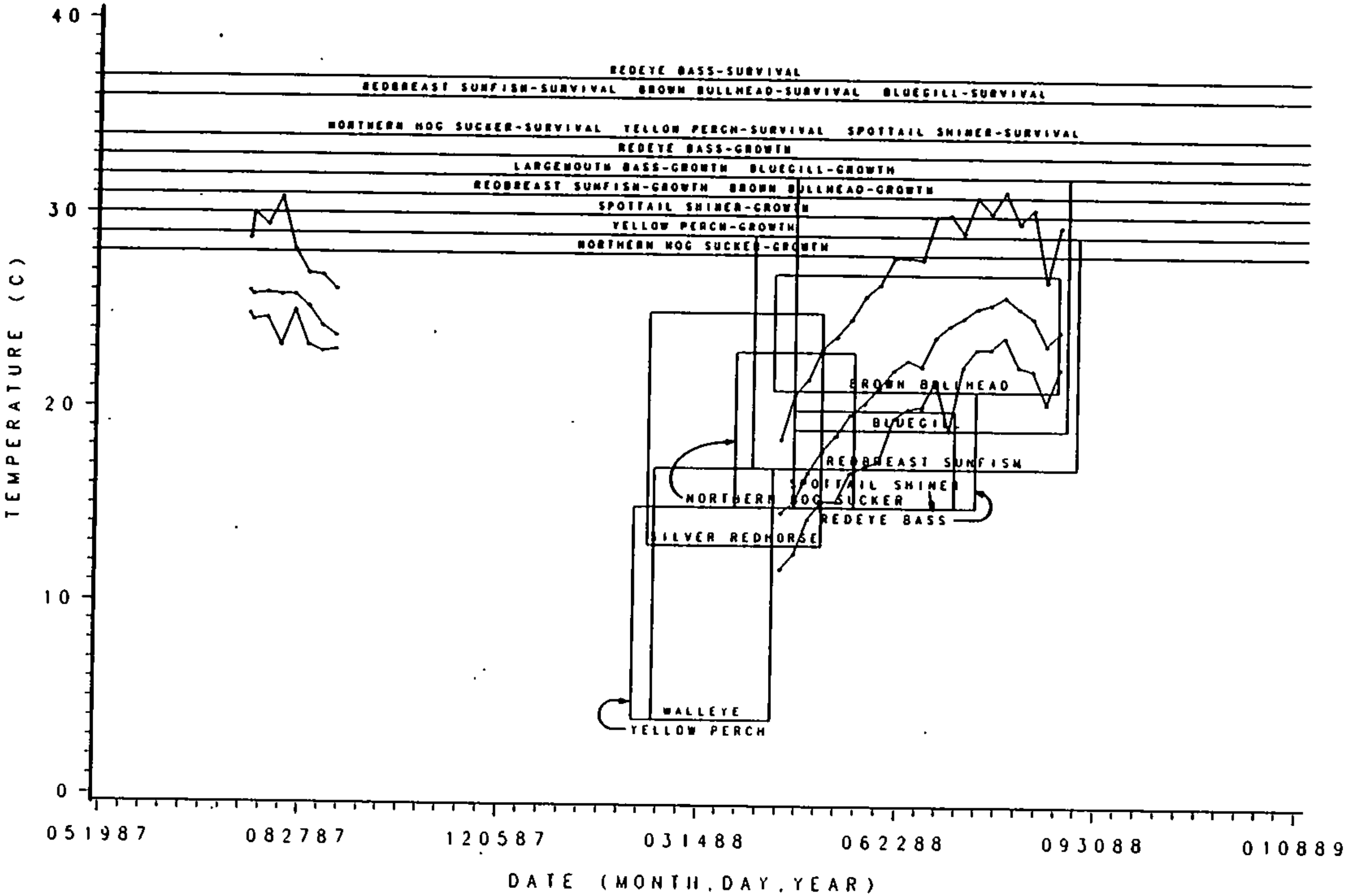


Figure 6-3. Weekly minimum, mean, and maximum stream temperatures in the Tugalo River at temperature monitoring site 2. Temperature criteria for growth and survival of representative fish species are illustrated as horizontal lines (see Table 6-1). Boxes indicate the optimum temperature range for spawning over the duration of the known spawning period.

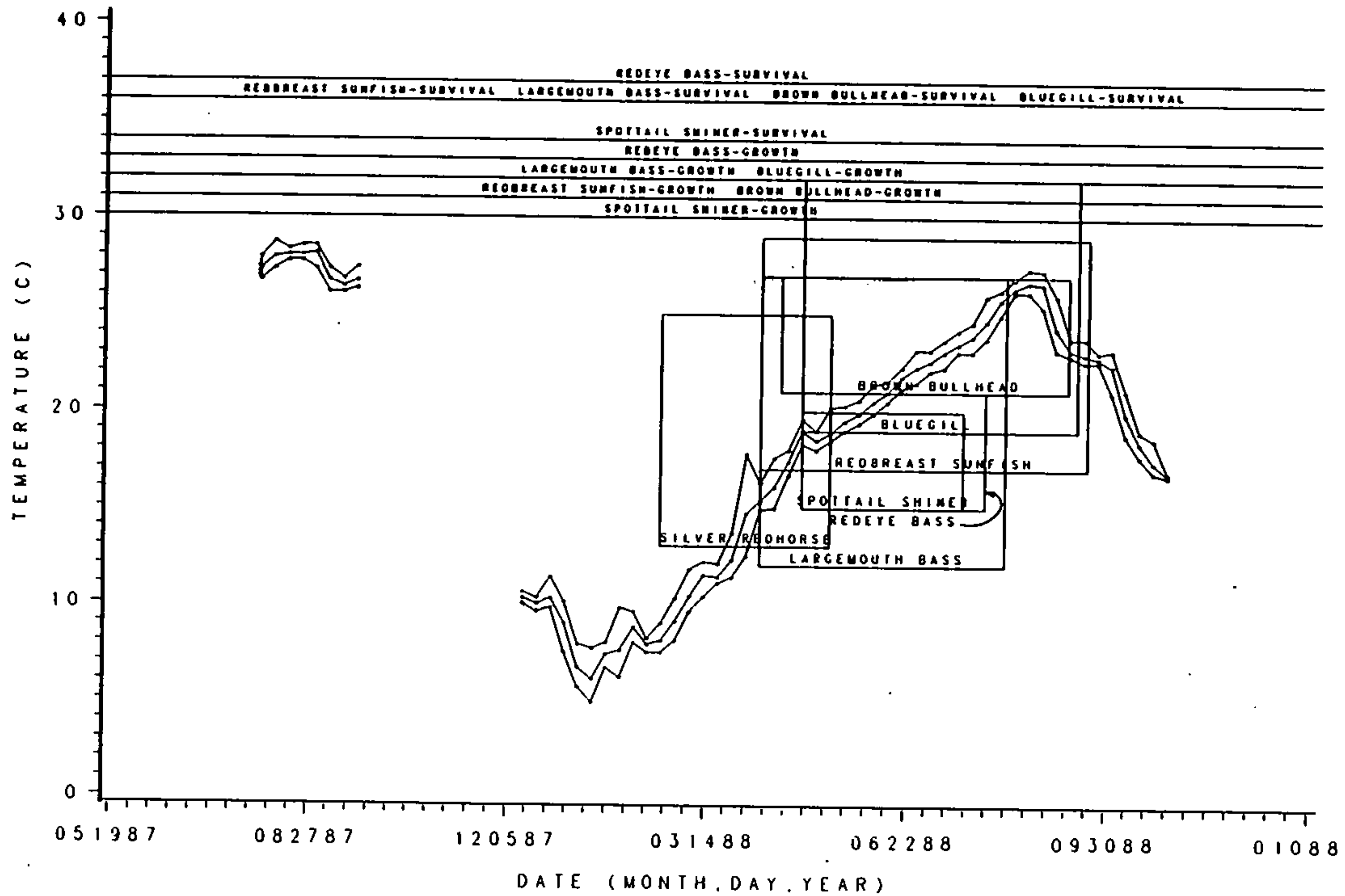


Figure 6-4. Weekly minimum, mean, and maximum stream temperatures in the Ocmulgee River at temperature monitoring site 1. Temperature criteria for growth and survival of representative fish species are illustrated as horizontal lines (see Table 6-1). Boxes indicate the optimum temperature range for spawning over the duration of the known spawning period.

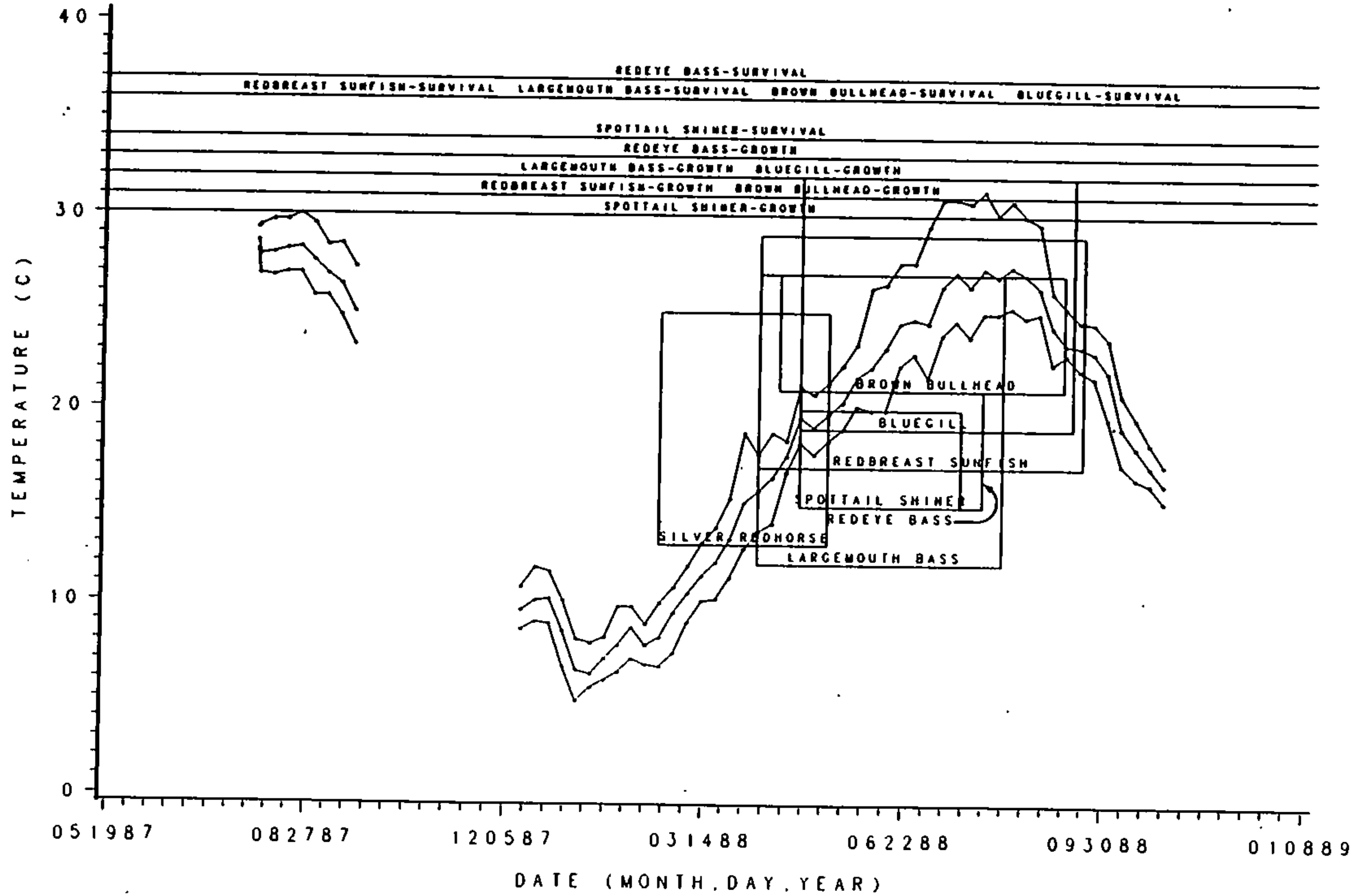


Figure 6-5. Weekly minimum, mean, and maximum stream temperatures in the Ocmulgee River at temperature monitoring site 2. Temperature criteria for growth and survival of representative fish species are illustrated as horizontal lines (see Table 6-1). Boxes indicate the optimum temperature range for spawning over the duration of the known spawning period.

TABLE 6-1 TEMPERATURE CRITERIA FOR VARIOUS LIFE STAGES AND ACTIVITIES OF ELEVEN COOL AND WARMWATER FISH SPECIES USED IN EVALUATION OF STREAM TEMPERATURE REGIMES IN THE TALLULAH, TUGALO, AND OCMULGEE RIVERS

Species	Function	Thermal Criteria	Life stage	Temperature	Optimum Spawning Temperature Range	Acclimated Temperature	Reference	Applications of Criteria: Ocmulgee River	Tugalo River	Tallulah River
Redeye bass	Spawning	ULS	Adult	21	15-21		a	X	X	X
	Growth[a]	MWAT	Juvenile	33			b	X	X	X
	Survival[b]	UILT	Juvenile	37			b	X	X	X
Redbreast sunfish	Spawning	ULS	Adult	29	17-29		c	X	X	X
	Growth	FP	Juvenile	31		29	d	X	X	X
	Survival	UA	Juvenile	36		29	q	X	X	X
Largemouth bass	Spawning	MTES	Eggs	27	12-27		e	X		
	Growth	MWAT	Juv/adult	32			e	X		
	Survival	UILT	Juv/adult	36		30	f	X		
Northern hog sucker	Spawning	ULS	Adult	23	15-23		g		X	X
	Growth	FP	Juvenile	28		27	h		X	X
	Survival	UA	Juvenile	34		33	i		X	X
Yellow perch	Spawning	ULS	Adult	15	4-15		c		X	
	Growth	MWAT		29			r		X	
	Survival	UUILT		34			r		X	
Central stoneroller	Spawning	ULS	Adult	27	13-27		c			X
	Growth	FP	Juvenile	29		27	j			X
	Survival	UA	Juvenile	33		27	j			X
Spottail shiner	Spawning	ULS	Adult	20	15-20		c	X	X	
	Growth	MWAT	Juvenile	30			l	X	X	
	Survival	UUILT	Juvenile	34			l	X	X	
Silver redhorse	Spawning[c]	ULS	Adult	25	13-25		c	X	X	
Brown bullhead	Spawning	MTES	Eggs	27	21-27		e	X	X	X
	Growth	OG	Adult	31			m	X	X	X
	Survival	UILT	Juv/adult	36		15	n	X	X	X
Bluegill	Spawning	ULS	Adult	32	19-32		c	X	X	
	Growth	MWAT	Juv/adult	32			e	X	X	
	Survival	UUILT	Juv/adult	36			p	X	X	
Walleye	Spawning	ULS	Adult	17	14-17		c		X	

(a) Growth criteria for smallmouth bass.
(b) Survival criteria for smallmouth bass.
(c) Spawning criteria for river redhorse.

References
a Parsons (1954), Emig (1966), Goodson (1966).
b Wrenn (1980).
c EPA (1983) Brungs and Jones (1977).
d Mathur et al. (1981).
e Brungs and Jones (1977).
f Hart (1952) cited in NAS (1973).
g Raney and Lachner (1946), Currie and Spacie (1984), Jenkins and Burkhead (in press).
h Stauffer et al. (1976), Cherry et al. (1977).
i Cherry et al. (1977).
j Cherry et al. (1975).
k McFarlane et al. (1975)
l Kellogg and Gift (1983).
m Crawshaw (1975).
n Trembley (1961).
o Allen and Strawn (1967)
p Speakman and Krenkel (1972), Peterson and Schutsky (1976).
q Mathur et al. (1983).
r Hokanson and Biesinger (draft).

Definitions of Thermal Criteria

ULS Upper limit of optimum temperature range for spawning.
MWAT Maximum weekly average temperature.
FP Final preferendum.
UA Upper avoidance.
MTES Maximum temperature for embryo survival.
UILT Upper incipient lethal temperature.
UUILT Ultimate upper incipient lethal temperature.
OG Optimum growth temperature.

TABLE 6-2 AVERAGE MONTHLY TEMPERATURES FOR SELECTED MONTHS OF 1987 AND 1988 AND THE DEPARTURES FROM NORMAL AVERAGES (from NOAA 1987 and NOAA 1988) (DEGREES FAHRENHEIT)

	June				July				August			
	1987		1988		1987		1988		1987		1988	
Station	Avg.[a]	Dept.[b]	Avg.	Dept.	Avg.	Dept.	Avg.	Dept.	Avg.	Dept.	Avg.	Dept.
Athens	77.9	1.9			81.3	2.1	80.5	1.3	81.9	3.4	80.5	2.0
Atlanta	77.8	2.0	78.6	2.8	81.0	2.4	80.5	1.9	82.0	3.8	81.0	2.8
Gainesville	75.6	2.0			79.3	2.4	77.9	1.0	80.0	3.4	78.8	2.2
Clayton	71.1	0.6			74.7	1.0	73.2	0.5	74.8	1.6	75.0	1.8
Cornelia	73.4	1.7			76.7	1.8	75.2	0.3	77.0	2.5	76.3	1.8
Toccoa	76.0	1.4			79.6	1.8	77.9	0.1	80.7	3.6	79.9	2.8
Forsyth	77.9				80.0		78.4		81.6		79.1	
Macon	79.1	0.2	78.7	-0.2	82.2	0.8	81.3	-0.1	84.2	3.2	82.2	1.2
Monticello	78.2				81.1				82.4		80.5	

a Avg. = Average.
b Dept. = Departure.

TABLE 6-3 WEEKLY MEAN, MINIMUM, AND MAXIMUM TEMPERATURES AT TUGALO RIVER #1 YONAH DAM TEMPERATURE MONITORING STATION

Week of	Number of Observations	Mean Weekly Temperature (C)	Minimum Weekly Temperature (C)	Maximum Weekly Temperature (C)	Week of	Number of Observations	Mean Weekly Temperature (C)	Minimum Weekly Temperature (C)	Maximum Weekly Temperature (C)
31 JUL 87	74	24.8	24.6	25.0	06 MAR 88	336	6.7	6.0	7.7
02 AUG 87	336	25.0	24.6	25.6	13 MAR 88	336	7.6	6.8	8.3
09 AUG 87	336	25.2	25.0	25.6	20 MAR 88	336	8.1	7.5	8.9
16 AUG 87	336	25.2	24.8	25.7	27 MAR 88	336	9.2	8.1	10.4
23 AUG 87	336	25.3	25.0	25.7	03 APR 88	336	11.5	9.7	13.0
30 AUG 87	336	25.2	25.0	25.5	10 APR 88	336	12.7	12.3	13.3
06 SEP 87	336	24.0	23.4	25.1	17 APR 88	336	13.1	12.6	13.9
13 SEP 87	336	23.3	23.1	23.8	24 APR 88	336	14.3	13.3	15.1
20 SEP 87	336	22.9	22.3	23.3	01 MAY 88	336	15.3	14.5	16.2
27 SEP 87	336	22.0	21.4	22.5	08 MAY 88	336	16.0	15.5	16.8
04 OCT 87	336	20.2	19.3	21.4	15 MAY 88	336	16.9	16.2	17.7
11 OCT 87	336	18.7	18.0	19.3	22 MAY 88	336	18.0	17.0	18.7
18 OCT 87	336	17.3	16.4	18.1	29 MAY 88	336	18.9	18.3	19.5
25 OCT 87	336	15.9	15.0	16.6	05 JUN 88	336	19.6	19.0	20.2
01 NOV 87	336	15.0	14.5	15.6	12 JUN 88	336	20.2	19.7	20.8
08 NOV 87	336	14.2	13.5	14.7	19 JUN 88	336	21.2	20.2	21.8
15 NOV 87	336	13.1	12.3	13.6	26 JUN 88	336	21.9	21.4	22.4
22 NOV 87	336	11.9	11.4	12.5	03 JUL 88	336	22.2	21.7	22.5
29 NOV 87	336	11.3	10.6	11.8	10 JUL 88	336	22.5	22.0	23.1
06 DEC 87	336	10.2	9.8	10.8	17 JUL 88	336	23.3	22.8	24.0
13 DEC 87	336	9.4	8.7	10.2	24 JUL 88	336	24.1	23.8	24.6
20 DEC 87	336	8.6	8.3	9.2	31 JUL 88	336	24.4	24.0	25.1
27 DEC 87	336	8.3	7.9	8.7	07 AUG 88	336	24.6	24.4	25.2
03 JAN 88	336	7.6	6.5	8.5	14 AUG 88	336	25.0	24.5	25.8
10 JAN 88	336	6.1	5.5	6.7	21 AUG 88	336	25.2	25.0	25.6
17 JAN 88	336	5.3	4.9	5.8	28 AUG 88	336	25.1	24.8	25.6
24 JAN 88	336	5.8	5.4	6.4	04 SEP 88	336	24.1	23.5	25.0
31 JAN 88	336	5.8	5.5	6.4	11 SEP 88	336	23.5	23.1	23.9
07 FEB 88	336	6.0	5.7	6.4	18 SEP 88	336	22.9	22.6	23.3
14 FEB 88	336	5.6	5.2	6.2	25 SEP 88	336	22.7	22.5	23.2
21 FEB 88	336	5.6	5.3	5.9	02 OCT 88	336	21.5	20.3	22.7
28 FEB 88	336	6.0	5.6	6.5	09 OCT 88	175	19.8	19.2	20.4

TABLE 6-4 WEEKLY MEAN, MINIMUM, AND MAXIMUM TEMPERATURES AT TUGALO RIVER #2 YONAH DAM TEMPERATURE MONITORING STATION

Week of	Number of Observations	Mean Weekly Temperature (C)	Minimum Weekly Temperature (C)	Maximum Weekly Temperature (C)
31 JUL 87	69	26.0	24.8	28.7
02 AUG 87	336	25.8	24.5	30.0
09 AUG 87	336	25.9	24.6	29.4
16 AUG 87	336	25.8	23.2	30.8
23 AUG 87	336	25.8	25.0	28.1
30 AUG 87	336	25.2	23.2	26.9
06 SEP 87	336	24.2	22.9	26.8
13 SEP 87	124	23.7	23.0	26.1
20 SEP 87	0	.	.	.
27 SEP 87	0	.	.	.
04 OCT 87	0	.	.	.
11 OCT 87	0	.	.	.
18 OCT 87	0	.	.	.
25 OCT 87	0	.	.	.
01 NOV 87	0	.	.	.
08 NOV 87	0	.	.	.
15 NOV 87	0	.	.	.
22 NOV 87	0	.	.	.
29 NOV 87	0	.	.	.
06 DEC 87	0	.	.	.
13 DEC 87	0	.	.	.
20 DEC 87	0	.	.	.
27 DEC 87	0	.	.	.
03 JAN 88	0	.	.	.
10 JAN 88	0	.	.	.
17 JAN 88	0	.	.	.
24 JAN 88	0	.	.	.
31 JAN 88	0	.	.	.
07 FEB 88	0	.	.	.
14 FEB 88	0	.	.	.
21 FEB 88	0	.	.	.
28 FEB 88	0	.	.	.
06 MAR 88	0	.	.	.
13 MAR 88	0	.	.	.
20 MAR 88	0	.	.	.
27 MAR 88	0	.	.	.
03 APR 88	0	.	.	.
10 APR 88	0	.	.	.
17 APR 88	0	.	.	.
24 APR 88	153	14.7	11.8	18.5
01 MAY 88	336	15.3	12.6	20.8
08 MAY 88	336	16.8	14.4	21.6
15 MAY 88	336	17.9	15.3	23.2
22 MAY 88	336	18.7	15.3	23.8
29 MAY 88	336	19.8	16.8	24.7
05 JUN 88	336	20.4	17.1	25.9
12 JUN 88	336	21.2	17.4	26.5
19 JUN 88	336	22.1	19.6	27.9
26 JUN 88	336	22.6	20.1	27.9
03 JUL 88	336	22.3	20.2	27.8
10 JUL 88	336	23.8	21.6	30.0
17 JUL 88	336	24.4	19.0	30.1
24 JUL 88	336	24.8	22.3	29.2
31 JUL 88	336	25.3	23.2	31.0
07 AUG 88	336	25.5	23.2	30.2
14 AUG 88	336	25.9	23.8	31.3
21 AUG 88	336	25.3	22.3	29.7
28 AUG 88	336	24.8	22.1	30.4
04 SEP 88	336	23.4	20.4	26.7
11 SEP 88	177	24.1	22.2	29.5

TABLE 6-5 WEEKLY MEAN, MINIMUM, AND MAXIMUM TEMPERATURES AT OCMULGEE RIVER #1 LLOYD SHOALS TEMPERATURE MONITORING STATION

Week of	Number of Observations	Mean Weekly Temperature (C)	Minimum Weekly Temperature (C)	Maximum Weekly Temperature (C)
01 AUG 87	26	27.1	26.9	27.4
02 AUG 87	336	27.3	26.7	27.9
09 AUG 87	336	27.9	27.3	28.7
16 AUG 87	336	28.0	27.7	28.3
23 AUG 87	336	28.0	27.7	28.5
30 AUG 87	336	28.1	27.3	28.5
06 SEP 87	336	26.7	26.1	27.3
13 SEP 87	336	26.4	26.1	26.8
20 SEP 87	81	26.7	26.3	27.4
27 SEP 87	0	.	.	.
04 OCT 87	0	.	.	.
11 OCT 87	0	.	.	.
18 OCT 87	0	.	.	.
25 OCT 87	0	.	.	.
01 NOV 87	0	.	.	.
08 NOV 87	0	.	.	.
15 NOV 87	0	.	.	.
22 NOV 87	0	.	.	.
29 NOV 87	0	.	.	.
06 DEC 87	0	.	.	.
13 DEC 87	107	10.3	10.0	10.6
20 DEC 87	336	10.0	9.6	10.3
27 DEC 87	336	10.3	9.8	11.4
03 JAN 88	336	9.0	7.5	10.1
10 JAN 88	336	6.7	5.7	7.9
17 JAN 88	336	6.1	4.9	7.7
24 JAN 88	336	7.4	6.7	8.0
31 JAN 88	336	7.6	6.2	9.8
07 FEB 88	336	8.8	8.0	9.6
14 FEB 88	336	7.9	7.5	8.2
21 FEB 88	336	8.1	7.5	9.0
28 FEB 88	336	9.1	8.1	10.3
06 MAR 88	336	10.4	9.6	11.8
13 MAR 88	336	11.5	10.4	12.2
20 MAR 88	336	11.4	11.1	12.1
27 MAR 88	336	12.3	11.4	13.7
03 APR 88	336	14.7	12.5	17.8
10 APR 88	336	15.4	14.9	16.3
17 APR 88	336	16.1	15.0	17.6
24 APR 88	107	17.4	16.7	18.0
01 MAY 88	75	19.0	18.3	19.6
08 MAY 88	336	18.5	18.0	19.0
15 MAY 88	336	18.9	18.5	20.2
22 MAY 88	336	19.5	19.0	20.3
29 MAY 88	336	19.9	19.4	20.6
05 JUN 88	336	20.5	19.9	21.4
12 JUN 88	336	21.0	20.5	21.6
19 JUN 88	336	21.8	21.2	22.3
26 JUN 88	336	22.3	21.5	23.2
03 JUL 88	336	22.6	22.1	23.2
10 JUL 88	336	23.1	22.3	23.7
17 JUL 88	336	23.5	23.1	24.2
24 JUL 88	336	23.9	23.1	24.6
31 JUL 88	336	24.7	23.8	26.0
07 AUG 88	336	25.8	25.0	26.3
14 AUG 88	336	26.4	26.2	26.9
21 AUG 88	336	26.7	26.2	27.4
28 AUG 88	336	26.6	25.4	27.3
04 SEP 88	336	24.3	23.2	26.0
11 SEP 88	336	23.2	22.9	23.8
18 SEP 88	336	23.0	22.6	23.8
25 SEP 88	336	22.8	22.6	23.1
02 OCT 88	336	22.4	21.0	23.2
09 OCT 88	336	19.9	18.8	21.1
16 OCT 88	336	18.4	17.7	19.0
23 OCT 88	336	17.4	16.9	18.6
30 OCT 88	75	16.8	16.7	16.9

TABLE 6-6 WEEKLY MEAN, MINIMUM, AND MAXIMUM TEMPERATURES AT OCMULGEE RIVER #2 LLOYD SHOALS TEMPERATURE MONITORING STATION

Week of	Number of Observations	Mean Weekly Temperature (C)	Minimum Weekly Temperature (C)	Maximum Weekly Temperature (C)
01 AUG 87	24	28.6	28.1	29.3
02 AUG 87	336	27.9	26.9	29.4
09 AUG 87	336	28.0	26.8	29.7
16 AUG 87	336	28.2	27.0	29.7
23 AUG 87	336	28.3	27.0	30.0
30 AUG 87	336	27.6	25.8	29.5
06 SEP 87	336	26.9	25.8	28.4
13 SEP 87	336	26.4	24.8	28.5
20 SEP 87	167	25.0	23.3	27.3
27 SEP 87	0	.	.	.
04 OCT 87	0	.	.	.
11 OCT 87	0	.	.	.
18 OCT 87	0	.	.	.
25 OCT 87	0	.	.	.
01 NOV 87	0	.	.	.
08 NOV 87	0	.	.	.
15 NOV 87	0	.	.	.
22 NOV 87	0	.	.	.
29 NOV 87	0	.	.	.
06 DEC 87	0	.	.	.
13 DEC 87	109	9.6	8.6	10.8
20 DEC 87	336	10.1	9.0	11.8
27 DEC 87	336	10.2	8.9	11.6
03 JAN 88	336	8.5	6.7	10.1
10 JAN 88	336	6.5	4.9	8.1
17 JAN 88	336	6.3	5.6	7.9
24 JAN 88	336	7.1	6.0	8.2
31 JAN 88	336	7.8	6.4	9.8
07 FEB 88	336	8.7	7.1	9.8
14 FEB 88	336	7.8	6.8	8.9
21 FEB 88	336	8.2	6.7	10.0
28 FEB 88	336	9.5	7.4	10.8
06 MAR 88	336	10.5	9.0	11.9
13 MAR 88	336	11.4	10.1	13.1
20 MAR 88	336	12.1	10.2	13.9
27 MAR 88	336	13.3	11.3	15.4
03 APR 88	336	15.2	12.8	18.8
10 APR 88	336	15.8	13.7	17.7
17 APR 88	336	16.5	14.1	18.8
24 APR 88	107	17.6	16.8	18.4
01 MAY 88	77	19.6	18.3	21.2
08 MAY 88	336	19.1	17.7	20.8
15 MAY 88	336	19.8	18.4	21.4
22 MAY 88	336	20.4	19.0	22.3
29 MAY 88	336	21.7	20.2	23.4
05 JUN 88	336	22.2	20.0	26.3
12 JUN 88	336	23.2	20.0	26.5
19 JUN 88	336	24.5	22.3	27.6
26 JUN 88	336	24.7	22.9	27.6
03 JUL 88	336	24.5	21.7	29.5
10 JUL 88	336	26.4	23.9	30.9
17 JUL 88	336	27.1	24.6	30.9
24 JUL 88	336	26.4	23.8	30.7
31 JUL 88	336	27.3	25.0	31.3
07 AUG 88	336	26.9	25.0	30.1
14 AUG 88	336	27.4	25.3	30.8
21 AUG 88	336	27.0	24.8	30.0
28 AUG 88	336	26.3	25.0	29.6
04 SEP 88	336	24.3	22.4	26.1
11 SEP 88	336	23.4	22.9	25.3
18 SEP 88	336	23.3	22.1	24.6
25 SEP 88	336	23.0	21.7	24.5
02 OCT 88	336	22.0	19.6	23.7
09 OCT 88	336	19.1	17.2	20.8
16 OCT 88	336	18.1	16.5	19.6
23 OCT 88	336	17.1	16.2	18.3
30 OCT 88	263	16.2	15.3	17.2

7. EVALUATION OF MINIMUM INSTREAM FLOW REGIMES

The purpose of this study was to develop an analytical framework, based on the U.S. Fish and Wildlife Service's Instream Flow Incremental Methodology, to evaluate the relationship between flow regime and the resulting amount of fish habitat in the project tailwaters. This report chapter contains a summary and integrated analysis of all aspects of the Instream Flow Studies conducted to this point, including macrohabitat analyses (i.e., water quality screening), biological information about fish species habitat needs and seasonal occurrence, stream temperature studies, and physical habitat modeling. The objective of this chapter is to provide a basis for evaluating and negotiating minimum instream flow regimes that will protect aquatic habitat for the fish assemblages in the project tailwaters.

Final deliberations about minimum flow needs must consider a wide range of multi-disciplinary water management objectives such as water quality maintenance, power generation, recreation, flood control, and fish habitat needs. When considering fish habitat needs, several important aspects to consider are seasonal changes in the habitat needs of fish species, conflicting flow needs of coexisting species having optimal habitat at different flows, seasonal changes in water availability, and habitat constraints that may be imposed by temperature and/or water quality. To address these considerations, the following report sections define biological seasons based on fish species life histories, identify flow regimes providing optimum habitat (and percentages of optimum) for all species life stages present in each season, provide a summary of historical regulated and synthetic unregulated stream flow records, and provide a basis for evaluating the effect of minimum flow regimes on fish habitat. These sections are preceded by a review and summary of the most pertinent aspects of the report to this point.

7.1 OVERVIEW OF INSTREAM FLOW STUDY COMPONENTS

7.1.1 Fish Community Status

The results of the fish survey (Section 3), literature reviews, and ecological/taxonomic guilding (Appendix A) indicate that the Tugalo and Ocmulgee River study areas support moderately diverse and abundant populations of fish. The fish assemblages in both study areas support representatives of the major taxonomic, trophic, and habitat guilds expected for the region and stream size. In both the Tugalo and Ocmulgee River study areas, several species of important game fish are present, and species considered to be moderately intolerant to stream degradation (e.g., darters, madtoms, some minnows) are present and, in some cases, abundant.

7.1.2 Macrohabitat Analysis

Water Quality Screening

Tugalo River

The review of existing water quality data and state water quality reports generally indicate that no substantial water quality problems exist in the Tugalo River. The Tugalo River is classified by Georgia as recreational waters, and in a report issued by the GDNR Environmental Protection Division (EPD) (GDNR 1988), the Tugalo River was reported to be fully supporting its designated use (i.e., meeting applicable state water quality standards for that river segment). A review of water quality data collected in Yonah tailwaters (EA 1990b) indicated that water quality was generally very good. Therefore, the analysis of minimum flow regimes for fish habitat can proceed on the basis of physical habitat simulation without explicit consideration of water quality variables.

Ocmulgee River

A review of water quality data and state water quality reports identified existing water quality problems in the Ocmulgee River study area. The Ocmulgee River in the study area is classified as fishing waters and was reported to be fully supporting its designated use as of 1987 (GDNR 1988). However, a review of the recently collected water quality data (EA 1989) shows some existing problems in the Ocmulgee River study area, most of which stem from accelerated eutrophication, excess nutrients, and hypolimnetic oxygen depletion in Lake Jackson. Water quality problems in Lake Jackson are largely due to heavy nutrient loading and poor tributary water quality due to major discharges (municipal treatment facilities) and urban nonpoint runoff sources in the tributaries of the upper Ocmulgee River basin (GDNR 1988). Intensive surveys by the GDNR EPD have shown that water quality improvement in Lake Jackson in recent years (1984-1987) has been largely due to treatment facility upgrades, phosphorus reduction measures, and stormwater management strategies in the upper Ocmulgee drainage basin (GDNR 1988).

The most important water quality problem in the Ocmulgee River study area, in terms of fish habitat, is that water low in dissolved oxygen is occasionally released from Lloyd Shoals Dam during some warm months. When dissolved oxygen levels of waters released from Lloyd Shoals Dam are unsuitable for fish, the results of physical habitat simulations cannot be assumed to adequately depict flow-habitat relations in the Ocmulgee River study area because water quality is reducing the habitat potential of the stream. This water quality consideration constrains the applicability of the results of the instream flow studies to those periods when Lloyd Shoals Dam releases are of suitable water quality.

Release of waters low in dissolved oxygen from Lloyd Shoals Dam should not be assumed to affect the habitat potential of the entire Ocmulgee River study area. Recovery of suitable dissolved oxygen levels occurs in a downstream direction (depending on biological and chemical oxygen demand, re-aeration rates, and other factors), typically within a relatively short distance. Studies by the GDNR EPD showed that during low flows, recovery of suitable dissolved oxygen levels occurred within 4.2 river miles (GDNR 1977).

During periods when suitable dissolved oxygen levels are maintained in the Lloyd Shoals Dam releases, the results of physical habitat simulations are appropriate for determining minimum instream flows.

Temperature

As stated in Section 6.2.7, based on the analysis of stream temperature monitoring data and comparison with fish temperature tolerance criteria and thermal regimes of similar unregulated streams, the temperature regimes of the Tugalo and Ocmulgee rivers are suitable for the survival and propagation of fish species representative of the resident fish assemblages. Therefore, temperature does not need to be explicitly considered and factored into the analysis of minimum flow regimes for the range of low flows and seasonal conditions encountered during the period of monitoring.

7.2 METHODS FOR EVALUATING MINIMUM FLOWS

The many methods currently used to determine instream flow needs (EA 1986) can be divided into those that produce a single, specific flow recommendation and those that do not. The physical habitat simulation component of the Instream Flow Incremental Methodology does not produce a specific flow recommendation, but rather produces a functional relationship between habitat and discharge for one or more species.

Several authors have proposed methods for evaluating the results of physical habitat simulations for multiple species life stages. Bovee (1982) suggested basing instream flow recommendations on (1) the concept of maximizing the habitat in least supply (i.e., optimization matrix) or

(2) weighting the absolute amount of habitat to correspond to the amount needed by the different life stages (i.e., habitat ratios). Steward and Stober (1985) and Geer and Wilson (1987) proposed methods for treatment of data from physical habitat simulations, which consisted of extensive mathematical treatment of the data requiring baseline hydrological data and species weighting factors based on occurrence and abundance, ecological sensitivity, and fishery management objectives. All of the above methods were rejected for use here because they required unsubstantiated assumptions, were largely conceptual (EA 1986), or required hydrological, ecological, or biological data that were not readily available.

In reviewing the results of physical habitat simulations, two important features were identified that should be incorporated when evaluating minimum flow recommendations. The first feature is the variability in flow-habitat relations among the various species life stages. The maximum habitat, or maximum weighted usable area (MWUA) occurs at a different flow for all species (Tables 5-2 and 5-3). Because of this variability, selecting a minimum flow release that will provide optimal habitat for each species life stage is not a straightforward process. The second feature is the timing of occurrence of species life stages throughout the year (Figure 6-1). Fish are adapted to seasonal flow variability and the minimum flows should reflect, to the degree possible, seasonal changes in the needs of the various fish species life stages present.

Accordingly, we developed a method for evaluating minimum instream flow regimes for each of three biologically-defined seasons. For those species present in a given biological period, we derived a composite WUA versus discharge relationship (by averaging over species and life stage) and used a statistical technique to determine the range of flows producing no significant decrease in the maximum average WUA value. Finally, we characterized the existing hydrologic data, for the existing regulated flows (i.e., plant discharge records) and unregulated flows (synthesized from upstream gauges), in order to characterize project effects on fish habitat. These methods are outlined in the following sections.

7.2.1 Biological Seasons

Three seasons were defined on the basis of the target species life history and temporal occurrence of various life stages in the study areas (Figure 7-1): the early spawning season, February-April; the spawning/rearing season, May-October; and the non-spawning season, November-January. The early spawning season included adults and juveniles of all species and spawning walleye; the spawning/rearing season included adults, juveniles, YOY, and spawning life stages of all target species except spawning walleye; and the non-spawning season included only adults and juveniles. No early spawning season is defined for the Ocmulgee River since walleye are not present and no habitat suitability criteria are available for other early spawning species.

The boundaries between seasons were drawn to the nearest month and represent a compromise among the timing of various species life stages. The spawning/rearing period was ended in late October because by this date most young-of-the-year (YOY) fishes will have attained a size sufficient to be considered juveniles.

7.2.2 Analysis of Flow-Habitat Relations: Single Species

For each species life stage, the maximum WUA (MWUA) (i.e., maximum available habitat) and the discharge producing the MWUA were determined from the results of physical habitat simulations (Tables 7-1 and 7-2). The WUA values reported in Tables 5-2 and 5-3, were converted to percent of maximum WUA (PMWUA) values by dividing each WUA value at a given discharge by the MWUA determined from the range of simulated flows and multiplying by 100. The PMWUA values, shown in Table 7-3, represent the percentage of maximum WUA attained under different flows; these PMWUA values will serve as the basis for further analyses described below.

The optimum habitat for any species life stage, considered individually, occurs at the discharge producing the maximum PMWUA (i.e., the peak of the habitat versus discharge curve); flows producing various percentages

(90%, 80%, 70%, etc.) of maximum habitat were calculated from Table 7-3 by linear interpolation and are summarized in Tables 7-1 and 7-2. The data presented in Tables 7-1 through Table 7-3 permit a simple determination of the discharge required to produce any specified percentage of maximum habitat, or the converse, the percentage of maximum habitat retained at a given discharge, for any single species life stage.

7.2.3 Analysis of Flow-Habitat Relations: Multiple Species

Although the evaluation of flow-habitat relations for individual species life stages is possible (Section 7.2.2), the presence of multiple species life stages in the study area during any time period (season) dictates the need for a method that considers the flow-habitat relations of multiple species simultaneously. That is, the objective of instream flow regimes should be to maintain the integrity of the aquatic fauna (Moyle and Baltz 1985) and the selected flows should represent a compromise among the habitat needs of the species in the various habitat-use groups (Leonard and Orth 1988).

One method of combining data from several different WUA versus discharge curves is to aggregate the curves, by averaging over all species and life stages present in a season, to get a composite PMWUA curve. The results of this process yielded three composite PMWUA curves for the Tugalo River (Figure 7-2) and two composite PMWUA curves for the Ocmulgee River (Figure 7-3) (i.e., one composite curve for each season). The peak of the composite PMWUA curve can be interpreted as the optimal habitat for all species life stages in a given season (i.e., maximizes the average PMWUA). Discharges producing levels of habitat less than the maximum average PMWUA were determined by linear interpolation and are reported in Table 7-4 for each river and season.

The dilemma that arises with averaging the data to obtain a composite PMWUA curve is that the process eliminates information on the dynamics of the individual PMWUA versus discharge relationships. For instance, while the composite PMWUA curve may be increasing, PMWUA for one or more species life stage curves may be sharply decreasing. What is needed is a method of analyzing the curves that considers the variability in the dynamics of the individual contributing curves.

Several different methods have been suggested for evaluating instream flows based on a collection of independent WUA versus discharge relationships (EA 1986). The method selected for use with the Tugalo and Ocmulgee River data is that of a single-factor analysis of variance (ANOVA), similar to the method of Annear and Conder (1984). With this approach the individual PMWUA versus discharge data for each species life stage are processed through an ANOVA where the different discharges (dam releases) serve as the treatment effects over which changes in PMWUA are compared (Annear and Conder 1984). The different species life stage curves serve as the replicates in the analysis, essentially substituting for the error term in a standard single-factor ANOVA. This approach uses ANOVA as a decision-making tool to quantify the uncertainty associated with the numerical significance of the average PMWUA value at a given flow; it should not be viewed as a strict application of the ANOVA linear additive statistical model.

The ANOVA procedure tests for significant differences in average PMWUA among the discharges (reservoir releases) tested. If the ANOVA indicates that discharge is a significant variable, a multiple mean comparison test--Fisher's Protected Least Significant Difference (PLSD)--can be used to identify which changes in average PMWUA are large enough to be considered significant. The PLSD is similar to a t-test between two "treatment" means; it computes the smallest difference between two means ($Mean_1$-$Mean_2$) that would be considered statistically significant given the pooled variance, sample size, and chosen alpha level. The PLSD is different from the commonly applied LSD statistic in that it is to be used only after a significant difference in treatment means has been determined by an ANOVA (Steel and Torrie 1980). This "protects" the user from drawing incorrect inferences (i.e., concluding that treatment effects occur when in fact they do not) in multiple comparisons performed on an a posteriori basis.

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TABLE 7-8 MONTHLY FLOW DURATION VALUES FOR PANTHER CREEK NEAR TOCCOA, USGS GAUGE 0218200[(a)]

Percent of Time Reached or Exceeded	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
95	28.6	39.3	45.2	50.4	43.4	33.6	26.4	21.2	16.6	17.2	21.2	21.1
90	33.4	45.0	53.3	55.3	47.9	37.4	30.4	24.1	19.8	20.6	23.8	25.0
85	37.1	48.2	57.6	59.5	51.4	40.7	33.8	26.4	22.0	23.5	25.2	27.9
80	40.5	51.4	62.0	63.6	54.6	43.9	36.7	28.7	24.0	24.8	26.6	29.9
75	43.7	55.9	66.8	67.9	57.6	47.0	39.2	31.0	26.1	26.0	28.2	31.8
70	46.5	61.7	71.6	72.1	60.5	50.0	41.2	33.1	27.9	27.4	29.9	33.6
65	49.1	66.4	75.8	76.5	63.8	53.0	43.2	35.0	29.4	28.9	31.6	35.3
60	51.6	71.0	79.4	80.8	67.5	55.3	45.2	36.9	30.8	30.4	33.3	37.1
55	54.6	75.3	83.0	85.2	71.2	57.6	47.5	38.8	32.4	31.9	34.9	39.9
50	58.0	79.0	86.5	90.2	74.8	59.8	49.8	40.6	34.2	33.5	36.5	44.0
45	61.4	82.7	91.8	95.9	77.9	62.2	52.0	42.4	36.1	35.1	38.1	47.4
40	67.0	86.5	97.6	102.0	81.1	65.0	54.6	44.2	37.9	36.7	40.2	50.6
35	73.1	92.2	104.0	108.0	84.4	67.8	57.4	46.7	40.4	38.4	42.4	54.4
30	79.7	98.2	111.0	114.0	88.0	70.5	60.3	49.7	42.8	41.1	44.6	59.4
25	86.5	107.0	118.0	121.0	93.6	73.4	64.1	52.8	45.6	43.9	48.6	65.9
20	96.9	118.0	128.0	131.0	99.2	78.4	69.2	57.6	49.8	48.5	53.0	73.8
15	109.0	134.0	139.0	143.0	108.0	84.2	74.7	63.2	55.9	54.8	59.3	85.0
10	124.0	156.0	164.0	163.0	117.0	93.4	85.6	73.8	66.7	62.3	70.7	102.0
05	170.0	193.0	222.0	200.0	139.0	115.0	110.0	90.7	81.7	79.5	95.3	135.0

(a) Based on average daily flow values for period of record; water years 1943-1971.

TABLE 7-7 SUMMARY OF STREAM DISCHARGE RECORDS USED IN HABITAT TIME SERIES AND HABITAT DURATION ANALYSES OF REGULATED AND UNREGULATED FLOWS IN THE TUGALO AND OCMULGEE RIVER STUDY AREAS

Location	Period of Record	Type of Record	Source of Record
Regulated Flows			
Tugalo River at Yonah Dam	1978-1988	Hourly Discharge	Yonah Plant Operating Records
Ocmulgee River at Lloyd Shoals Dam	1978-1988	Hourly Discharge	Lloyd Shoals Plant Operating Records
Unregulated Flows			
Tugalo River at Yonah Dam	1978-1986	Daily Average Dishcarge	Synthesized from upstream gauges on the Tallulah River near Clayton (USGS gauge 02178400) and Chattooga River near Clayton (USGS gauge 02177000)
Ocmulgee River at Lloyd Shoals Dam	1976-1982	Daily Average Discharge	Synthesized from upstream gauges on the Yellow River near Covington (USGS gauge 02207500), South River near McDonough (USGS gauge 02204500), and Alcovy River above Covington (USGS gauge 02208450)

Unregulated Flows

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
95	701	997	1065	907	580	405	309	269	193	185	357	548	340
90	854	1119	1215	1038	675	488	376	332	249	322	441	611	432
85	971	1208	1338	1149	754	557	441	380	309	380	493	665	504
80	1083	1295	1453	1258	838	613	486	421	353	419	534	718	573
75	1174	1380	1563	1363	920	661	540	460	386	446	572	775	641
70	1262	1466	1675	1465	1000	708	586	495	413	472	606	833	713
65	1350	1550	1792	1576	1076	753	633	527	438	498	638	895	790
60	1450	1645	1908	1688	1147	797	679	562	463	524	678	967	882
55	1550	1769	2030	1813	1225	843	729	599	491	556	718	1049	982
50	1657	1900	2173	1940	1308	891	780	634	520	586	761	1132	1090
45	1784	2059	2327	2074	1390	946	832	673	552	617	813	1215	1205
40	[illegible]	2227	2484	2220	1482	1021	893	717	588	658	872	1301	1331
35	2058	2411	2699	2386	1588	1101	962	778	631	715	951	1436	1476
30	2279	2621	2954	2549	1700	1190	1037	846	673	779	1044	1595	1649
25	2544	2882	3267	2767	1850	1312	1141	926	728	850	1153	1782	1863
20	2877	3229	3707	3054	2037	1453	1261	1029	804	963	1283	2007	2134
15	3420	3807	4387	3527	2319	1659	1487	1186	917	1112	1517	2374	2514
10	4370	4841	5679	4257	2840	1969	1807	1453	1115	1351	1995	2984	3116
5	6461	7251	9369	6303	4428	2700	2449	2066	1778	1940	3545	4317	4674
Mean	2430	2651	3189	2636	1742	1184	1017	865	729	793	1290	1642	1677

TABLE 7-6 MONTHLY AND ANNUAL FLOW-DURATION TABLES FOR THE OCMULGEE RIVER AT LLOYD SHOALS DAM. REGULATED FLOW STATISTICS WERE DERIVED FROM ANALYSIS OF HOURLY PLANT OPERATING RECORDS FOR THE PERIOD 1978-1988. UNREGULATED FLOW STATISTICS WERE SYNTHESIZED FROM FLOW-DURATION CURVES PRODUCED BY THE USGS FOR GAUGES ON THE SOUTH, YELLOW, AND ALCOVY RIVERS

Regulated Flows

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
100	240	240	240	240	240	240	240	240	240	240	240	240	240
95	529	529	529	529	385	385	240	240	240	240	385	385	385
90	529	529	529	529	385	385	385	385	385	385	385	385	385
85	529	529	529	529	529	385	385	385	385	385	385	529	385
80	529	529	529	529	529	385	385	385	385	385	385	529	529
75	529	818	529	529	529	529	385	385	385	385	385	529	529
70	529	1830	529	529	529	529	529	385	529	385	385	529	529
65	529	1830	963	529	529	529	529	385	529	385	529	529	529
60	674	1975	1541	963	529	529	529	529	529	529	529	529	529
55	1541	2119	1830	1107	529	529	529	529	529	529	529	529	529
50	1830	2264	1975	1830	529	529	529	529	529	529	529	963	529
45	1975	2409	2119	1975	674	529	529	529	529	529	529	1107	529
40	2119	2409	2409	1975	963	529	529	529	529	529	529	1830	674
35	2264	2553	2553	2264	1541	529	529	529	529	529	674	1975	1252
30	2409	2553	2698	2409	1830	674	529	529	529	529	818	2264	1830
25	2553	2698	2698	2553	2119	818	529	529	529	529	1397	2409	1975
20	2553	2842	2842	2698	2409	1397	529	529	529	529	1830	2553	2409
15	2698	2842	2842	2842	2553	1686	1541	1686	529	1397	1975	2698	2553
10	2842	2842	2987	2987	2842	2119	1975	2119	1397	2119	2409	2698	2698
5	2987	2987	3131	3131	3131	2698	2409	2553	2409	2698	2842	2842	2842
1	3276	3131	3276	3276	3276	2987	2842	2842	2987	3131	3131	2987	3131

TABLE 7-5 (Cont.)

Unregulated Flows

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
95	532	810	899	910	742	593	485	404	356	353	399	490	453
90	722	998	1070	1042	877	702	556	476	421	416	463	580	539
85	838	1133	1208	1144	991	793	613	528	465	452	502	661	622
80	976	1236	1326	1237	1075	860	656	577	501	485	546	735	701
75	1073	1337	1425	1327	1142	912	699	623	531	519	597	817	779
70	1154	1428	1511	1415	1209	960	742	671	563	553	659	892	862
65	1254	1506	1592	1510	1274	1012	787	720	597	587	715	966	948
60	1361	1585	1681	1604	1341	1057	833	771	630	624	770	1055	1034
55	1467	1665	1772	1710	1417	1105	884	820	668	660	830	1139	1119
50	1568	1744	1865	1836	1498	1156	938	867	705	710	900	1232	1215
45	1671	1824	1966	1967	1579	1216	996	914	748	763	978	1344	1319
40	1778	1949	2070	2104	1672	1279	1062	964	794	826	1058	1464	1434
35	1902	2088	2190	2247	1772	1354	1126	1027	856	889	1158	1593	1548
30	2045	2250	2331	2398	1882	1445	1202	1095	926	982	1262	1748	1688
25	2195	2445	2506	2567	2028	1544	1280	1184	1033	1088	1379	1933	1855
20	2394	2651	2732	2786	2193	1680	1394	1294	1176	1236	1548	2136	2055
15	2650	2927	3059	3079	2415	1901	1540	1464	1384	1437	1777	2392	2327
10	3102	3379	3585	3534	2728	2307	1772	1798	1656	1721	2089	2793	2707
5	3948	4262	4585	4383	3658	3009	2192	2610	2231	2315	2884	3676	3533
Mean	1801	2075	2228	2127	1761	1375	1097	1102	932	986	1188	1579	1521

TABLE 7-5 MONTHLY AND ANNUAL FLOW-DURATION TABLES FOR THE TUGALO RIVER AT YONAH DAM. REGULATED FLOW STATISTICS WERE DERIVED FROM ANALYSIS OF HOURLY PLANT OPERATING RECORDS FOR 1978-1988. UNREGULATED FLOW STATISTICS WERE SYNTHESIZED FROM FLOW-DURATION CURVES PRODUCED BY THE USGS FOR GAUGES ON THE TALLULAH AND CHATTOOGA RIVERS.

Regulated Flows

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
100	120	120	120	120	120	120	120	120	120	120	120	120	120
95	120	120	120	120	120	120	120	120	120	120	120	120	120
90	120	120	120	120	120	120	120	120	120	120	120	120	120
85	120	120	120	120	120	120	120	120	120	120	120	120	120
80	120	120	120	120	120	120	120	120	120	120	120	120	120
75	120	120	120	120	120	120	120	120	120	120	120	120	120
70	120	120	120	120	120	120	120	120	120	120	120	120	120
65	120	120	120	120	120	120	120	120	120	120	120	120	120
60	120	120	120	120	120	120	120	120	120	120	120	120	120
55	120	120	120	120	120	120	120	120	120	120	120	120	120
50	299	1299	1103	513	120	120	120	120	120	120	120	1103	120
45	693	693	1693	1693	120	120	120	120	120	120	906	1299	120
40	2282	2282	2479	2479	1299	120	120	120	120	120	1299	1889	1299
35	2479	2479	2675	2479	2086	906	120	120	120	120	1496	2282	1693
30	2872	3069	3265	3265	2479	1693	1103	1299	120	1103	1889	2479	2282
25	3265	3462	3658	3658	3265	2479	1693	1889	1103	1496	2282	2872	2479
20	3658	3658	3658	3658	3658	2479	2282	2479	1693	2282	2479	3265	3265
15	3658	3658	3658	4052	3658	3265	2479	2479	2479	2479	2872	3658	3658
10	3658	3855	4445	4838	3855	3658	3265	3462	2675	3069	3658	3658	3658
5	4838	4838	4838	4838	4838	3658	3658	3658	3658	3658	3658	4445	4445
1	5428	5428	5428	5428	5428	4838	4838	4838	4445	4445	4838	4838	5231

TABLE 7-4 SUMMARY OF FLOWS PRODUCING THE MAXIMUM AVERAGE PERCENT MAXIMUM WEIGHTED USABLE AREA (PMWUA) AND SELECTED PERCENTAGES OF AVERAGE PMWUA FOR ALL SPECIES LIFE STAGES IN EACH SEASON FOR THE TUGALO AND OCMULGEE RIVER STUDY AREAS [a]

River/Season	Flow (cfs) Producing Maximum Average PMWUA (reference flow)	Fisher's PLSD Statistic[a]	Lowest Simulated Flow Producing Non-Significant Decreases in WUA[b]	Flow (cfs) Producing Selected Percentages of the Maximum Average PMWUA		
				80%	60%	40%
Tugalo River						
Early spawning	600	11.5 %	300	203	112	55
Spawning/rearing	350	15.1 %	100	75	25	<20
Non-spawning	600	12.2 %	300	199	106	50
Ocmulgee River						
Spawning/rearing	400	12.0 %	150	91	<50	<50
Non-spawning	800	7.2 %	400	218	89	<50

(a) Results of the Fishers Protected Least-Significant Difference test (PLSD) at the 0.10 level of significance in units of PMWUA.
(b) The lowest flow producing an average PMWUA value not significantly different from the maximum average PMWUA.

TABLE 7-3 SUMMARY OF AVAILABLE HABITAT, EXPRESSED AS THE PERCENTAGE OF MAXIMUM WEIGHTED USABLE AREA (PMWUA), FOR EACH SPECIES LIFE STAGE AND DISCHARGE IN THE TUGALO AND OCMULGEE RIVERS

TUGALO RIVER

SPECIES-LIFE STAGE	DISCHARGE (CFS)																			
	20	40	60	80	100	120	140	160	200	250	300	350	400	500	600	800	1000	1500	2000	3000
Bluehead chub-spawn	13	49	70	81	89	93	98	99	100	99	98	93	90	80	66	42	32	20	15	10
Bluehead chub-yoy	100	80	67	54	45	41	39	38	32	30	29	29	30	30	30	27	22	15	13	7
Margined madtom-yoy	77	93	96	97	98	100	99	99	97	93	88	83	77	65	55	38	30	19	13	6
Margined madtom-adult	65	80	86	89	91	94	97	98	100	100	100	99	97	92	87	75	67	53	40	25
Northern hog sucker-yoy	96	100	90	80	74	64	57	52	45	40	33	30	25	27	33	31	27	17	13	6
Northern hog sucker-juvenile	1	10	29	44	53	61	67	73	80	88	92	95	98	100	100	96	93	81	62	39
Northern hog sucker-adult	15	21	26	36	45	55	61	65	73	80	85	89	91	95	98	100	99	94	86	64
Redeye bass-yoy	82	95	98	99	100	99	98	98	98	97	94	92	89	85	82	74	67	53	43	33
Redeye bass-juvenile	32	39	53	65	75	81	86	89	93	97	98	99	99	100	99	97	94	78	62	47
Redeye bass-adult	16	21	25	30	34	37	47	53	69	83	90	94	96	99	100	99	97	89	83	64
Redbreast sunfish-spawn	59	83	93	96	98	100	100	99	97	94	91	87	85	80	80	79	78	67	59	47
Redbreast sunfish-adult	31	35	39	43	46	50	55	62	74	86	92	96	98	99	100	96	91	69	62	51
Striped jumprock-yoy	88	100	98	94	89	83	78	74	68	64	59	53	49	43	49	43	38	30	27	22
Striped jumprock-adult	27	44	54	61	67	73	77	80	84	90	94	97	99	99	100	97	91	75	61	38
Silver redhorse-adult	13	18	21	23	26	28	32	34	38	50	61	71	79	89	95	100	97	82	66	54
Walleye-spawn	6	10	21	31	43	51	57	64	73	82	89	92	96	100	99	93	84	55	37	22
Whitefin shiner-adult	24	42	59	68	75	80	83	87	91	95	97	99	100	100	100	98	94	81	68	52

OCMULGEE RIVER

SPECIES-LIFE STAGE	DISCHARGE (CFS)																			
	50	75	100	125	150	175	200	250	300	350	400	450	600	800	1000	1300	1500	2000	2500	3500
Altamaha shiner-yoy	52	65	71	77	81	84	86	91	95	97	99	100	97	93	83	72	64	43	31	20
Altamaha shiner-adult	48	57	64	70	76	80	83	88	92	96	98	97	100	97	92	82	75	60	49	33
Redeye bass-yoy	90	94	97	98	99	100	100	99	98	96	94	91	83	74	66	56	51	40	32	21
Redeye bass-juvenile	65	70	73	77	80	83	84	87	90	94	95	96	100	100	98	93	87	71	57	34
Redeye bass-adult	39	46	53	58	63	67	71	75	77	82	86	89	94	98	100	96	93	83	74	55
Redbreast sunfish-spawn	84	90	93	96	98	99	100	100	100	98	97	96	87	78	69	59	54	45	40	31
Redbreast sunfish-adult	67	74	77	82	84	87	89	92	93	95	97	98	100	100	98	90	85	68	49	29
Shoal bass-yoy	93	98	98	100	99	98	96	92	88	86	82	77	65	52	42	31	26	19	15	11
Shoal bass-adult	41	47	54	58	62	67	70	76	82	87	91	93	97	100	97	90	86	74	59	41
Striped jumprock-yoy	98	99	99	100	99	98	96	90	84	81	75	69	54	39	27	20	17	14	11	8
Striped jumprock-adult	45	53	61	66	71	75	79	85	90	92	95	97	99	100	97	91	87	74	62	39
Silver redhorse-adult	39	47	52	57	60	64	67	72	77	80	83	85	91	99	99	100	99	89	74	50

TABLE 7-2 SUMMARY OF DISCHARGES PRODUCING THE MAXIMUM AMOUNT OF HABITAT (WUA) AND SELECTED PERCENTAGES OF MAXIMUM HABITAT (PMWUA) FOR EACH SPECIES LIFE STAGE IN THE OCMULGEE RIVER STUDY AREA

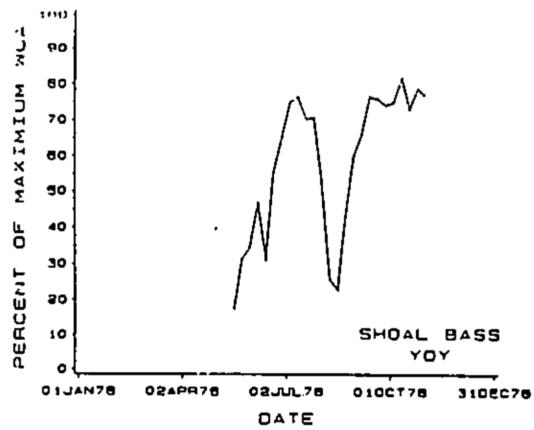
Species-Life Stage	Maximum Weighted Usable Area (WUA) (ft^2/ 1,000 ft.)	Discharge Producing Maximum WUA	Discharge Producing Selected Percentages of Maximum WUA (PMWUA)[a]						
			90%	80%	70%	60%	50%	40%	30%
Nonspawning Life Stages									
Altamaha shiner-adult	66,323	600	272	176	123	85	56	<50	<50
Redeye bass-juvenile	105,110	800	296	149	75	<50	<50	<50	<50
Redeye bass-adult	102,799	1000	491	328	195	134	89	53	<50
Redbreast sunfish-adult	75,966	800	209	113	61	<50	<50	<50	<50
Shoal bass-adult	90,658	800	389	280	199	135	86	<50	<50
Striped jumprock-adult	74,716	800	308	205	144	98	65	<50	<50
Silver redhorse-adult	107,736	1300	577	352	229	146	89	52	<50
Spawning/YOY Life Stages									
Altamaha shiner-yoy	63,672	450	237	142	96	65	<50	<50	<50
Redbreast sunfish-spawn	67,306	250	76	<50	<50	<50	<50	<50	<50
Redeye bass-yoy	85,567	200	<50	<50	<50	<50	<50	<50	<50
Shoal bass-yoy	65,600	125	<50	<50	<50	<50	<50	<50	<50
Striped jumprock-yoy	57,203	125	<50	<50	<50	<50	<50	<50	<50

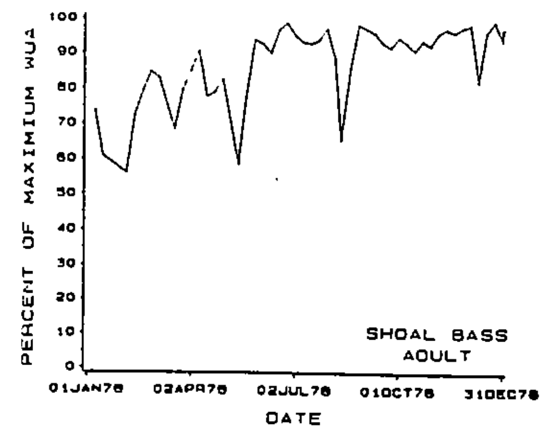
(a) A lower limit of physical habitat simulation was 50 cfs.

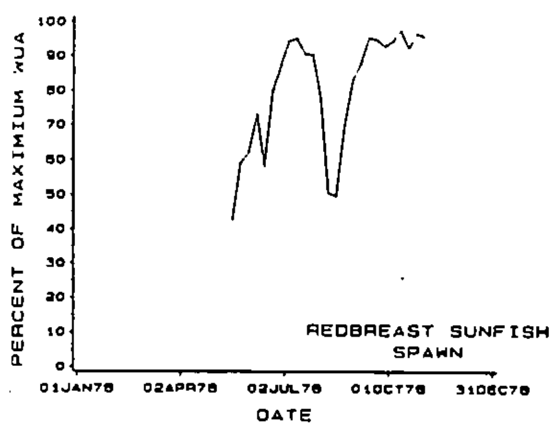
TABLE 7-1 SUMMARY OF DISCHARGES PRODUCING THE MAXIMUM AMOUNT OF HABITAT (WUA) AND SELECTED PERCENTAGES OF MAXIMUM HABITAT (PMWUA) FOR EACH SPECIES LIFE STAGE IN THE TUGALO RIVER STUDY AREA

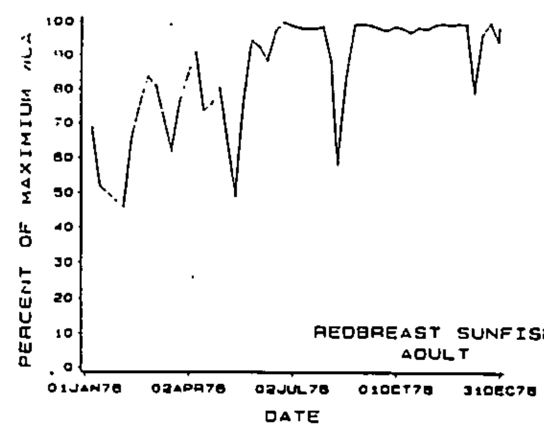
Species-Life Stage	Maximum Weighted Usable Area (WUA) (ft^2/) 1,000 ft.)	Discharge Producing Maximum WUA	Discharge Producing Selected Percentages of Maximum WUA (PMWUA)[(a)]						
			90%	80%	70%	60%	50%	40%	30%
Nonspawning Life Stages									
Margined madtom-adult	139,679	250	91	39	26	<20	<20	<20	<20
Northern hog sucker-juvenile	109,790	600	278	197	151	117	92	74	61
Northern hog sucker-adult	106,826	800	372	249	182	135	109	88	68
Redeye bass-juvenile	124,268	500	171	117	89	71	55	41	<20
Redeye bass-adult	112,313	600	305	239	202	176	148	125	81
Redbreast sunfish-adult	80,243	600	281	225	186	154	119	64	<20
Striped jumprock-adult	97,496	600	247	162	110	76	51	35	23
Silver redhorse-adult	82,753	800	511	408	344	296	251	206	129
Whitefin shiner-adult	124,368	500	190	121	86	62	49	37	26
Spawning/YOY Life Stages									
Bluehead chub-spawn	97,746	200	105	78	59	50	41	35	29
Bluehead chub-yoy	63,395	20	<20	<20	<20	<20	<20	<20	<20
Margined madtom-yoy	102,004	120	36	23	<20	<20	<20	<20	<20
Northern hog sucker-yoy	59,884	40	<20	<20	<20	<20	<20	<20	<20
Redeye bass-yoy	122,189	100	32	<20	<20	<20	<20	<20	<20
Redbreast sunfish-spawn	84,481	120	54	37	29	20	<20	<20	<20
Striped jumprock-yoy	63,977	40	23	<20	<20	<20	<20	<20	<20
Walleye-spawn	118,501	500	319	238	185	147	118	95	77

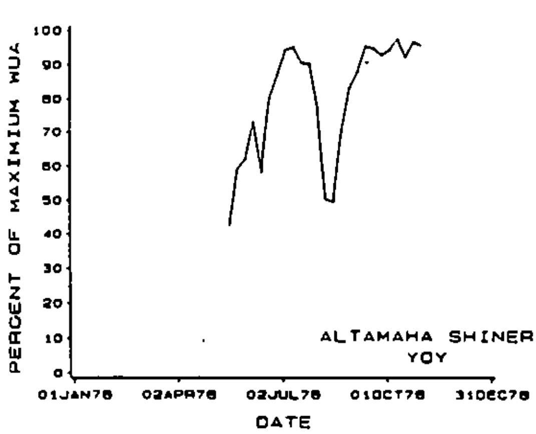
(a) Lower limit of physical habitat simulation was 20 cfs.











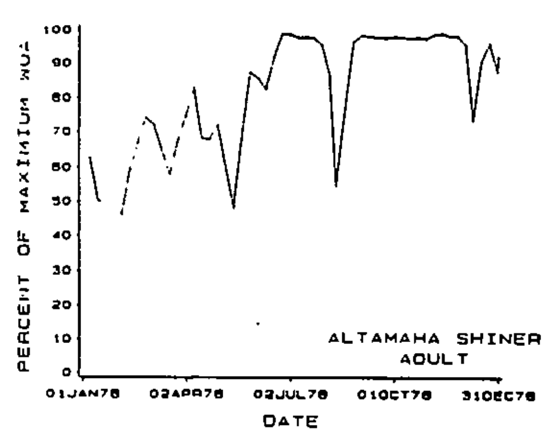


Figure 7-7 (Cont.)

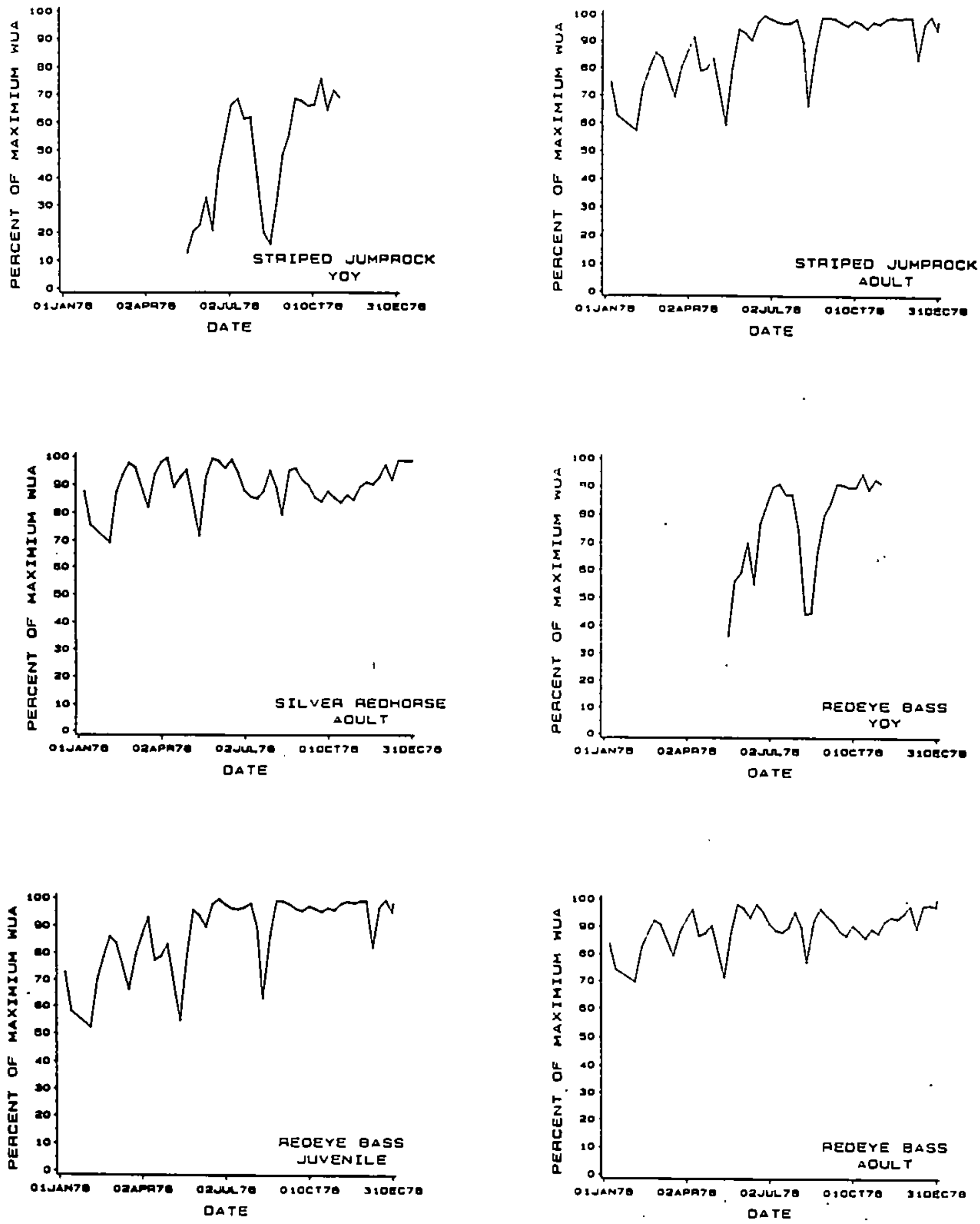


Figure 7-7. Time series of weekly mean habitat values (percent of maximum weighted usable area) in the Ocmulgee River study area for each species life stage based on daily average unregulated flows for 1978. Unregulated flows were synthesized from historical gauging records at upstream gauges. Weekly mean values are averages of daily habitat values.

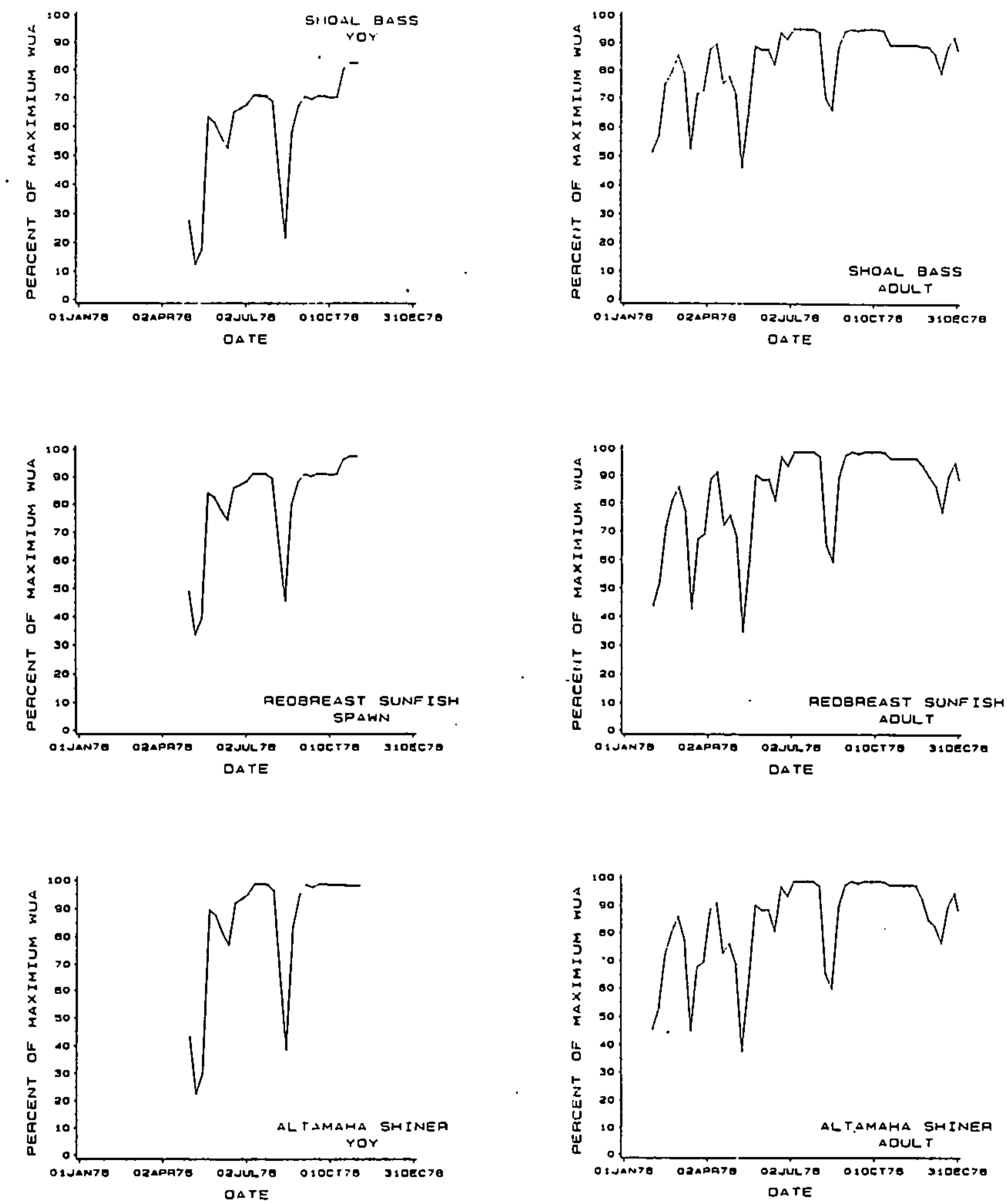


Figure 7-6 (Cont.)

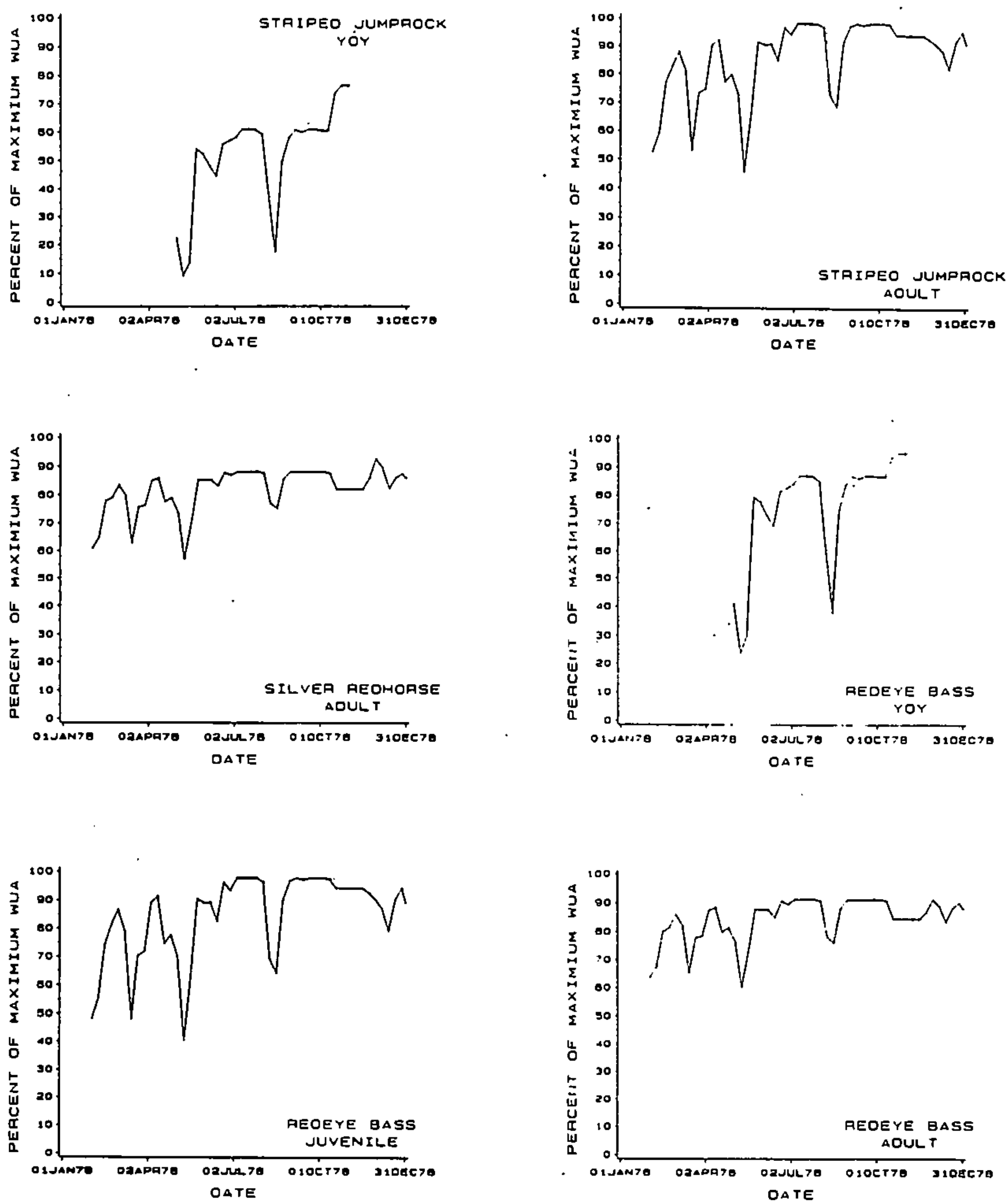


Figure 7-6. Time series of weekly mean habitat values (percent of maximum weighted usable area) in the Ocmulgee River study area for each species life stage based on hourly regulated flows (dam releases) during 1978. Weekly mean values are averages of hourly habitat values.

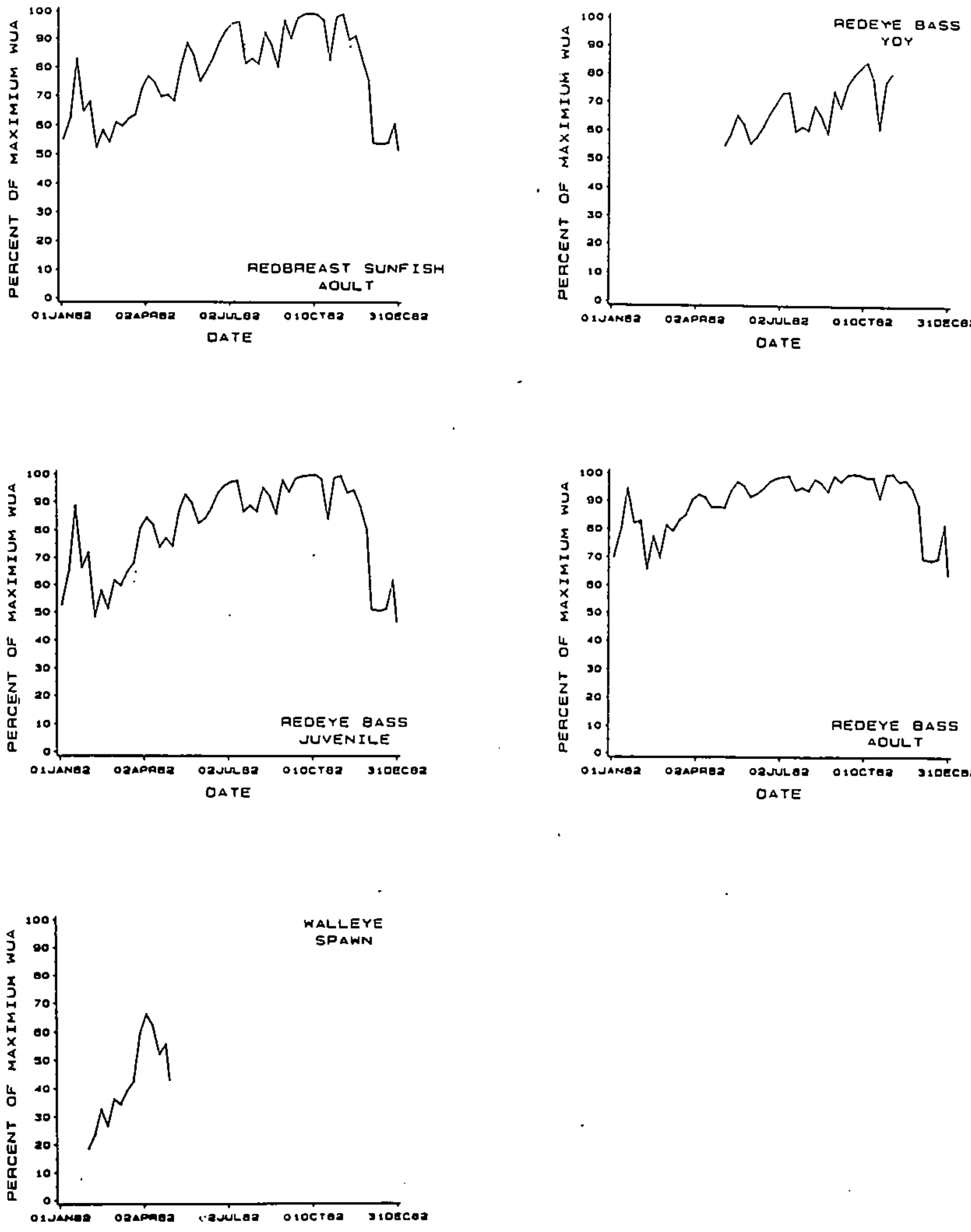


Figure 7-5 (Cont.)

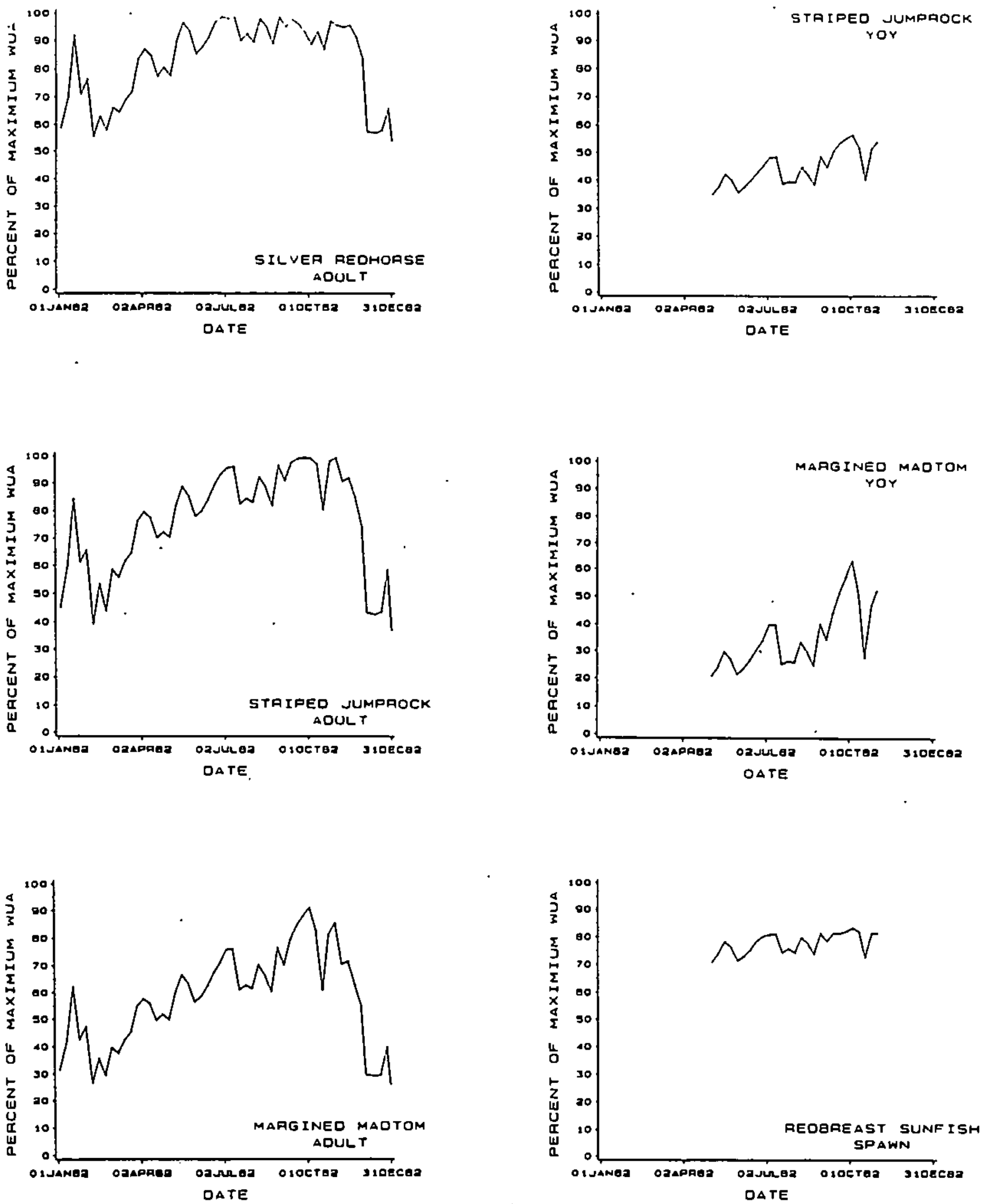


Figure 7-5 (Cont.)

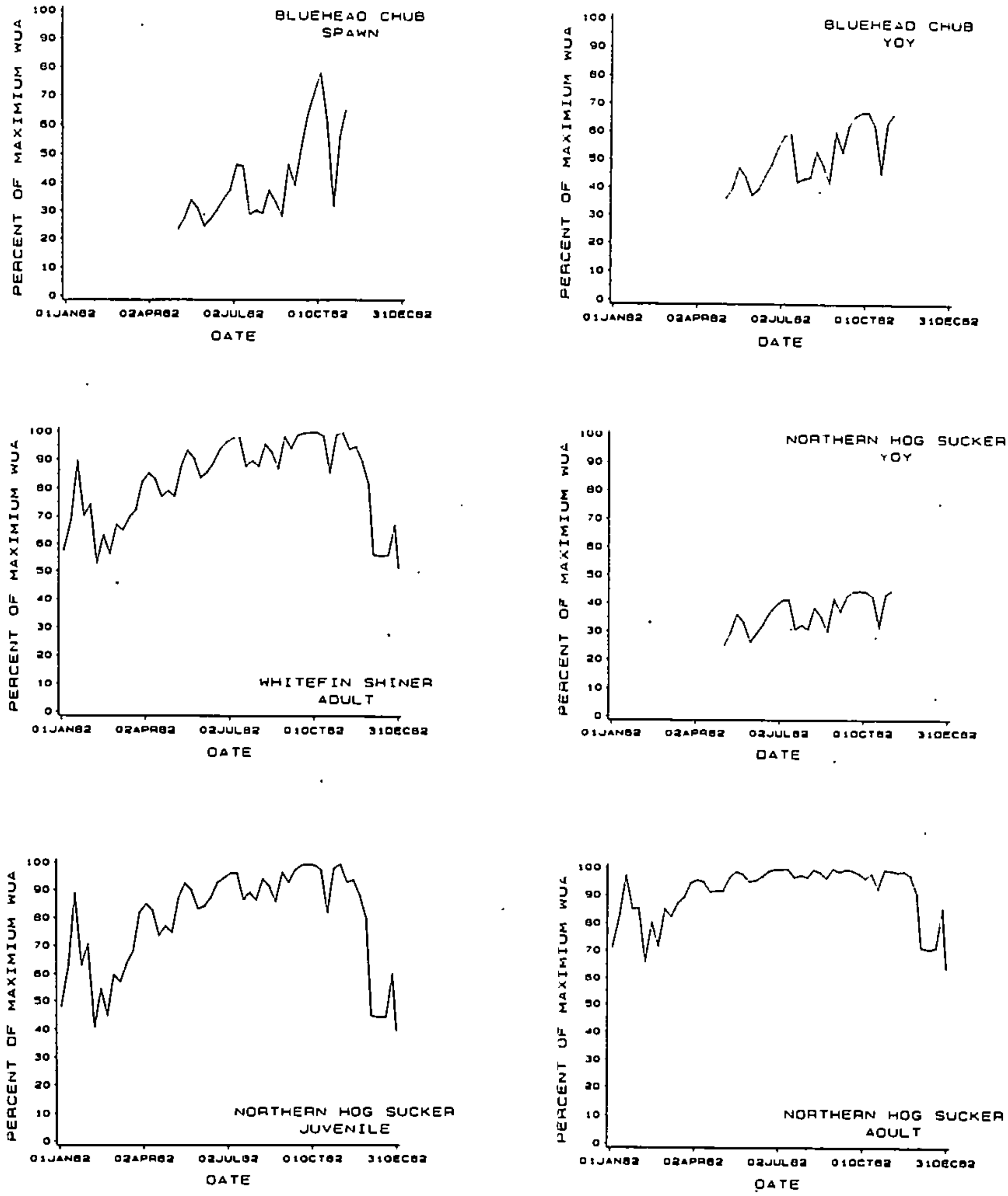
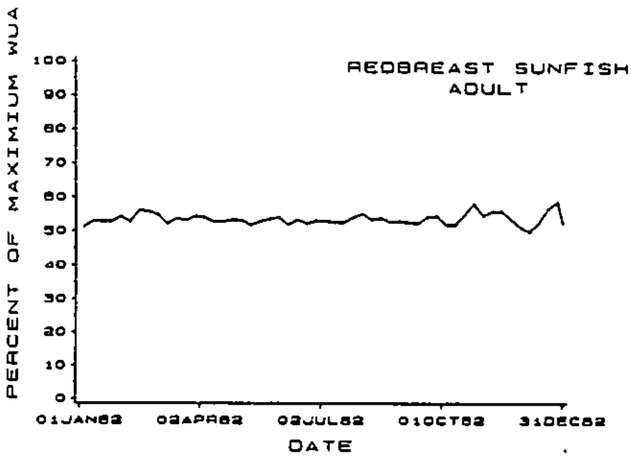
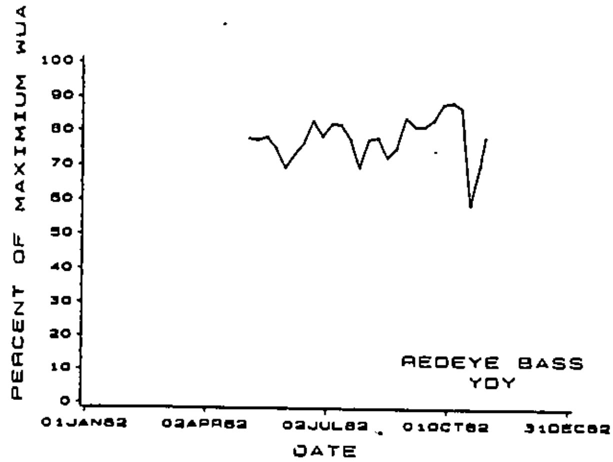
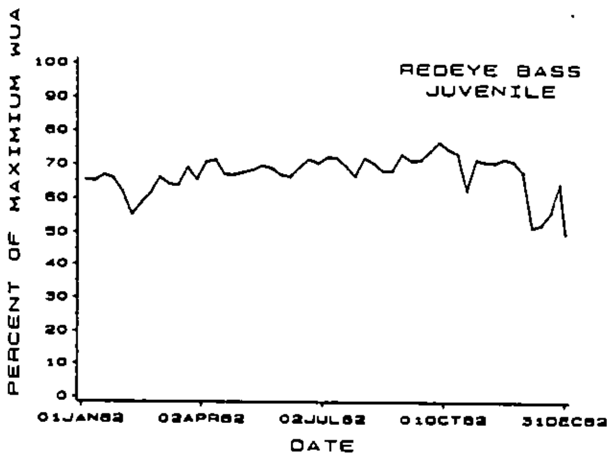
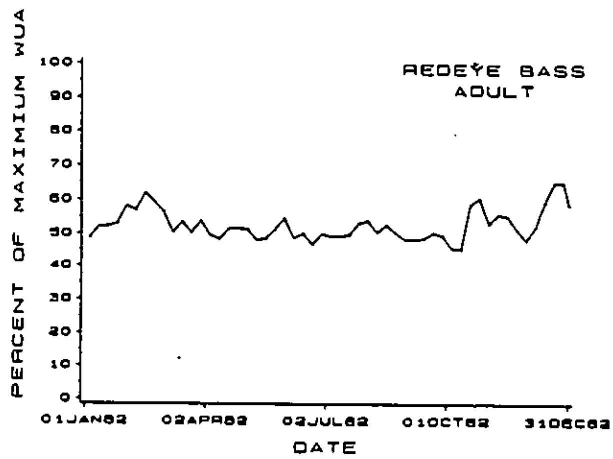


Figure 7-5. Time series of weekly mean habitat values (percent of maximum weighted usable area) in the Tugalo River study area for each species life stage based on daily average unregulated flows for 1982. Unregulated flows were synthesized from historical gauging records at upstream gauges. Weekly mean values are averages of daily habitat values.









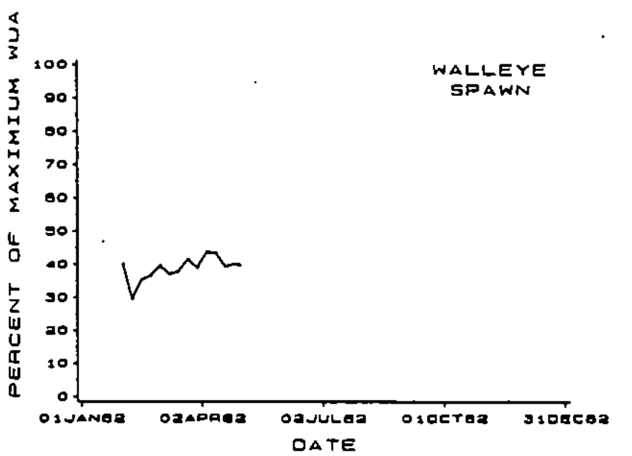


Figure 7-4 (Cont.)

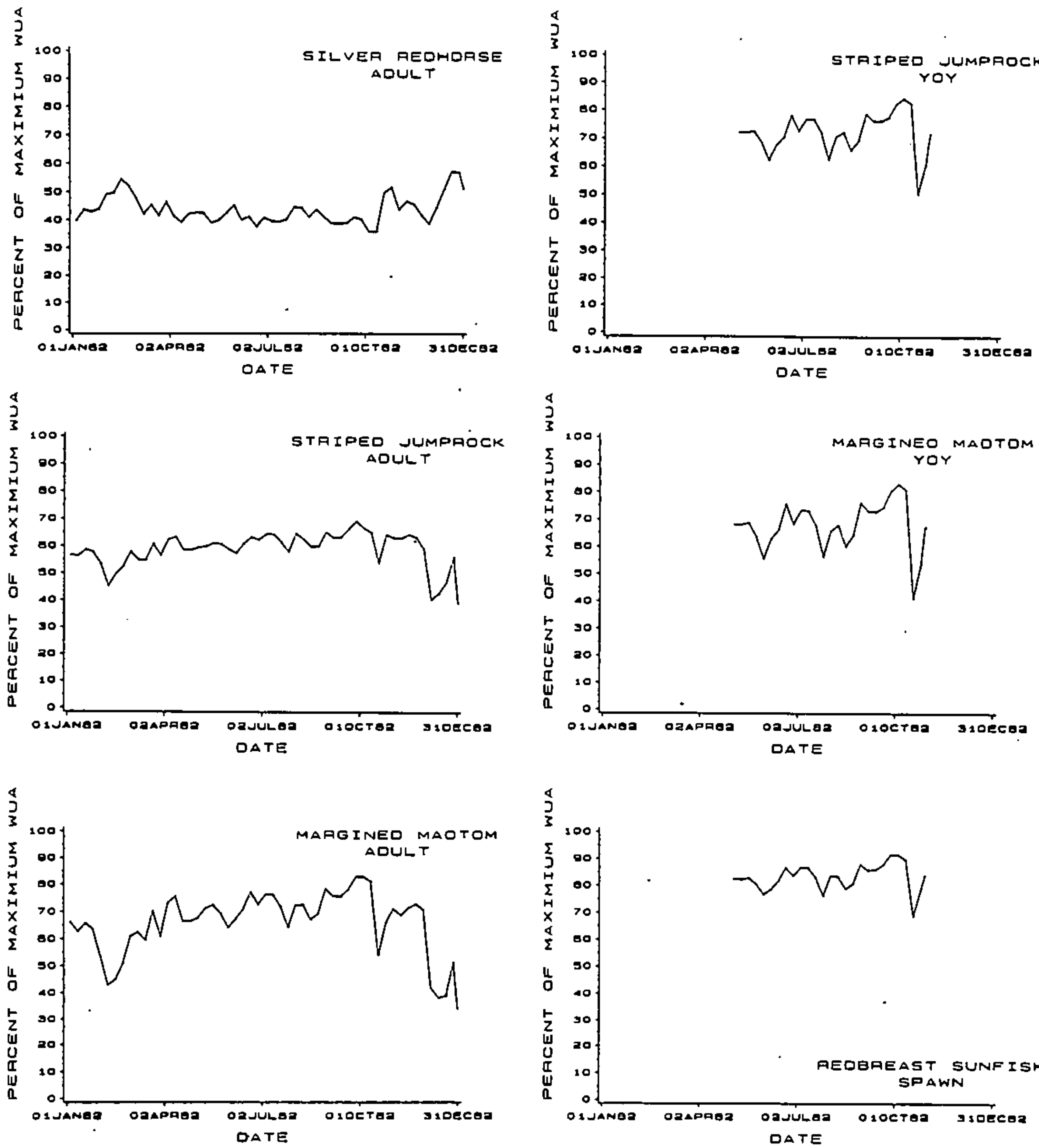


Figure 7-4 (Cont.)

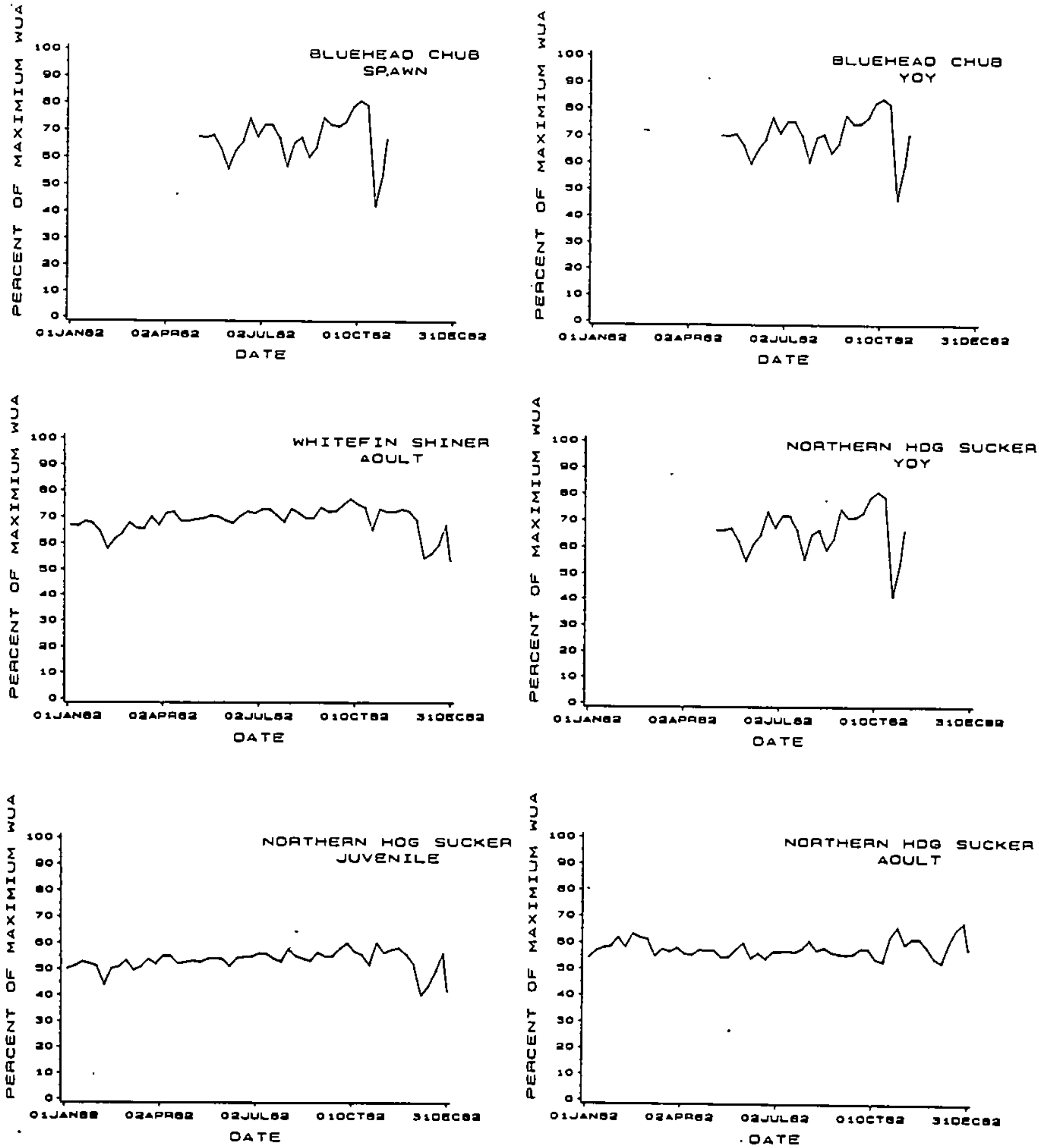


Figure 7-4. Time series of weekly mean habitat values (percent of maximum weighted usable area) in the Tugalo River study area for each species life stage based on hourly regulated flows (dam releases) during 1982. Weekly mean values are averages of hourly habitat values.

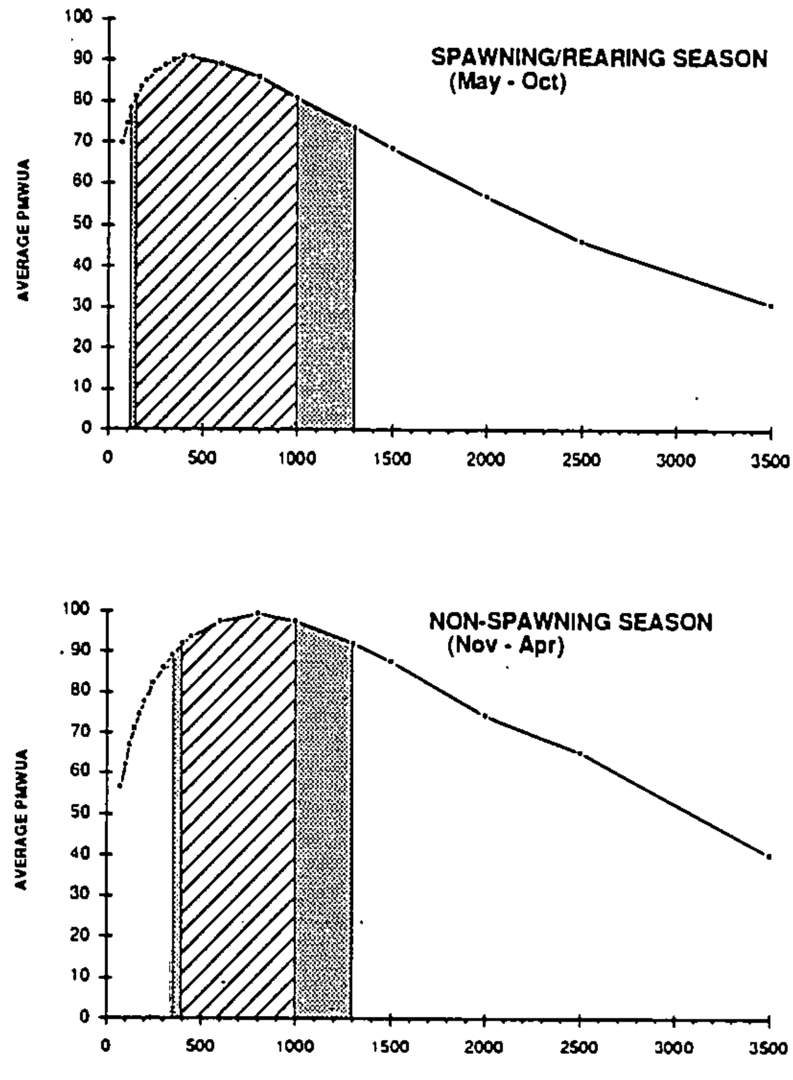


Figure 7-3. Plot of average percent of maximum WUA (PMWUA) for all species and life stages within seasons in the Ocmulgee River. Discharges in the central region (cross-hatching) produce average PMWUA values not significantly different (Fisher's Protected LSD, p = 0.10) from the maximum average PMWUA. Stippling indicates region where discharges begin to produce average habitat values (PMWUA) significantly less than the maximum average PMWUA. Unshaded regions indicate discharges producing average PMWUA values significantly lower than the maximum average PMWUA.

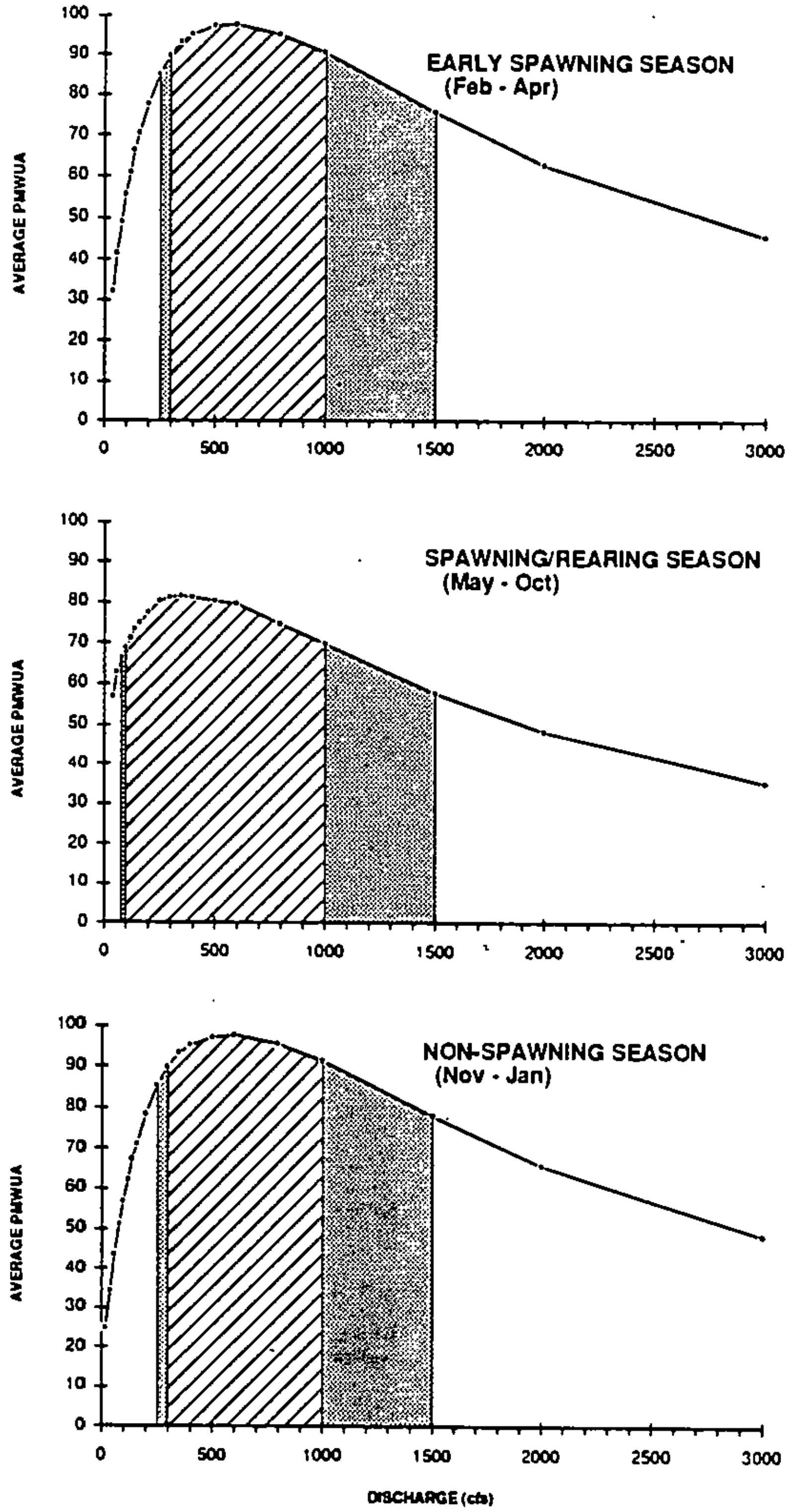


Figure 7-2. Plot of average percent of maximum WUA (PMWUA) for all species and life stages within seasons in the Tugalo River. Discharges in the central region (cross-hatching) produce average PMWUA values not significantly different (Fisher's Protected LSD, p = 0.10) from the maximum average PMWUA. Stippling indicates region where discharges begin to produce average habitat values (PMWUA) significantly less than the maximum average PMWUA. Unshaded regions indicate discharges producing average PMWUA values significantly lower than the maximum average PMWUA.

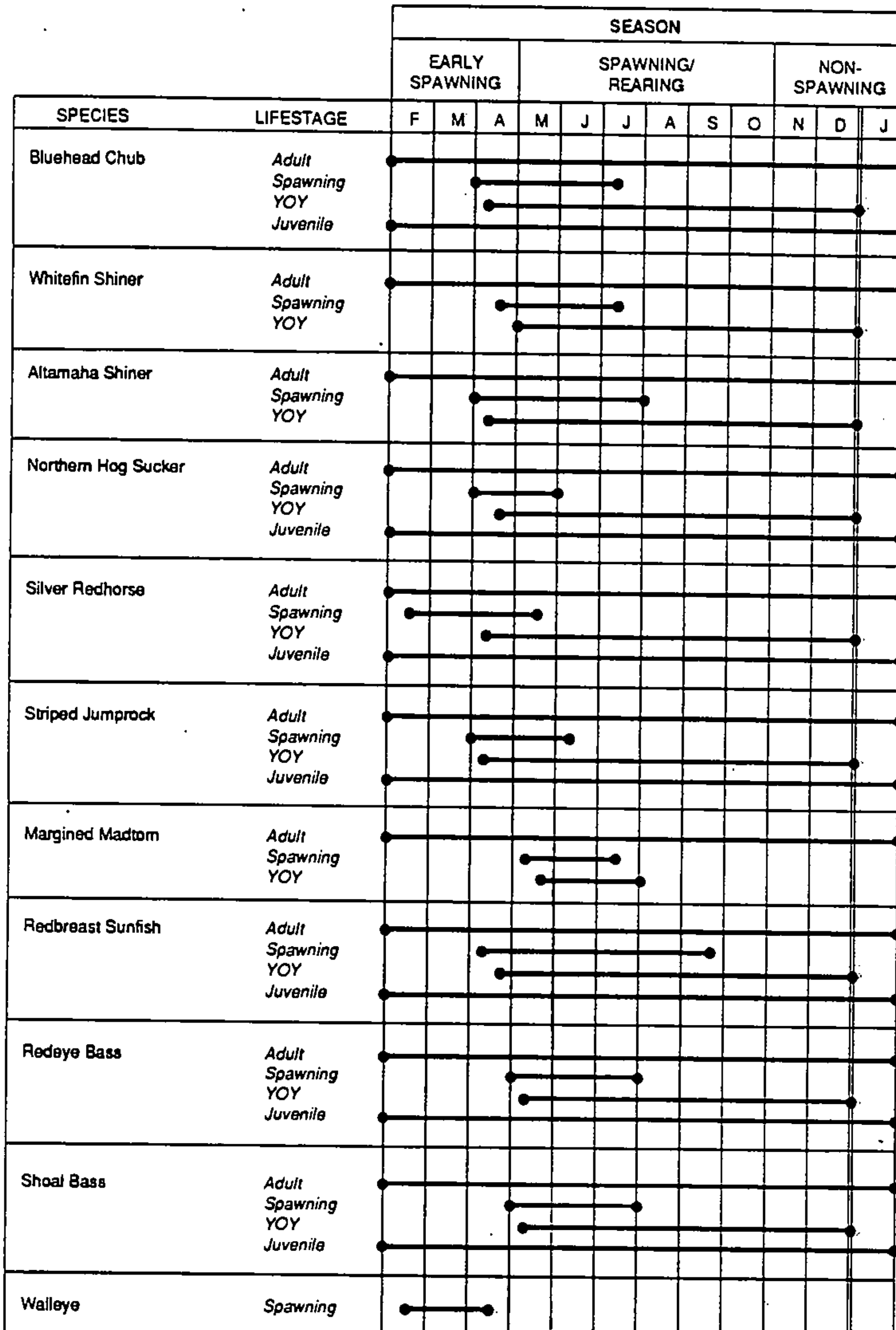


Figure 7-1. Illustration of the seasonal occurrence of target species life stages in the Tugalo and Ocmulgee rivers. Three biologically defined seasons are designated for use in evaluating instream flow regimes.

the period of record--water years 1943-1971. The results of a monthly flow-duration analysis completed by the USGS are presented in Table 7-8.

When minimum flow regimes for the Tugalo River study area are established, the flows required at Yonah Dam should be determined in consideration of the flow contributed by Panther Creek. Minimum flow required at Yonah Dam (Q_Y) would be computed as:

$$Q_Y = Q_{HM} - Q_P$$

where Q_{HM} is the flow required to provide a given level of habitat maintenance in the Tugalo River study area and Q_P is the flow contributed by Panther Creek.

The flow contributed by Panther Creek in any given month can be established from Table 7-8. Since stream flow is a stochastic phenomenon, the flow in Panther Creek on any particular day or month can only be estimated in a probabilistic sense. From Table 7-8, these probabilities can be determined and a "dependable flow" can be selected. An appropriate certainty or dependability level might be the 80th percentile flow (Table 7-8), which is the flow that will be equaled or exceeded 80 percent of the time in any given month. These flows could be determined for months within biological seasons, and be used in calculating flows required at Yonah Dam to ensure the selected levels of habitat maintenance in the Tugalo River study area.

with unimodal flow-habitat relationships, the same level of habitat can be produced at two different flows (EA 1986).

7.2.6 Tributary Flow Accrual in Study Reaches

The relationships between flow and habitat that are presented in Section 6 and Section 7 of this report are all based on discharges at the dam or the study site of interest. The amount of water in a stream channel changes in a downstream direction as a result of tributary additions and gain (or loss) of water through the stream bed. If this addition of water is significant, any minimum flow regime required for fish habitat maintenance would have to be adjusted for addition of water by tributaries.

In the Ocmulgee River study area, a number of small tributaries enter the mainstem Ocmulgee River along the length of the study area. However, none of these tributaries constitute a significant flow addition (i.e., >5 percent of total drainage area) to the Ocmulgee River. Consequently, they can be ignored for the purpose of establishing minimum flow regimes.

In the Tugalo River, two tributaries enter within the study reach (Table 2-1): Panther Creek and Brasstown Creek. With a drainage area of 33 mi^2, Panther Creek contributes a significant addition of flow to the Tugalo River (i.e., 7 percent of total drainage area of Tugalo River at confluence with Panther Creek), and must be factored in when establishing minimum flow regimes.

Panther Creek Hydrology

Water from Panther Creek enters the Tugalo River at the upper end of the study area, approximately 0.25 mi downstream of Yonah Dam, and upstream of all Tugalo River transects. A monthly statistical analysis of discharge records for Panther Creek near Toccoa (USGS Gauge 0218200; approximately 0.25 mi upstream of confluence with Tugalo River) was performed by the USGS for GPC. This analysis included daily discharge values for

Weekly mean habitat values were calculated for the calendar years 1982 (Tugalo River) and 1978 (Ocmulgee River) from the habitat time series for both the regulated and unregulated cases. The resulting time series of weekly mean habitat values for each species and life stage are presented in Figures 7-4 and 7-5 for the Tugalo River and in Figures 7-6 and 7-7 for the Ocmulgee River. These data provide a characterization of average habitat conditions over a typical year for historical plant operations and for flows that would have occurred in the absence of flow regulation by the dams.

While average habitat conditions serve to characterize general patterns of available habitat over time, a more detailed examination of the frequency and duration of the habitat values contributing to those averages is made possible by examining habitat duration tables.

Habitat Duration

The time series of habitat values produced in the previous section for the Tugalo River (1978-1986) and Ocmulgee River (1976-1982) study areas were analyzed with the Statistical Analysis System (SAS 1988) to produce monthly cumulative frequency distributions of habitat values. These data, presented as habitat duration tables in Appendix H, permit a determination of the percent of time in any month that various percentages of maximum WUA (PMWUA) are equalled or exceeded for any species life stage for regulated and unregulated flows in the Tugalo and Ocmulgee River study areas.

The habitat duration tables provide a more detailed characterization of range of habitat values that occur within each study area under the current regulated flows and habitat values that would occur in the absence of flow regulation. The values of the habitat duration tables show the range of PMWUA values that occur and the frequency of their occurrence within any given month. The habitat duration tables closely resemble the flow duration tables (Tables 7-5 and 7-6), but caution must be used in the interpretation of the habitat duration tables because, for species yield daily average flows for the Ocmulgee River at Lloyd Shoals Dam for the period of record February 1972 - September 1982.

7.2.5 Habitat Time Series

The final analysis of flow-habitat relations in project tailwaters involves a synthesis of a continuous record of fish habitat over time. This record of fish habitat over time, termed a habitat time series (Bovee 1982), was accomplished by interfacing each time series of stream flow records (Section 7.2.4) with the WUA versus discharge relationship of each species life stage (Tables 5-2 and 5-3) from physical habitat modeling using EA's TSERIES computer program. The TSERIES program converts (linear interpolation) each stream flow (hourly or daily average discharge) record into its corresponding habitat value for each species life stage.

Habitat time series were produced for both the regulated and unregulated cases for the stream flow records and periods summarized in Table 7-7. Hourly stream flow records for the period 1978-1988 described the stream flows for the regulated case in both the Tugalo and Ocmulgee rivers. The daily average flow records describing the unregulated flow case were limited to those times of overlapping periods of record for upstream gauges for the Tugalo River (1978-1986) and Ocmulgee River (1976-1982). The time period for comparison of regulated and unregulated habitat time series was defined by the overlap in periods of record for these cases: Tugalo River, 1978-1986 and Ocmulgee River, 1978-1982.

A "normal" water year was selected for graphical display of the results of the habitat time series analysis. Review of GPC plant records, USGS gauging data, and discussions with USGS personnel (R. McFarlane 1989) identified 1982 as typifying an average or "normal" water year for the Tugalo River study area and 1978 as a "normal" water year for the Ocmulgee River study area.

Unregulated Flows

Unregulated flows are those river discharges that would have occurred in the study areas without flow regulation by existing dams. Unregulated flow statistics were synthesized from historical flow records at unregulated river sites in the upper basins of the study areas. Monthly and annual flow-duration analyses of average daily flows were conducted by USGS for the following gauges:

USGS Gauge Number	Location	Period of Record for USGS Flow-Duration Analysis
Tugalo River Basin		
02178400	Tallulah River near Clayton	AUG 1964 - SEP 1986
02177000	Chattooga River near Clayton	OCT 1939 - SEP 1986
Ocmulgee River Basin		
02207500	Yellow River near Covington	JUL 1944 - SEP 1982
02204500	South River near McDonough	OCT 1939 - SEP 1982
02208450	Alcovy River above Covington	FEB 1972 - SEP 1986

These flow-duration analyses were used to estimate flow-duration statistics for the Tugalo River at Yonah Dam and the Ocmulgee River at Lloyd Shoals Dam by correcting for drainage area and summing. The monthly and annual flow-duration tables were produced by GPC and provided to EA. These data are summarized in Tables 7-5 and 7-6 for the Tugalo and Ocmulgee rivers, respectively.

The USGS data described above were also used to construct a synthetic historical record of daily average flows that would have occurred in the Tugalo and Ocmulgee River study areas in the absence of flow regulation. The Tallulah and Chattooga River flow records were corrected for drainage area and summed to yield daily average flows for the period of record 1964-1986 for the Tugalo River at Yonah Dam. The Yellow, South, and Alcovy River flow records were corrected for drainage area and summed to report sections integrate data on flow-habitat relationships with plant operations data to examine patterns of fish habitat availability over time.

7.2.4 Analysis of Historical Stream Flow Records

A full evaluation of fish habitat-flow relations in the project tail-waters should include an examination of seasonal water availability and patterns of fish habitat availability over time. To complete this final step, the available historical stream flow records (USGS gauging data and GPC plant operation data) were analyzed to characterize the existing regulated flows in the study area and, for comparison, the flow patterns that would occur if the river was unregulated.

Regulated Flows

Regulated flows are those river discharges that actually occurred in the study areas as a result of release of water from the dams. All regulated flow analyses below were based on GPC plant operating records. Hourly flows were estimated from plant generation records by converting megawatts of electricity produced to discharge (cfs) using recent estimates of the relationship between electricity production and plant discharge. These estimates were adjusted for leakage of water through turbines that were not generating power.

A time series of plant discharge records for the Tugalo River and Ocmulgee River study areas were created by GPC from plant operating records for an 11-year period (1978-1988) and supplied to EA. These hourly discharge records were analyzed using the Statistical Analysis System (SAS 1988) software to produce monthly and annual flow-duration tables, which are presented in Table 7-5 for the Tugalo River and in Table 7-6 for the Ocmulgee River.

For the non-spawning seasons, only juveniles and adults are present and considered when evaluating flow-habitat relations. All adults and juveniles of the species in the Tugalo River exhibit Type I and Type II habitat-discharge responses; consequently, there is less variability in habitat responses and a greater ability to detect significant differences in PMWUA values across discharges (i.e., smaller PLSD statistic).

One implication of the preceding analysis is that it suggests that due to the presence of spawning and YOY life stages, minimum flow requirements would be lower during the spawning/rearing season than during non-spawning and early spawning seasons. This conclusion is consistent with the fact that more species with lower flow requirements are present during this season.

Summary

The flow that produces optimum habitat conditions across all species life stages in a given season can be identified as the peak of the average PMWUA curve. However, due to the variability of responses of the individual species life stages, there is some range of flows producing average PMWUA values not significantly different from the maximum. Within that range, there is a single simulated discharge below which decreases in discharge produce levels of average habitat that are significantly less than the habitat produced at the optimum flow (Table 7-4).

For each study area, river, and season, the following statistics have been tabulated and presented in Table 7-4: the flow producing maximum average PMWUA, Fishers PLSD statistic, and the lowest flow producing non-significant decreases in habitat. Additionally, the flows producing 80, 60, and 40 percent of the maximum average PMWUA are provided; all of which are significantly lower values of average PMWUA than the maximum.

The information provided in this report section provides an objective, quantitative basis for examining the relationship between fish habitat and a variety of possible seasonal minimum flow scenarios. The following flows (stippled areas on Figure 7-2) within which the average PMWUA values become significantly lower than the maximum average PMWUA.

The results of the statistical analysis for the Tugalo River non-spawning season can be better understood by examining the WUA versus discharge relationships for the individual species life stages present in that biological season (Figure 5-6). In the flow range of 300-1,000 cfs, the various species life stages exhibit either relatively flat habitat responses or there is such a variation in habitat response across species life stages (some increasing, some decreasing) that changes in the average PMWUA are not significant. That is, there is no significant net gain or loss of habitat for all species considered together. Stream flows less than 250 cfs produce average PMWUA significantly lower than the maximum. In the range of flows less than 300 cfs, the habitat response of most species life stages is moderately or sharply declining (Figure 5-6) leading to significantly lower average PMWUA (Figure 7-2).

The results for the Tugalo River during the early spawning/rearing season are noticeably different than those outlined above for the Tugalo River during the non-spawning season (Figure 7-2; Table 7-4). The average PMWUA curve peaks at 350 cfs and the range of flows producing average PMWUA not significantly different from the maximum is 100-1,000 cfs.

The reason for the different results for the two seasons compared above is easily explained by the flow-habitat relations of the species life stages present in the two seasons (see Section 5.2.4). During the spawning/rearing seasons, the spawning and YOY life stages are present. This group typically occupies shallow-slow habitats and habitat for this group is maximized at near-zero flows (i.e., Type III habitat-discharge response). Pooling these species together with other species life stages that exhibit dissimilar habitat-discharge responses (i.e., species exhibiting Type I and Type II responses- low amounts of habitat at low flows) results in greater variability in response and a wider range of flows having no significant change in PMWUA.

The benefit of performing ANOVA and multiple mean comparisons is that it allows one to evaluate the significance of the composite (average) PMWUA curve. The composite PMWUA curve may be the result of individual curves of similar or different shapes. The greater the variability or discordance in the shapes and trends of the individual curves, the less likely that comparisons of average PMWUA between two releases will be significant. Generally speaking, significantly different comparisons will only exist in sections of the composite PMWUA curve where individual curves are behaving similarly (i.e., rising or falling). Ranges of reservoir releases where the individual curves behave differently (e.g., some increasing, some decreasing) will not generally result in a significant difference in average PMWUA.

For both the Tugalo River and Ocmulgee River data, ANOVA results showed a significant difference in average PMWUA over the range of flows simulated ($p < 0.01$) for each biological season. Accordingly, Fisher's PLSD test was performed at the $P = 0.10$ level of significance for each season. The maximum average PMWUA (peak of the average PMWUA curve) was used in our analysis as a reference flow for all of the comparisons. That is, given the maximum PMWUA, what changes in flow result in a significant decrease in habitat? A summary of the results of the PLSD analysis are presented in Table 7-4, and plots of average PMWUA versus discharge for each biological season are presented in Figures 7-2 and 7-3. An example interpretation of these results is provided below for the Tugalo River data; interpretation of the results for the Ocmulgee River follows the same logic.

For the Tugalo River during the non-spawning season, flows in the range of 300-1,000 cfs produce average PMWUA values that are not significantly different from the maximum average PMWUA (i.e., reference flow) (Figure 7-2; Table 7-4). The next highest and next lowest simulated flows outside this range produce average PMWUA values significantly lower than the maximum average PMWUA. Thus, there is some threshold range of

APPENDIX A

AGENCY CONSULTATION SUBMITTAL: DESCRIPTION AND RATIONALE FOR SELECTION OF TARGET SPECIES FOR INSTREAM FLOW STUDIES

DESCRIPTION AND RATIONALE
FOR SELECTION OF TARGET SPECIES
FOR INSTREAM FLOW STUDIES

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January 1988

PREFACE

The attached materials are designed to supplement previously submitted documents concerning Georgia Power Company hydroelectric project relicensing. These documents are:

Georgia Power Company. 1987a. Hydroelectric Project Relicensing, North Georgia Hydro Group, FERC Project #2354: First Stage Consultation for FERC Relicensing.

Georgia Power Company. 1987b. Hydroelectric Project Relicensing, Lloyd Shoals Dam, FERC Project #2336: First Stage Consultation for FERC Relicensing.

The purpose of this document is to provide agencies involved in the consultation process an opportunity to review and comment on the selection of candidate target species for physical habitat and temperature analyses tasks of the instream flow studies. Specifically, the project scoping step "Selection of Target Species/Identification of Existing Habitat Suitability Information" and the selection of species for the temperature monitoring step "Data Analysis" are described herein.

Two caveats are necessary at this point. First, the results of fish surveys reported here are based on preliminary data. However, only minor corrections to the fish survey data are expected. Second, the candidate target species selections have been made on the best available information but may be modified somewhat as the study progresses due to unknown factors or as additional information becomes available.

INTRODUCTION

The project scoping for instream flow studies described in GPC (1987a) and GPC (1987b) requires selection of evaluation (target) species for physical habitat simulation (Task 4) and for analysis of temperature monitoring data (Task 5). The objective of the following is to describe the basis and rationale for selecting candidate target fish species. A provisional suite of candidate species is identified rather than a final list because factors such as data availability, observability, etc. may affect the final selection.

SPECIES SELECTION FOR PHYSICAL HABITAT ANALYSIS

The criteria for selecting target species are: (1) fisheries management status, (2) abundance in the fish community, (3) riverine adaptation (ecological guilds), and (4) status of existing information about fish habitat preferences. This broad-based approach is used to ensure that important or abundant game or forage fish are included, that the range of habitat needs of the faunal assemblage of the stream is considered, and that existing habitat suitability criteria (HSC) information is effectively utilized. These goals are consistent with other published target species selection guidelines (U.S. Fish and Wildlife Service (USFWS) 1980; Roberts and O'Neil 1985; Bovee 1986). No federal- or state-listed threatened or endangered fish species were found to be present at the study sites, so this factor is not a consideration in the target species selection process. Finally, the spawning lifestage of walleye is included as a target species for the Tugalo River study site due to the high level of interest in this species expressed to date by natural resource agencies.

The first step in selecting target species is to establish a list of species and their relative abundances at each study site. GPC completed a fish survey during September 1987 in each of the three instream flow study reaches: Tallulah River in the Tallulah Gorge, Tugalo River downstream of Yonah Dam, and the Ocmulgee River downstream of Lloyd Shoals Dam. Additionally, the Mathis-Terrora Bypass (Tiger Creek) was included in the survey. Although no instream flow studies will be conducted in the latter site, this area may serve as a surrogate site for fish habitat preference studies due to difficulty in accessing the Tallulah Gorge. The preliminary results of the fish survey are presented in Appendix A.

Following completion of the fish survey, a search for existing HSC was conducted. The sources for this search were: (1) USFWS Instream Flow Group's Library of Habitat Suitability Criteria (CURVFIL), (2) USFWS Habitat Suitability Index (HSI) model series (Schamberger et al. 1982; Terrell et al. 1982), and (3) published and unpublished instream flow studies. The results of this search are summarized in Table 1 and Appendix B.

Existing HSC from the USFWS CURVFIL and HSI model series were summarized for fish species identified in the fish survey (Appendix B). The quality of these HSC is highly variable and the applicability of these data to sites in Georgia is unknown at this time. Additionally, other published

TABLE 1. SUMMARY OF EXISTING HABITAT SUITABILITY CRITERIA DATA, RIVERINE ATTRIBUTES, ECOLOGICAL GUILDS, AND MANAGEMENT STATUS FOR FISH SPECIES FOUND IN GEORGIA POWER COMPANY FISH SURVEYS OF THE TALLULAH, TUGALO, AND OCMULGEE RIVERS DURING SEPTEMBER 1987

	Habitat Suitability Information			Typical Stream Size	Typical Stream Temperature	Habitat Preference	Feeding Guild	Breeding Guild	Management Status
	General	U.S. FWS CURVFIL	Other Studies						
LEPISOSTEIDAE									
Longnose Gar	D	-	-	M-L	W	P, B	P	A.1.5	-
ANGUILLIDAE									
American Eel	D	X*	—	M-L	W-C	G	GI, P	A.1.1	-
CLUPEIDAE									
Blueback Herring	D, HSI	-	-	-	-	-	Pl	A.1.4	-
Gizzard Shad	HSI	X	-	L-M	W	P	H, O	A.1.2	-
ESOCIDAE									
Chain Pickerel	D	-	-	M	C-W	P, B	P	A.1.5	G
CYPRINIDAE									
Central Stoneroller	D	X*	X	S-M	C-W	Ri, Ru	H	A.2.1	-
Common Carp	HSI	X*	-	L-M	W	P	O	A.1.5	-
Bluehead Chub	D	-	X	S-M	C-W	G	O	A.2.1	-
Spottail Shiner	D	-	-	L-M	C-W	Ri, Ru	I	A.1.6	-
Yellowfin Shiner	L	-	-	S	C	?	I	?	-
Whitefin Shiner	L	-	-	M-L	C-W	Ri, Ru	I	?	-
Altamaha Shiner	L	-	-	M	C-W	P, Ru	I	?	-
Bandfin Shiner	L	-	-	S-M	C	Ru, Ri	I	?	—
CATOSTOMIDAE									
Northern Hog Sucker	D	X*	X	M-S	C-W	Ru	BI	A.1.3	-
Spotted Sucker	D	-	-	S-M	W	P	BI	A.1.3	-
Silver Redhorse	D	-	-	M-L	W-C	P	BI	A.1.3	-
Striped Jumprock	L	-	-	S-M	C-W	Ri, Ru	BI	A.1.3?	-
ICTALURIDAE									
Snail Bullhead	L	-	-	M-L	W	Ri, Ru?	BI/P	B.2.?	G
White Catfish	D	-	-	L-LAKE	W	P	BI/P	B.2.?	G
Brown Bullhead	D	-	-	S-L	W	P	BI,O	B.2	G
Channel Catfish	HSI	X*	-	M-L	W	Ru, P	BI,O	B.2	G
Margined Madtom	D	-	-	S-M	C-W	Ri, Ru	BI	B.2	G
PERCICHTHYIDAE									
White Bass	HSI	X*	-	-	W	P, Ru	P, C	A.1.?	G
Striped Bass	HSI	-	-	-	C	P	P	A.1.2	G

TABLE 1 (Cont.)

	Habitat Suitability Information			Typical Stream Size	Typical Stream Temperature	Habitat Preference	Feeding Guild	Breeding Guild	Management Status
	General	U.S. FWS CURVFIL	Other Studies						
CENTRARCHIDAE									
Redbreast Sunfish	HSI	X	X	M-L	W-C	P, Ru	GI/P	B.2.1	G
Green Sunfish	HSI	X*	-	S-M	C-W	P	GI/P	B.2.1	G
Warmouth	HSI	X	-	M-L	W	P	P/GI	B.2	G
Bluegill	HSI	X*	-	M	W	P	GI	B.2.1	G
Dollar Sunfish	L	-	-	M ?	W	P	GI ?	B.2	G
Redear Sunfish	HSI	-	-	M ?	W	P	S	B.2	G
Spotted Sunfish	L	-	-	M-L	W	P	GI ?	B.2	G
Redeye Bass	L, D	-	-	S-M	W-C	Ru, P	GI/P	B.2.1	G
Largemouth Bass	HSI	X*	-	L-M	W	P, B	P/GI	B.2.2	G
White Crappie	HSI	X*	-	L-M	W-C	P, B	P	B.1.2	G
PERCIDAE									
Turquoise Darter	L	-	-	S-M	W-C	Ri, Ru	I	?	-
Yellow Perch	HSI	X*	-	L-M	C-W	P, B	GI/P	A.1.4	G
Blackbanded Darter	L	-	-	S-M	W-C	Ri, Ru	I	?	-
Walleye	HSI	X*	-	M	C	P, Ru	P	A.1.3	G

(a) Categories from Hokanson (1977).
(b) Designations patterned after Ohio EPA (1987) and Horowitz (1978)
(c) Categories and most designations from Balon (1975).

LEGEND

Habitat Suitability Information

General
- D = general descriptive information available from literature
- L = very limited or no information available
- HSI = U.S. Fish and Wildlife Service habitat suitability index model published

U.S. Fish and Wildlife Service CURVFILE
- X = suitability index curves available for instream flow analysis as of July 1987
- * = based on actual field measurements

Typical Stream Size

- S = small, headwaters and creeks
- M = medium-sized river
- L = large-sized river or sluggish streams

Habitat Preference

- Ri = riffle
- Ru = run
- P = pool
- B = backwater
- G = generalist

Breeding Guild(c

A. Nonguarders

- A.1 Open substratum spawners
  - A.1.1 Pelagophils
  - A.1.2 Litho-pelagophils
  - A.1.3 Lithophils
  - A.1.4 Phyto-lithophils
  - A.1.5 Phytophils
  - A.1.6 Psammophils
- A.2 Brood hiders
  - A.2.1 Lithophils

B. Guarders

- B.1 Substratum choosers
  - B.1.2 Phytophils
- B.2 Nest spawners
  - B.2.1 Lithophils
  - B.2.2 Pbytophils
  - B.2.5 Spelophils

Typical Stream Temperature[a]

- CO = stenotherm, optimum temperature <20 C (cold)
- C = mesotherm, optimum temperature 20-28 C (cool)
- W = eurytherm, optimum temperature >28 C (warm)

Feeding Guild[b]

- P = piscivore, consume primarily fishes
- I = insectivore, consume primarily aquatic insects from bottom, surface, or water column
- H = herbivore, consume attached algae and benthic diatoms
- O = omnivore, consume a wide range of animal and plant food including terrestrial/aquatic insects, fish, detritus, etc.
- Pl = planktivore, midwater fishes which strain zooplankton and phytoplankton
- BI = benthic invertivore, consume a variety of benthic invertebrates such as aquatic insects, mollusks, benthic microcrustacea, etc.
- GI = generalized invertivore, consume insects, zooplankton, crayfish, insect drift, etc. from the bottom, surface, and water column
- S = snail eater

Management Status

- G = gamefish

and unpublished instream flow studies were identified that may provide supplementary or new HSC for four species (Table 1).

For each fish species reported in Appendix A, the pertinent basic ecology and habitat use attributes for the adult lifestage have been summarized (Table 1). The specific species designations were derived from basic regional ichthyological texts and descriptions of ecology and life history (Carlander 1969, 1977; Scott and Crossman 1973; Pflieger 1975; Gilbert 1978; Smith 1979; Lee et al. 1980; Trautman 1981; Becker 1983; Page 1983), as well as review of additional literature sources cited therein. In some cases, these designations are based on professional judgement due to lack of data. Previously published ecological classifications were utilized where possible:

- Breeding guilds: Balon (1975); Berkman and Rabeni (1987)
- River size, habitat, and trophic guilds: Horowitz (1978); Karr et al. (1986); Berkman and Rabeni (1987); Ohio EPA (1987);

The target species selection, based on habitat, trophic, and reproductive guilding, follows the reasoning used in the assessment of biotic integrity (Karr et al. 1986). An array of fish community representatives is used, resulting in a broad-based ecological assessment, in this case from a habitat perspective.

The proposed suite of candidate species for each site is summarized in Table 2. For each site the selection process yielded species typical of that stream size and general temperature regime (e.g., Tallulah River target species include primarily cool-water species typical of small to medium-sized streams, whereas Ocmulgee River target species include primarily warm-water species typical of medium to large streams). Abundant species were preferentially selected. The selection process was designed to result in the inclusion of one or more important sportfish (predaceous centrarchids or ictalurids), important forage species (insectivorous minnows), and other non-game species (benthic invertivores). In some cases, a species may have been preferentially selected to maximize data sharing or pooling among streams (i.e., data collected in one stream being applied to another stream).

The suite of proposed candidate target species selected for each study area effectively represents a cross section of habitat, feeding, and breeding guilds and taxonomic groups. For each study area, a centrarchid, cyprinid, catostomid, and ictalurid have been selected, and pool/riffle/run habitat preferences, insectivores, invertivores, and piscivores, and a range of spawning types (nest spawners, broadcast spawners, etc.) are represented. When the different ecological attributes of the potential lifestages (spawning, young-of-the-year, juvenile, adult) to be studied are included, this representation becomes even broader.

The specific lifestages to be studied are not known at this time, but should in most cases include adults and juveniles. Stream conditions, short duration of spawning events, or inability to observe certain

TABLE 2 SUMMARY OF CANDIDATE TARGET SPECIES TO BE USED FOR PHYSICAL HABITAT ANALYSIS (see text for explanation)

Tallulah River

1. Redbreast sunfish[a]/Redeye bass
2. Northern hog sucker/Margined madtom
3. Yellowfin shiner/Bandfin shiner
4. Stoneroller/Bluehead chub

Tugalo River

1. Redbreast sunfish[a]/Largemouth bass
2. Snail bullhead/Margined madtom
3. Whitefin shiner/Spottail shiner
4. Northern hog sucker/Silver redhorse

Walleye is a definite target species for this site.

Ocmulgee River

1. Largemouth bass/Redbreast sunfish[a]
2. Spottail shiner/Altamaha shiner
3. Snail bullhead/Brown bullhead
4. Spotted sucker/Silver redhorse

(a) Redbreast sunfish may be replaced by bluegill.

lifestages due to size or secretive habits may preclude development of habitat suitability criteria for spawning, fry, or young-of-the-year lifestages. These lifestages will be added whenever possible.

For the 18 potential target species, existing HSC for instream flow analysis are available for six (Appendix B): largemouth bass, bluegill, stoneroller, northern hog sucker, redbreast sunfish, and walleye. The type of HSC available is variable and ranges from those based largely on literature and/or expert opinion (e.g., redbreast sunfish) to those largely based on field measurements and corrected for environmental bias (e.g., largemouth bass) (Appendix B). These existing HSC will form the basis of the screening-level evaluation or field verification studies described in GPC (1987a) and GPC (1987b). Existing HSC from other studies (Hill and Hauser 1985; Leonard et al. 1986; Ebert et al. 1987) will be used in a similar fashion. For the remaining species, development of site-specific HSC would be required.

In summary, a group of appropriate candidate target species has been identified for each study site. Physical habitat analysis at each site will not include all species listed in Table 2. At a minimum, the analysis will include two lifestages (adult, juvenile) of three species or a total of six species-lifestage combinations. Table 2 lists four pairs of species for each site, a primary choice and an ecologically or taxonomically similar substitute target species. Species will be selected so that one species from each of three target species pairs (Table 2) is included in physical habitat analysis to meet the above stated minimum. Analysis at Yonah will also include spawning walleye. Overlap in the applicability of HSC among sites will most likely ensure that a sufficient number of HSC are available for analysis at each site.

SPECIES SELECTION FOR TEMPERATURE ANALYSIS

The temperature monitoring program (Task 5) previously described in GPC (1987a, 1987b) outlined a study to determine if stream temperature in the study reaches attain levels unsuitable for target species during the warm season under existing flow regimes. The rationale for selecting representative species and a more detailed description of analysis methods are described below.

The objective in selecting target species for analysis of temperature monitoring data parallels that for physical habitat analysis (e.g., selection on basis of abundance, community function, etc.) but is constrained to a greater extent by availability of published temperature requirements data. Our reasoning follows the intent of Brungs and Jones (1977) and Nestler et al. (1986) that thermal criteria should protect appropriate desirable/important fish species but should not be unnecessarily restrictive in terms of project operations. Accordingly, species have been selected to be appropriate for the general temperature regime of the study site under consideration. For the Tallulah Gorge site, the target species will be representative of species in coolwater to warmwater streams, and primarily warmwater species will be used for the Tugalo River and Ocmulgee River sites.

A list of tentative target species for analysis of temperature monitoring data is presented in Table 3. These species generally represent the more abundant species found at each for which sufficient temperature requirements data exist. These target species selections are tentative based on the temperature requirements data that have been evaluated to date. These data were obtained from sources such as Reutter and Herdendorf (1974), Cherry et al. (1975, 1977), Stauffer et al. (1975, 1976), Reynolds and Casterlin (1976), Brungs and Jones (1977), Coutant (1977), and references cited therein. For some species, insufficient temperature requirements data existed for them to be considered for inclusion as target species (e.g., yellowfin shiner, whitefin shiner, altamaha shiner, bandfin shiner, striped jumprock, snail bullhead, margined madtom, turquoise darter, blackbanded darter, redeye bass, dollar sunfish, spotted sunfish).

An attempt was made to select target species from each of the most important families of fishes. Recent studies have demonstrated the similarity of temperature responses among fish species within families across geographic regions (Mathur et al. 1981, 1983). Consequently, protection of a limited number of target species should ensure protection of most other related species.

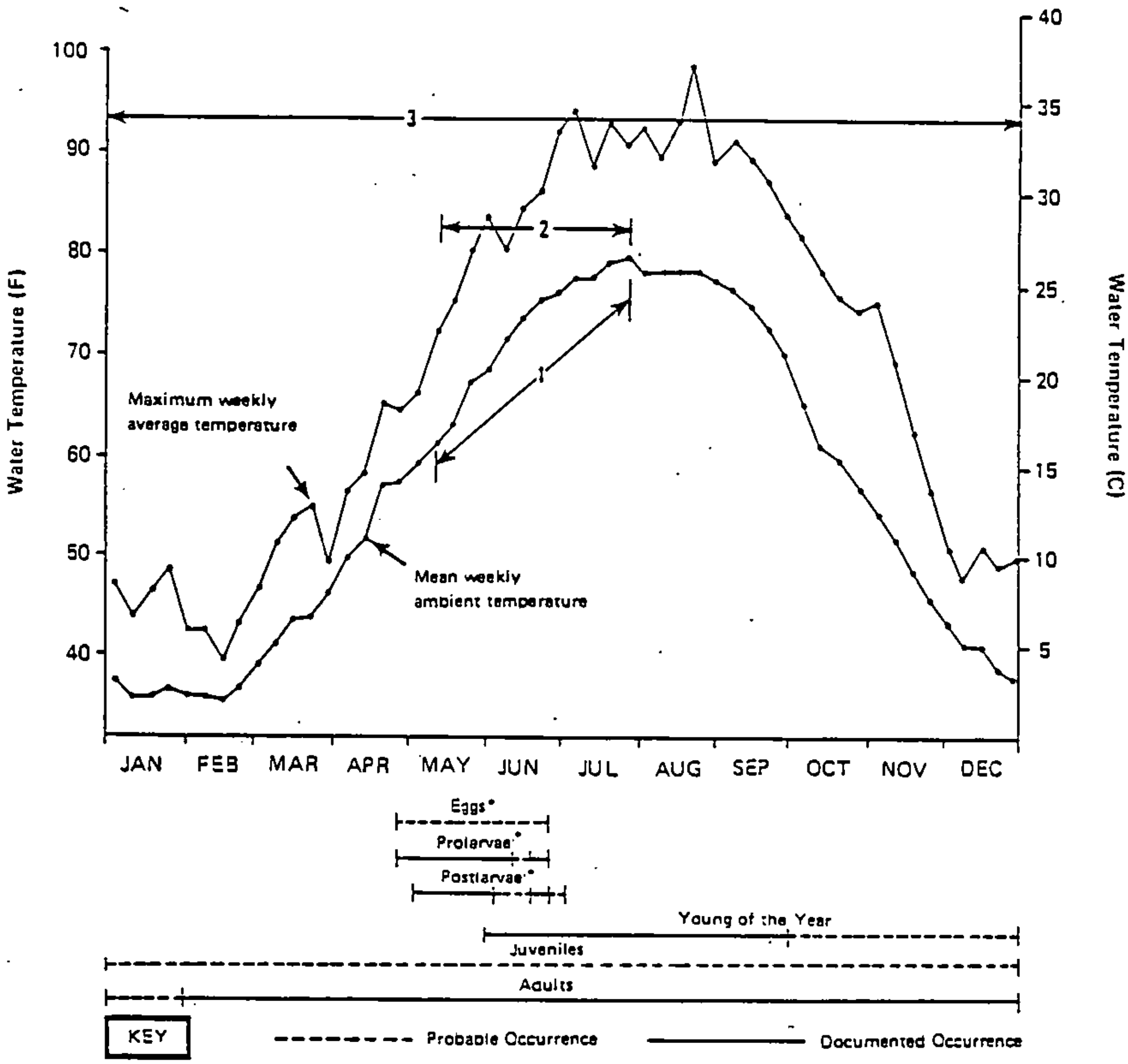
In some cases, there may be limited temperature requirements data for a target species. For such cases, potential surrogate species have been identified for which more complete temperature requirements data exist (Table 3). Following the reasoning of Mathur et al. (1983) outlined above, this substitution of species should be valid, but such surrogates will be carefully selected to have similar temperature requirements.

The approach to be used for analysis of temperature data will be similar to that outlined by Brungs and Jones (1977) and NAS/NAE (1973). Briefly, these publications outline the development of thermal criteria which consider the multiple thermal requirements of aquatic species such as for growth, spawning, hatching, as well as temperature limitations for survival (i.e., short-term maximum). Thermal criteria will be developed from such published data as optimum, upper lethal, maximum spawning, and maximum egg-incubation temperatures. Examples of criteria that may be used include maximum weekly average temperatures (MWAT) for growth and spawning and short-term maximum temperatures to protect against lethal effects (Brungs and Jones 1977). Published data are rarely available to calculate all criteria for each species, so the criteria used in the final analysis will be dependent on the final target species selection and data availability.

Once the thermal criteria have been established, ambient stream temperatures (e.g., maximum, mean weekly, etc.) from temperature monitoring will be evaluated. Thermal criteria and ambient stream temperatures will be presented graphically in a fashion similar to Figure 1. The frequency and duration of thermal criteria exceedances will be described.

TABLE 3 SUMMARY OF CANDIDATE TARGET SPECIES FOR ANALYSIS OF TEMPERATURE MONITORING DATA

Target Species	Surrogate
Tallulah River	
1. Redeye bass	Smallmouth bass
2. Northern hog sucker	
3. Redbreast sunfish	Bluegill
4. Bluehead chub	
5. Central stoneroller	
Tugalo River	
1. Bluegill	
2. Largemouth bass	
3. Brown bullhead	Channel catfish
4. Spottail shiner	Spotfin shiner
5. Northern hog sucker	
Ocmulgee River	
1. Bluegill	
2. Largemouth bass	
3. Brown bullhead	Channel catfish
4. Spottail shiner	Spotfin shiner
5. Gizzard shad	



*Seasonal distribution of early life stages based on Catostomidae.

KEY TO THERMAL EFFECTS DATA POINTS

1. Spawning temperatures: 61-82 F (Ecological Analysts 1978a).
2. Maximum temperature for embryo survival: 82 F (Brungs and Jones 1977).
3. Upper limit of optimum temperature range for adults: 93 F (Gammon 1973; Yoder 1976).

Figure 1. Example graphic display of ambient stream temperature and fish species thermal criteria.

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APPENDIX A

GEORGIA POWER COMPANY
FISH SURVEY DATA
(PRELIMINARY RESULTS)

PRELIMINARY DATA
SUBJECT TO REVISION

TABLE A-1 GEORGIA POWER COMPANY FISH SURVEY DATA. SPECIES COMPOSITION FOR ALL SAMPLING SITES COMBINED AND OCCURRENCE OF FISH SPECIES AT EACH SAMPLING SITE; COLLECTION PERIOD 15-25 SEPTEMBER 1987

Species	Frequency	Percent	Site			
			Tallulah River	Mathis-Terrora	Tugalo River	Ocmulgee River
Longnose Gar	3	0.1				X
American Eel	51	2.5				X
Blueback Herring	26	1.3			X	
Gizzard Shad	34	1.6			X	X
Chain Pickerel	1	0.0				X
Central Stoneroller	41	2.0	X	X		X
Bluehead Chub	241	11.6	X	X	X	X
Yellowfin Shiner	87	4.2	X	X		X
Whitefin Shiner	55	2.7		X	X	
Bandfin Shiner	40	1.9		X		
Spottail Shiner	172	8.3			X	X
Altamaha Shiner	69	3.3				X
Common Carp	8	0.4			X	X
Northern Hog Sucker	78	3.8	X	X	X	
Spotted Sucker	63	3.0				X
Silver Redhorse	34	1.6			X	X
Striped Jumprock	16	0.8	X	X	X	X
Snail Bullhead	111	5.4	X		X	X
White Catfish	4	0.2				X
Yellow Bullhead	2	0.1	X			
Brown Bullhead	27	1.3		X		X
Margined Madtom	92	4.4	X	X	X	X
Channel Catfish	1	0.0			X	
Redbreast Sunfish	443	21.4	X	X	X	X
Green Sunfish	13	0.6		X	X	X
Warmouth	5	0.2			X	X
Bluegill	96	4.6		X	X	X
Dollar Sunfish	1	0.0				X
Redear Sunfish	8	0.4				X
Spotted Sunfish	5	0.2				X

TABLE A-1 (Cont.)

Species	Frequency	Percent	Site: Tallulah River	Site: Mathis-Terrora	Site: Tugalo River	Site: Ocmulgee River
Redeye Bass	43	2.1	X	X	X	X
Largemouth Bass	64	3.1		X	X	X
Blackbanded Darter	82	4.0			X	X
Turquoise Darter	16	0.8				X
Yellow Perch	36	1.7			X	X
White Bass	4	0.2			X	X

PRELIMINARY DATA
SUBJECT TO REVISION

TABLE A-2 GEORGIA POWER COMPANY FISH SURVEY DATA. SPECIES COMPOSITION AND LENGTH DATA BY SAMPLING SITE; COLLECTION PERIOD 15-25 SEPTEMBER 1987

	Tallulah River Gorge Site					
			Length (mm)			
Species	Number	Percent	Mean	Minimum	Maximum	Standard Deviation
Bluehead Chub	129	51.4	52.0	30	163	25.8
Redbreast Sunfish	48	19.1	63.8	29	180	46.6
Central Stoneroller	32	12.7	64.9	38	127	26.9
Redeye Bass	16	6.4	101.6	76	208	34.1
Northern Hog Sucker	10	4.0	84.6	72	100	10.6
Snail Bullhead	7	2.8	201.4	170	230	22.1
Yellowfin Shiner	5	2.0	41.8	38	47	3.9
Yellow Bullhead	2	0.8	69.5	68	71	2.1
Striped Jumprock	1	0.4	193.0	193	193	--
Margined Madtom	1	0.4	54.0	54	54	--
All	251	100.0	65.0	29	230	41.4

PRELIMINARY DATA
SUBJECT TO REVISION

TABLE A-2 (Cont.)

Species	Mathis-Terrora Bypass Site					
			Length (mm)			
	Number	Percent	Mean	Minimum	Maximum	Standard Deviation
Bluehead Chub	88	19.8	78.0	33	153	26.8
Redbreast Sunfish	75	16.9	98.0	50	186	33.3
Yellowfin Shiner	74	16.7	57.8	31	80	9.0
Northern Hog Sucker	62	14.0	127.3	46	256	53.0
Bandfin Shiner	40	9.0	85.5	60	106	12.4
Whitefin Shiner	39	8.8	61.4	31	88	12.1
Margined Madtom	33	7.4	98.5	30	146	22.4
Central Stoneroller	8	1.8	93.5	77	125	14.8
Redeye Bass	8	1.8	125.5	59	211	48.6
Striped Jumprock	7	1.6	197.3	165	252	33.2
Brown Bullhead	3	0.7	101.7	98	105	3.5
Green Sunfish	3	0.7	155.0	136	171	17.7
Largemouth Bass	3	0.7	132.3	41	236	98.1
Bluegill	1	0.2	75.0	75	75	--
All	444	100.0	89.7	30	256	40.3

PRELIMINARY DATA
SUBJECT TO REVISION

TABLE A-2 (Cont.)

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
			Tugalo River Site			
Blackbanded Darter	74	15.6	78.2	46	101	11.2
Bluegill	65	13.7	112.8	51	193	26.3
Margined Madtom	57	12.1	89.6	44	128	15.5
Redbreast Sunfish	50	10.6	134.4	46	195	37.5
Snail Bullhead	35	7.4	162.5	100	240	40.8
Yellow Perch	31	6.6	105.2	60	162	31.0
Blueback Herring	26	5.5	80.5	73	87	3.4
Largemouth Bass	26	5.5	157.0	41	450	112.5
Spottail Shiner	20	4.2	92.4	58	114	13.2
Bluehead Chub	17	3.6	128.4	85	200	28.6
Whitefin Shiner	16	3.4	79.5	68	95	9.0
Silver Redhorse	13	2.7	398.4	303	466	41.6
Redeye Bass	11	2.3	172.4	64	301	98.0
Green Sunfish	9	1.9	105.9	78	132	19.6
Common Carp	6	1.3	489.2	433	530	44.5
Northern Hog Sucker	6	1.3	158.8	140	194	20.7
Warmouth	4	0.8	171.8	139	195	26.7
Gizzard Shad	2	0.4	300.0	290	310	14.1
Striped Jumprock	2	0.4	146.0	141	151	7.1
White Bass	2	0.4	380.5	361	400	27.6
Channel Catfish	1	0.2	310.0	310	310	--
All	473	100.0	126.7	41	530	81.9

PRELIMINARY DATA
SUBJECT TO REVISION

PRELIMINARY DATA
SUBJECT TO REVISION

TABLE A-2 (Cont.)

Species	Ocmulgee River Site[a]					
			Length (mm)			
	Number	Percent	Mean	Minimum	Maximum	Standard Deviation
Redbreast Sunfish	270	29.9	116.8	27	195	30.5
Spottail Shiner	152	16.8	83.3	63	117	13.1
Altamaha Shiner	69	7.6	60.4	38	93	12.5
Snail Bullhead	69	7.6	177.3	45	347	67.1
Spotted Sucker	63	7.0	352.2	100	505	92.8
American Eel	51	5.6	295.2	190	610	78.6
Largemouth Bass	35	3.9	184.4	70	387	88.2
Gizzard Shad	32	3.5	322.2	243	386	34.9
Bluegill	30	3.3	150.2	56	220	43.8
Brown Bullhead	24	2.7	225.4	86	345	51.0
Silver Redhorse	21	2.3	338.6	205	445	86.5
Turquoise Darter	16	1.8	48.8	40	71	7.3
Yellowfin Shiner	8	0.9	48.3	40	54	5.8
Redear Sunfish	8	0.9	193.9	145	300	63.6
Redeye Bass	8	0.9	205.6	73	340	84.1
Blackbanded Darter	8	0.9	72.9	59	100	15.9
Bluehead Chub	7	0.8	120.4	72	155	27.3
Striped Jumprock	6	0.7	179.3	160	204	17.0
Spotted Sunfish	5	0.6	105.6	85	131	19.7
Yellow Perch	5	0.6	196.8	102	285	72.8
White Catfish	4	0.4	196.5	68	280	90.5
Longnose Gar	3	0.3	553.0	376	790	213.4
Common Carp	2	0.2	575.0	470	680	148.5
White Bass	2	0.2	465.0	460	470	7.1
Chain Pickerel	1	0.1	402.0	402	402	--
Central Stoneroller	1	0.1	25.0	125	125	--
Margined Madtom	1	0.1	90.0	90	90	--
Green Sunfish	1	0.1	124.0	124	124	--
Warmouth	1	0.1	150.0	150	150	--
Dollar Sunfish	1	0.1	135.0	135	135	--
All	904	100.0	161.0	27	790	109.0

(a) One white crappie (*Poxomis annularis*) was captured but escaped at this site.

APPENDIX B

HABITAT SUITABILITY CURVES AVAILABLE FROM THE U.S. FISH AND WILDLIFE SERVICE FOR INSTREAM FLOW PHYSICAL HABITAT ANALYSIS

TABLE B-1 AVAILABILITY OF HABITAT SUITABILITY INDEX CURVES FOR SPECIES FOUND IN GPC FISH SURVEYS AS OBTAINED FROM THE U.S. FISH AND WILDLIFE SERVICE, AQUATIC SYSTEMS BRANCH[a], NATIONAL ECOLOGY CENTER

Species	Spawning VDSCT	Egg Incubation VDSCT	Fry VDSCT	Juvenile VDSCT	Adult VDSCT
Largemouth bass[b]	333X1	101X1	33311	33311	33311
White bass	222X1	011X1	22201	22001	22201
Bluegill[b]	333X1	101X1	33301	33311	33311
Common carp	33311	11011	33311	33311	33311
Channel catfish	33312	11011	33312	33312	33312
White crappie	21211	00011	21211	12211	22111
American eel	00000	00000	00000	33300	00000
Yellow perch	11101	11101	22201	22211	22211
Gizzard shad	11101	11101	11001	11001	11001
Stoneroller[b]	000X0	222X0	00000	22200	33300
Northern hog sucker[b]	00000	00000	00000	22000	22000
Green sunfish	11101	10101	22201	22201	33311
Redbreast sunfish[b]	11111	11101	11111	11111	11001
Redear sunfish	10011	10011	10011	10011	10011
Walleye[b]	221X1	221X1	22211	22211	22211
Warmouth	10011	10011	10011	10011	10011

KEY: V = Velocity
D = Depth
S = Substrate
C = Cover
T = Temperature
0 = No suitability index (SI) curve available
X = No SI curve necessary (variable considered unimportant to species well-being)
1 = Category one SI curve available (based on literature and/or expert opinion)
2 = Category two (utilization) SI curve available (based on field observations; for application in streams of similar size and complexity)
3 = Category three (preference) SI curve available (based on field observations; environmental bias removed; more broadly transportable to other streams)

(a) Formerly the instream flow group.
(b) Potential target species.

APPENDIX B

PART I:

AGENCY CONSULTATION SUBMITTALS: HABITAT MAPPING AND TRANSECT SELECTION. CONTENTS:

TUGALO RIVER	TABLES 1, 2, 3
OCMULGEE RIVER	TABLES 1, 2, 3

PART II:

SUMMARY OF HABITAT MAPPING DATA BASE FOR THE TUGALO (TABLE B-1) AND OCMULGEE (TABLE B-2) RIVERS

TABLE B-2 (Cont.)

SECTION	LENGTH (FT)	AVE WIDTH (FT)	AREA (ACRES)	CHANNEL TYPE	FEATURE	DOMINANT SUBSTRATE	SUBDOMINANT SUBSTRATE
	Attribute						
50	118	126	0.3410	DIVIDED	SHOAL	IR BED	GRAVEL
51	368	91	0.7649	DIVIDED	RUN/POOL	FINES	GRAVEL
52	107	116	0.2853	DIVIDED	SHOAL	IR BED	GRAVEL
60	120	363	1.0013	SINGLE	SHOAL	IR BED	FINES
61	210	329	1.5848	SINGLE	RUN/POOL	IR BED	GRAVEL
62	755	230	3.5300	DIVIDED	POOL	GRAVEL	IR BED
63	593	95	1.2914	DIVIDED	POOL	FINES	IR BED
64	446	396	4.0539	SINGLE	SHOAL	IR BED	FINES
65	126	341	0.9878	SINGLE	RUN/POOL	GRAVEL	IR BED
66	1221	214	5.9965	SINGLE	POOL	FINES	IR BED
67	805	263	4.8556	SINGLE	POOL	FINES	GRAVEL
68	577	270	3.5784	SINGLE	RUN/POOL	IR BED	GRAVEL
69	524	164	1.9733	DIVIDED	SHOAL	IR BED	GRAVEL
70	305	103	0.7233	DIVIDED	RUN	IR BED	SM BO
71	260	114	0.6797	DIVIDED	POOL	IR BED	FINES
72	197	74	0.3343	DIVIDED	RUN/POOL	IR BED	FINES
75	205	203	0.9555	SINGLE	SHOAL	IR BED	GRAVEL
76	185	217	0.9199	SINGLE	POOL	IR BED	GRAVEL
77	1107	203	5.1532	SINGLE	RUN/POOL	IR BED	FINES
78	889	467	9.5291	SINGLE	SHOAL	IR BED	GRAVEL
79	1005	85	4.3806	DIVIDED	SHOAL	IR BED	SM BO
80	562	108	1.3907	DIVIDED	RUN	GRAVEL	SM BO
81	707	111	1.7977	DIVIDED	RUN	GRAVEL	SM BO
82	783	154	2.7726	SINGLE	GRAVEL RUN	GRAVEL	FINES
83	231	174	0.9250	SINGLE	SHOAL	IR BED	GRAVEL
84	361	134	1.1097	SINGLE	GRAVEL RUN	GRAVEL	FINES
85	80	144	0.2644	SINGLE	SHOAL	IR BED	GRAVEL
86	716	128	2.1033	SINGLE	GRAVEL RUN	GRAVEL	FINES
90	239	95	0.5217	SINGLE	SHOAL	IR BED	GRAVEL
91	977	63	1.4133	DIVIDED	RUN	FINES	GRAVEL
92	581	90	1.1949	DIVIDED	SHOAL	IR BED	GRAVEL
93	450	91	0.9362	DIVIDED	RUN	GRAVEL	IR BED
95	2640	178	10.7879	SINGLE	SANDY RUN/POOL	FINES	GRAVEL

TABLE 2 LOCATION, HABITAT TYPE, AND RATIONALE FOR INSTREAM FLOW TRANSECT PLACEMENT IN THE TUGALO RIVER DOWNSTREAM OF YONAH DAM. A TOTAL OF NINE FINAL TRANSECTS WILL BE USED; ACCEPTABLE SUBSTITUTE TRANSECTS (IN PARENTHESES) ARE LISTED FOR SOME HABITAT TYPES

Transect Located in Section	Habitat Type	Reason for Placing Transect in Selected Location
19 (or 25)	Riffle	. Representative of dominant riffle habitat (primarily cobble; no secondary channel feature)
28/29 (island)	Riffle	. Representative of dominant riffle habitat . Known walleye spawning/stranding area . Island with subchannel pool area
16 (or 20)	Run	. Representative of dominant cobble/gravel run habitat . Very similar to or actual habitat in which walleye were observed spawning and eggs were found
12	Run	. Representative of irregular bedrock/small boulder runs with bedrock outcrop and chutes
17 (or 24)	Riffle/run	. Typical of dominant cobble/small boulder riffle/run habitat
21	Riffle/run	. Represents less dominant riffle/run habitat
7	Run/pool	. Represents dominant gravel/ cobble run/pool . Includes unique backwater habitat
26	Run/pool	. Represents subdominant run/pool habitat . Contains slow-water gravel areas-possibly important spawning areas
9	Backwater	. Represents the only large backwater habitat

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TABLE 1 OCCURRENCE OF SPECIFIC HABITAT FEATURES IN THE TALLULAH AND TUGALO RIVER STUDY AREAS

Tallulah River

Habitat Type	Section
(5) Plunge pools	41, 51, 58, 64, 66
(12) Pools	3, 5, 9, 22, 27, 34, 46, 48, 53, 54, 56, 62
(4) Trench pools	19, 36, 37, 38
(10) Chain pools	7, 11, 14, 17, 20, 25, 30, 33, 43, 68
(6) Boulder run - HG	21, 28, 32, 45, 47, 69
(15) Boulder run - LG	1, 2, 12, 13, 15, 16, 24, 29, 35, 39, 40, 44, 49, 50, 63
(3) Cascades	23, 31, 57
(4) Falls	55, 59, 61, 65
(5) Chutes	6, 10, 18, 60, 70
(6) Outcrops	4, 8, 26, 42, 52, 67

Tugalo River

Habitat Type	Section
(7) Riffle	5, 19, 25, 28, 29, 31, 36
(10) Run	2, 3, 12, 16, 20, 23, 32, 34, 38, 42
(6) Riffle/run	13, 17, 21, 24, 33, 39
(1) Pool	41
(1) Backwater	9
(6) Run/Pool	4,7,26,35,37,40

TUGALO RIVER: PRIMARY HABITAT TYPES[a]

Riffle:	Area of stream where water velocity is fast, stream depths are relatively shallow, and surface turbulence is present; channel profile typically straight to convex; water surface gradient relatively steep; frequently formed by presence of point, transverse, or mid-channel bars
Run:	Area of stream where water velocity is moderate to fast but with little surface turbulence; stream depths are moderate to deep; channel profile is typically uniform and flat; water surface gradient is low
Riffle/Run	Area of stream with characteristics of both riffles and runs
Pool:	Area of stream with low water velocity and deep water; channel profile is typically concave in shape; water surface gradient is near zero.
Run/Pool:	Areas with characteristics of both runs and pools
Backwater:	Area along channel margin with little or no current; usually behind point of land or vegetation

TUGALO RIVER: SECONDARY HABITAT TYPES[a]

Chutes:	Area of fast water flowing through bedrock or boulder constrictions
Snag:	Deeper water area with fallen tree(s)
Subchannel:	Secondary within channel banks; flowing water separated at low flow from main channel by bar or other channel feature; three subchannel types are recognized depending on their characteristics: riffle, run, pool
Backwater:	Area along channel margin with little or no current; usually behind point of land or vegetation

(a) Habitat types derived from habitat mapping, with definitions and terminology adapted from Chamberlin (1980), Bisson et al. (1982), and Platts et al. (1983).

TABLE 3 LOCATION, HABITAT TYPE, AND RATIONALE FOR INSTREAM FLOW TRANSECT PLACEMENT IN THE TALLULAH RIVER DOWNSTREAM OF TALLULAH FALLS DAM. A TOTAL OF SEVEN FINAL TRANSECTS WILL BE USED; ACCEPTABLE SUBSTITUTE TRANSECTS (IN PARENTHESES) ARE LISTED FOR SOME HABITAT TYPES

Transect Located in Section	Habitat Type	Reason for Placing Transect in Selected Location
41 (or 66)	Plunge pool	. Representative of plunge pools in upper Tallulah Gorge
9	Pool	. Representative of sand/boulder/ bedrock pool habitat . Unique pool backwater habitat
22	Pool	. Included to represent/characterize pool habitat variability
20	Chain pool	. Representative of chain pool habitat
21	Boulder Run--HG	. Representative of high gradient boulder run habitat
15	Boulder Run--LG	. Representative of dominant low gradient boulder run habitat
13 (or 24)	Boulder Run--LG	. Included to represent/characterize low gradient boulder run habitat variability
No proposed transect	Cascade	. Difficult or impossible to model . Constitutes little or no fish habitat
No proposed transect	Falls	. Difficult or impossible to model . Constitutes little or no fish habitat
No proposed transect	Chutes	. Difficult or impossible to model . Constitutes little or no fish habitat
No proposed transect	Outcrops	. Difficult or impossible to model . Constitutes little or no fish habitat
No proposed transect	Trench pools	. Difficult or impossible to model . Constitutes little or no fish habitat

TALLULAH RIVER GORGE: HABITAT TYPES[a]

Pool: Area of low velocity and deep water relative to main current; water surface gradient near zero; streambed profile concave; contains water at all flows due to presence of hydraulic control; mostly open water with some flow obstructions; in Tallulah Gorge, often formed of bends and channel constrictions

Plunge Pool: Same as pool, but formed in depressions scoured where flow drops over a channel obstruction (outcrop, falls); in Tallulah Gorge, formed by plunge over convex bedrock outcrops and high falls

Chain Pool: Small, shallow pool typically occurring in series in low gradient areas of channel; often sharing a single hydraulic control; flow is moderate to slow with interspersed bedrock or boulder obstructions

Trench Pool: Long, narrow pool formed in stable substrate; range from shallow to deep; in Tallulah Gorge, formed in bedrock slots along axis of outcrop, often resulting in divided flow with small falls or chutes between pools

Boulder Run: Area of moderate to shallow depths and moderate velocities; in Tallulah Gorge, these are wider, U-shaped, boulder-strewn areas of the channel; flow is circuitous with areas of flow constriction and pocket water (small pools behind objects); these areas would become rapids at high flows; two categories are recognized:

- Low Gradient: gradient 0-230 ft/mi; fewer drops and chutes
- High Gradient: gradient 230-350 ft/mi; abundant drops and chutes

Cascade: Area of very steep channel gradient (>350 ft/mi) and large boulder substrate; alternating drops and small pocket water areas

Falls: Area of water free-falling over an extremely steep bedrock outcrop or cliff

Chutes: Area of channel confined or constricted between bedrock or large boulders; extremely high water velocity

Outcrops: Area of steep gradient, convex-shaped bedrock outcrop; high velocity sheet-flow

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(a) Habitat types derived from habitat mapping, with definitions and terminology adapted from Chamberlin (1980), Bisson et al. (1982), and Platts et al. (1983).

Substrate Types:

Aquatic vegetation	Aquatic vascular plants
Organic debris	Derived from vegetation (leaves, twigs, etc.)
Silt	<0.06 mm
Sand	0.06-2 mm
Gravel	2-64 mm
Cobble	64-256 mm
Small boulder	256-1,000 mm
Large boulder	>1,000 mm
Irregular bedrock	Bedrock with irregularities >100 mm
Smooth bedrock	Bedrock with irregularities <100 mm

Cover Types:

No cover	Lack of cover
Outcrop/ledge	Irregular bedrock
Large boulders	Boulders >1,000 mm
Logs/roots	Submerged logs and root systems of trees
Undercut	Undercut stream banks
Vegetation	Beds of vascular plants
Snag	Fallen, partially or fully submerged tree

REFERENCES

Bisson, P.A., J.L. Nielsen, R.A. Palmson, and L.E. Grove. 1982. A system for naming habitat types in small streams, with examples of habitat utilization by salmonids during low streamflow, in Acquisition and Utilization of Aquatic Habitat Inventory Information (N.B. Armantrout, ed.). Western Division, American Fisheries Society, Bethesda, Maryland.

Chamberlin, T.W. 1980. Aquatic Survey Terminology. ADP Technical Paper 2. Ministry of the Environment, Victoria, British Columbia, Canada.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for Evaluating Stream, Riparian, and Biotic Conditions. Gen. Tech. Rep. INT-138. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah.

TABLE 2 SUMMARY OF CHANNEL/HABITAT SECTION ATTRIBUTES

Channel Type	Habitat Type	Total Area (acres)	Mean Width (ft)	Most Frequent Dominant Substrate
Single	Pool	75.0	209	Irregular bedrock
	Run/pool	233.7	220	Irregular bedrock
	Run	10.6	149	Gravel
	Shoal	35.6	285	Irregular bedrock
	Backwater	0.56	78	Irregular bedrock
Divided	Pool	10.8	140	Fines
	Run/pool	8.4	104	Fines
	Run	10.7	102	Gravel
	Shoal	27.7	143	Irregular bedrock

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TABLE 1 OCCURRENCE OF SPECIFIC CHANNEL AND HABITAT TYPES IN THE OCMULGEE RIVER STUDY AREA (LLOYD SHOALS DAM)

Channel Type	Habitat Type	Section
Single	Pool(11)	5, 7, 31, 33, 35, 66, 67, 76, 99, 101, 104
Single	Run/pool(15)	1, 6, 30, 32, 34, 36, 61, 65, 68, 77, 95, 96, 98, 100, 105
Single	Run(4)	82, 84, 86, 97
Single	Shoal(12)	4, 37, 45, 60, 64, 75, 78, 83, 85, 90, 102, 103
Single	Backwater(1)	2
Divided	Pool(6)	15, 40, 46, 62, 63, 71
Divided	Run/pool(11)	10, 12, 14, 20, 21, 24, 26, 39, 49, 51, 72
Divided	Run(12)	16, 18, 22, 25, 27, 38, 48, 70, 80, 81, 91, 93
Divided	Shoal(14)	9, 11, 13, 17, 19, 23, 41, 42, 47, 50, 52, 69, 79, 92,

Total Sections (86)

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OCMULGEE RIVER: HABITAT TYPES AND TERMINOLOGY[a]

TERMINOLOGY

Pool: Area of low velocity and deep water relative to main current; water surface gradient near zero; streambed profile concave; contains water at all flows due to presence of hydraulic control; mostly open water with some flow obstructions

Run: Area of stream where water velocity is moderate to fast but with little surface turbulence; stream depths are moderate to deep; channel profile is typically uniform and flat; water surface gradient is low

Shoal: Area of stream where dominant feature is the outcropping of bedrock resulting in locally steeper than average gradient; stream habitat in shoal areas is diverse, with the following typically present: chutes, cascades, runs, trench pools, and riffle-like areas. In shoals, water depth is typically shallower and velocity is typically faster than adjacent habitat types

Riffle: Area of stream where water velocity is fast, stream depths are relatively shallow, and surface turbulence is present; channel profile typically straight to convex; water surface gradient relatively steep; frequently formed by presence of point, transverse, or mid-channel bars

Cascade: Area of steep channel gradient and bedrock or boulder substrate; alternating drops and pocket water area

Chute: Area of fast water flowing through bedrock or boulder constrictions

Trench Pool: Long, narrow pool formed in stable substrate; range from shallow to deep; formed in bedrock slots along axis of outcrop, often resulting in divided flow with small falls or chutes between pools

Backwater: Area along channel margin with little or no current; usually behind point of land of vegetation

Run/Pool: Area of stream with characteristics of both runs and pools

(a) Habitat types derived from habitat mapping, with definitions and terminology adapted from Chamberlin (1980), Bisson et al. (1982), and Platts et al. (1983).

TABLE 3 LOCATION, CHANNEL AND HABITAT TYPE, AND RATIONALE FOR INSTREAM FLOW TRANSECT PLACEMENT IN THE OCMULGEE RIVER STUDY SEGMENT (LLOYD SHOALS DAM TO ROUTE 83 BRIDGE). A TOTAL OF NINE TRANSECTS WILL BE USED; PREFERRED CANDIDATE TRANSECTS ARE LISTED WITH ACCEPTABLE SUBSTITUTES (IN PARENTHESIS).

Transect Located In Section	Channel/Habitat	Reason For Placing Transect In Selected Location
33 (7, 66)	Single--Pool	. Representative of main channel pool habitat; irregular bedrock, fines, gravel; good access
32 (6, 30)	Single--Run/pool	. Representative of main channel run/pool habitat; irregular bedrock, gravel
86 (84)	Single--Run	. Representative of gravel run habitat found in Fourty Acre and Nelson Islands vicinity
60 (37, 45, 64)	Single--Shoal	. Representative of main channel shoal habitat
62 (46, 63)	Divided--Pool	. Representative of island pool habitat
51 (10, 49)	Divided--Run/pool	. Representative of island run/pool habitat
48 (16, 91, 93)	Divided--Run	. Representative of island run habitat
47 (9, 50, 52)	Divided--Shoal	. Representative of island shoal habitat
95	Single--Run/pool	. Representative of sandy run/pool habitat that dominates river downstream of Nelson Island

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REFERENCES

Bisson, P.A., J.L. Nielsen, R.A. Palmson, and L.E. Grove. 1982. A system for naming habitat types in small streams, with examples of habitat utilization by salmonids during low streamflow, in Acquisition and Utilization of Aquatic Habitat Inventory Information (N.B. Armantrout, ed.). Western Division, American Fisheries Society, Bethesda, Maryland.

Chamberlin, T.W. 1980. Aquatic Survey Terminology. ADP Technical Paper 2. Ministry of the Environment, Victoria, British Columbia, Canada.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for Evaluating Stream, Riparian, and Biotic Conditions. Gen. Tech. Rep. INT-138. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah.

Channel Type: Islands are present in the upper reach of the Ocmulgee River (Lloyd Shoals Dam to Fourty Acre Island). Since the presence of islands affects habitat composition, two channel types, single and divided, are recognized.

Single channel: Nearly the entire flow of river is within one channel, no islands present or islands are very small

Divided channel: River flows through two or more distinct channels; channels typically divided by large, well-vegetated islands

In the upper reach of the Ocmulgee River study area divided channel situations are fairly common. Typically, a single island is present, dividing the flow into two channels. An atypical situation is present in the vicinity of Fourty Acre Island, where multiple islands are present and the river channel is braided.

The attached tables describe the occurrence of specific channel and habitat types (Table 1), summarize the total acreage, mean width, and dominant substrate type of each river section mapped (Table 2), and review the location of proposed transects for instream flow studies (Table 3) in the Ocmulgee River study segment.

<u>Ocmulgee River Study Area</u>:

Study Area: Lloyd Shoals Dam to Route 83 Bridge.

Total Length: 16.8 miles.

Total Area: 413 acres

Substrate Types:

Aquatic vegetation	Aquatic vascular plants
Organic debris	Derived from vegetation (leaves, twigs, etc.)
Silt	<0.06 mm
Sand	0.06-2 mm
Gravel	2-64 mm
Cobble	64-256 mm
Small boulder	256-1,000 mm
Large boulder	>1,000 mm
Irregular bedrock	Bedrock with irregularities >100 mm
Smooth bedrock	Bedrock with irregularities <100 mm

Cover Types:

No cover	Lack of cover
Outcrop/ledge	Irregular bedrock
Large boulders	Boulders >1,000 mm
Logs/roots	Submerged logs and root systems of trees
Undercut	Undercut stream banks
Vegetation	Beds of vascular plants
Snag	Fallen, partially or fully submerged tree

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TABLE B-1 SUMMARY OF HABITAT MAPPING RESULTS FOR THE TUGALO RIVER STUDY AREA FROM YONAH DAM TO THE VICINITY OF THE CORPS BOAT RAMP. DEFINITIONS FOR THE HABITAT ATTRIBUTES OF EACH RIVER SECTION ARE LISTED IN TABLE 4-3 AND IN THE FOLLOWING APPENDIX B SECTIONS.

		Attribute						
SECTION	LENGTH (FT)	DOMINANT SUBSTRATE	SUBDOMINANT SUBSTRATE	CHANNEL ROUGHNESS	PRIMARY FEATURE	SECONDARY FEATURE	DOMINANT COVER	SUBDOMINANT COVER
2	969	SM BO	COBBLE	M/H	RUN-PRIMARY	NONE	NO COVER	LARGE BOULDERS
3	27	IR BED	SM BO	H	RUN-SECONDARY	CHUTES	OUTCROP/LEDGE	NO COVER
4	269	COBBLE	GRAVEL	L/M	RUN/POOL-PRIMARY	NONE	NO COVER	LARGE BOULDERS
5	281	COBBLE	SM BO	M/H	RIFFLE-SECONDARY	SUBCH RUN	NO COVER	LOGS/ROOTS
7	666	GRAVEL	COBBLE	L	RUN/POOL-SECONDARY	SUBCH POOL	NO COVER	LOGS/ROOTS
9	1236	COBBLE	GRAVEL	L/M	BACKWATER	NONE	NO COVER	LOGS/ROOTS
12	318	IR BED	SM BO	M/H	RUN-SECONDARY	SNAG	OUTCROP/LEDGE	SNAG
13	453	COBBLE	SM BO	M/H	RIFFLE/RUN-PRIMARY	SUBCH RUN	NO COVER	LARGE BOULDERS
16	426	COBBLE	GRAVEL	M/H	RUN-PRIMARY	NONE	NO COVER	LARGE BOULDERS
17	375	COBBLE	SM BO	M/H	RIFFLE/RUN-PRIMARY	NONE	NO COVER	LARGE BOULDERS
19	102	COBBLE	GRAVEL	L/M	RIFFLE-PRIMARY	NONE	NO COVER	LOGS/ROOTS
20	566	COBBLE	GRAVEL	L	RUN-PRIMARY	NONE	NO COVER	LOGS/ROOTS
21	127	IR BED	COBBLE	H	RIFFLE/RUN-SECONDARY	CHUTES	OUTCROP/LEDGE	NO COVER
23	246	GRAVEL	COBBLE	L/M	RUN-PRIMARY	NONE	NO COVER	LARGE BOULDERS
24	319	COBBLE	SM BO	M	RIFFLE/RUN-PRIMARY	NONE	NO COVER	LARGE BOULDERS
25	185	COBBLE	IR BED	M	RIFFLE-SECONDARY	NONE	NO COVER	OUTCROP/LEDGE
26	560	COBBLE	SM BO	L/M	RUN/POOL-PRIMARY	NONE	NO COVER	LOGS/ROOTS
28	789	COBBLE	GRAVEL	M	RIFFLE-PRIMARY	NONE	NO COVER	LOGS/ROOTS
29	430	COBBLE	GRAVEL	M	RIFFLE-PRIMARY	SUBCH POOL	NO COVER	LOGS/ROOTS
31	488	GRAVEL	COBBLE	M	RIFFLE-PRIMARY	SUBCH POOL	NO COVER	LOGS/ROOTS
32	599	COBBLE	GRAVEL	L/M	RUN-PRIMARY	NONE	NO COVER	LOGS/ROOTS
33	647	COBBLE	GRAVEL	L/M	RIFFLE/RUN-PRIMARY	NONE	NO COVER	LOGS/ROOTS
34	816	COBBLE	IR BED	M	RUN-PRIMARY	NONE	NO COVER	LOGS/ROOTS
35	293	IR BED	COBBLE	M	RUN/POOL-PRIMARY	SNAG	NO COVER	LOGS/ROOTS
36	131	SM BO	COBBLE	M/H	RIFFLE-PRIMARY	NONE	NO COVER	LARGE BOULDERS
37	257	SM BO	COBBLE	M/H	RUN/POOL-PRIMARY	NONE	NO COVER	OUTCROP/LEDGE
38	169	IR BED	SM BO	M/H	RUN-SECONDARY	CHUTES	OUTCROP/LEDGE	NO COVER
39	498	SM BO	COBBLE	M/H	RIFFLE/RUN-SECONDARY	CHUTES	NO COVER	LOGS/ROOTS
40	658	GRAVEL	COBBLE	M/H	RUN/POOL-SECONDARY	NONE	NO COVER	LOGS/ROOTS
42	260	IR BED	SM BO	M/H	RUN-SECONDARY	NONE	NO COVER	LARGE BOULDERS

TABLE B-2 SUMMARY OF HABITAT MAPPING RESULTS FOR THE OCMULGEE RIVER STUDY AREA FROM LLOYD SHOALS DAM TO THE VICINITY OF NELSON ISLAND. DEFINITIONS FOR THE HABITAT ATTRIBUTES OF EACH RIVER SECTION ARE LISTED IN TABLE 4-3 AND IN THE FOLLOWING APPENDIX B SECTIONS.

	Attribute						
SECTION	LENGTH (FT)	AVE WIDTH (FT)	AREA (ACRES)	CHANNEL TYPE	FEATURE	DOMINANT SUBSTRATE	SUBDOMINANT SUBSTRATE
1	1732	197	6.6954	SINGLE	RUN/POOL	IR BED	LG BO
2	313	78	0.5634	SINGLE	BACKWATER	IR BED	GRAVEL
4	222	181	0.9214	SINGLE	SHOAL	IR BED	GRAVEL
5	508	246	2.8694	SINGLE	POOL	IR BED	GRAVEL
6	934	262	5.6075	SINGLE	RUN/POOL	IR BED	GRAVEL
7	2615	206	12.1195	SINGLE	POOL	FINES	GRAVEL
9	1138	193	5.0349	DIVIDED	SHOAL	GRAVEL	IR BED
10	416	87	0.8348	DIVIDED	RUN/POOL	IR BED	GRAVEL
11	187	78	0.3352	DIVIDED	SHOAL	IR BED	GRAVEL
12	369	81	0.6871	DIVIDED	RUN/POOL	GRAVEL	SM BO
13	201	107	0.4946	DIVIDED	SHOAL	IR BED	GRAVEL
14	300	118	0.8159	DIVIDED	RUN/POOL	FINES	GRAVEL
15	590	84	1.0918	DIVIDED	POOL	FINES	GRAVEL
16	528	60	0.6619	DIVIDED	RUN	GRAVEL	IR BED
17	488	122	1.3687	DIVIDED	SHOAL	GRAVEL	IR BED
18	123	128	0.3610	DIVIDED	RUN	GRAVEL	IR BED
19	468	179	1.9189	DIVIDED	SHOAL	IR BED	SM BO
20	276	109	0.6913	DIVIDED	RUN/POOL	FINES	GRAVEL
21	224	139	0.7124	DIVIDED	RUN/POOL	IR BED	SM BO
22	363	120	0.9981	DIVIDED	RUN	GRAVEL	FINES
23	202	100	0.4638	DIVIDED	SHOAL	IR BED	GRAVEL
24	446	97	0.9907	DIVIDED	RUN/POOL	GRAVEL	FINES
25	158	106	0.3839	DIVIDED	RUN	GRAVEL	IR BED
26	290	107	0.7112	DIVIDED	RUN/POOL	GRAVEL	FINES
27	185	101	0.4288	DIVIDED	RUN	GRAVEL	IR BED
30	651	190	2.8365	SINGLE	RUN/POOL	IR BED	GRAVEL
31	553	145	1.8468	SINGLE	POOL	GRAVEL	IR BED
32	680	164	2.5544	SINGLE	RUN/POOL	IR BED	GRAVEL
33	3440	178	11.8030	SINGLE	POOL	FINES	GRAVEL
34	910	248	5.1756	SINGLE	RUN/POOL	IR BED	GRAVEL
35	3424	214	14.9814	SINGLE	POOL	IR BED	FINES
36	715	130	1.8403	SINGLE	RUN/POOL	GRAVEL	IR BED
37	1163	355	9.4746	SINGLE	SHOAL	IR BED	GRAVEL
38	413	107	1.0144	DIVIDED	RUN	IR BED	SM BO
39	635	92	1.3375	DIVIDED	RUN/POOL	FINES	IR BED
40	353	145	1.0594	DIVIDED	POOL	IR BED	GRAVEL
41	546	200	2.7101	DIVIDED	SHOAL	IR BED	SM BO
42	897	297	6.1084	DIVIDED	SHOAL	IR BED	GRAVEL
45	318	602	4.3941	SINGLE	SHOAL	IR BED	GRAVEL
46	796	173	3.1655	DIVIDED	POOL	FINES	GRAVEL
47	321	146	1.0732	DIVIDED	SHOAL	IR BED	GRAVEL
48	226	129	0.6685	DIVIDED	RUN	GRAVEL	IR BED
49	152	152	0.5318	DIVIDED	RUN/POOL	FINES	IR BED

APPENDIX C

FISH SPECIES COMPOSITION AND LENGTH DATA BY SAMPLING SITE ON THE MATHIS-TERRORA BYPASS, TALLULAH GORGE, TUGALO RIVER, AND OCMULGEE RIVER STUDY AREAS

APPENDIX C

FISH SPECIES COMPOSITION AND LENGTH DATA BY SAMPLING SITE ON THE MATHIS TERRORA BYPASS, TALLULAH GORGE, TUGALO RIVER, AND OCMULGEE RIVER ; COLLECTION PERIOD 16-23 SEPTEMBER 1987.

Study Area = Mathis-Terrora Bypass, Site 1

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Bluehead chub	42	24.1	68.8	33	147	21.7
Whitefin shiner	34	19.5	61.1	31	88	12.7
Redbreast sunfish	33	19.0	107.5	73	186	28.6
Northern hog sucker	23	13.2	141.8	63	256	57.7
Margined madtom	11	6.3	107.0	77	130	18.5
Yellowfin shiner	8	4.6	61.4	58	66	2.8
Stoneroller	7	4.0	95.0	77	125	15.3
Redeye bass	6	3.4	112.2	59	147	40.2
Bandfin shiner	5	2.9	77.4	69	85	6.3
Snail bullhead	3	1.7	101.7	98	105	3.5
Green sunfish	1	0.6	136.0	136	136	.
Striped jumprock	1	0.6	252.0	252	252	.
All	174	100.0	91.2	31	256	41.5

Study Area = Mathis-Terrora Bypass, Site 2

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Bluehead chub	35	21.0	87.9	39	153	28.5
Bandfin shiner	30	18.0	88.7	63	106	11.8
Yellowfin shiner	29	17.4	61.3	44	80	7.6
Redbreast sunfish	22	13.2	96.9	52	183	43.6
Northern hog sucker	22	13.2	122.1	61	253	46.7
Margined madtom	20	12.0	89.9	30	130	19.3
Whitefin shiner	5	3.0	63.0	56	75	8.3
Largemouth bass	2	1.2	178.0	120	236	82.0
Redeye bass	1	0.6	211.0	211	211	.
Green sunfish	1	0.6	171.0	171	171	.
All	167	100.0	90.9	30	253	36.5

APPENDIX C (Cont.)

Site Area = Mathis-Terrora Bypass, Site 3

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Yellowfin shiner	37	48.1	54.2	31	68	9.6
Northern hog sucker	13	16.9	89.7	46	129	23.0
Bluehead chub	10	13.0	77.1	38	122	26.2
Striped jumprock	6	7.8	188.2	165	229	25.0
Bandfin shiner	5	6.5	74.6	60	92	11.6
Redbreast sunfish	2	2.6	127.5	120	135	10.6
Margined madtom	2	2.6	138.5	131	146	10.6
Redeye bass	1	1.3	120.0	120	120	.
Stoneroller	1	1.3	83.0	83	83	.
All	77	100.0	80.3	31	229	41.2

Study Area = Mathis-Terrora Bypass, Site 4

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Redbreast sunfish	18	69.2	78.8	50	115	16.2
Northern hog sucker	4	15.4	194.3	170	251	38.2
Largemouth bass	1	3.8	41.0	41	41	.
Bluegill	1	3.8	75.0	75	75	.
Green sunfish	1	3.8	158.0	158	158	.
Bluehead chub	1	3.8	127.0	127	127	.
All	26	100.0	99.8	41	251	49.3

APPENDIX C (Cont.)

Study Area = Tallulah R. Gorge, Site 1

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Redbreast sunfish	32	86.5	50.1	29	166	29.9
Redeye bass	3	8.1	101.7	90	110	10.4
Bluehead chub	2	5.4	50.5	47	54	4.9
All	37	100.0	54.3	29	166	31.3

Study Area = Tallulah R. Gorge, Site 2

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Redbreast sunfish	5	22.7	60.0	38	125	36.8
Redeye bass	4	18.2	95.0	87	103	7.7
Snail bullhead	4	18.2	202.5	170	218	21.9
Bluehead chub	4	18.2	56.0	41	66	12.2
Northern hog sucker	2	9.1	98.5	97	100	2.1
Margined madtom	1	4.5	54.0	54	54	.
Yellowfin shiner	1	4.5	38.0	38	38	.
Stoneroller	1	4.5	48.0	48	48	.
All	22	100.0	93.2	38	218	59.0

APPENDIX C (Cont.)

Study Area = Tallulah R. Gorge, Site 3

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Bluehead chub	19	35.2	85.3	45	163	40.7
Redeye bass	10	18.5	123.0	76	290	72.8
Northern hog sucker	8	14.8	81.1	72	96	8.6
Redbreast sunfish	5	9.3	50.2	42	60	8.6
Yellowfin shiner	4	7.4	42.8	38	47	3.8
Stoneroller	4	7.4	68.0	45	113	30.9
Snail bullhead	3	5.6	200.0	177	230	27.2
Striped jumprock	1	1.9	193.0	193	193	.
All	54	100.0	92.4	38	290	54.9

Study Area = Tallulah R. Gorge, Site 4

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Bluehead chub	104	75.9	45.7	30	135	17.0
Stoneroller	27	19.7	65.0	38	127	27.2
Redbreast sunfish	6	4.4	151.7	39	180	55.4
All	137	100.0	54.2	30	180	31.1

Study Area = Tallulah R. Gorge, Site 5

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Brown bullhead	2	100.0	69.5	68	71	2.1
All	2	100.0	69.5	68	71	2.1

APPENDIX C (Cont.)

Study Area = Tugalo R. Below Yonah, Site 1

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Blackbanded darter	74	20.9	78.2	46	101	11.2
Margined madtom	57	16.1	89.6	44	128	15.5
Bluegill	55	15.5	108.7	51	190	22.7
Yellow perch	31	8.8	105.2	60	162	31.0
Redbreast sunfish	29	8.2	114.3	46	192	33.8
Snail bullhead	27	7.6	159.8	100	226	41.7
Bluehead chub	17	4.8	128.4	85	200	28.6
Largemouth bass	15	4.2	79.1	41	180	34.2
Whitefin shiner	15	4.2	79.9	68	95	9.1
Green sunfish	9	2.5	105.9	78	132	19.6
Brown bullhead	7	2.0	162.0	130	200	29.1
Northern hog sucker	6	1.7	158.8	140	194	20.7
Redeye bass	5	1.4	95.8	64	170	43.3
Spottail shiner	4	1.1	74.3	58	98	17.5
Striped jumprock	2	0.6	146.0	141	151	7.1
White bass	1	0.3	361.0	361	361	.
All	354	100.0	103.9	41	361	37.6

APPENDIX C (Cont.)

Study Area = Tulago R. Below Yonah, Site 2

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Blueback herring	26	21.8	80.5	73	87	3.4
Redbreast sunfish	21	17.6	162.1	120	195	21.4
Spottail shiner	16	13.4	96.9	86	114	7.2
Silver redhorse	13	10.9	398.4	303	466	41.6
Largemouth bass	11	9.2	263.4	152	450	92.0
Bluegill	10	8.4	135.2	80	193	34.3
Redeye bass	6	5.0	236.2	76	301	83.4
Carp	6	5.0	489.2	433	530	44.5
Warmouth	4	3.4	171.8	139	195	26.7
Gizzard shad	2	1.7	300.0	290	310	14.1
White bass	1	0.8	400.0	400	400	.
Channel catfish	1	0.8	310.0	310	310	.
Snail bullhead	1	0.8	240.0	240	240	.
Whitefin shiner	1	0.8	74.0	74	74	.
All	119	100.0	194.4	73	530	128.3

APPENDIX C (Cont.)

Study Area = Ocmulgee R., Site 1

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Redbreast sunfish	197	33.8	113.3	37	188	28.3
Spottail shiner	128	22.0	80.4	63	117	12.1
Altamaha shiner	62	10.7	58.4	38	82	10.4
Snail bullhead	41	7.0	186.3	45	300	70.2
Spotted sucker	35	6.0	304.1	100	475	83.7
American eel	21	3.6	325.4	200	495	63.8
Largemouth bass	17	2.9	219.4	82	387	94.0
Silver redhorse	17	2.9	328.3	205	420	81.0
Turquoise darter	16	2.7	48.8	40	71	7.3
Brown bullhead	11	1.9	215.2	86	285	51.4
Redeye bass	8	1.4	205.6	73	340	84.1
Redear sunfish	6	1.0	181.7	145	300	59.0
Bluegill	5	0.9	133.2	87	178	38.5
Bluehead chub	4	0.7	126.3	72	155	37.1
Blackbanded darter	3	0.5	81.7	63	100	18.5
Striped jumprock	3	0.5	165.0	160	170	5.0
Longnose gar	2	0.3	434.5	376	493	82.7
Dollar sunfish	1	0.2	135.0	135	135	.
Margined madtom	1	0.2	90.0	90	90	.
Yellowfin shiner	1	0.2	45.0	45	45	.
Stoneroller	1	0.2	125.0	125	125	.
Chain pickeral	1	0.2	402.0	402	402	.
Gizzard shad	1	0.2	386.0	386	386	.
All	582	100.0	138.3	37	495	93.6

APPENDIX C. (Cont.)

Study Area = Ocmulgee R., Site 2

Species	Number	Percent	Length (mm) Mean	Minimum	Maximum	Standard Deviation
Redbreast sunfish	78	24.1	124.9	27	195	33.8
Gizzard shad	31	9.6	320.2	243	385	33.4
American eel	30	9.3	274.0	190	610	81.9
Snail bullhead	28	8.7	164.1	65	347	61.2
Spotted sucker	28	8.7	412.3	230	505	64.8
Bluegill	25	7.7	153.6	56	220	44.7
Spottail shiner	24	7.4	98.3	84	112	6.1
Largemouth bass	18	5.6	151.3	70	350	69.7
Brown bullhead	13	4.0	234.0	160	345	51.2
Altamaha shiner	7	2.2	78.3	57	93	16.1
Yellowfin shiner	7	2.2	48.7	40	54	6.2
Yellow perch	5	1.5	196.8	102	285	72.8
Blackbanded darter	5	1.5	67.6	59	91	13.4
White catfish	4	1.2	196.5	68	280	90.5
Silver redhorse	4	1.2	382.3	220	445	108.3
Striped jumprock	3	0.9	193.7	187	204	9.1
Bluehead chub	3	0.9	112.7	110	115	2.5
White bass	2	0.6	465.0	460	470	7.1
Redear sunfish	2	0.6	230.5	170	291	85.6
Carp	2	0.6	575.0	470	680	148.5
Black crappie	1	0.3	.	.	.	.
Warmouth	1	0.3	150.0	150	150	.
Green sunfish	1	0.3	124.0	124	124	.
Longnose gar	1	0.3	790.0	790	790	.
All	323	100.0	202.0	27	790	122.3

APPENDIX D

FIGURES ILLUSTRATING THE DISTRIBUTION OF AVAILABLE DEPTHS, VELOCITIES, SUBSTRATE, AND COVER TYPES IN THE CHATTOOGA, TUGALO, AND OCMULGEE RIVER STUDY AREAS (FIGURES D-1 THROUGH D-6) AND FIGURES ILLUSTRATING THE DEVELOPMENT OF HABITAT SUITABILITY CRITERIA FOR EACH SPECIES LIFE STAGE FROM HABITAT USE DATA COLLECTED IN THE CHATTOOGA, TUGALO, AND OCMULGEE RIVER STUDY AREAS.

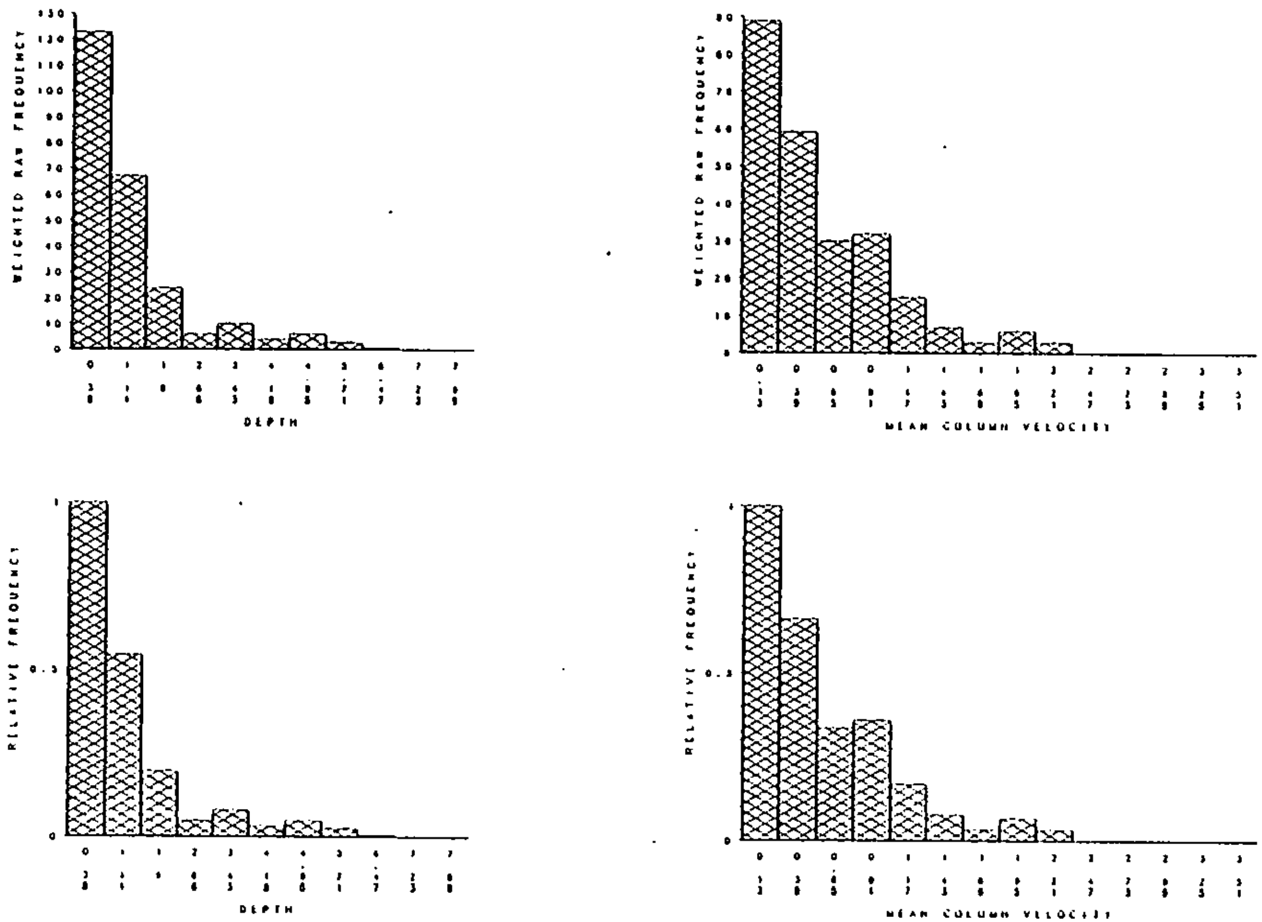


Figure D-1. Distribution of available depths and mean column velocities in the Chattooga River expressed as raw frequencies (top graph) and normalized to a scale of 1.0 (bottom graph).

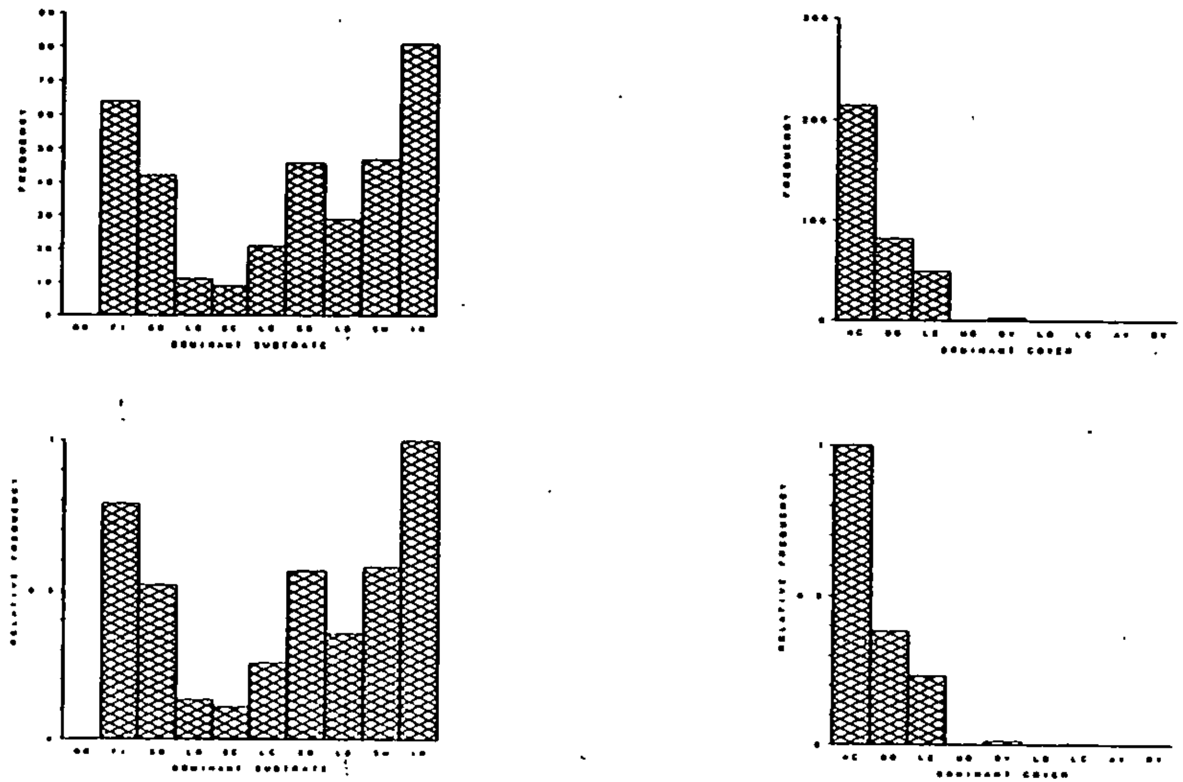


Figure D-2. Distribution of available substrate and cover types in the Chattooga River expressed as raw frequencies (top graph) and normalized to a scale of 1.0 (bottom graph).

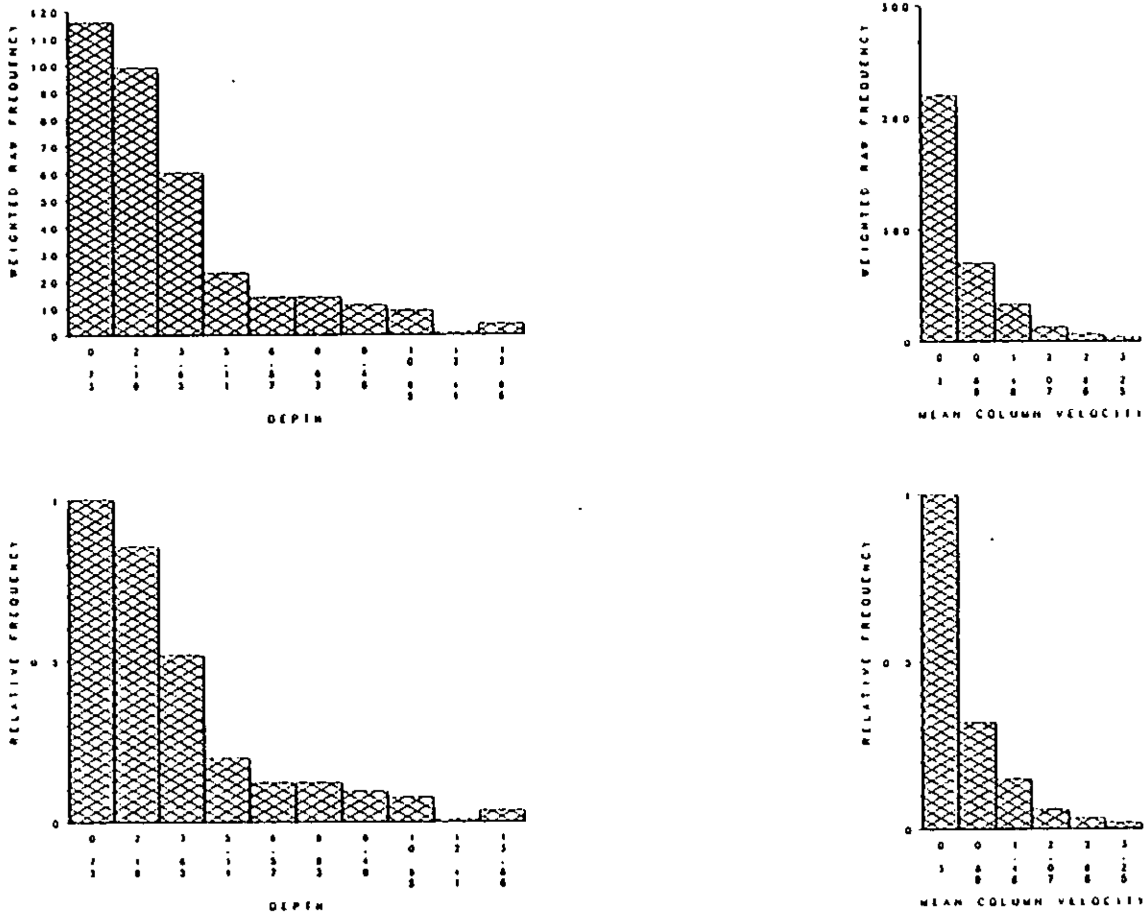


Figure D-3. Distribution of available depths and mean column velocities in the Tugalo River expressed as raw frequencies (top graph) and normalized to a scale of 1.0 (bottom graph).

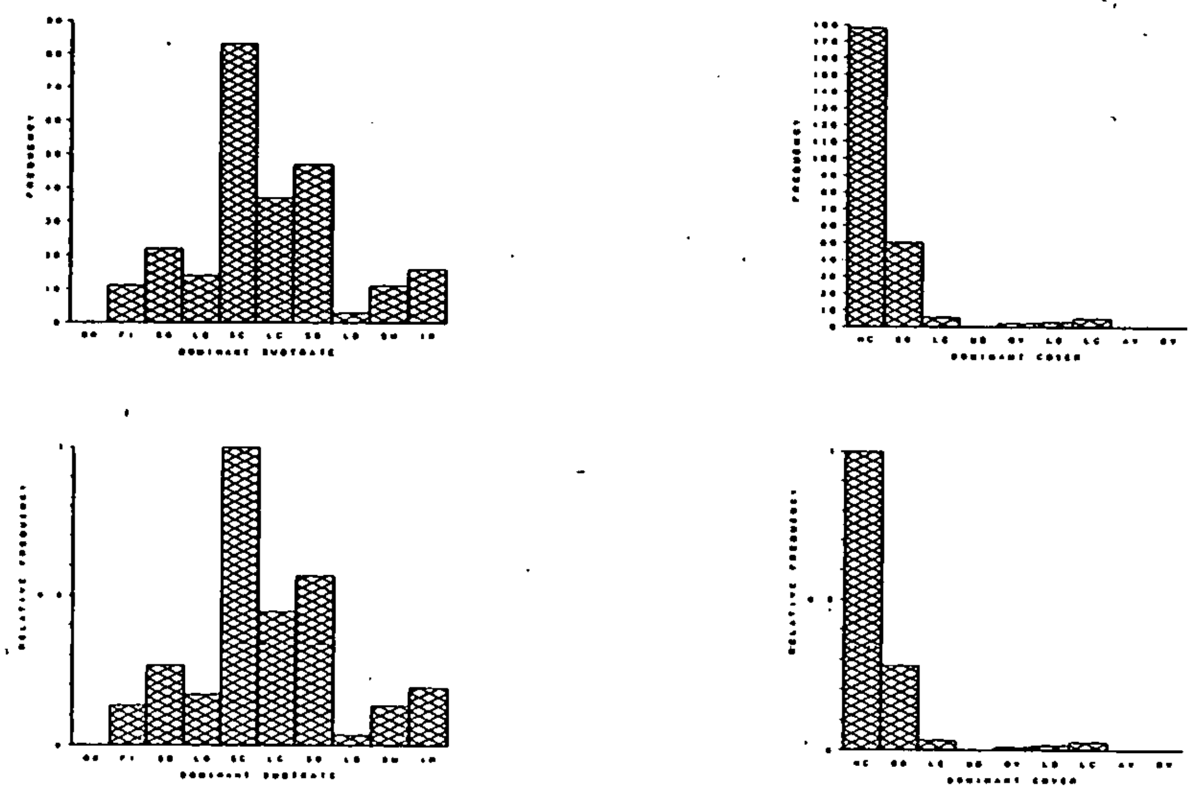


Figure D-4. Distribution of available substrate and cover types in the Tugalo River expressed as raw frequencies (top graph) and normalized to a scale of 1.0 (bottom graph).

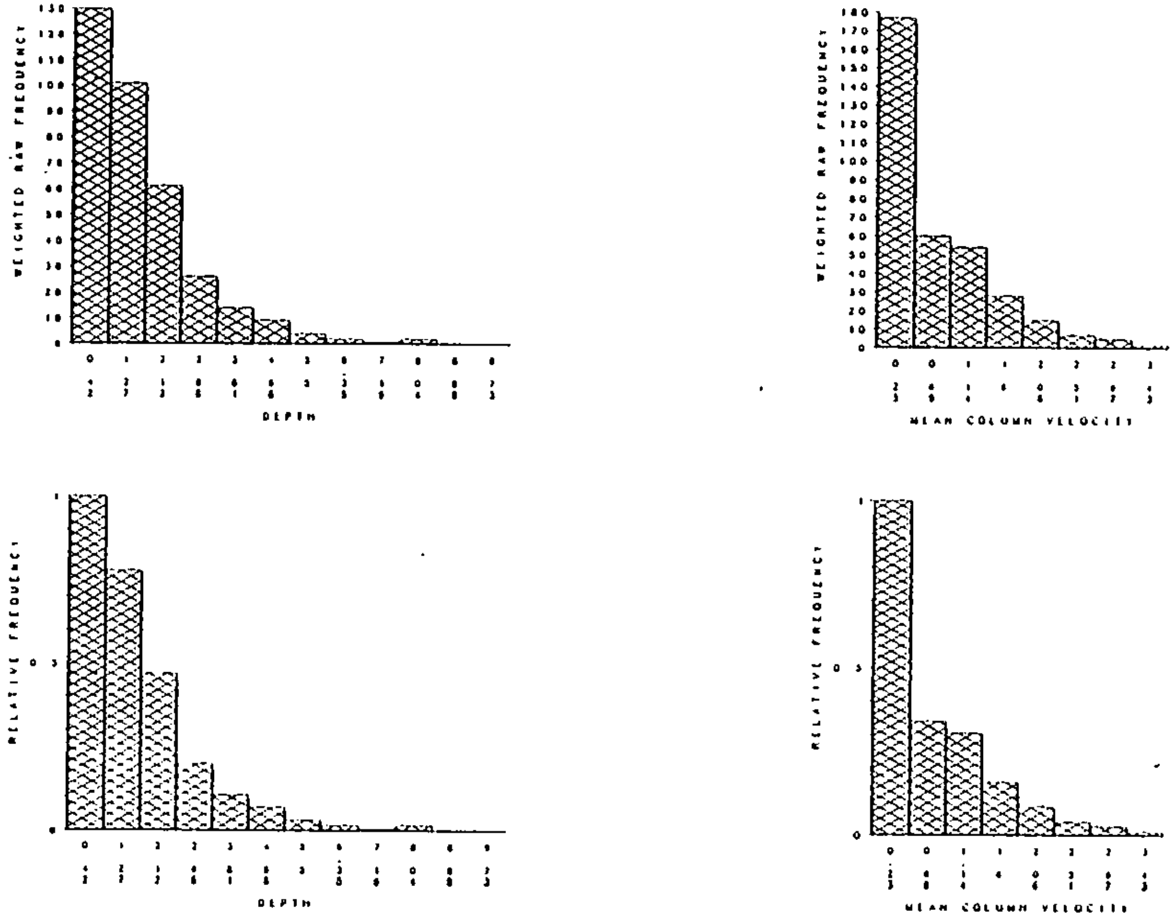


Figure D-5. Distribution of available depths and mean column velocities in the Ocmulgee River expressed as raw frequencies (top graph) and normalized to a scale of 1.0 (bottom graph).

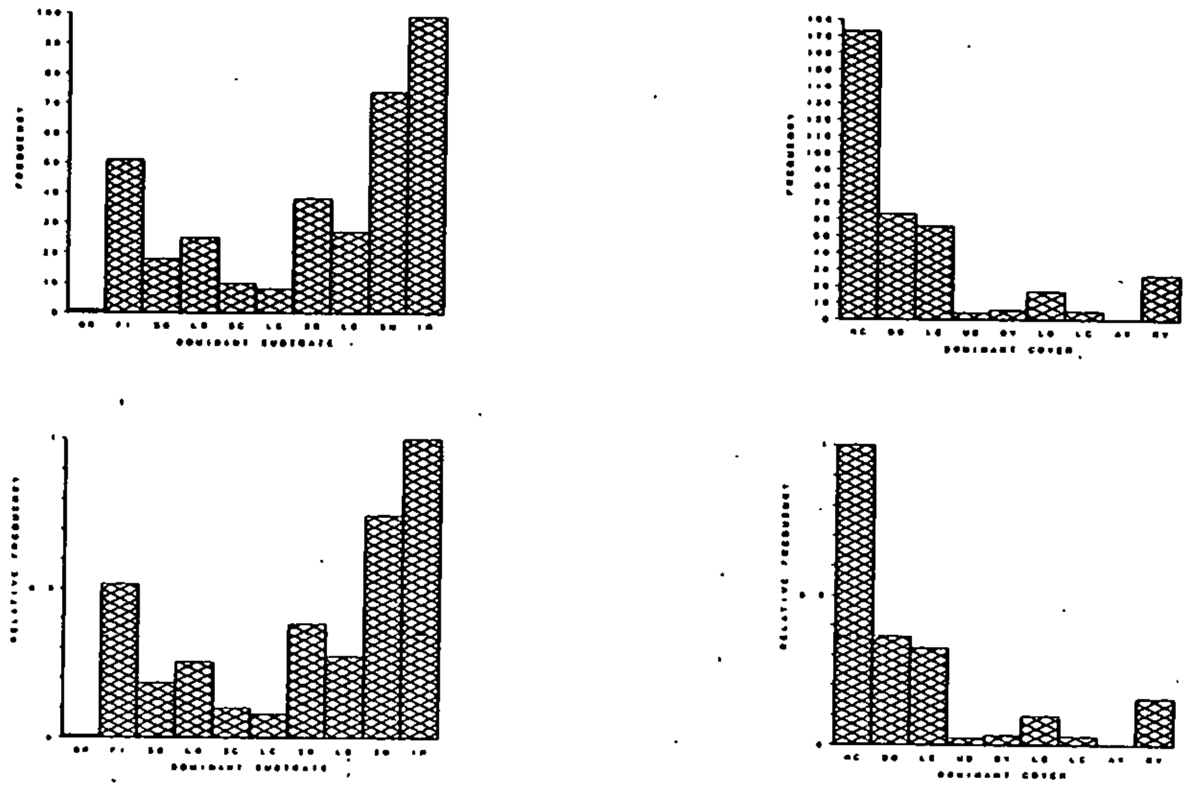


Figure D-6. Distribution of available substrate and cover types in the Ocmulgee River expressed as raw frequencies (top graph) and normalized to a scale of 1.0 (bottom graph).

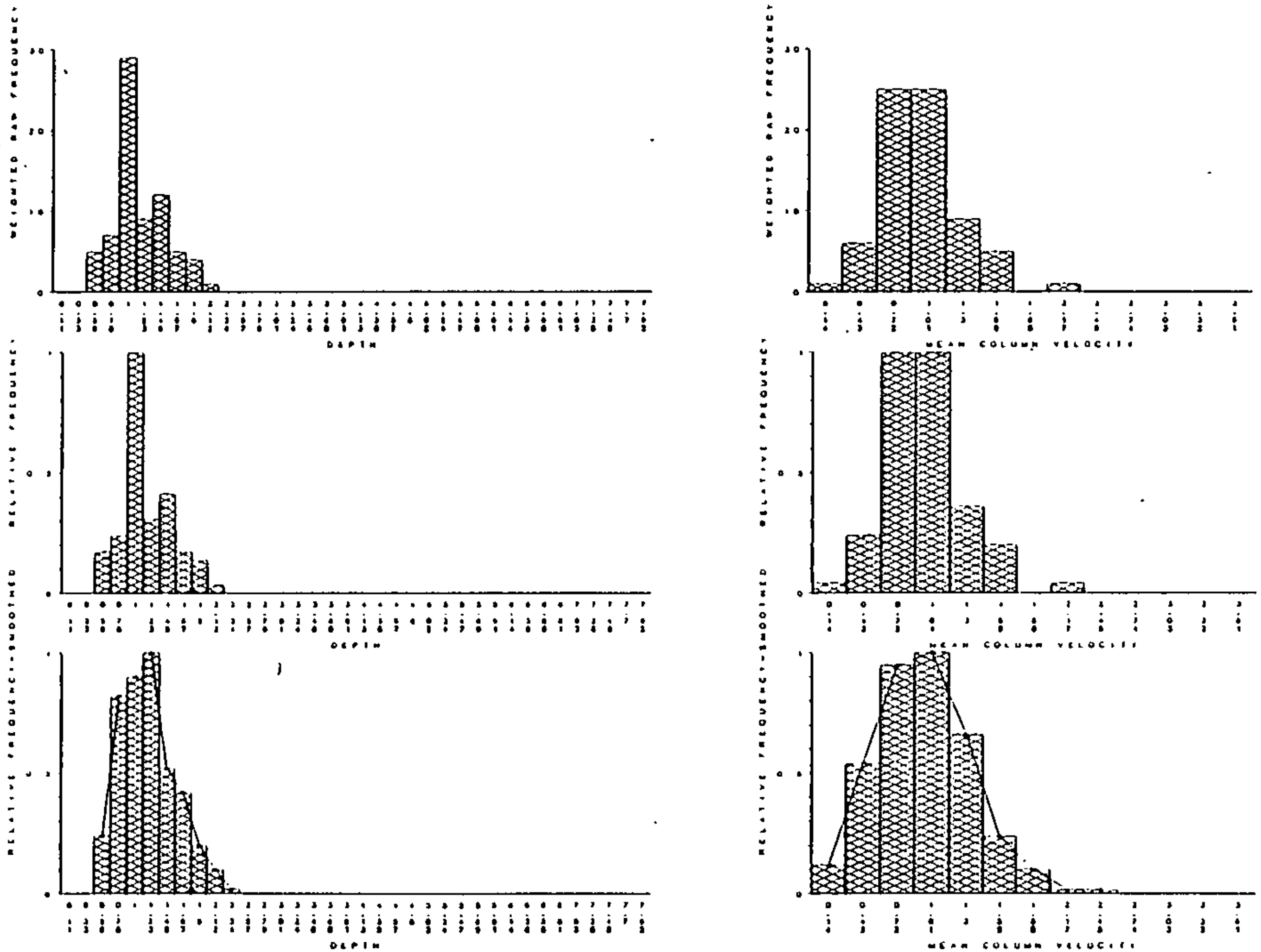


Figure D-7. Development of depth and velocity suitability criteria for spawning bluehead chub from data collected in the Tugalo River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

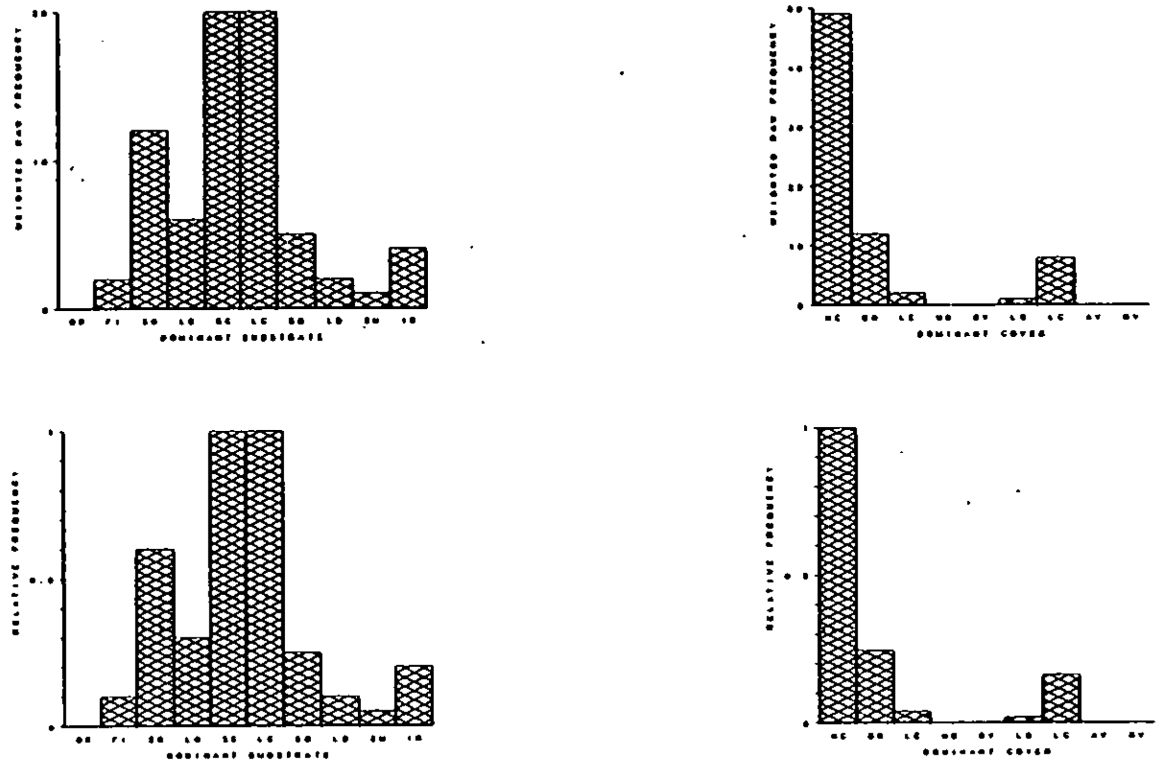


Figure D-8. Development of substrate and cover suitability criteria for spawning bluehead chub from data collected in the Tugalo River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

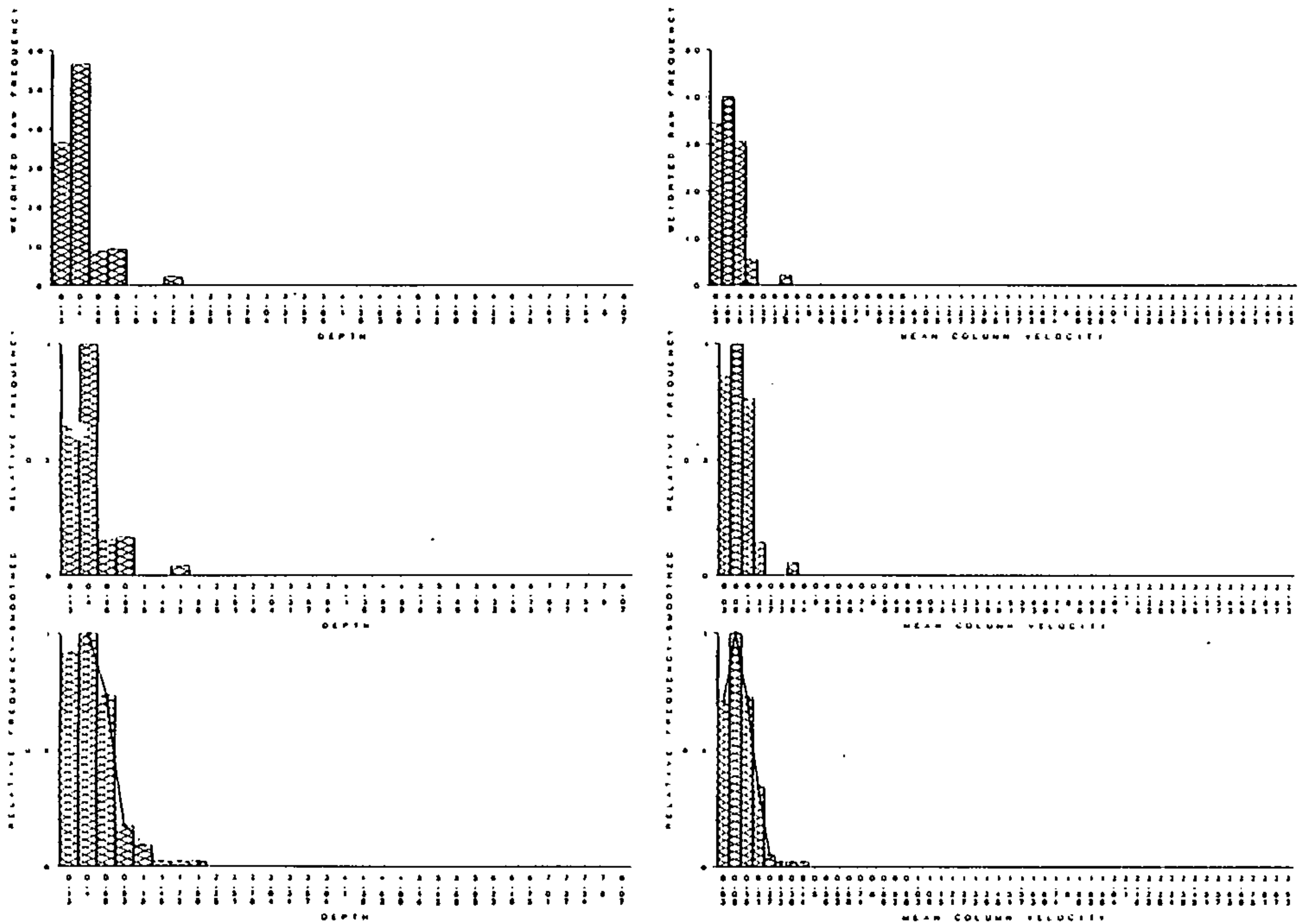


Figure D-9. Development of depth and velocity suitability criteria for YOY bluehead chub from data collected in the Tugalo River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

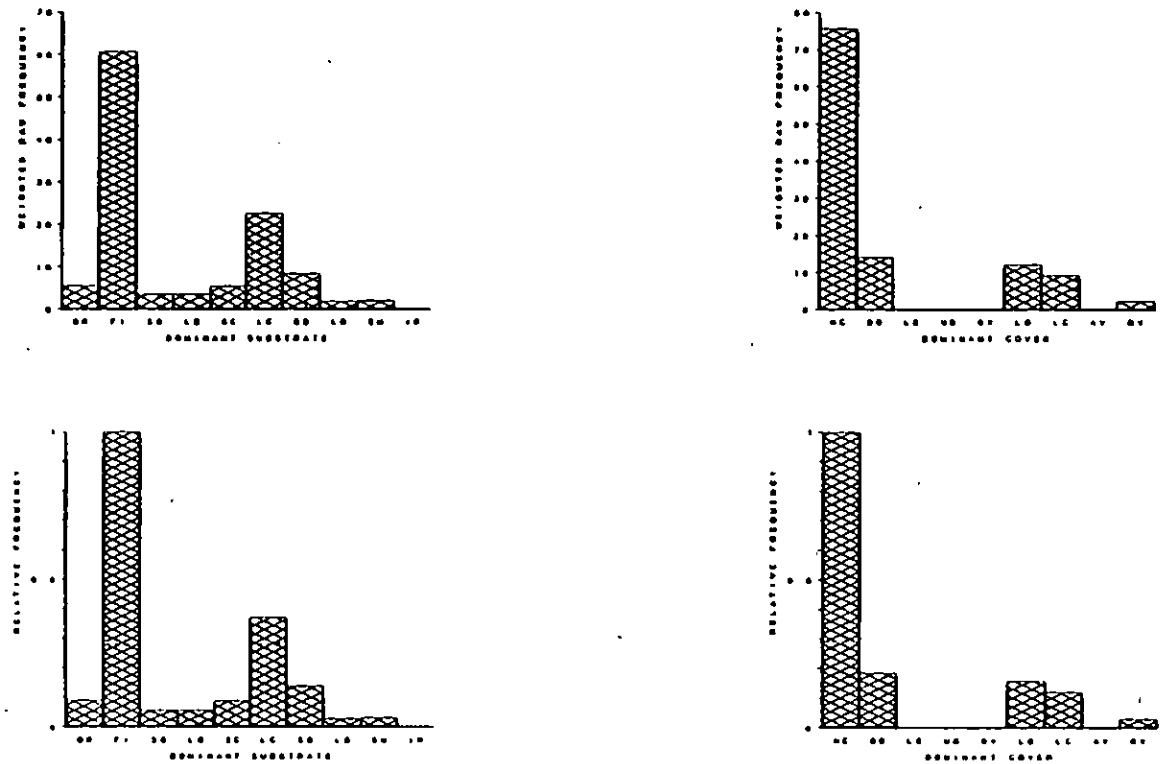


Figure D-10. Development of substrate and cover suitability criteria for YOY bluehead chub from data collected in the Tugalo River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

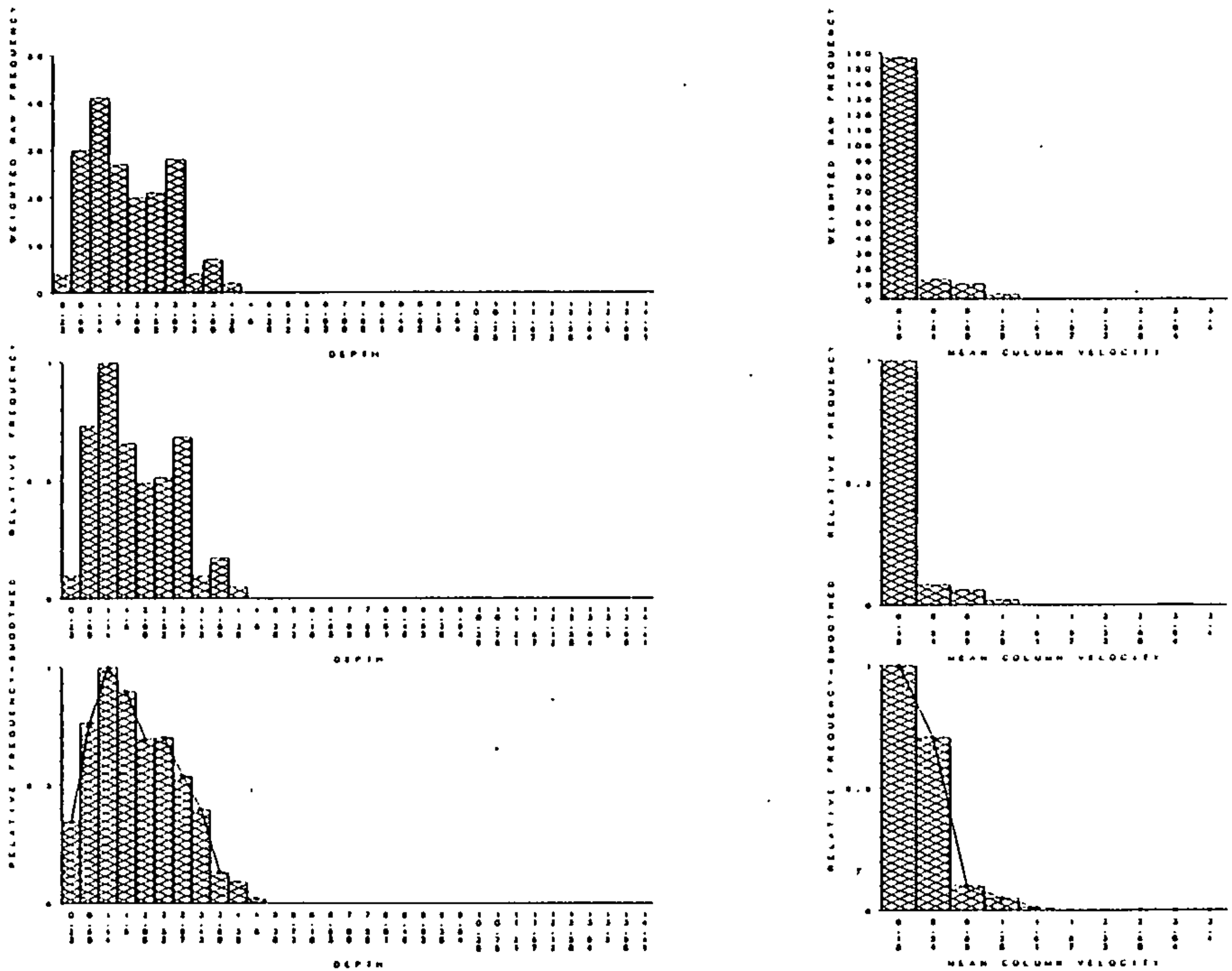


Figure D-11. Development of depth and velocity suitability criteria for spawning redbreast sunfish from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

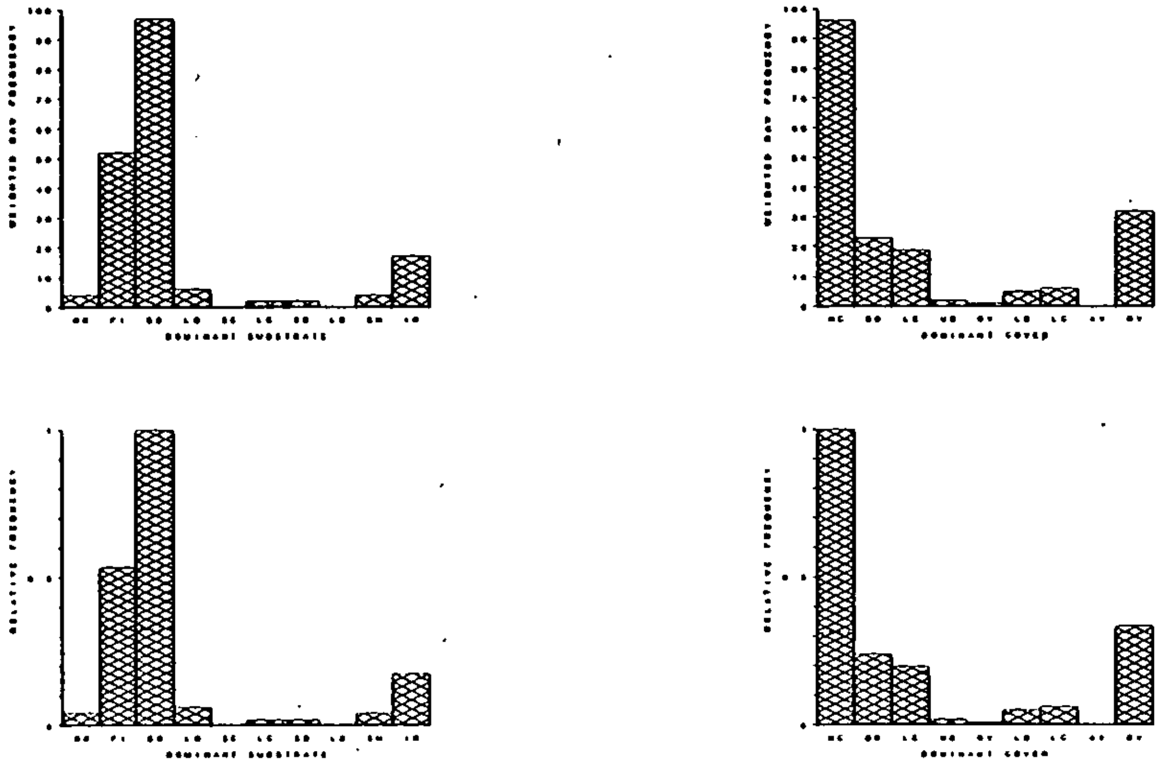


Figure D-12. Development of substrate and cover suitability criteria for spawning redbreast sunfish from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

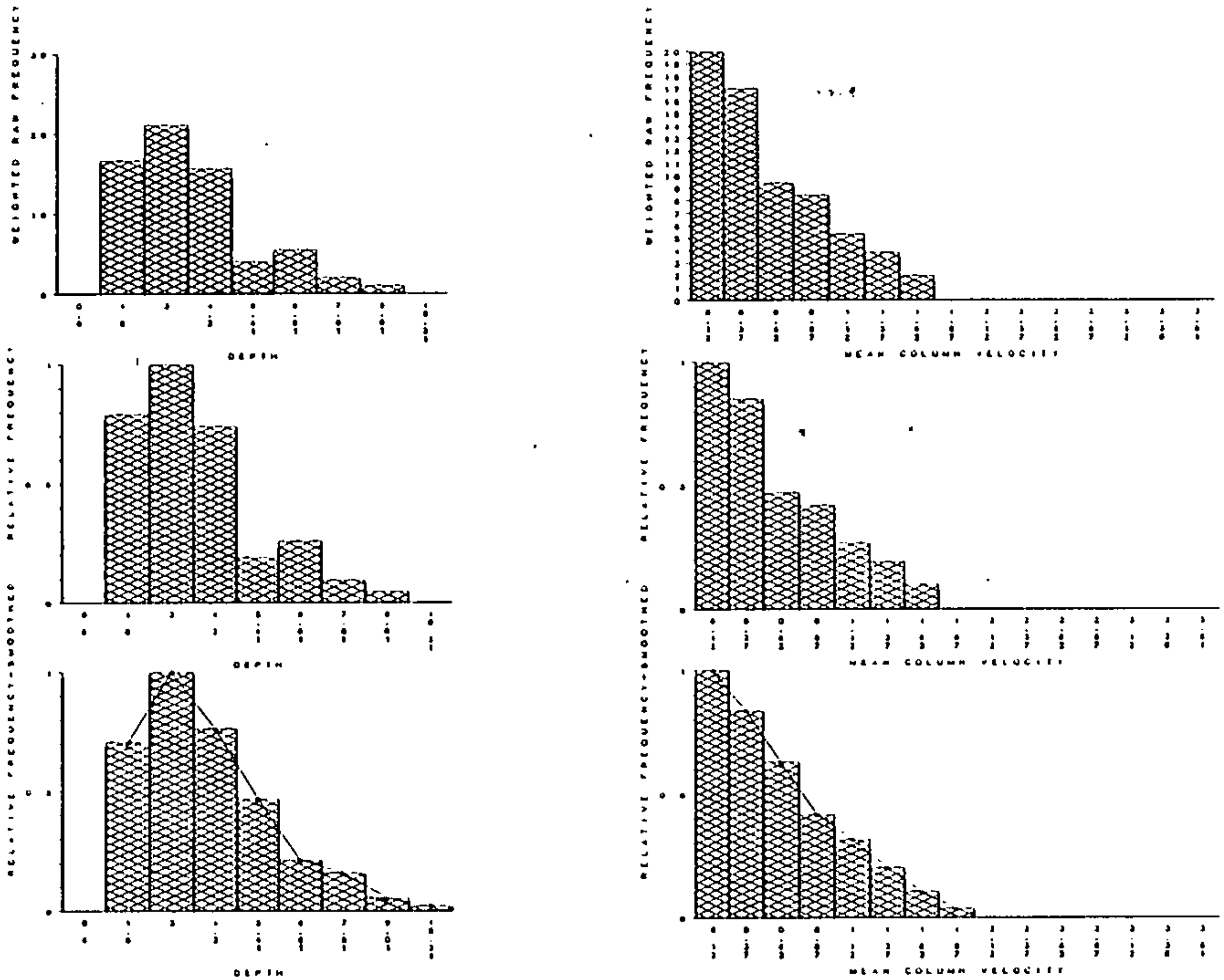


Figure D-13. Development of depth and velocity suitability criteria for adult redbreast sunfish from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

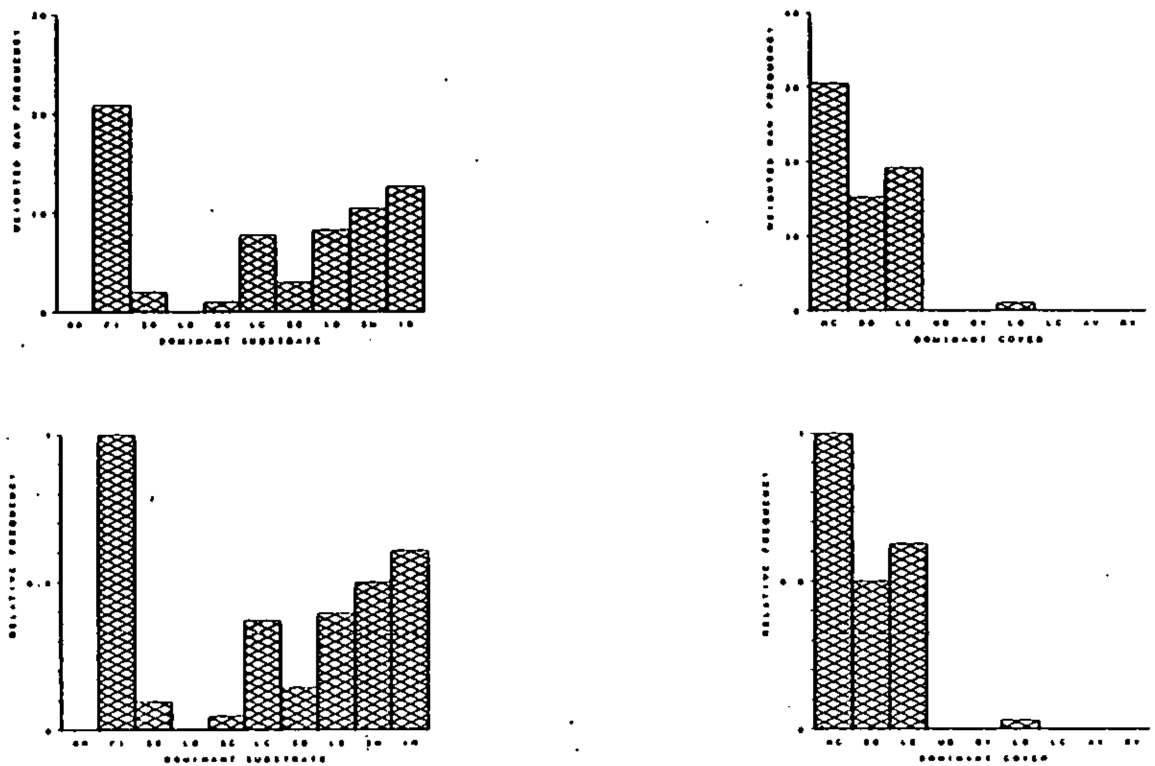


Figure D-14. Development of substrate and cover suitability criteria for adult redbreast sunfish from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

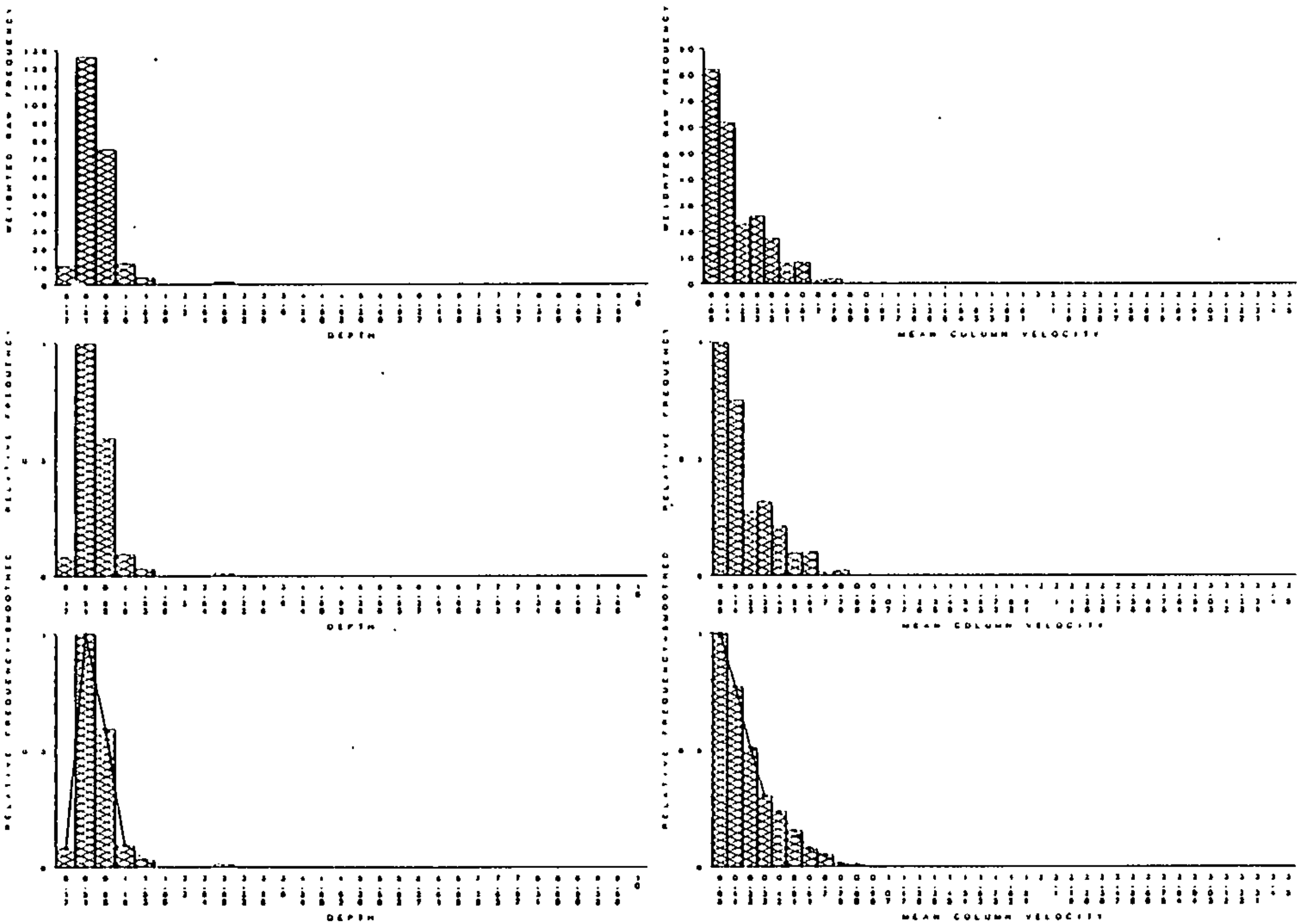


Figure D-15. Development of depth and velocity suitability criteria for YOY northern hog sucker from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

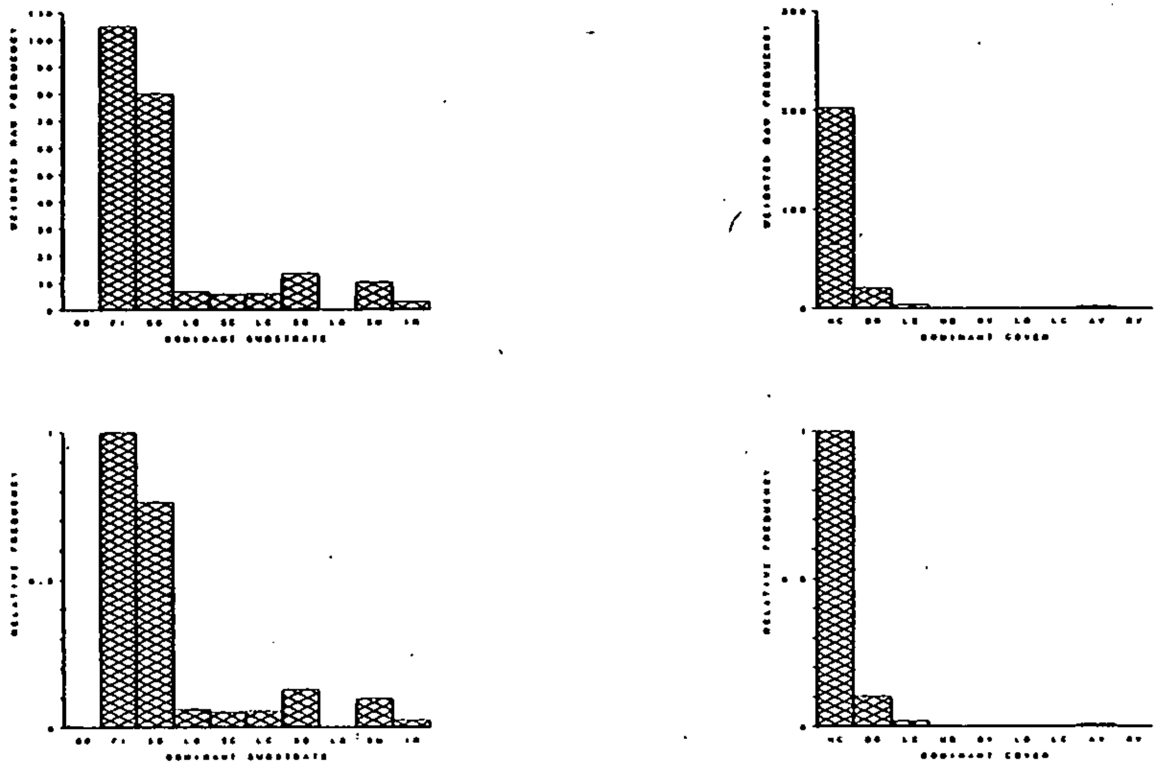


Figure D-16. Development of substrate and cover suitability criteria for YOY northern hog sucker from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

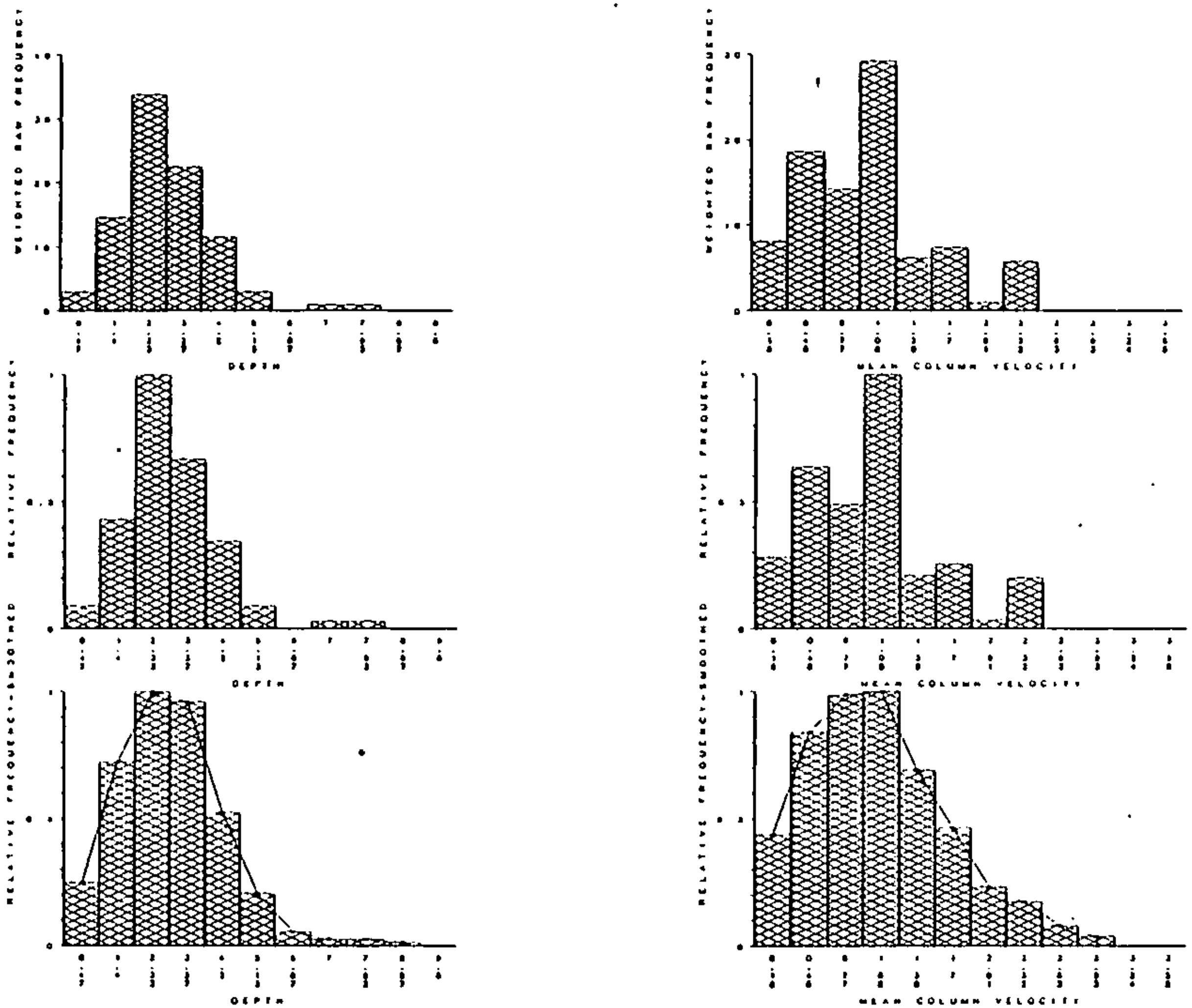


Figure D-17. Development of depth and velocity suitability criteria for juvenile northern hog sucker from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

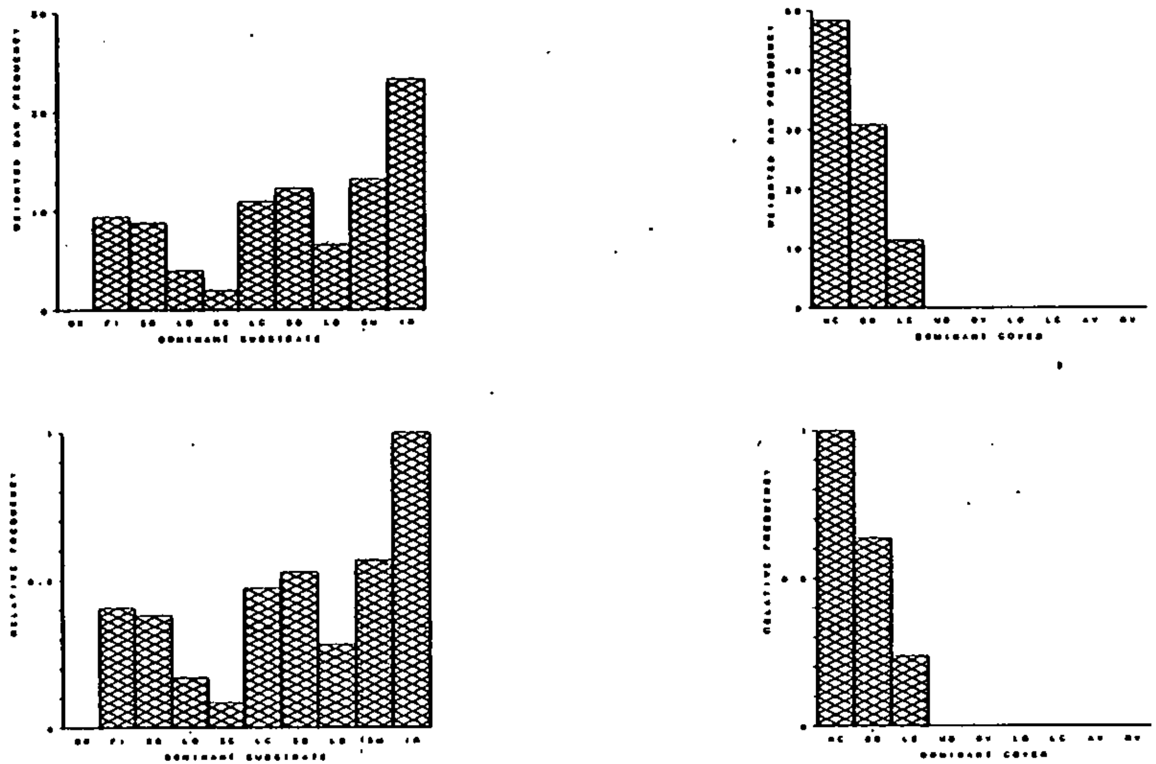


Figure D-18. Development of substrate and cover suitability criteria for juvenile northern hog sucker from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

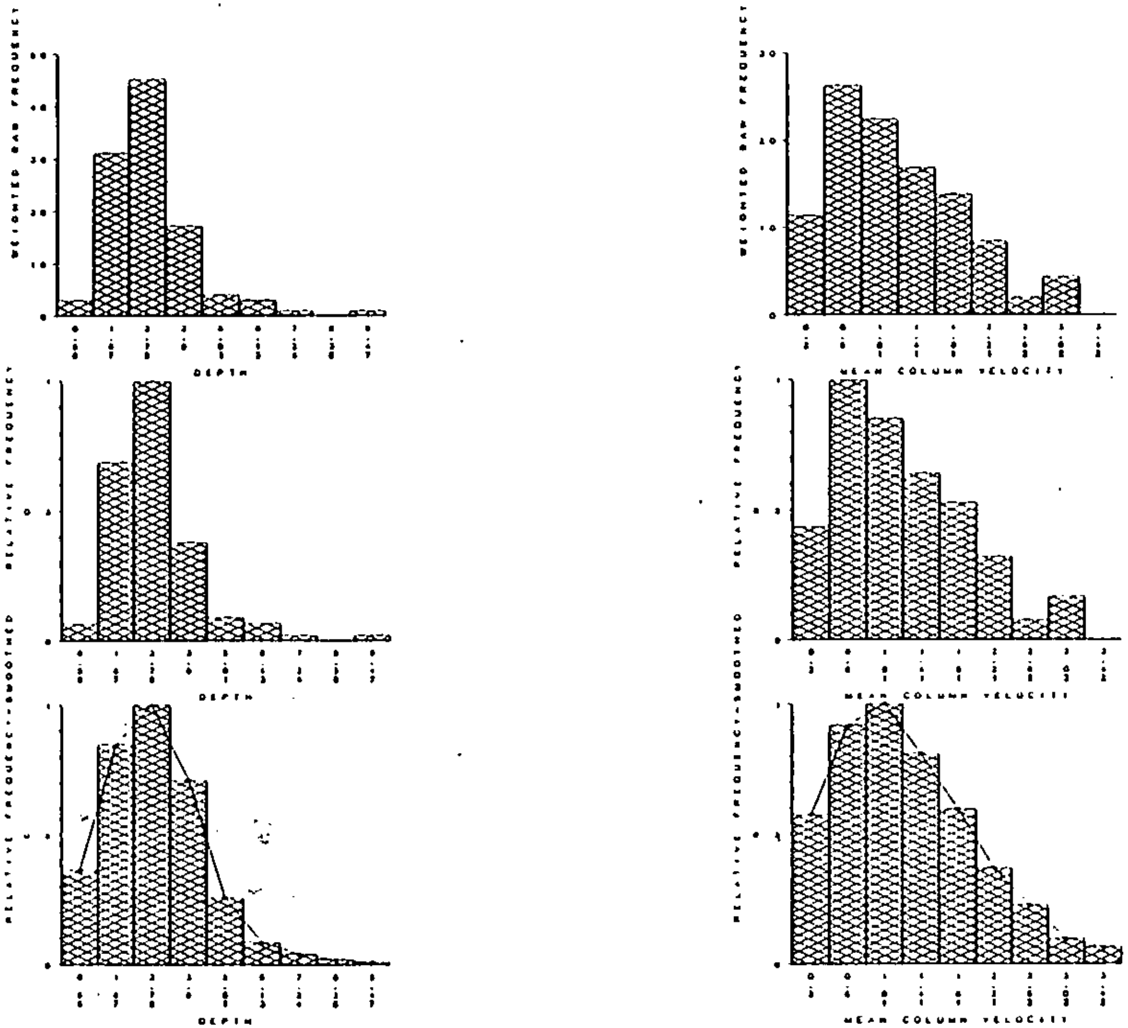


Figure D-19. Development of depth and velocity suitability criteria for adult northern hog sucker from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

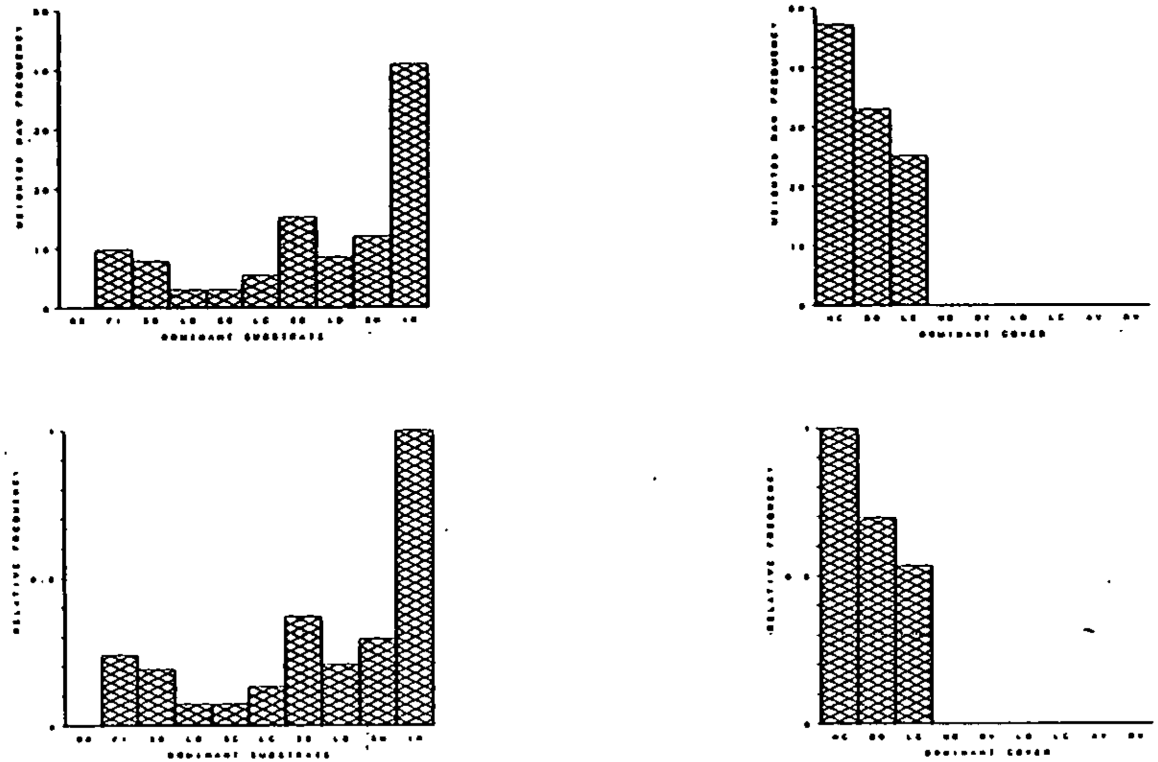


Figure D-20. Development of substrate and cover suitability criteria for adult northern hog sucker from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

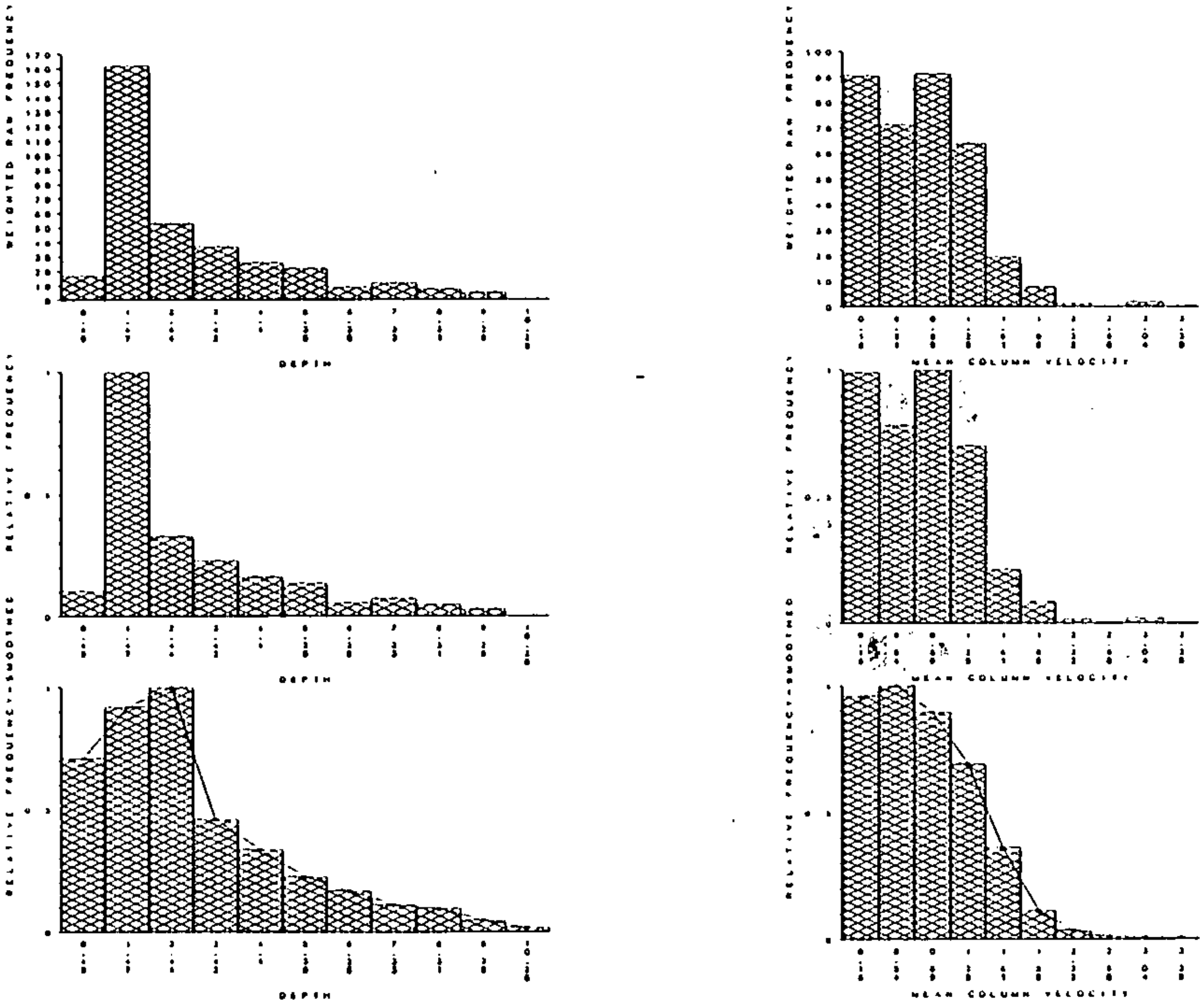


Figure D-21. Development of depth and velocity suitability criteria for adult whitefin shiner from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

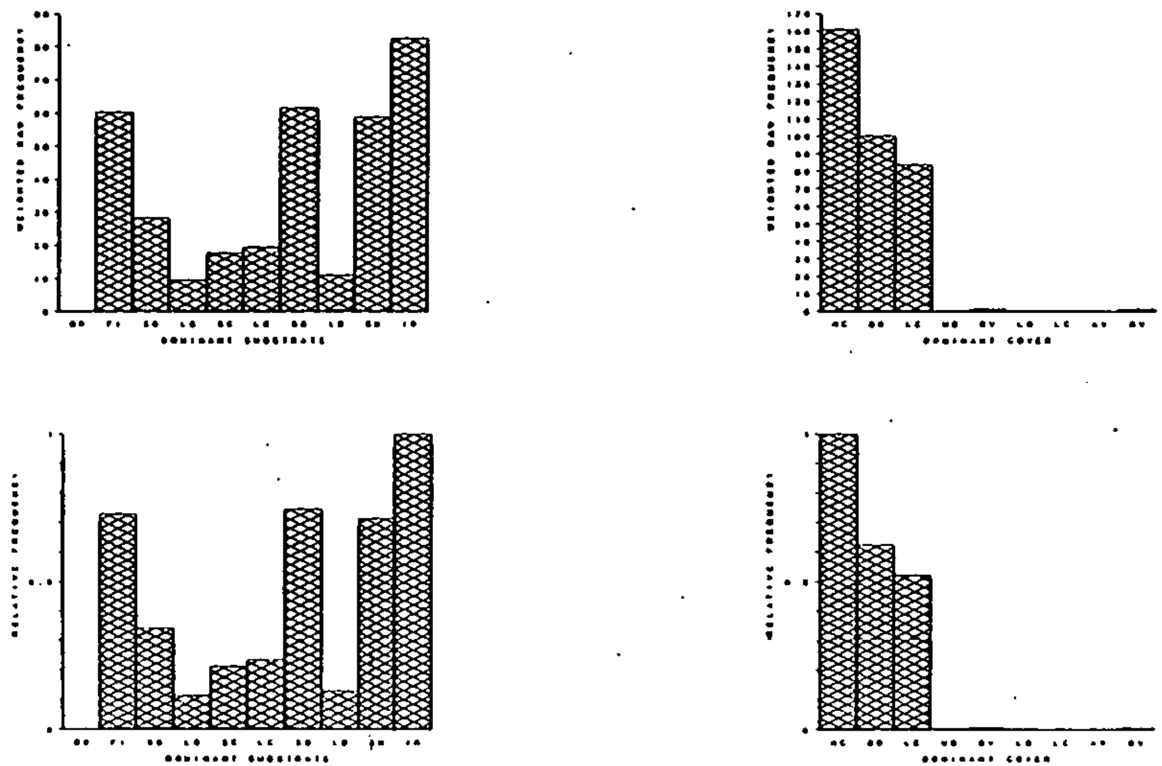


Figure D-22. Development of substrate and cover suitability criteria for adult whitefin shiner from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

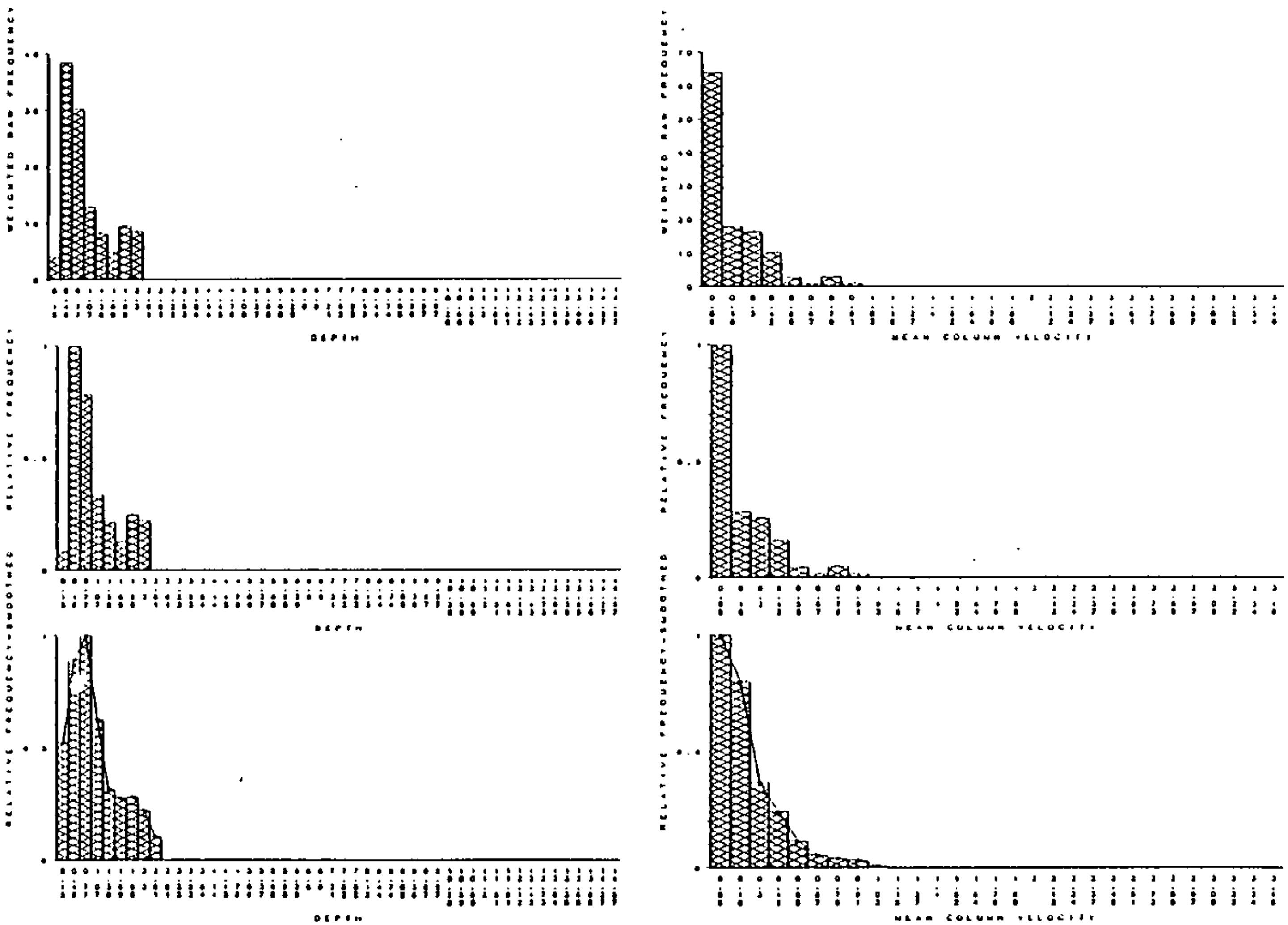


Figure D-23. Development of depth and velocity suitability criteria for YOY striped jumprock from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

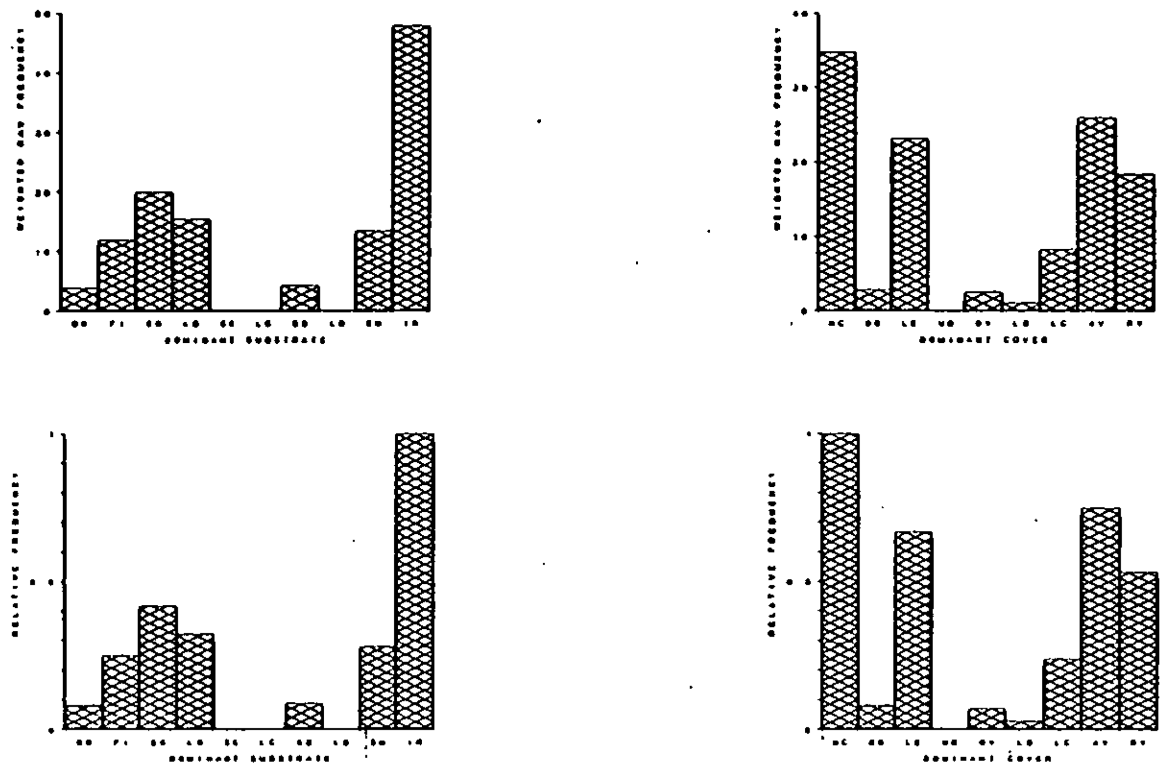


Figure D-24. Development of substrate and cover suitability criteria for YOY striped jumprock from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

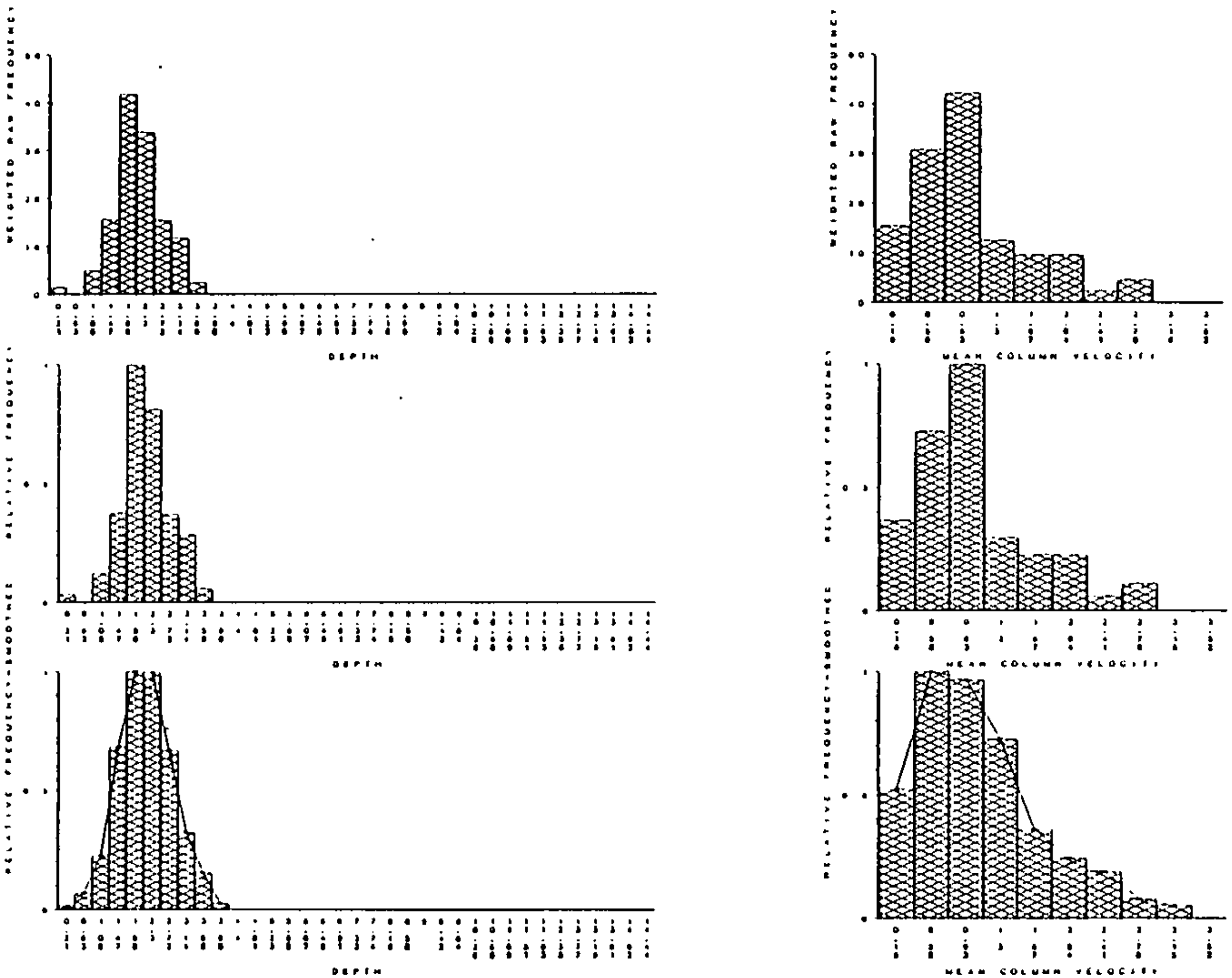


Figure D-25. Development of depth and velocity suitability criteria for adult striped jumprock from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

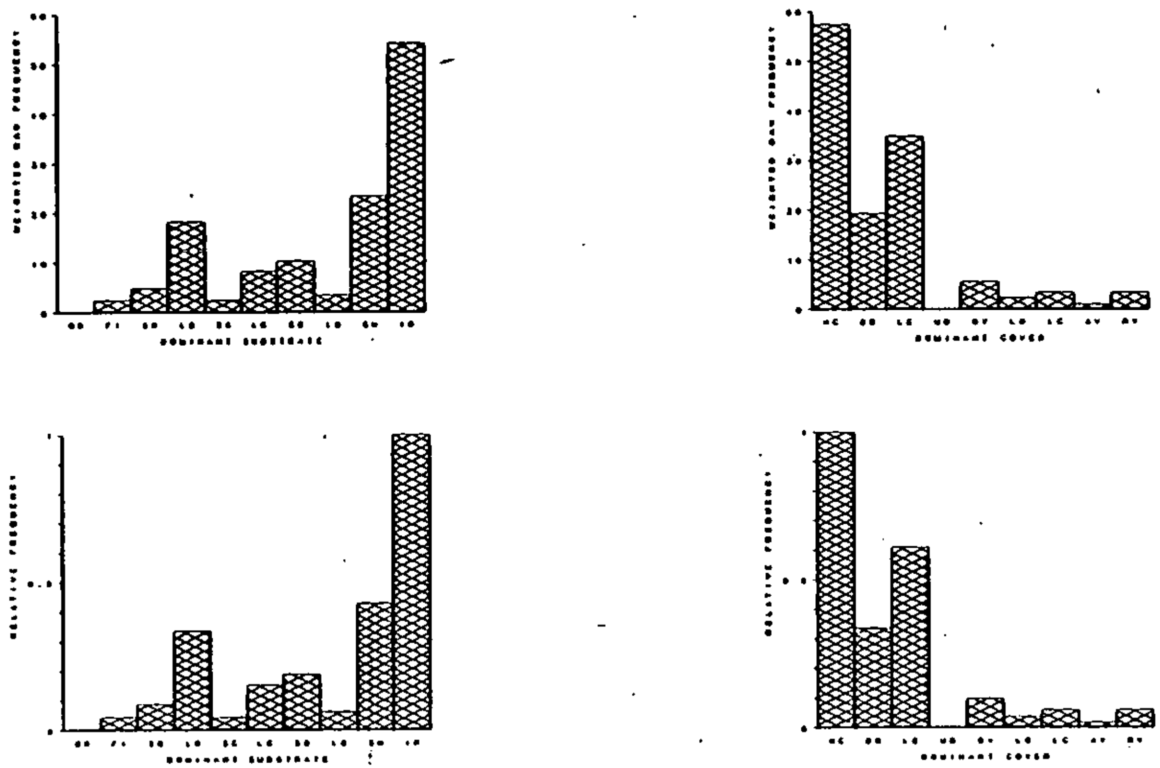


Figure D-26. Development of substrate and cover suitability criteria for adult striped jumprock from data collected in the Ocmulgee River. Micro-habitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

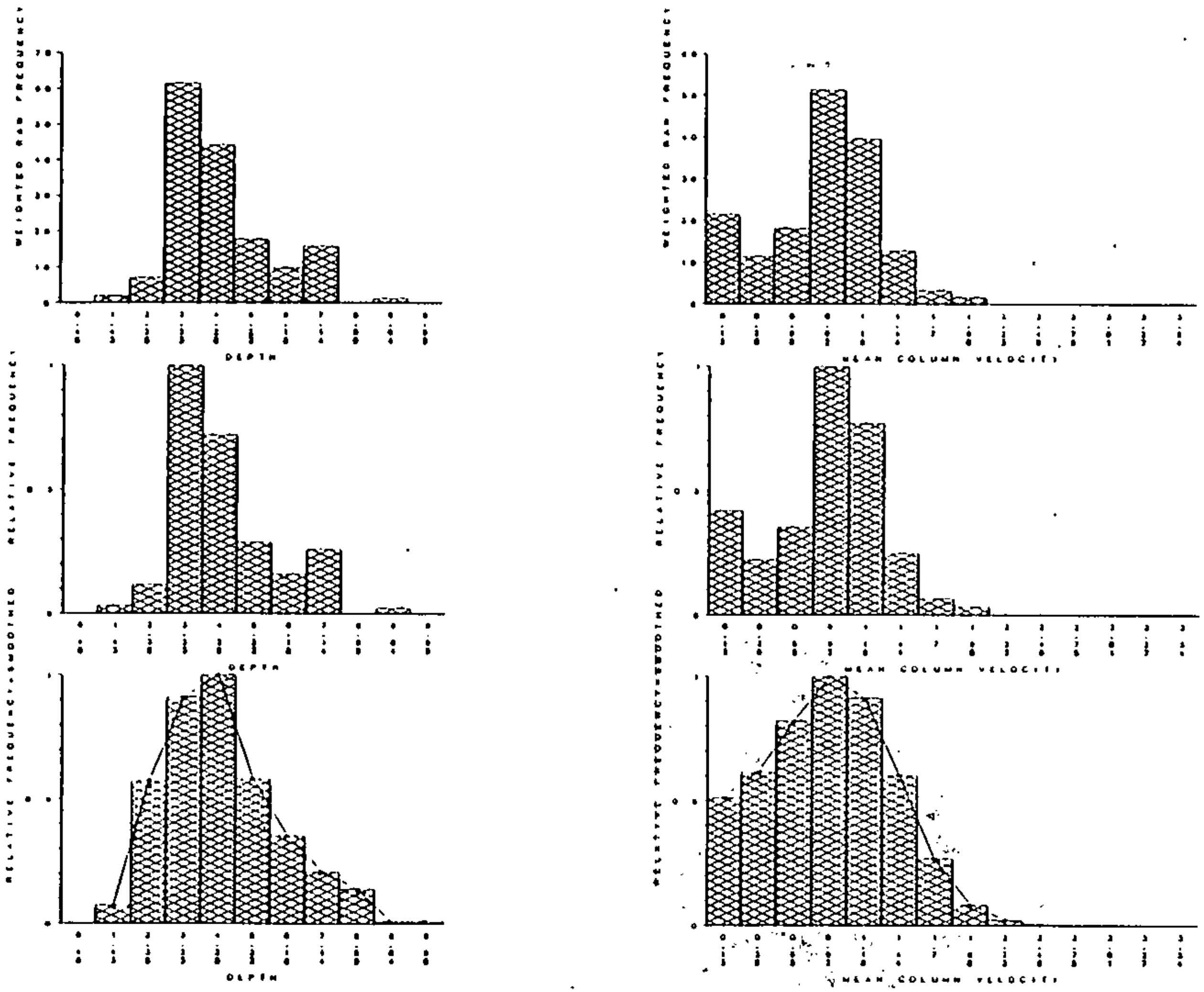


Figure D-27. Development of depth and velocity suitability criteria for adult silver redhorse from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

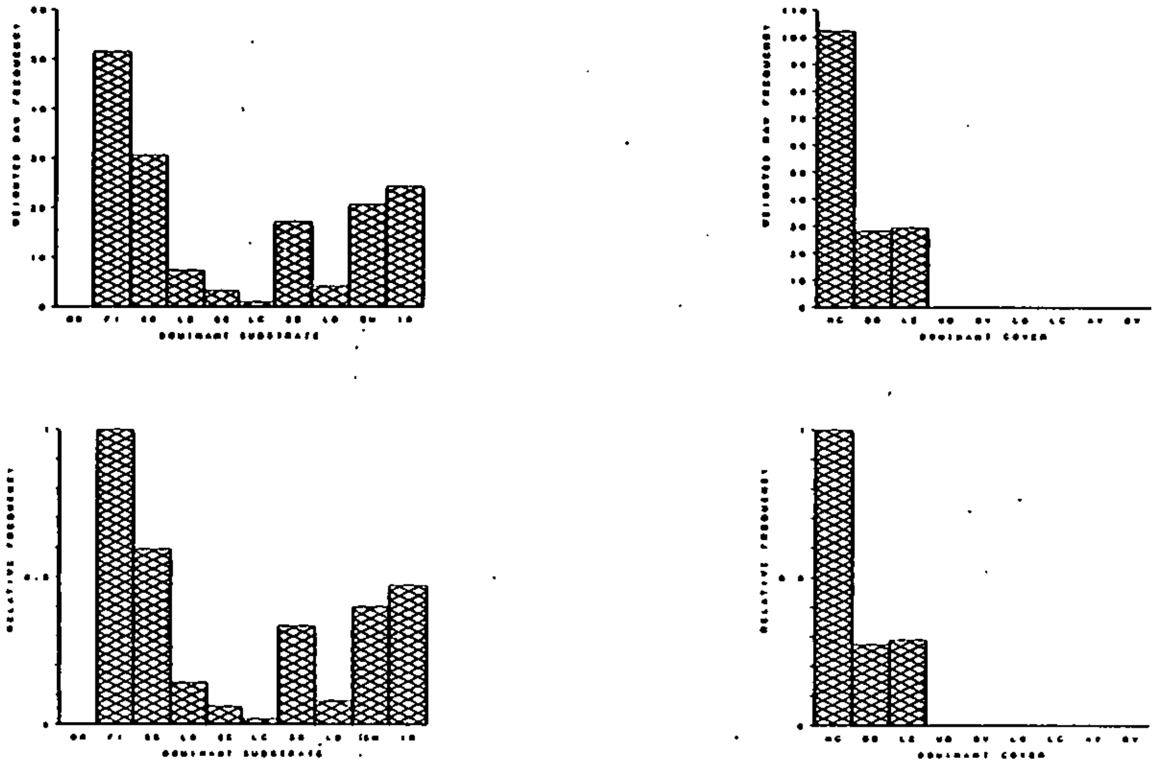


Figure D-28. Development of substrate and cover suitability criteria for adult silver redhorse from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

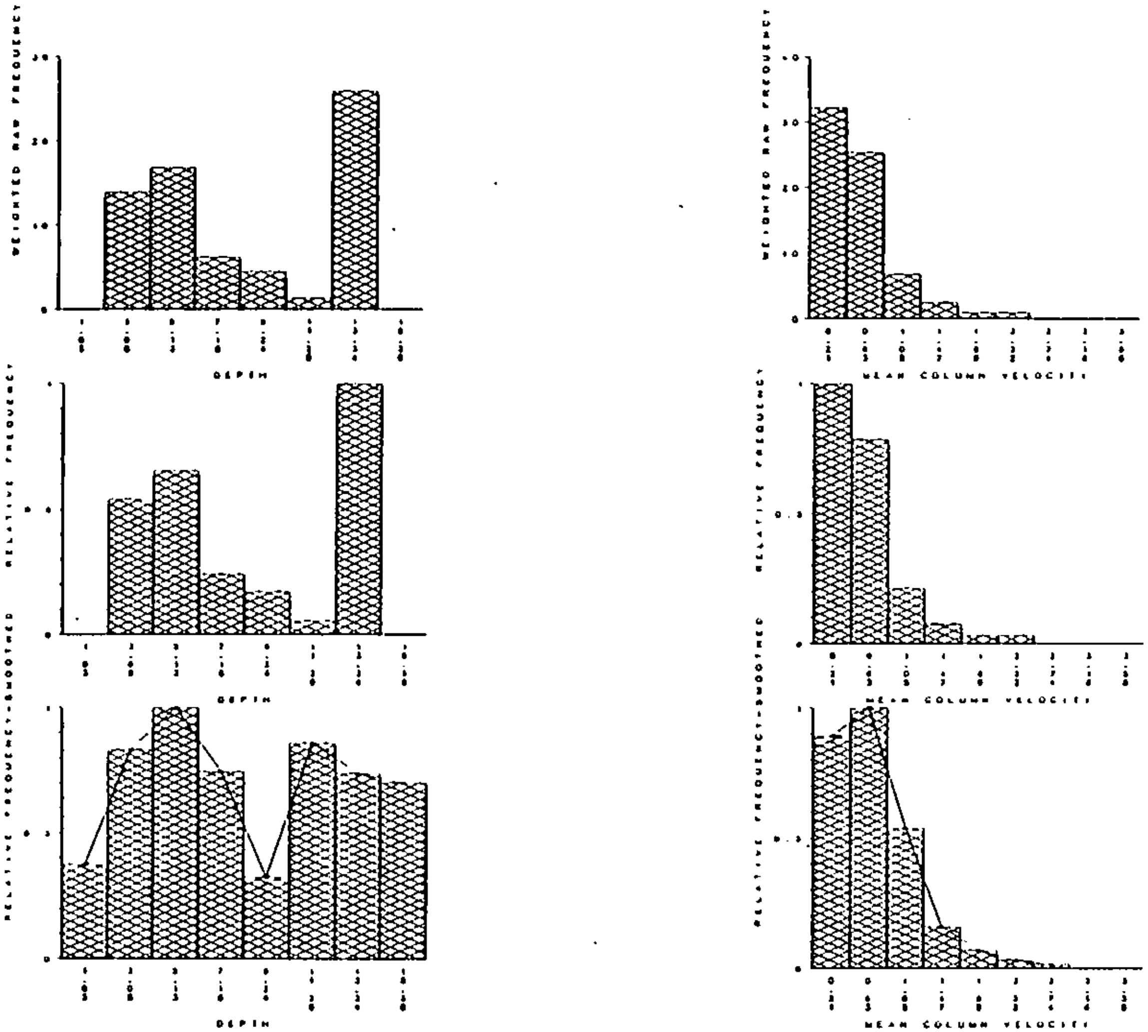


Figure D-29. Development of depth and velocity suitability criteria for adult silver redhorse from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

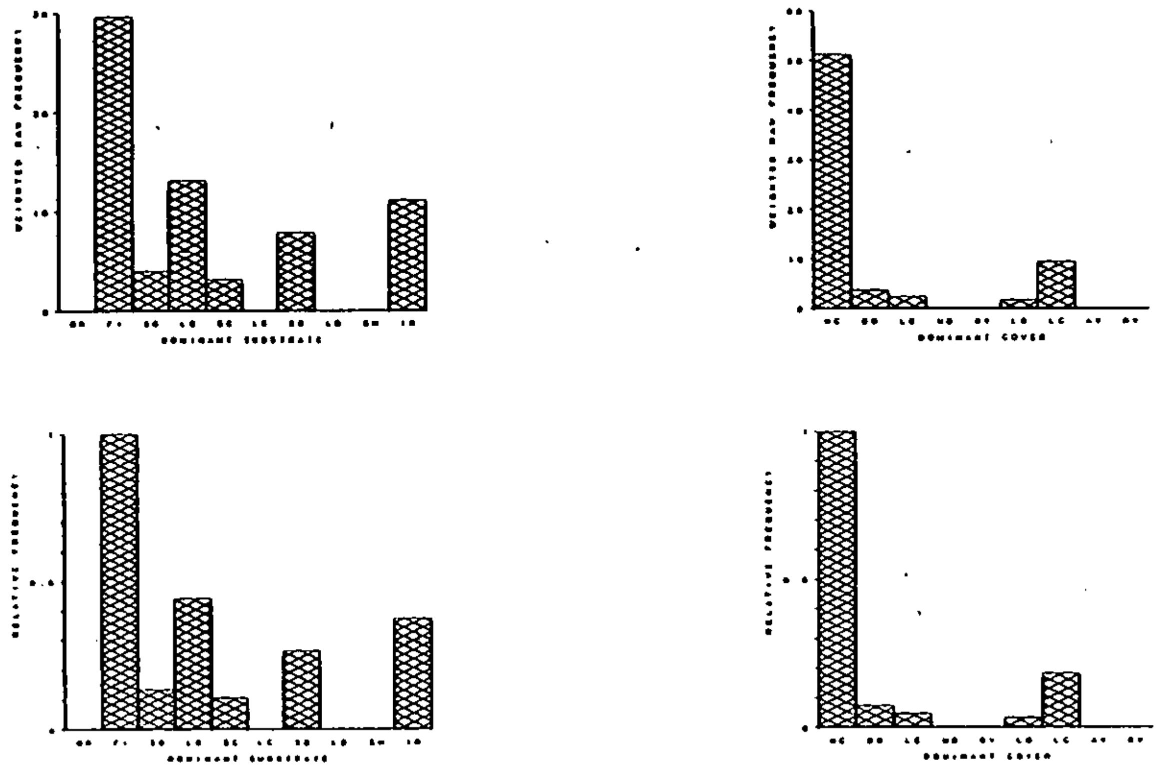


Figure D-30. Development of substrate and cover suitability criteria for adult silver redhorse from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

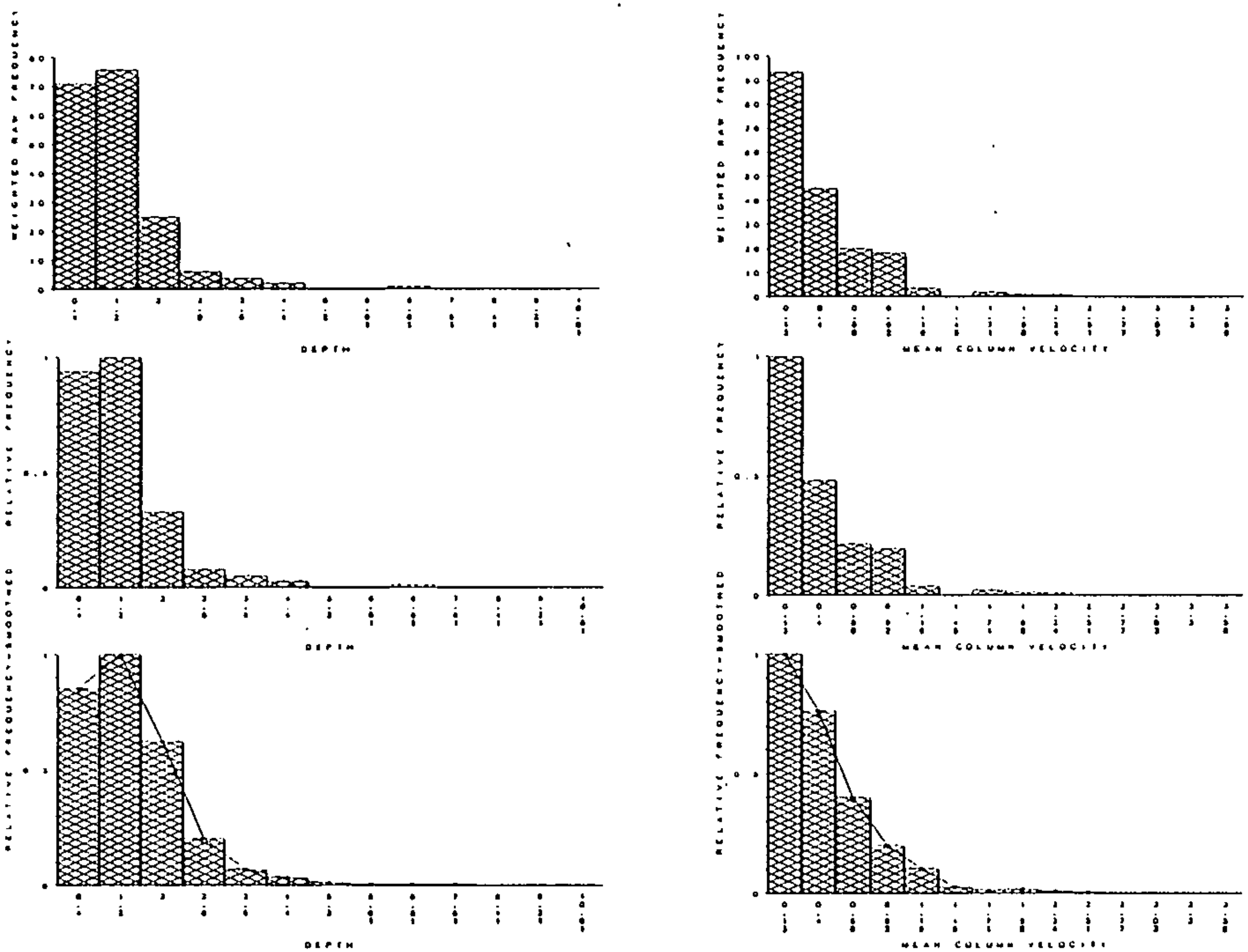


Figure D-31. Development of depth and velocity suitability criteria for YOY redeye bass from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

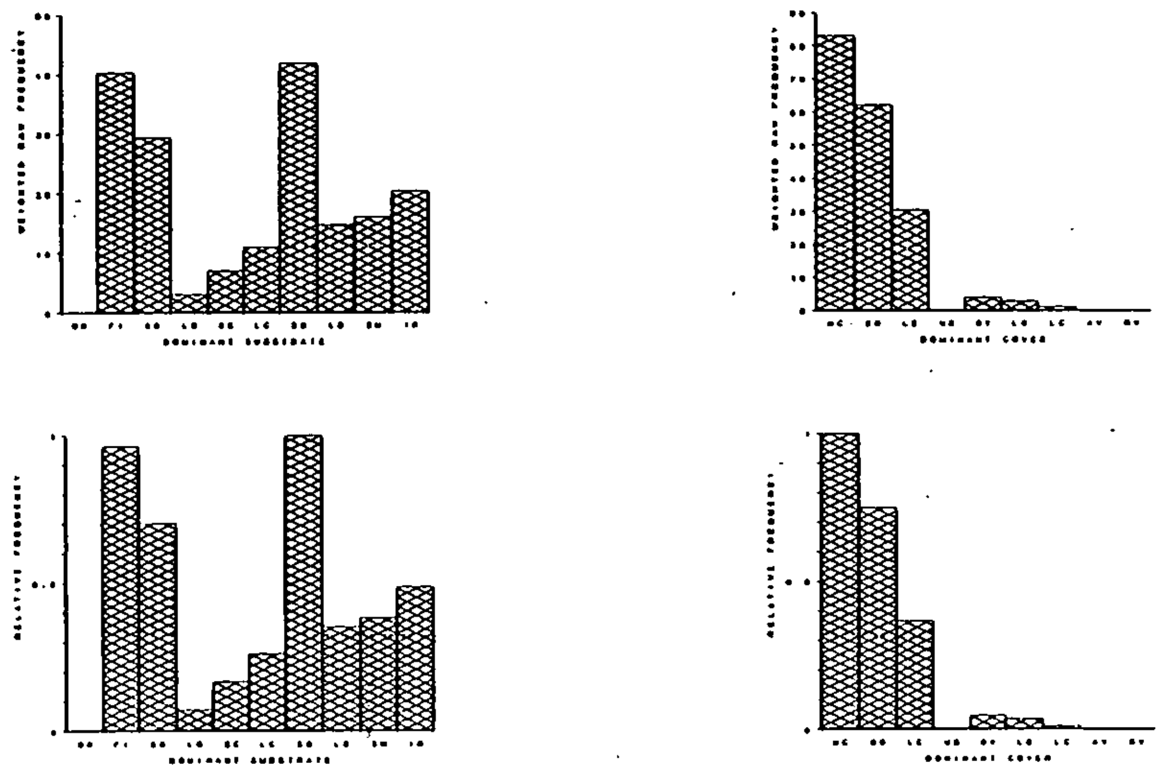


Figure D-32. Development of substrate and cover suitability criteria for YOY redeye bass from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

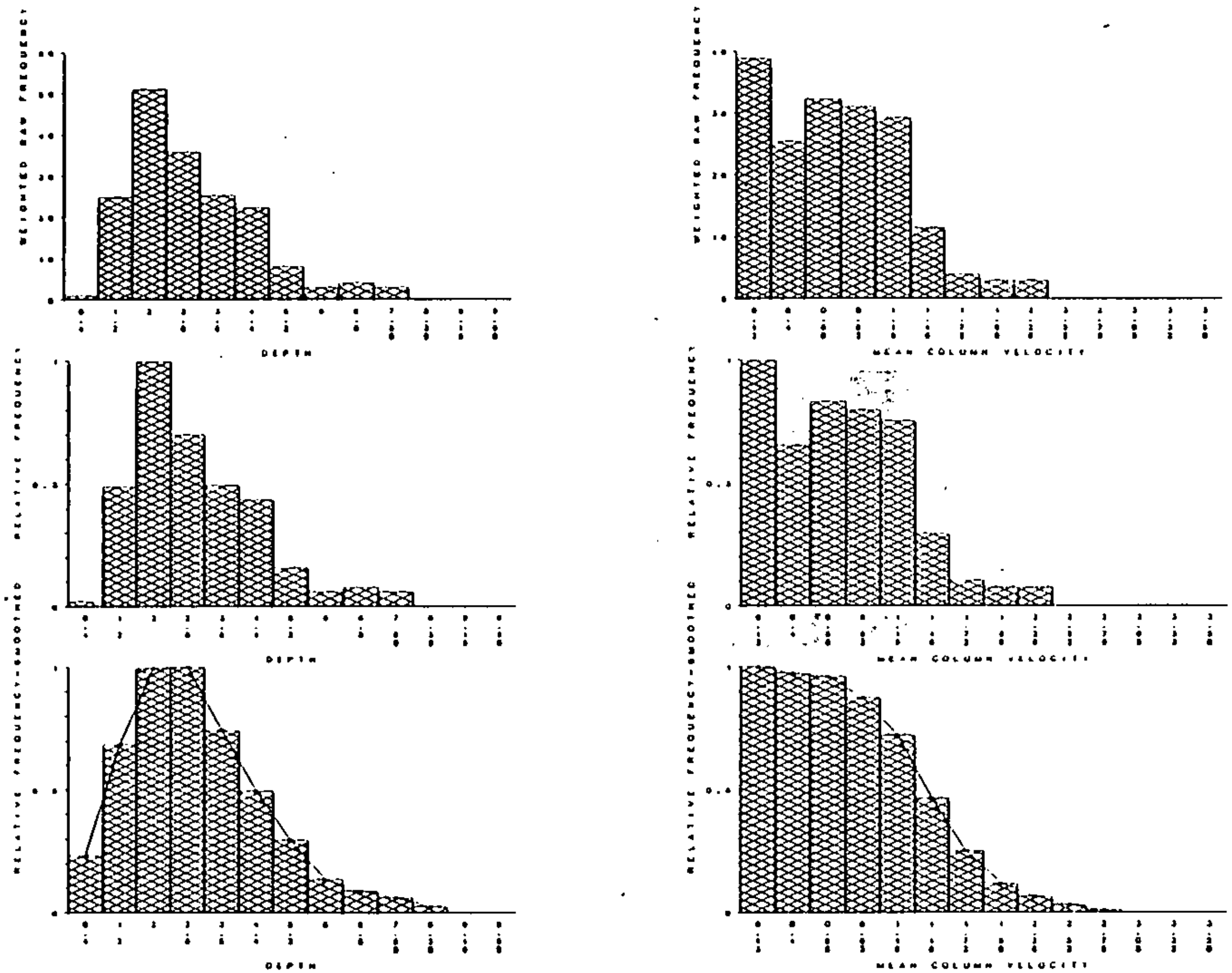


Figure D-33. Development of depth and velocity suitability criteria for juvenile redeye bass from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

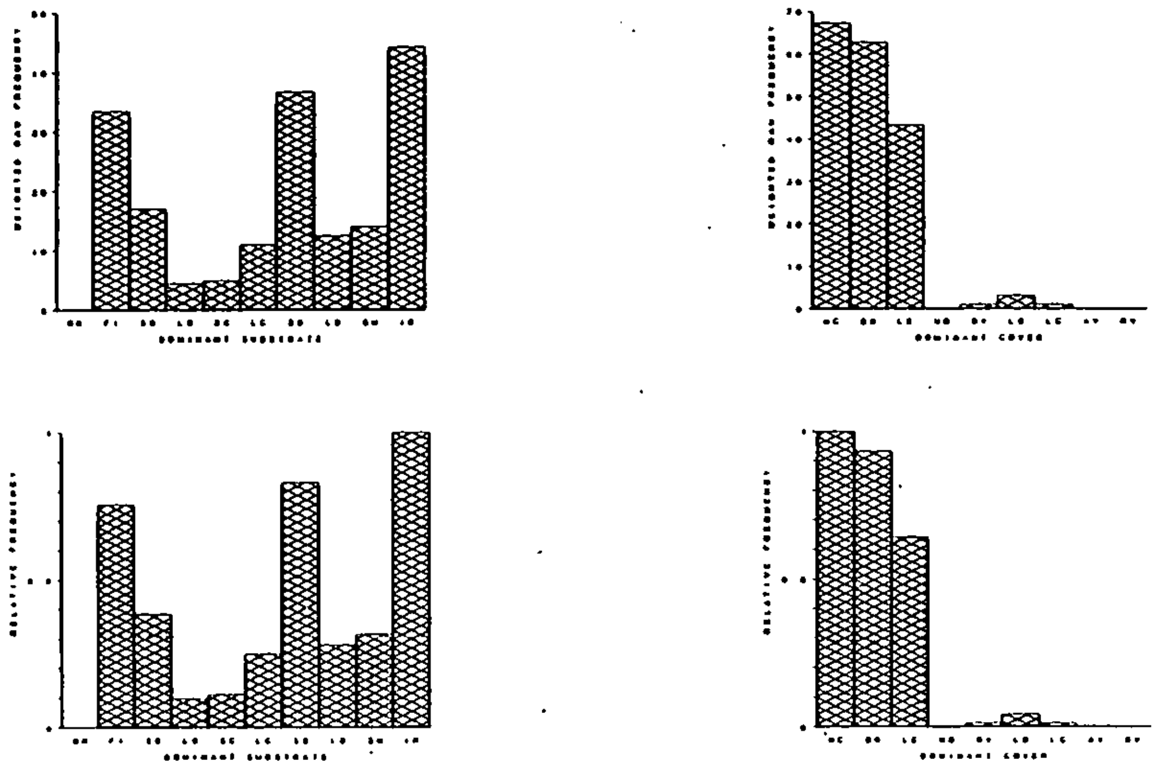


Figure D-34. Development of substrate and cover suitability criteria for juvenile redeye bass from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

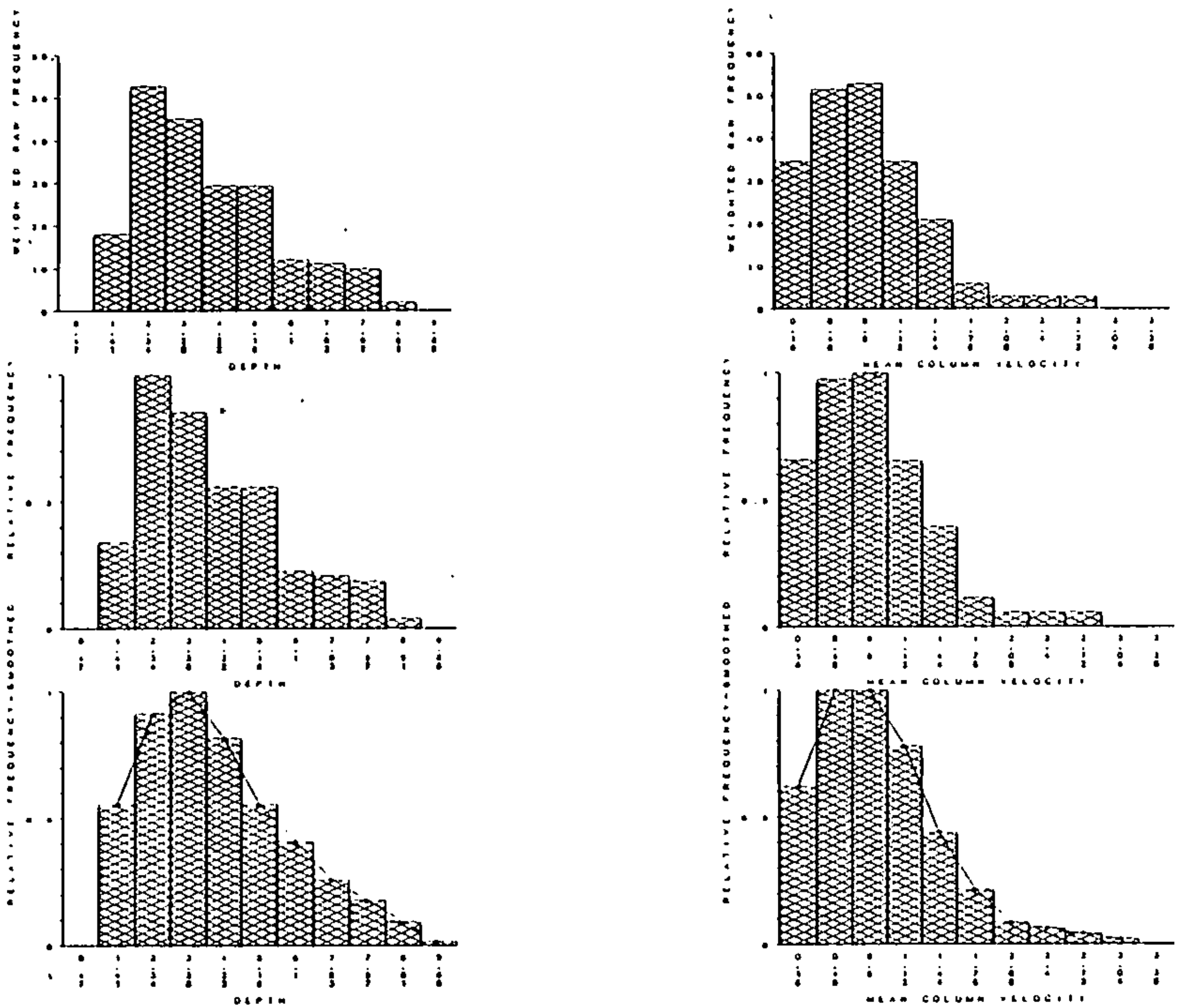


Figure D-35. Development of depth and velocity suitability criteria for adult redeye bass from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

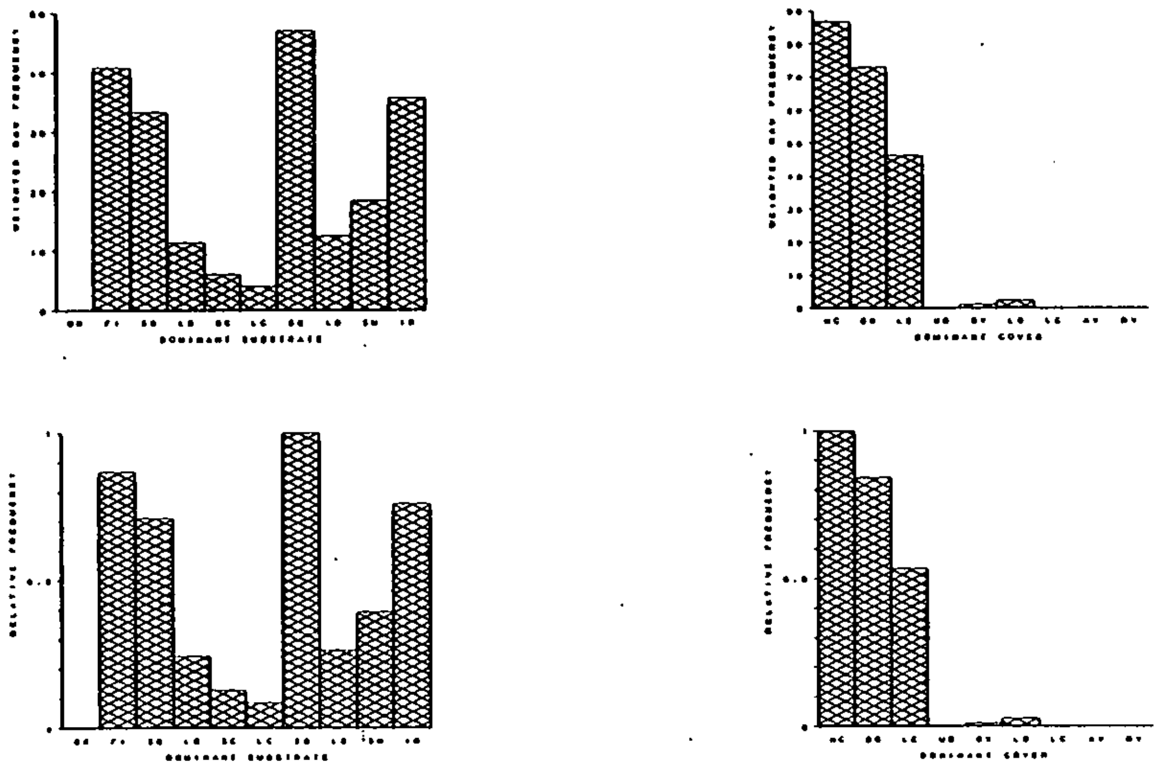


Figure D-36. Development of substrate and cover suitability criteria for adult redeye bass from data collected in the Chattooga River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

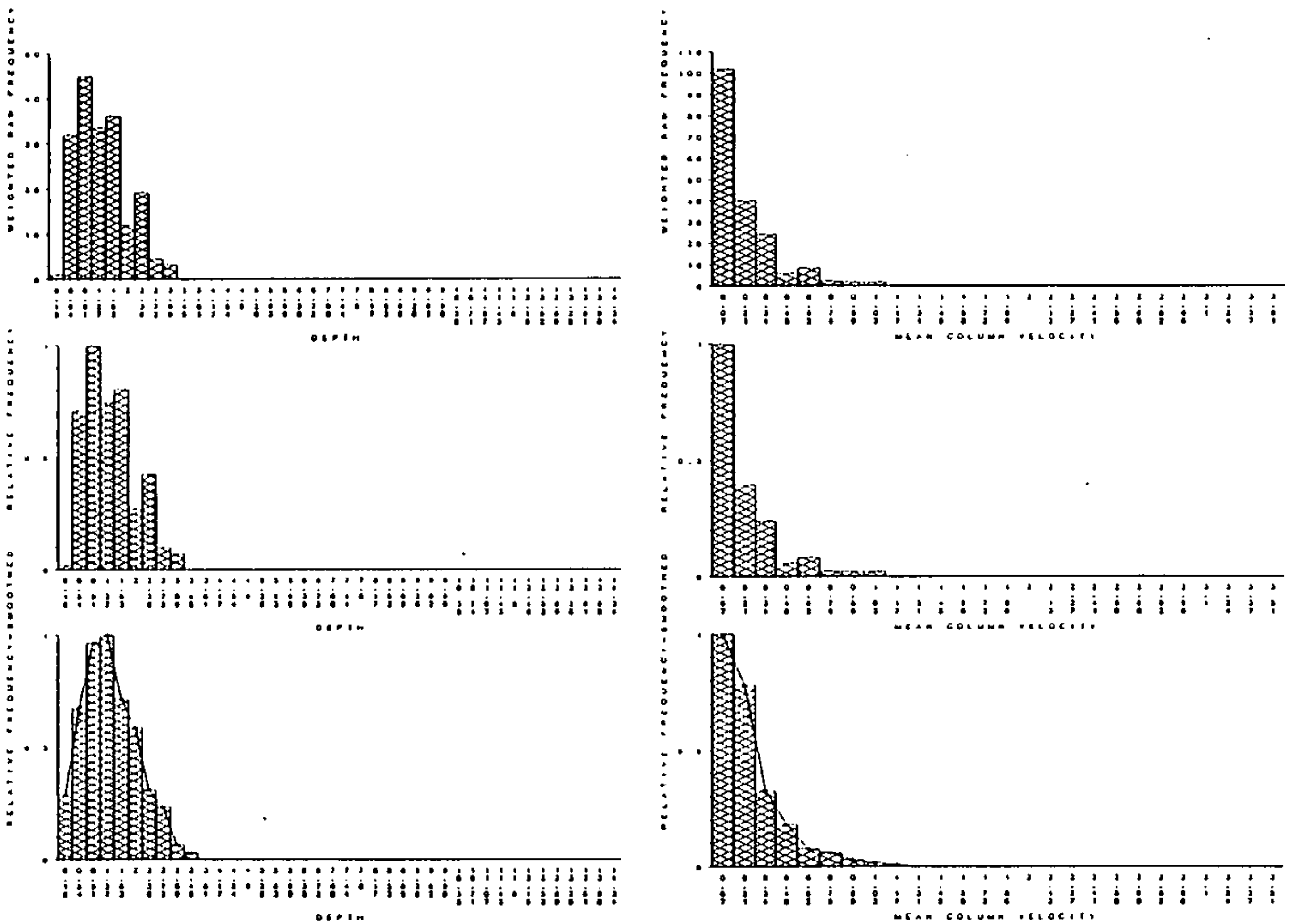


Figure D-37. Development of depth and velocity suitability criteria for YOY shoal bass from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

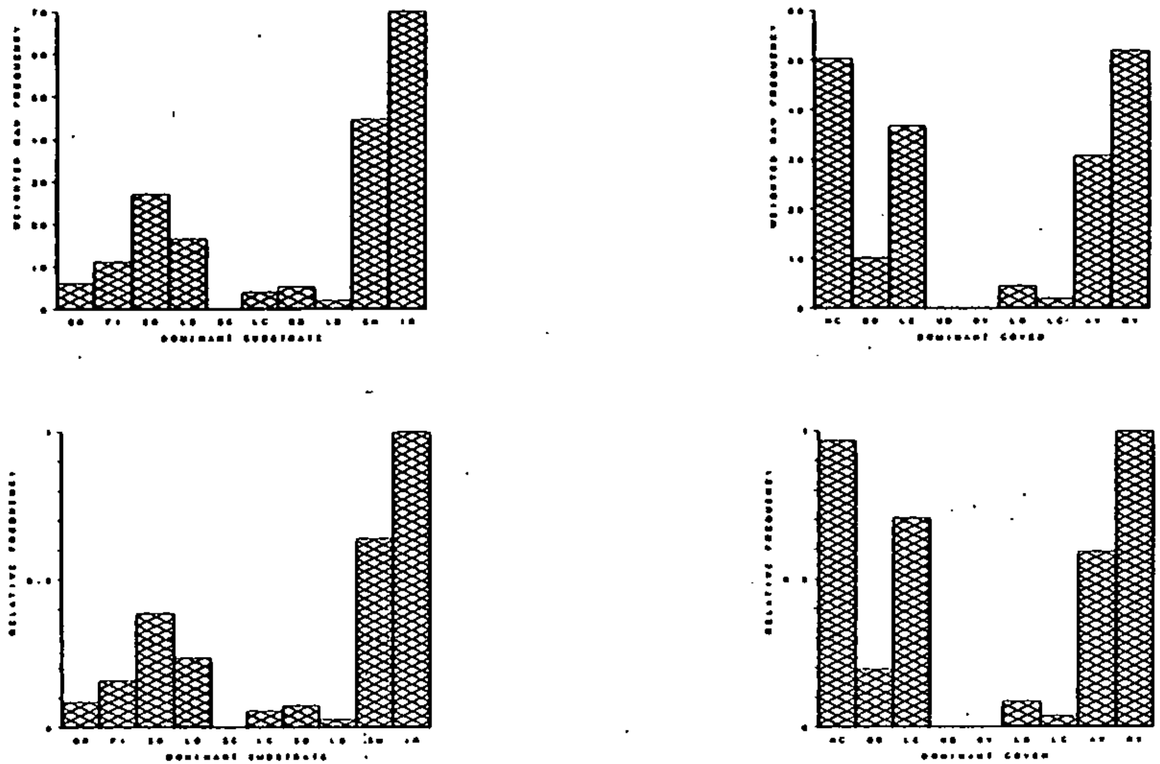


Figure D-38. Development of substrate and cover suitability criteria for YOY shoal bass from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

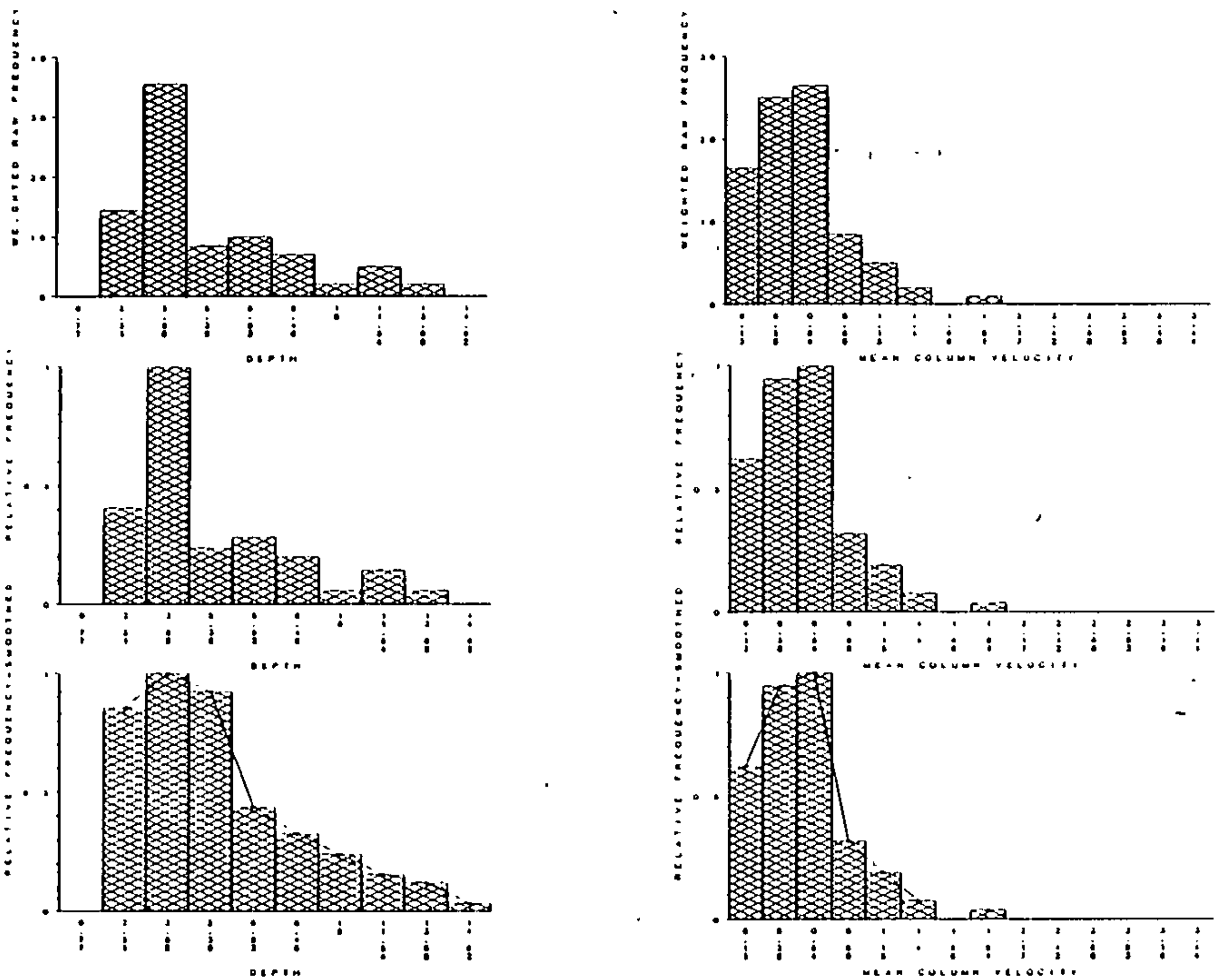


Figure D-39. Development of depth and velocity suitability criteria for adult shoal bass from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

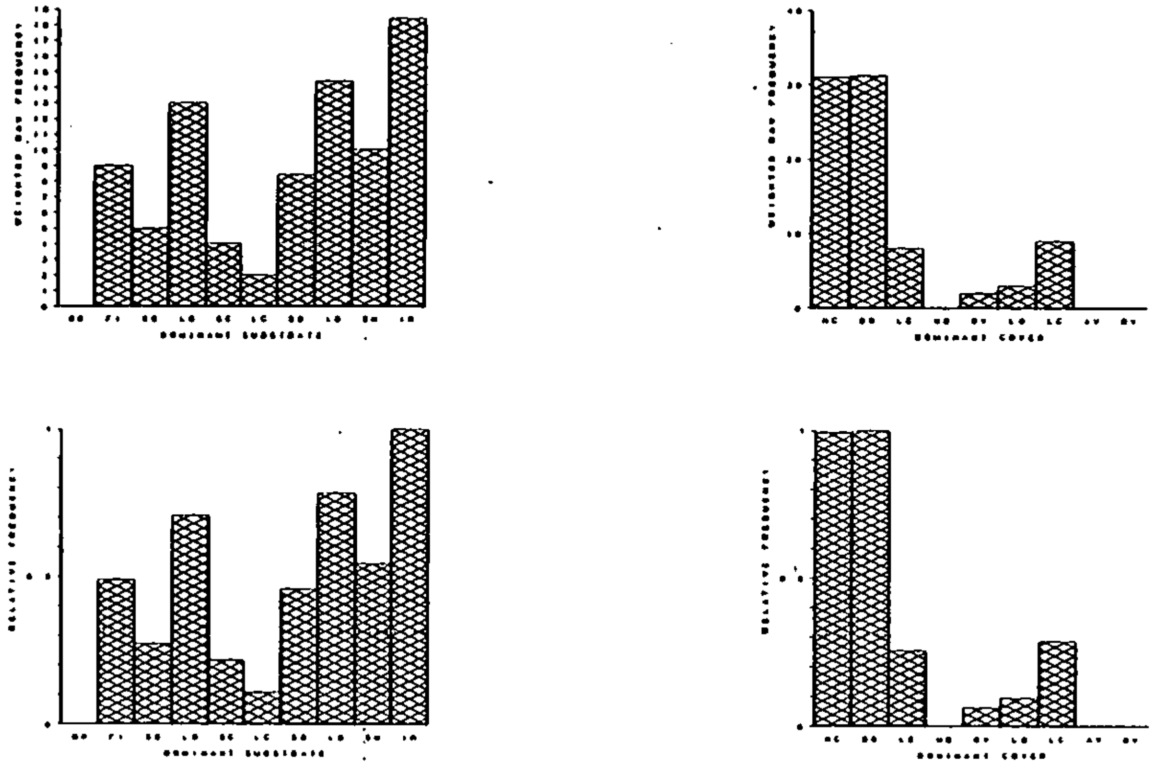


Figure D-40. Development of substrate and cover suitability criteria for adult shoal bass from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

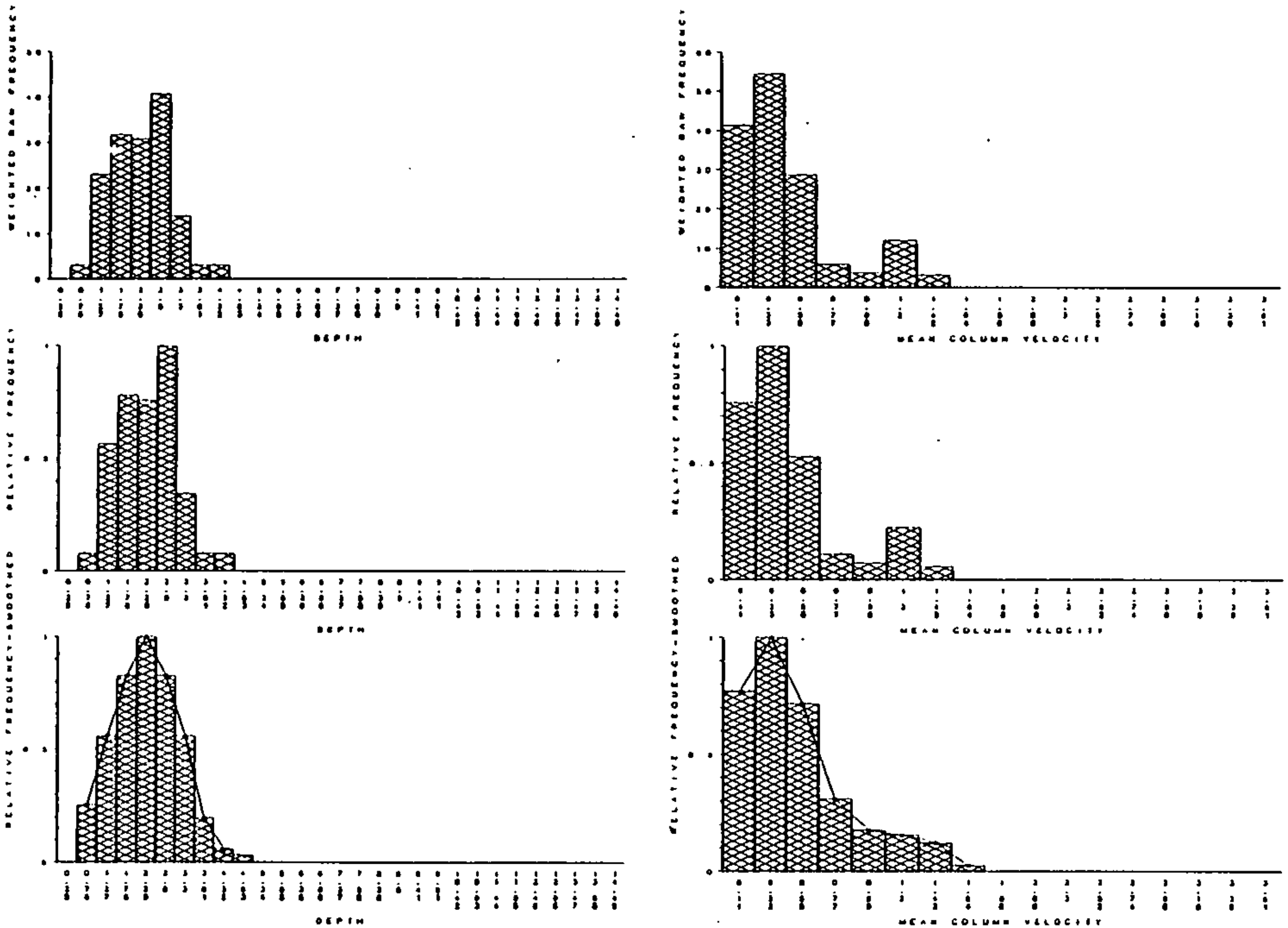


Figure D-41. Development of depth and velocity suitability criteria for YOY altamaha shiner from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

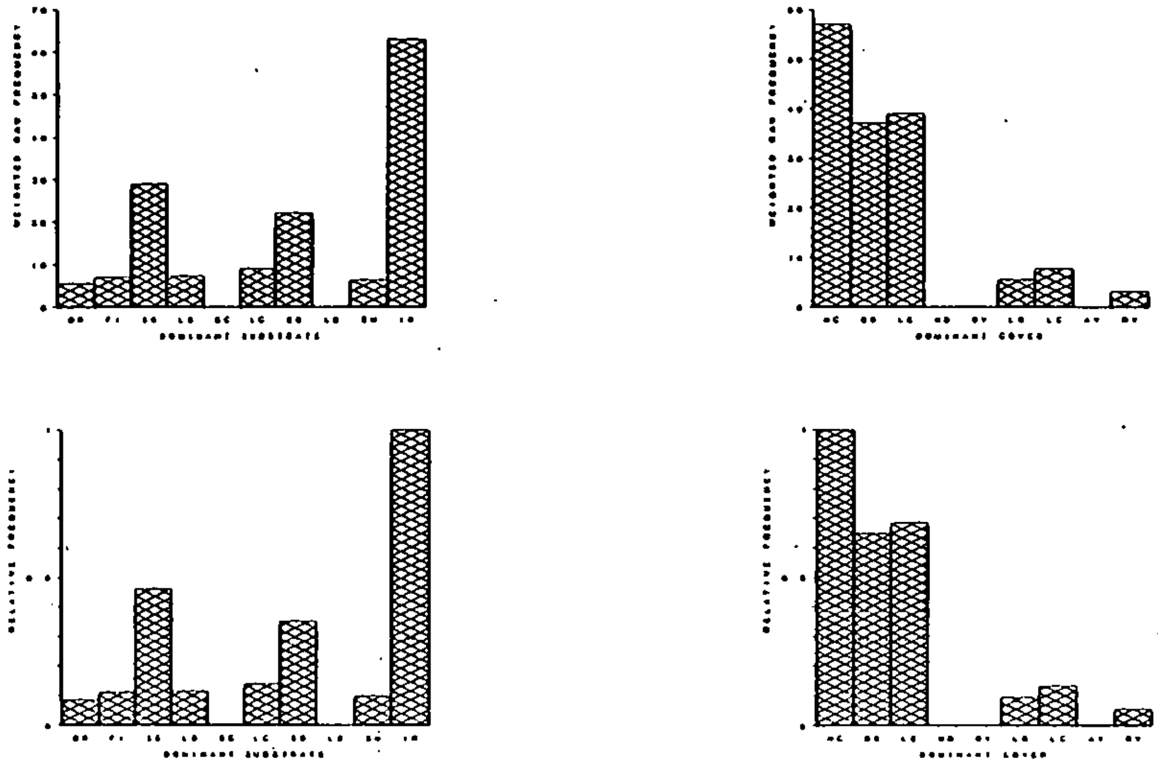


Figure D-42. Development of substrate and cover suitability criteria for YOY altamaha shiner from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

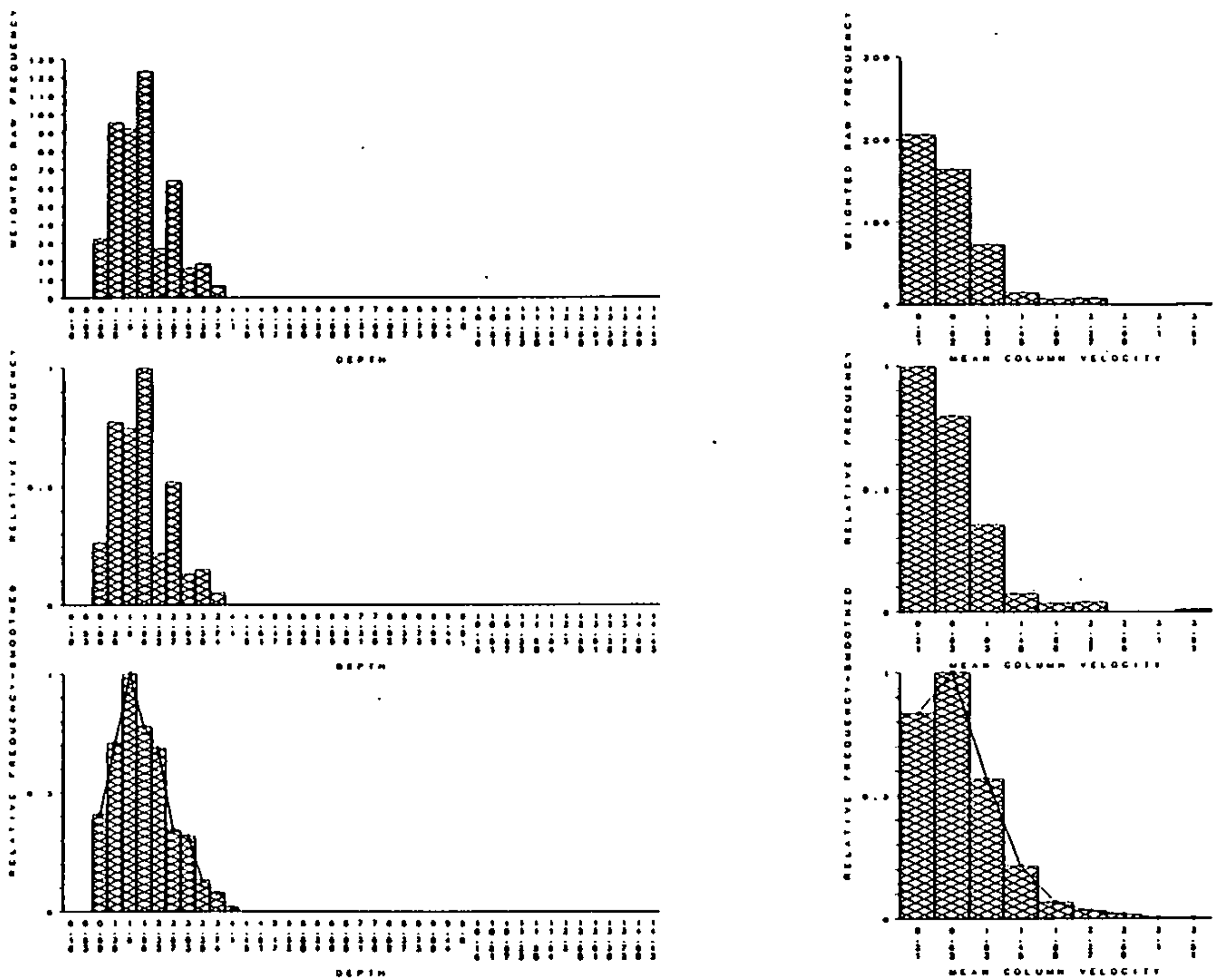


Figure D-43. Development of depth and velocity suitability criteria for adult altamaha shiner from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

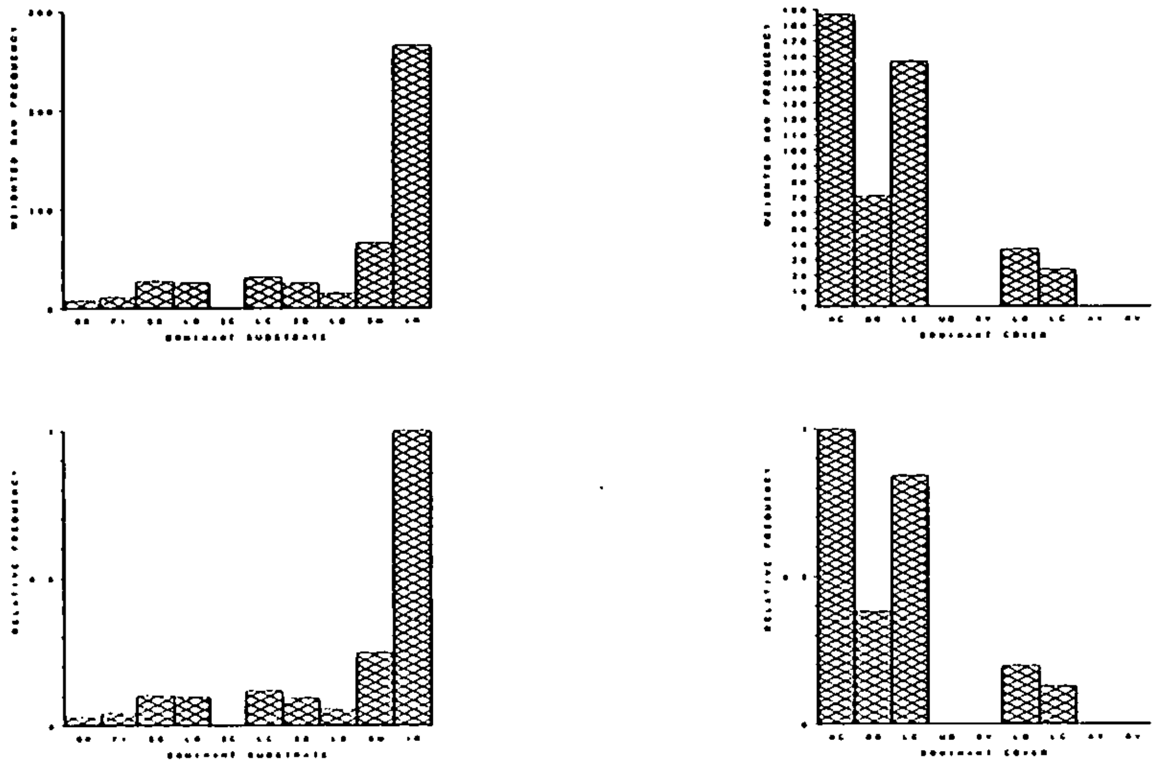


Figure D-44. Development of substrate and cover suitability criteria for adult altamaha shiner from data collected in the Ocmulgee River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

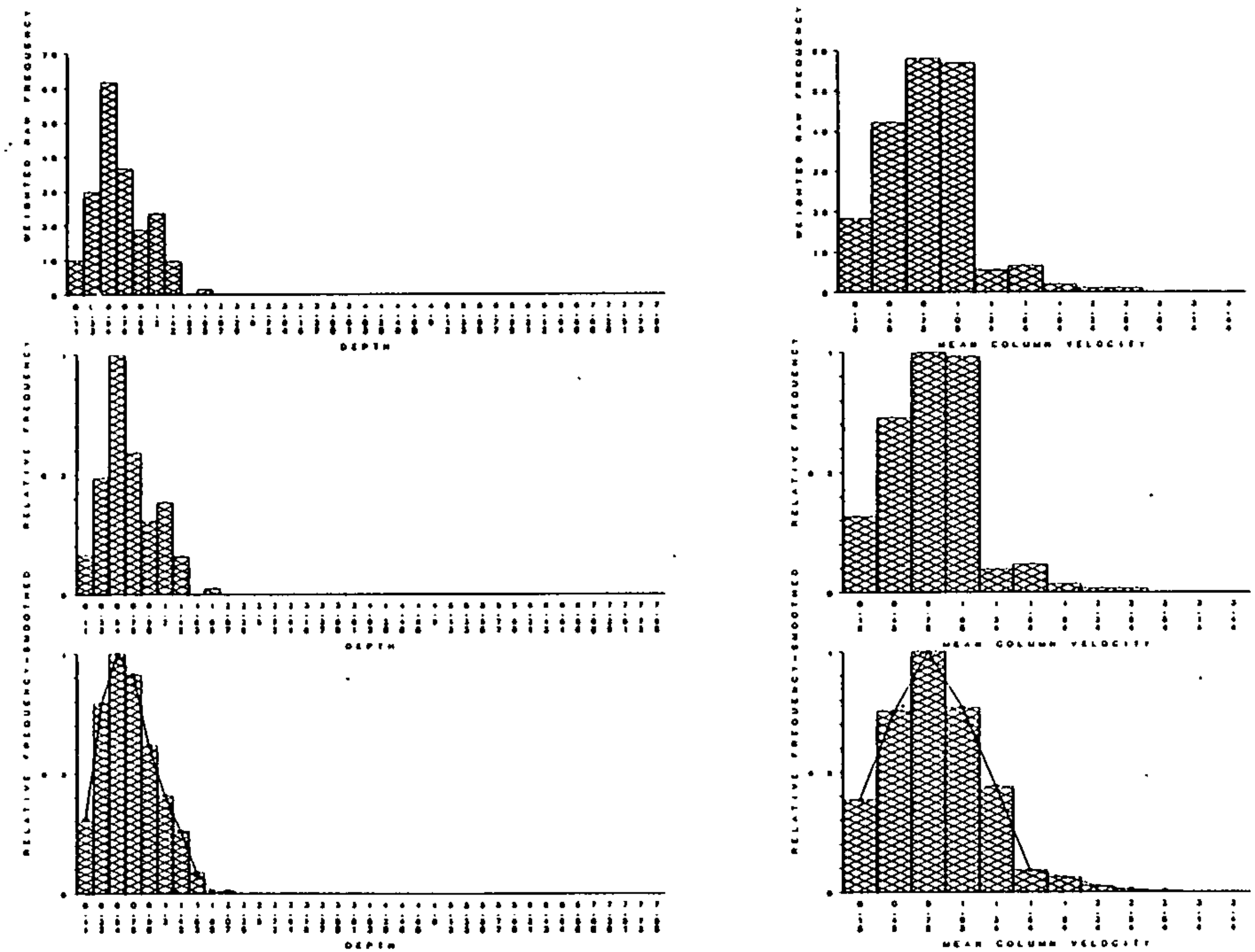


Figure D-45. Development of depth and velocity suitability criteria for YOY margined madtom from data collected in the Tugalo River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

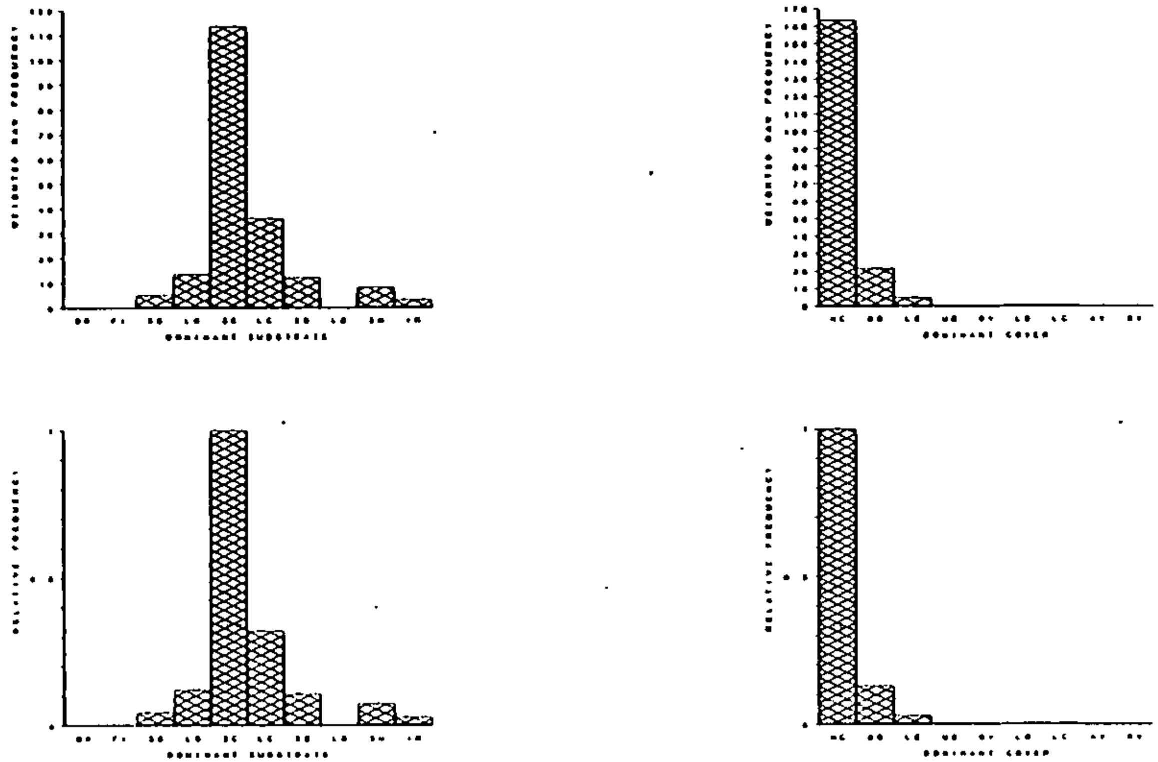


Figure D-46. Development of substrate and cover suitability criteria for YOY margined madtom from data collected in the Tugalo River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

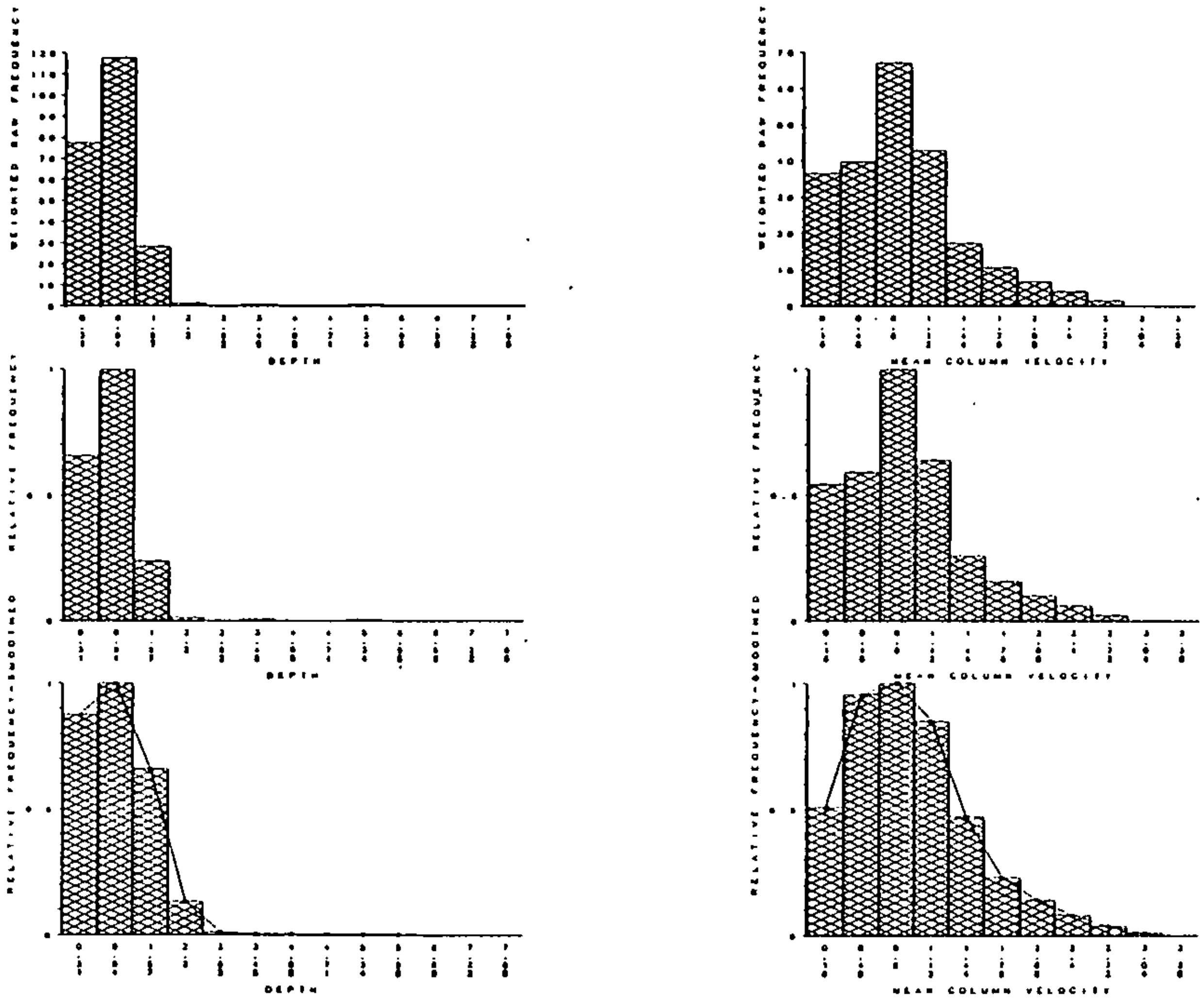


Figure D-47. Development of depth and velocity suitability criteria for adult margined madtom from data collected in the Tugalo River. Microhabitat utilization data were plotted as frequency histograms (top graph), normalized to a scale of 1.0 (middle graph), smoothed, and renormalized (bottom graph) to produce suitability criteria (polygons) (See text for complete explanation).

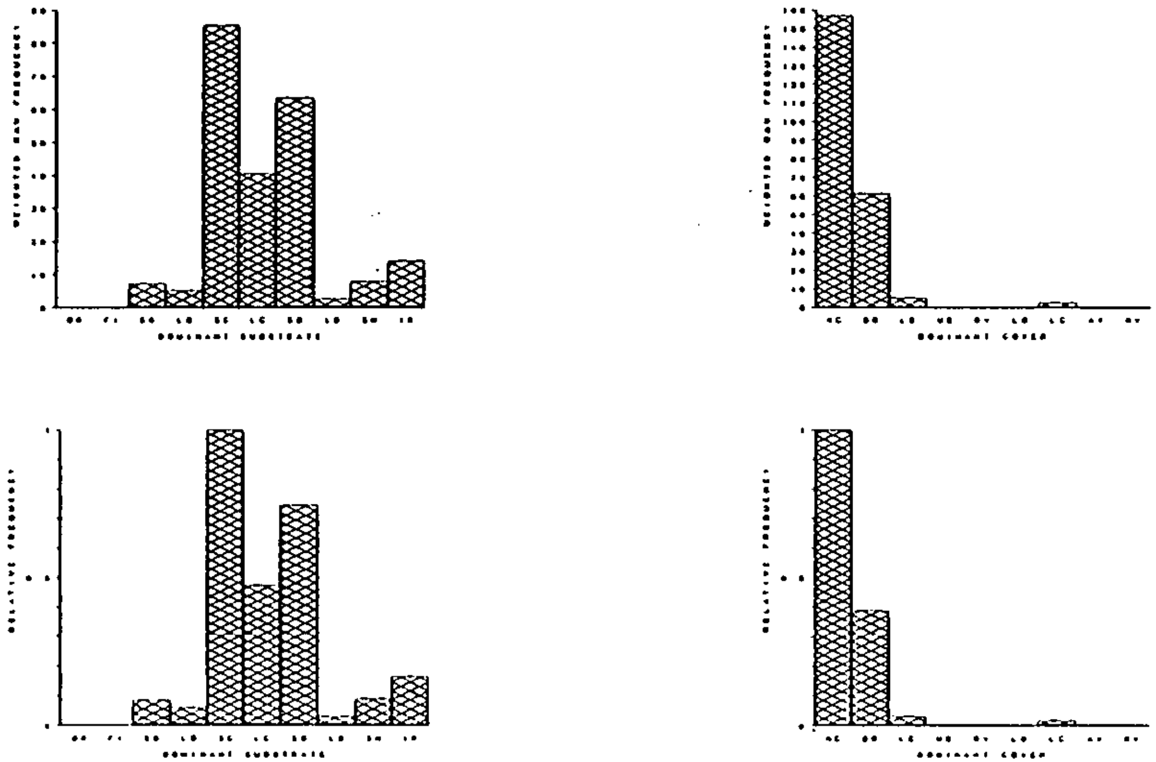


Figure D-48. Development of substrate and cover suitability criteria for adult margined madtom from data collected in the Tugalo River. Microhabitat utilization data were plotted as frequency histograms (top graph) and normalized to a scale of 1.0 (bottom graph) to produce suitability criteria (See text for complete explanation).

APPENDIX E

HABITAT SUITABILITY CRITERIA COORDINATE FILES USED IN PHSYICAL HABITAT SIMULATION OF THE TUGALO AND OCMULGEE RIVERS. FOR EACH SPECIES AND LIFE STAGE AND VARIABLE, PAIRS OF HABITAT VARIABLE VALUE AND CORRESPONDING SUITABILITY VALUE ARE GIVEN.

HABITAT SUITABILITY CRITERIA FOR NORTHERN HOG SUCKER

YOY NORTHERN HOG SUCKER
NH2
10 6 10 9
VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	1.00
00.10	1.00
00.14	0.77
00.23	0.51
00.33	0.31
00.42	0.24
00.51	0.16
00.61	0.08
00.70	0.05
00.84	0.00

DEPTH XY PAIRS

DEPTH (FT.)	SUIT.
00.20	0.00
00.34	1.00
00.68	1.00
00.85	0.59
01.19	0.09
01.70	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
1.00	FINES	1
0.76	SM GRAVEL	2
0.06	LG GRAVEL	3
0.05	SM COBBLE	4
0.05	LG COBBLE	5
0.13	SM BOULDER	6
0.00	LG BOULDER	7
0.10	SM BEDROCK	8
0.03	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.10	BOULDER	1
0.02	LEDGE	2
0.00	UNDERCUT	3
0.00	OVERHANG	4
0.00	LOG	5
0.00	LOG COMPLEX	6
0.01	ATT VEG	7
0.00	RT VEG	8

JUVENILE NORTHERN HOG SUCKER
NH3
11 10 10 9
VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.15	0.00
00.46	0.84
00.77	0.99
00.93	1.00
01.24	1.00
01.39	0.69
01.70	0.46
02.01	0.23
02.32	0.17
02.63	0.08
02.78	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
00.70	0.00
01.40	0.72
01.87	1.00
02.80	1.00
03.27	0.96
04.20	0.52
05.13	0.21
06.07	0.06
07.00	0.03
08.40	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.41	FINES	1
0.38	SM GRAVEL	2
0.17	LG GRAVEL	3
0.09	SM COBBLE	4
0.47	LG COBBLE	5
0.53	SM BOULDER	6
0.28	LG BOULDER	7
0.57	SM BEDROCK	8
1.00	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	COOE
1.00	NO COVER	0
0.64	BOULDER	1
0.24	LEDGE	2
0.00	UNDERCUT	3
0.00	OVERHANG	4
0.00	LOG	5
0.00	LOG COMPLEX	6
0.00	ATT VEG	7
0.0D	RT VEG	8

ADULT NORTHERN HOG SUCKER
NB4
12 11 10 9
VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
OD.00	0.00
00.20	0.58
00.60	0.92
00.81	1.00
01.21	1.00
01.41	0.81
01.81	0.60
02.21	0.37
02.62	0.23
03.02	0.10
03.42	0.07
03.62	0.00

DEPTH XY PAIRS

OEPTH (FT)	SUIT.
00.90	0.00
01.67	0.85
02.23	1.00
03.35	1.00
03.90	0.71
05.01	0.26
06.13	0.09
07.24	0.04
08.36	0.02
09.47	0.01
10.37	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.24	FINES	1
0.19	SM GRAVEL	2
0.07	LG GRAVEL	3
0.07	SM COBBLE	4
0.13	LG COBBLE	5
0.37	SM BOULDER	6
0.21	LG BOULDER	7
0.29	SM BEDROCK	8
1.00	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.70	BOULDER	1
0.53	LEDGE	2
0.00	UNDERCUT	3
0.00	OVERHANG	4
0.00	LOG	5
0.00	LOG COMPLEX	6
0.0D	ATT VEG	7
0.00	RT VEG	8

HABITAT SUITABILITY CRITERIA FOR REDEYE BASS

YOY REDEYE BASS
RB2
11 10 10 9
VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	1.00
00.26	1.00
00.40	0.76
00.66	0.40
00.92	0.20
01.19	0.10
01.45	0.03
01.71	0.02
01.98	0.02
02.24	0.01
02.64	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
00.20	0.00
00.40	0.85
00.80	1.00
01.60	1.00
02.00	0.62
02.80	0.20
03.60	0.07
04.40	0.03
05.20	0.01
08.01	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.96	FINES	1
0.70	SM GRAVEL	2
0.07	LG GRAVEL	3
0.17	SM COBBLE	4
0.26	LG COBBLE	5
1.00	SM BOULDER	6
0.35	LG BOULDER	7
0.38	SM BEDROCK	8
0.49	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.75	BOULDER	1
0.37	LEDGE	2
0.00	UNDERCUT	3
0.05	OVERHANG	4
0.04	LOG	5
0.01	LOG COMPLEX	6
0.00	ATT VEG	7
0.00	RT VEG	8

JUVENILE REDEYE BASS
RB3
10 10 10 9
VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	1.00
00.26	1.00
00.40	0.97
00.66	0.96
00.93	0.87
01.19	0.72
01.46	0.47
01.72	0.25
01.99	0.12
02.39	0.00

DEPTH XY PAIRS

OEPTH (FT)	SUIT.
00.75	0.00
01.20	0.69
01.60	1.00
03.20	1.00
03.60	0.74
04.40	0.50
05.20	0.30
06.00	0.13
06.80	0.09
07.99	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.76	FINES	1
0.38	SM GRAVEL	2
0.10	LG GRAVEL	3
0.11	SM COBBLE	4
0.25	LG COBBLE	5
0.83	SM BOULDER	6
0.28	LG BOULDER	7
0.32	SM BEDROCK	8
1.00	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.93	BOULDER	1
0.64	LEDGE	2
0.00	UNDERCUT	3
0.01	OVERHANG	4
0.04	LOG	5
0.01	LOG COMPLEX	6
0.00	ATT VEG	7
0.00	RT VEG	8

ADULT REDEYE BASS
RB4
11 12 10 9
VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	0.00
00.16	0.62
00.32	1.00
00.96	1.00
01.12	0.78
01.44	0.44
01.76	0.21
02.08	0.09
02.40	0.06
02.72	0.04
03.20	0.00

DEPTH XY PAIRS

OEPTH (FT)	SUIT.
01.20	0.00
01.41	0.56
02.34	0.91
02.81	1.00
03.75	1.00
04.22	0.82
05.16	0.56
06.10	0.41
07.03	0.26
07.97	0.18
08.91	0.09
10.32	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.87	FINES	1
0.71	SM GRAVEL	2
0.24	LG GRAVEL	3
0.13	SM COBBLE	4
0.09	LG COBBLE	5
1.00	SM BOULDER	6
0.26	LG BOULDER	7
0.39	SM BEDRDCK	8
0.76	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.84	BOULDER	1
0.53	LEDGE	2
0.00	UNDERCUT	3
0.01	OVERHANG	4
0.03	LOG	5
0.00	LOG COMPLEX	6
0.00	ATT VEG	7
0.00	RT VEG	8

HABITAT SUITABILITY CRITERIA FOR REDBREAST SUNFISH

SPAWN REDBREAST SUNFISH
RS1
7 11 10 9

VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	1.00
00.36	1.00
00.54	0.71
00.89	0.10
01.25	0.05
01.61	0.01
03.58	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
00.40	0.00
00.69	0.77
00.92	1.00
01.37	1.00
01.60	0.90
02.06	0.70
02.52	0.70
02.97	0.54
03.43	0.40
03.89	0.13
04.58	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.04	ORGANIC	0
0.54	FINES	1
1.00	SM GRAVEL	2
0.06	LG GRAVEL	3
0.00	SM COBBLE	4
0.02	LG COBBLE	5
0.02	SM BOULDER	6
0.00	LG BOULOER	7
0.04	SM BEDROCK	8
0.18	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.24	BOULDER	1
0.20	LEDGE	2
0.02	UNDERCUT	3
0.01	OVERHANG	4
0.05	LOG	5
0.06	LOG COMPLEX	6
0.00	ATT VEG	7
0.33	RT VEG	8

ADULT REDBREAST SUNFISH
RS4
10 11 10 9

VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	1.00
00.24	1.00
00.37	0.84
00.62	0.63
00.87	0.42
01.12	0.32
01.37	0.20
01.62	0.11
01.87	0.04
01.99	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
01.25	0.00
01.80	0.71
02.40	1.00
03.60	1.00
04.20	0.76
05.41	0.47
06.61	0.21
07.81	0.16
09.01	0.06
10.21	0.02
10.81	0.00

SUBSTRATE TABLE

SUIT.	TYPE	COOE
0.00	ORGANIC	0
1.00	FINES	1
0.10	SM GRAVEL	2
0.00	LG GRAVEL	3
0.05	SM COBBLE	4
0.37	LG COBBLE	5
0.14	SM BOULDER	6
0.40	LG BOULDER	7
0.50	SM BEDROCK	8
0.61	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	COOE
1.00	NO COVER	0
0.50	BOULDER	1
0.63	LEDGE	2
0.00	UNDERCUT	3
0.00	OVERHANG	4
0.03	LOG	5
0.00	LOG COMPLEX	6
0.00	ATT VEG	7
0.00	RT VEG	8

HABITAT SUITABILITY CRITERIA FOR SILVER REDHORSE

ADULT SILVER REDHORSE
SR4
12 12 10 9

VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	0.00
00.13	0.51
00.39	0.62
00.65	0.82
00.79	1.00
01.05	1.00
01.18	0.91
01.44	0.60
01.70	0.27
01.96	0.08
02.23	0.02
02.36	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
01.50	0.00
02.38	0.57
03.33	0.91
03.81	1.00
04.76	1.00
05.23	1.00
06.18	1.00
07.14	1.00
08.09	1.00
09.04	1.00
09.52	1.00
14.95	1.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
1.00	FINES	1
0.59	SM GRAVEL	2
0.14	LG GRAVEL	3
0.06	SM COBBLE	4
0.02	LG COBBLE	5
0.33	SM BOULDER	6
0.08	LG BOULDER	7
0.40	SM BEDROCK	8
0.47	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.27	BOULDER	1
0.29	LEDGE	2
0.00	UNDERCUT	3
0.00	OVERHANG	4
0.00	LOG	5
0.00	LOG COMPLEX	6
0.00	ATT VEG	7
0.00	RT VEG	8

HABITAT SUITABILITY CRITERIA FOR WHITEFIN SHINER

ADULT WHITEFIN SHINER
WS4
11 13 10 9

VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	0.00
00.18	0.96
00.36	1.00
00.72	1.00
00.89	0.90
01.25	0.69
01.61	0.36
01.96	0.11
02.32	0.04
02.68	0.01
03.57	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
00.60	0.00
01.47	0.92
01.96	1.00
02.93	1.00
03.42	0.46
04.40	0.34
05.38	0.23
06.35	0.17
07.33	0.11
08.31	0.10
09.29	0.05
10.26	0.02
10.75	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.73	FINES	1
0.34	SM GRAVEL	2
0.11	LG GRAVEL	3
0.21	SM COBBLE	4
0.23	LG COBBLE	5
0.74	SM BOULDER	6
0.13	LG BOULDER	7
0.71	SM BEDROCK	8
1.00	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.62	BOULDER	1
0.52	LEDGE	2
0.00	UNDERCUT	3
0.01	OVERHANG	4
0.00	LOG	5
0.00	LOG COMPLEX	6
0.00	ATT VEG	7
0.01	RT VEG	8

HABITAT SUITABILITY CRITERIA FOR ALTAMAHA SHINER

YOY ALTAMAHA SHINER
AS2
10 10 10 9

VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	0.00
00.11	0.77
00.22	1.00
00.44	1.00
00.55	0.72
00.77	0.31
00.99	0.18
01.20	0.15
01.42	0.12
01.75	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
00.95	0.00
01.27	0.56
01.78	0.83
02.04	1.00
02.55	1.00
02.80	0.83
03.30	0.56
03.81	0.20
04.32	0.06
04.58	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.09	ORGANIC	0
0.11	FINES	1
0.46	SM GRAVEL	2
0.12	LG GRAVEL	3
0.00	SM COBBLE	4
0.14	LG COBBLE	5
0.35	SM BOULDER	6
0.00	LG BOULDER	7
0.10	SM BEDROCK	8
1.00	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.65	BOULDER	1
0.69	LEDGE	2
0.00	UNDERCUT	3
0.00	OVERHANG	4
0.10	LOG	5
0.14	LOG COMPLEX	6
0.00	ATT VEG	7
0.06	RT VEG	8

ADULT ALTAMAHA SHINER
AS4
11 13 10 9

VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	0.00
00.21	0.83
00.42	1.00
00.83	1.00
01.03	0.57
01.45	0.22
01.86	0.07
02.27	0.03
02.69	0.02
03.10	0.01
03.72	0.00

DEPTH XY PAIRS

VEL. (FPS)	SUIT.
00.80	0.00
00.89	0.41
01.25	0.71
01.43	1.00
01.78	1.00
01.96	0.78
02.32	0.69
02.67	0.34
03.03	0.32
03.39	0.13
03.74	0.08
04.10	0.02
04.28	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.03	ORGANIC	0
0.04	FINES	1
0.10	SM GRAVEL	2
0.10	LG GRAVEL	3
0.00	SM COBBLE	4
0.12	LG COBBLE	5
0.09	SM BOULDER	6
0.06	LG BOULDER	7
0.25	SM BEDROCK	8
1.00	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.38	BOULDER	1
0.84	LEDGE	2
0.00	UNDERCUT	3
0.00	OVERHANG	4
0.20	LOG	5
0.13	LOG COMPLEX	6
0.00	ATT VEG	7
0.00	RT VEG	8

HABITAT SUITABILITY CRITERIA FOR SHOAL BASS

YOY SHOAL BASS
SH2
11 11 10 9

VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	1.00
00.14	1.00
00.21	0.78
00.34	0.33
00.48	0.18
00.62	0.08
00.76	0.06
00.89	0.03
01.03	0.02
01.17	0.01
01.24	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
00.30	0.00
00.54	0.68
00.91	0.96
01.09	1.00
01.45	1.00
01.63	0.71
02.00	0.59
02.36	0.31
02.72	0.23
03.09	0.07
03.63	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.09	ORGANIC	0
0.16	FINES	1
0.39	SM GRAVEL	2
0.24	LG GRAVEL	3
0.00	SM COBBLE	4
0.06	LG COBBLE	5
0.07	SM BOULDER	6
0.03	LG BOULDER	7
0.64	SM BEDROCK	8
1.00	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
0.97	NO COVER	0
0.20	BOULDER	1
0.71	LEDGE	2
0.00	UNDERCUT	3
0.00	OVERHANG	4
0.08	LOG	5
0.04	LOG COMPLEX	6
0.59	ATT VEG	7
1.00	RT VEG	8

ADULT SHOAL BASS
SH4
9 10 10 9

VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	0.00
00.13	0.62
00.38	0.95
00.51	1.00
00.77	1.00
00.89	0.32
01.15	0.19
01.40	0.08
02.04	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
01.65	0.00
02.31	0.86
03.08	1.00
04.62	1.00
05.39	0.92
06.93	0.44
08.46	0.33
10.00	0.24
11.54	0.15
13.85	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.49	FINES	1
0.27	SM GRAVEL	2
0.71	LG GRAVEL	3
0.22	SM COBBLE	4
0.11	LG COBBLE	5
0.46	SM BOULDER	6
0.78	LG BOULDER	7
0.54	SM BEDROCK	8
1.00	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
0.99	NO COVER	0
1.00	BOULDER	1
0.26	LEDGE	2
0.00	UNDERCUT	3
0.06	OVERHANG	4
0.10	LOG	5
0.29	LOG COMPLEX	6
0.00	ATT VEG	7
0.00	RT VEG	8

HABITAT SUITABILITY CRITERIA FOR STRIPED JUMPROCK

YOY STRIPED JUMPROCK
SJ2
9 10 10 9
VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	1.00
00.12	1.00
00.18	0.80
00.30	0.36
00.42	0.24
00.55	0.12
00.67	0.06
00.79	0.04
00.97	0.00

DEPTH XY PAIRS

DEPTH (FT.)	SUIT.
00.25	0.00
00.46	0.89
00.62	1.00
00.92	1.00
01.07	0.63
01.38	0.32
01.69	0.28
01.99	0.28
02.30	0.22
02.76	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.08	ORGANIC	0
0.25	FINES	1
0.42	SM GRAVEL	2
0.32	LG GRAVEL	3
0.00	SM COBBLE	4
0.00	LG COBBLE	5
0.09	SM BOULDER	6
0.00	LG BOULDER	7
0.28	SM BEDROCK	8
1.00	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.08	BOULDER	1
0.67	LEDGE	2
0.00	UNDERCUT	3
0.07	OVERHANG	4
0.03	LOG	5
0.24	LOG COMPLEX	6
0.75	ATT VEG	7
0.53	RT VEG	8

ADULT STRIPED JUMPROCK
SJ4
11 10 10 9
VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	0.00
00.19	0.52
00.38	1.00
00.75	1.00
00.93	0.97
01.30	0.73
01.67	0.36
02.04	0.25
02.41	0.19
02.78	0.08
03.34	0.00

OEPTH XY PAIRS

OEPTH (FT)	SUIT.
00.40	0.00
00.63	0.07
01.05	0.23
01.47	0.68
01.68	1.00
02.51	1.00
02.72	0.67
03.14	0.33
03.56	0.16
04.19	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.04	FINES	1
0.09	SM GRAVEL	2
0.34	LG GRAVEL	3
0.05	SM COBBLE	4
0.15	LG COBBLE	5
0.19	SM BOULDER	6
0.06	LG BOULDER	7
0.43	SM BEDROCK	8
1.00	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.34	BOULDER	1
0.61	LEDGE	2
0.00	UNDERCUT	3
0.10	OVERHANG	4
0.04	LOG	5
0.06	LOG COMPLEX	6
0.02	ATT VEG	7
0.06	RT VEG	8

HABITAT SUITABILITY CRITERIA FOR BLUEHEAD CHUB

SPAWN BLUEHEAD CHUB
BC1
11 10 10 9
VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.13	0.00
00.14	0.12
00.43	0.54
00.72	0.95
00.87	1.00
01.16	1.00
01.30	0.66
01.59	0.24
01.8B	0.10
02.17	0.02
02.60	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
00.50	0.00
00.56	0.24
00.78	0.82
01.00	0.90
01.12	1.00
01.34	1.00
01.45	0.52
01.67	0.42
01.90	0.20
02.23	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.10	FINES	1
0.60	SM GRAVEL	2
0.30	LG GRAVEL	3
1.00	SM COBBLE	4
1.00	LG COBBLE	5
0.25	SM BOULDER	6
0.10	LG BOULDER	7
0.05	SM BEDROCK	8
0.20	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.24	BOULDER	1
0.04	LEDGE	2
0.00	UNDERCUT	3
0.00	OVERHANG	4
0.02	LOG	5
0.16	LOG COMPLEX	6
0.00	ATT VEG	7
0.00	RT VEG	8

YOY BLUEHEAD CHUB
BC2
10 10 10 9
VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	0.71
00.03	0.71
00.06	1.00
00.12	1.00
00.15	0.73
00.21	0.34
00.27	0.05
00.33	0.02
00.38	0.02
00.47	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
00.10	0.00
00.13	0.91
00.27	1.00
00.53	1.00
00.66	0.73
00.93	0.18
01.19	0.09
01.45	0.02
01.72	0.02
02.11	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.09	ORGANIC	0
1.00	FINES	1
0.06	SM GRAVEL	2
0.06	LG GRAVEL	3
0.09	SM COBBLE	4
0.37	LG COBBLE	5
0.14	SM BOULDER	6
0.03	LG BOULDER	7
0.03	SM BEDROCK	8
0.00	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
0.42	BOULDER	1
0.00	LEDGE	2
0.00	UNDERCUT	3
0.00	OVERHANG	4
0.16	LOG	5
0.12	LOG COMPLEX	6
0.00	ATT VEG	7
0.03	RT VEG	8

HABITAT SUITABILITY CRITERIA FOR MARGINED MADTOM

YOY MARGINED MADTOM
MM2
11 12 10 9

VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	0.00
00.15	0.39
00.45	0.75
00.60	1.00
00.90	1.00
01.05	0.77
01.34	0.44
01.64	0.09
01.94	0.06
02.24	0.03
02.69	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
00.10	0.00
00.11	0.31
00.33	0.79
00.44	1.00
00.65	1.00
00.76	0.91
00.98	0.62
01.20	0.41
01.42	0.26
01.63	0.09
01.85	0.01
02.18	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.00	FINES	1
0.04	SM GRAVEL	2
0.12	LG GRAVEL	3
1.00	SM COBBLE	4
0.32	LG COBBLE	5
0.11	SM BOULDER	6
0.00	LG BOULDER	7
0.07	SM BEDROCK	8
0.03	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
1.00	BOULDER	1
1.00	LEDGE	2
1.00	UNDERCUT	3
1.00	OVERHANG	4
1.00	LOG	5
1.00	LOG COMPLEX	6
1.00	ATT VEG	7
1.00	RT VEG	8

ADULT MARGINED MADTOM
MM4
11 7 10 9

VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	0.00
00.16	0.51
00.48	0.96
00.64	1.00
00.96	1.00
01.12	0.85
01.44	0.47
01.76	0.23
02.08	0.14
02.40	0.08
02.88	0.00

DEPTH XY PAIRS

DEPTH (FT.)	SUIT.
00.10	0.00
00.31	0.87
00.63	1.00
01.26	1.00
01.57	0.66
02.20	0.13
06.27	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.00	FINES	1
0.09	SM GRAVEL	2
0.06	LG GRAVEL	3
1.00	SM COBBLE	4
0.47	LG COBBLE	5
0.74	SM BOULDER	6
0.03	LG BOULDER	7
0.09	SM BEDROCK	8
0.16	IR BEDROCK	9

COVER TABLE

SUIT.	TYPE	CODE
1.00	NO COVER	0
1.00	BOULDER	1
1.00	LEDGE	2
1.00	UNDERCUT	3
1.00	OVERHANG	4
1.00	LOG	5
1.00	LOG COMPLEX	6
1.00	ATT VEG	7
1.00	RT VEG	8

HABITAT SUITABILITY CRITERIA FOR WALLEYE

SPAWN WALLEYE (BECHTEL [1986])
WE1
9 9 10 9

VELOCITY XY PAIRS

VEL. (FPS)	SUIT.
00.00	0.00
00.20	0.06
00.50	0.40
00.80	0.80
00.85	1.00
01.90	1.00
02.80	0.25
03.60	0.09
03.75	0.00

DEPTH XY PAIRS

DEPTH (FT)	SUIT.
00.80	0.00
01.00	0.25
01.35	0.63
01.50	1.00
02.00	1.00
02.35	0.38
02.55	0.15
02.80	0.05
03.00	0.00

SUBSTRATE TABLE

SUIT.	TYPE	CODE
0.00	ORGANIC	0
0.00	FINES	1
0.17	SM GRAVEL	2
1.00	LG GRAVEL	3
1.00	SM COBBLE	4
0.50	LG COBBLE	5
0.00	SM BOULDER	6
0.00	LG BOULDER	7
0.00	SM BEDROCK	8
0.00	IR BEDROCK	9

COVER TABLE.

SUIT.	TYPE	CODE
1.00	NO COVER	0
1.00	BOULDER	1
1.00	LEDGE	2
1.00	UNDERCUT	3
1.00	OVERHANG	4
1.00	LOG	5
1.00	LOG COMPLEX	6
1.00	ATT VEG	7
1.00	RT VEG	8

APPENDIX F

HYDRAULIC SIMULATION DIAGNOSTICS AND GRAPHICAL DISPLAY OF CROSS-SECTIONAL PROFILES, VELOCITY DISTRIBUTIONS, AND WATER SURFACE ELEVATIONS FOR EACH TRANSECT IN THE TUGALO AND OCMULGEE RIVER STUDY AREAS

TUGALO RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT Y-7; RUN/POOL HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 0.0 TO 346.0 FEET

STAGE OF ZERO FLOW (SZF)= 90.24

INTERCEPT (LN(A)) = -0.8555
SLOPE (B) = 0.2941

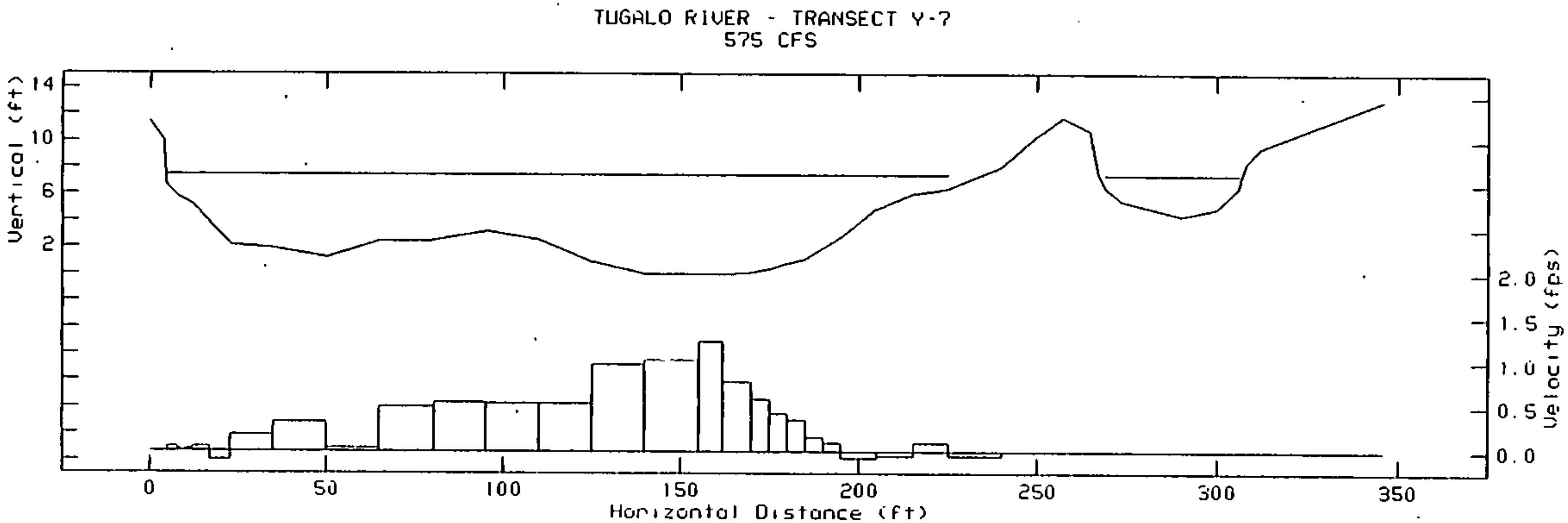
SUMMARY STATISTICS :

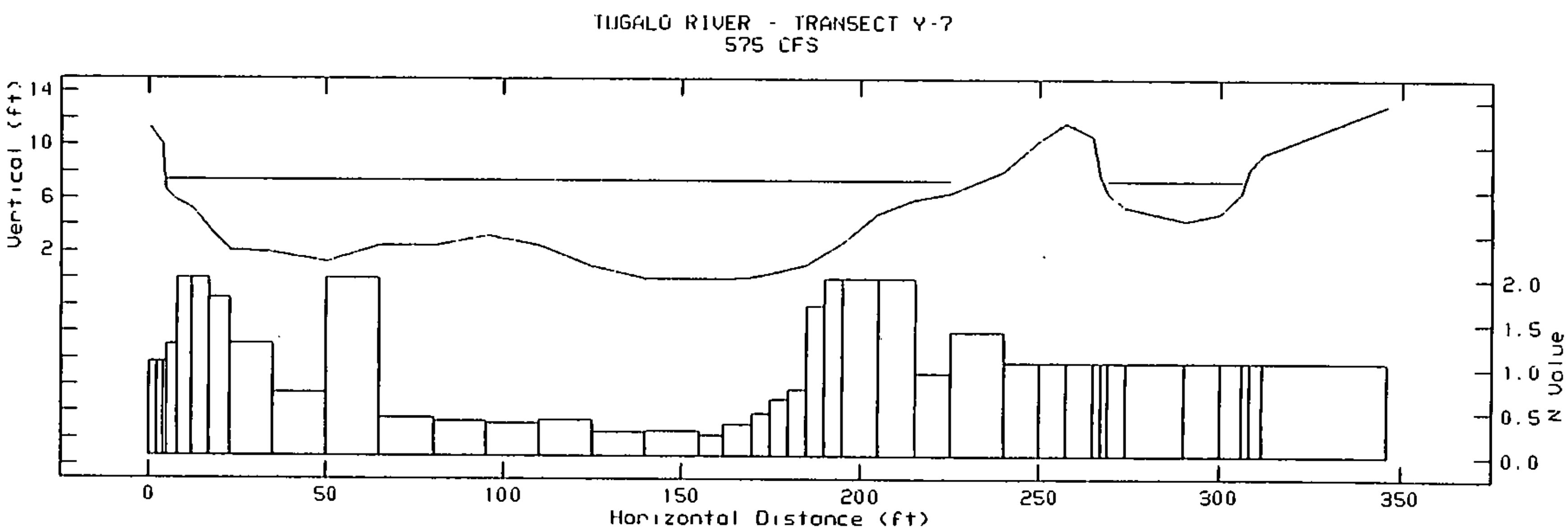
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	3096.900	0.936
1545.000	1511.026	1.022
575.000	517.064	1.112
150.000	159.714	0.939

MEAN % ERROR	6.39
VARIANCE	10.44
STANDARD DEVIATION	3.23
SAMPLE SIZE	4

HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 2900 CFS DATA	1545 CFS DATA	575 CFS DATA	150 CFS DATA
50	242.2	3.6	0.06	0.005	0.047	0.065	0.124	0.308
100	252.3	3.8	0.10	0.009	0.085	0.117	0.224	0.550
150	257.9	3.9	0.15	0.013	0.119	0.163	0.314	0.767
200	260.0	4.0	0.19	0.017	0.150	0.206	0.398	0.969
250	261.7	4.1	0.23	0.020	0.179	0.246	0.477	1.157
300	263.2	4.2	0.27	0.023	0.207	0.285	0.553	1.335
350	264.5	4.3	0.31	0.026	0.234	0.321	0.626	1.506
400	265.7	4.4	0.34	0.029	0.260	0.356	0.696	1.670
500	267.8	4.5	0.41	0.034	0.309	0.423	0.830	1.981
700	271.2	4.8	0.54	0.044	0.400	0.546	1.078	2.554
900	273.7	5.0	0.66	0.053	0.483	0.658	1.307	3.076
1100	275.9	5.1	0.78	0.061	0.561	0.763	1.523	3.561
1300	277.2	5.2	0.90	0.069	0.635	0.864	1.724	4.030
1500	278.1	5.4	1.01	0.077	0.705	0.958	1.918	4.467
2000	280.9	5.6	1.27	0.094	0.868	1.178	2.370	5.482
2400	282.8	5.8	1.46	0.107	0.989	1.340	2.706	6.229
2800	284.6	6.0	1.65	0.119	1.103	1.493	3.023	6.931
3200	286.1	6.1	1.83	0.130	1.211	1.637	3.325	7.596
3600	287.6	6.2	2.00	0.141	1.315	1.776	3.614	8.232
4000	289.7	6.4	2.17	0.152	1.415	1.908	3.892	8.840


TUGALO RIVER - TRANSECT Y-7
575 CFS
Vertical (ft)
Velocity (fps)
Horizontal Distance (ft)


TUGALO RIVER - TRANSECT Y-7
575 CFS
Vertical (ft)
N Value
Horizontal Distance (ft)

TUGALO RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT Y-9; BACKWATER HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 0.0 TO 295.5 FEET

STAGE OF ZERO FLOW (SZF)= 94.20

INTERCEPT (LN(A)) = 0.0100
SLOPE (B) = 0.2895

SUMMARY STATISTICS :

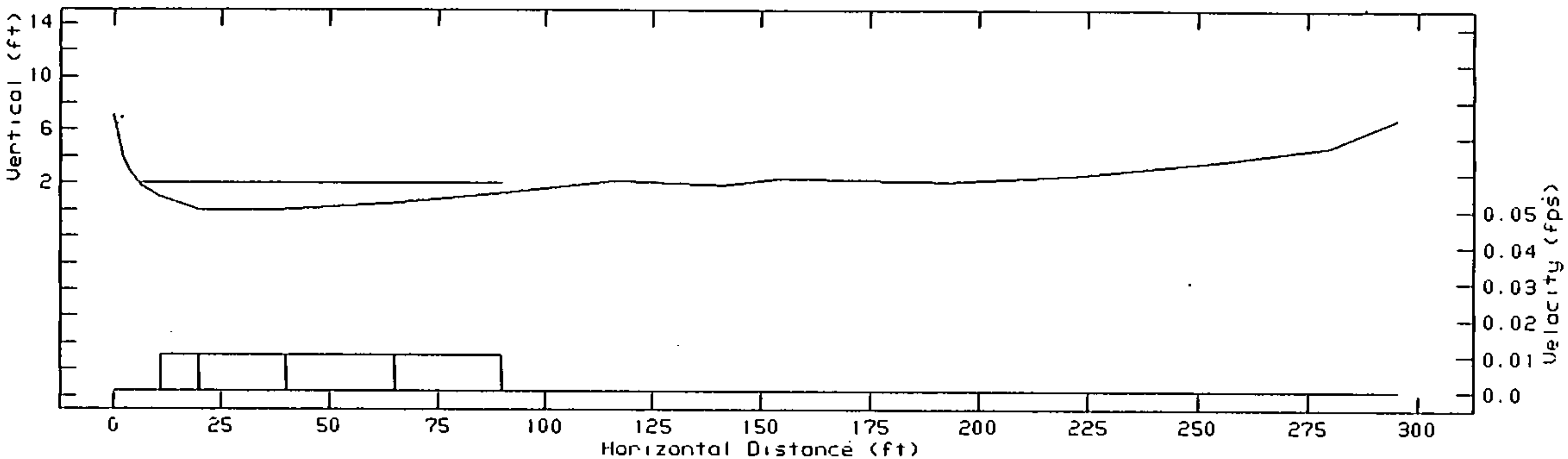
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
83.000	83.000	1.000
1.000	1.000	1.000

MEAN % ERROR	0.00
VARIANCE	0.00
STANDARD DEVIATION	0.00
SAMPLE SIZE	2

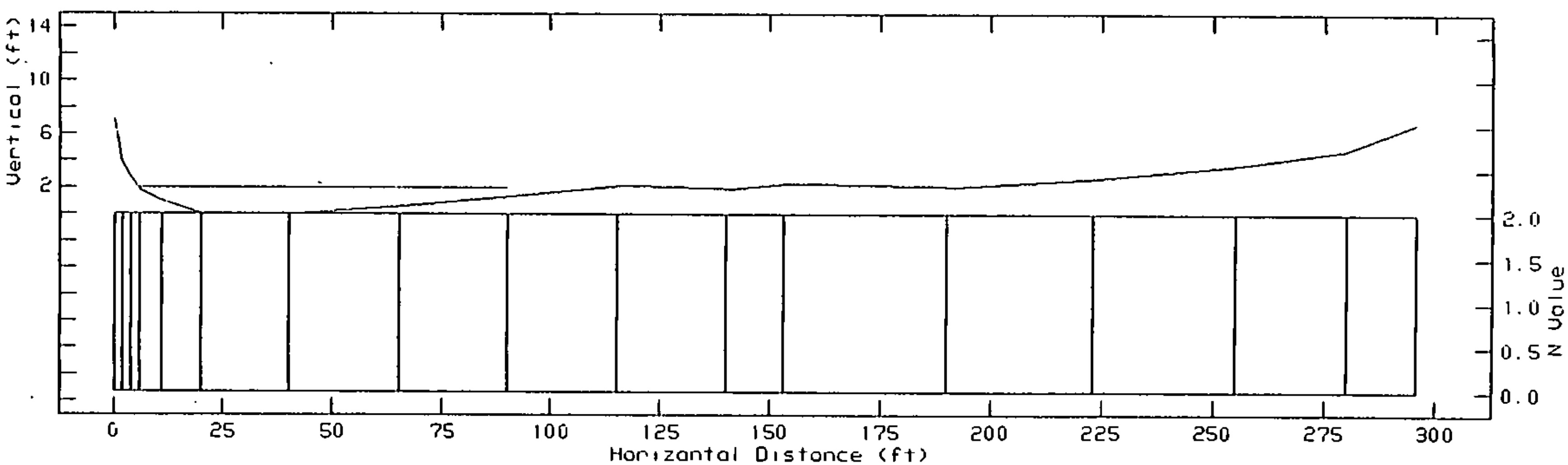
HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 83 CFS DATA SET	VELOCITY ADJUSTMENT FACTOR 1 CFS DATA SET
0	87.7	1.0	0.00	0.000	0.006	0.070
0	87.7	1.0	0.00	0.000	0.006	0.070
0	87.7	1.0	0.00	0.000	0.006	0.070
0	87.7	1.0	0.00	0.000	0.006	0.070
0	93.2	1.1	0.00	0.000	0.012	0.139
1	98.5	1.2	0.00	0.001	0.019	0.227
1	107.4	1.2	0.01	0.001	0.025	0.302
1	118.9	1.2	0.01	0.001	0.029	0.364
1	128.5	1.2	0.01	0.001	0.034	0.418
2	144.3	1.1	0.01	0.002	0.037	0.466
2	161.6	1.0	0.01	0.002	0.043	0.535
2	172.8	1.0	0.01	0.002	0.047	0.580
2	182.9	1.0	0.01	0.002	0.050	0.621
3	192.4	1.0	0.01	0.002	0.054	0.658
5	212.9	1.2	0.02	0.003	0.081	0.959
12	230.7	1.5	0.03	0.005	0.134	1.487
18	239.2	1.7	0.04	0.006	0.169	1.782
34	254.2	2.0	0.07	0.008	0.242	2.371
50	262.1	2.3	0.08	0.010	0.299	2.808
83	273.7	2.7	0.11	0.012	0.389	3.475

TUGALO RIVER - TRANSECT Y-9
150 CFS



TUGALO RIVER - TRANSECT Y-9
150 CFS



TUGALO RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT Y-12; RUN HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 0.0 TO 287.0 FEET

STAGE OF ZERO FLOW (SZF)= 93.07

INTERCEPT (LN(A)) = -0.7498
SLOPE (B) = 0.2745

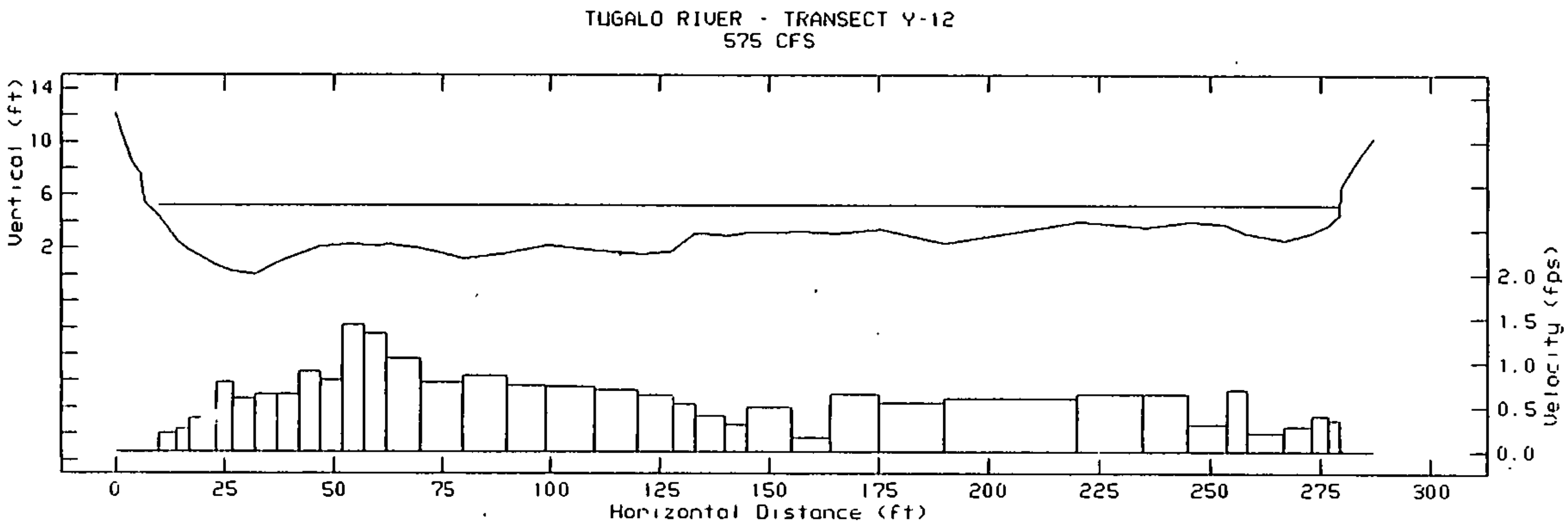
SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	3066.481	0.946
1545.000	1488.839	1.038
575.000	542.179	1.061
150.000	156.119	0.961

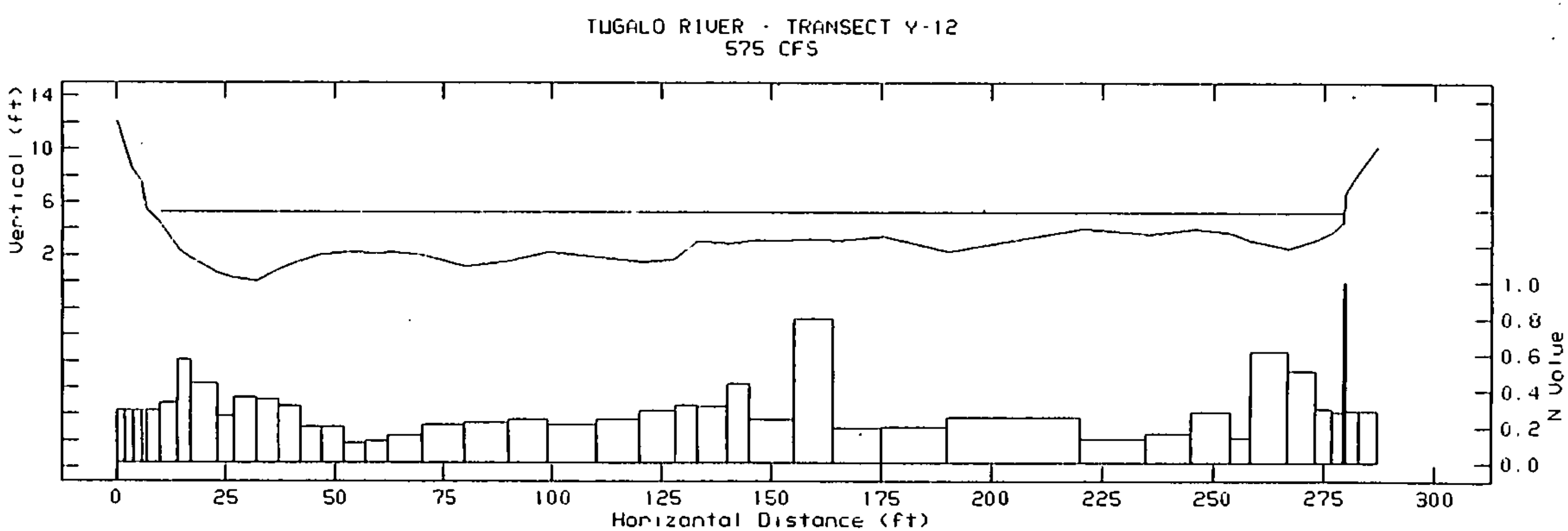
MEAN % ERROR	4.79
VARIANCE	1.20
STANDARD DEVIATION	1.09
SAMPLE SIZE	4

HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 2900 CFS DATA	1545 CFS DATA	575 CFS DATA	150 CFS DATA
50	261.4	1.6	0.12	0.017	0.105	0.120	0.257	0.488
100	268.4	1.7	0.22	0.029	0.175	0.197	0.425	0.804
150	269.5	1.9	0.30	0.038	0.223	0.251	0.546	1.034
200	270.1	2.0	0.36	0.045	0.264	0.296	0.650	1.231
250	270.5	2.2	0.43	0.051	0.300	0.337	0.742	1.406
300	270.9	2.3	0.49	0.057	0.333	0.373	0.825	1.567
350	271.2	2.4	0.55	0.063	0.363	0.407	0.903	1.716
400	271.5	2.4	0.60	0.068	0.391	0.439	0.975	1.856
500	272.0	2.6	0.71	0.077	0.443	0.497	1.108	2.113
700	272.7	2.8	0.90	0.095	0.533	0.599	1.341	2.568
900	272.9	3.0	1.08	0.110	0.612	0.688	1.544	2.966
1100	273.0	3.2	1.25	0.123	0.683	0.767	1.727	3.326
1300	273.1	3.4	1.42	0.136	0.748	0.840	1.895	3.657
1500	273.2	3.5	1.57	0.148	0.809	0.908	2.052	3.966
2000	273.4	3.8	1.93	0.175	0.945	1.061	2.404	4.665
2400	273.5	4.0	2.20	0.195	1.042	1.171	2.658	5.168
2800	273.6	4.2	2.46	0.213	1.132	1.272	2.892	5.634
3200	274.0	4.3	2.72	0.231	1.217	1.367	3.111	6.072
3600	274.3	4.4	2.96	0.247	1.296	1.456	3.317	6.485
4000	274.6	4.6	3.19	0.263	1.371	1.541	3.513	6.877



TUGALO RIVER - TRANSECT Y-12
575 CFS
Vertical (ft)
14
10
6
2
Velocity (fps)
2.0
1.5
1.0
0.5
0.0
0
25
50
75
100
125
150
175
200
225
250
275
300
Horizontal Distance (ft)



TUGALO RIVER - TRANSECT Y-12
575 CFS
Vertical (ft)
14
10
6
2
N Value
1.0
0.8
0.6
0.4
0.2
0.0
0
25
50
75
100
125
150
175
200
225
250
275
300
Horizontal Distance (ft)

TUGALO RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT Y-20; RUN HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 1.5 TO 295.5 FEET

STAGE OF ZERO FLOW (SZF)= 91.23

INTERCEPT (LN(A)) = -1.0460
SLOPE (B) = 0.3146

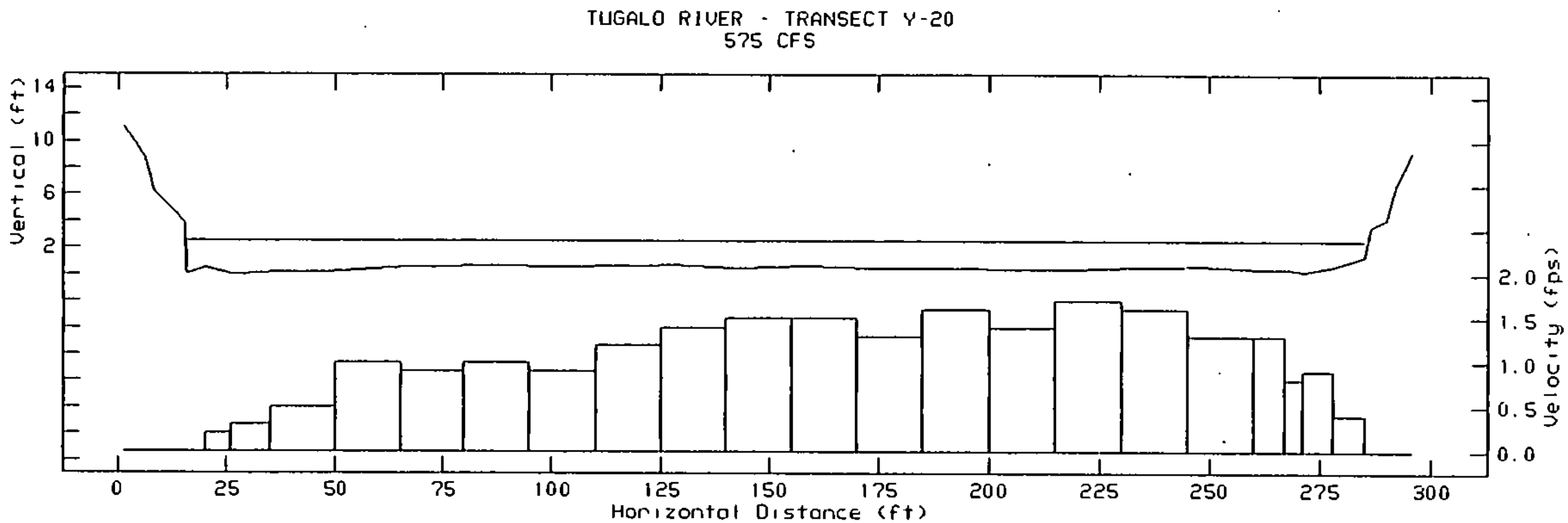
SUMMARY STATISTICS :

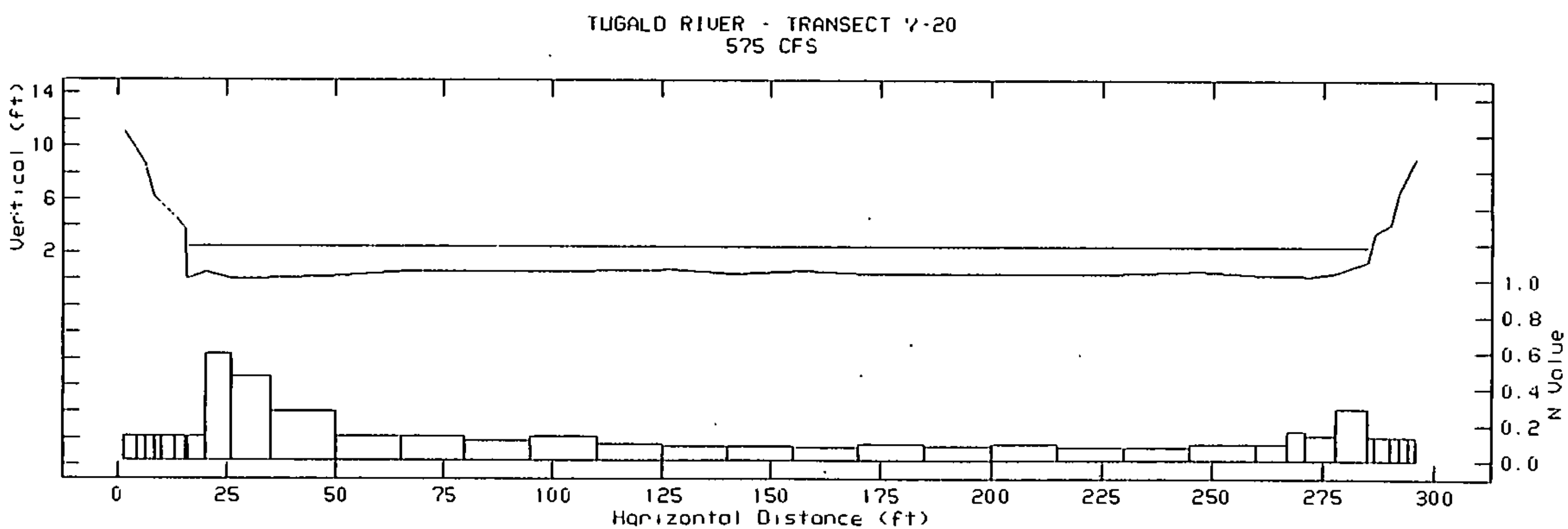
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	3171.795	0.914
1545.000	1475.684	1.047
575.000	511.103	1.125
150.000	161.539	0.929

MEAN % ERROR	8.17
VARIANCE	7.97
STANDARD DEVIATION	2.82
SAMPLE SIZE	4

HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 2900 CFS DATA	1545 CFS DATA	575 CFS DATA	150 CFS DATA
50	267.4	0.7	0.26	0.053	0.276	0.344	0.449	0.785
100	269.3	1.0	0.37	0.064	0.316	0.392	0.508	0.885
150	269.4	1.2	0.46	0.073	0.349	0.434	0.560	0.974
200	269.6	1.4	0.54	0.081	0.379	0.470	0.605	1.053
250	269.7	1.5	0.61	0.088	0.405	0.503	0.646	1.124
300	269.8	1.6	0.68	0.094	0.429	0.532	0.683	1.189
350	269.9	1.7	0.75	0.100	0.451	0.559	0.717	1.248
400	269.9	1.8	0.81	0.106	0.471	0.585	0.749	1.303
500	270.1	2.0	0.93	0.116	0.509	0.631	0.807	1.404
700	270.3	2.3	1.14	0.133	0.573	0.711	0.907	1.579
900	270.5	2.5	1.33	0.149	0.628	0.780	0.994	1.730
1100	270.7	2.7	1.51	0.162	0.678	0.841	1.070	1.863
1300	270.8	2.9	1.68	0.175	0.722	0.896	1.140	1.985
1500	270.9	3.0	1.83	0.186	0.764	0.947	1.204	2.096
2000	272.9	3.3	2.21	0.214	0.856	1.061	1.349	2.348
2400	274.7	3.5	2.48	0.233	0.920	1.141	1.450	2.523
2800	276.0	3.7	2.74	0.250	0.979	1.215	1.543	2.684
3200	276.6	3.9	2.98	0.266	1.034	1.282	1.628	2.833
3600	277.2	4.0	3.21	0.281	1.085	1.346	1.707	2.971
4000	277.7	4.2	3.44	0.296	1.133	1.406	1.783	3.103


TUGALO RIVER - TRANSECT Y-20
575 CFS
Vertical (ft)
14
10
6
2
Velocity (fps)
2.0
1.5
1.0
0.5
0.0
0
25
50
75
100
125
150
175
200
225
250
275
300
Horizontal Distance (ft)


TUGALO RIVER - TRANSECT Y-20
575 CFS
Vertical (ft)
14
10
6
2
N Value
1.0
0.8
0.6
0.4
0.2
0.0
0
25
50
75
100
125
150
175
200
225
250
275
300
Horizontal Distance (ft)

TUGALO RIVER INSTREAM FLOW STUDY- GPC71 1027604
TRANSECT Y-21; RIFFLE/RUN HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 1.0 TO 80.0 FEET

STAGE OF ZERO FLOW (SZF)= 90.86

INTERCEPT (LN(A)) = -2.4845
SLOPE (B) = 0.4494

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	3075.654	0.943
1545.000	1499.270	1.031
575.000	532.134	1.081
150.000	157.488	0.952

MEAN % ERROR	5.37
VARIANCE	3.59
STANDARD DEVIATION	1.89
SAMPLE SIZE	4

TRANSECT SECTION : 95.0 TO 324.0 FEET

STAGE OF ZERO FLOW (SZF)= 89.74

INTERCEPT (LN(A)) = -0.9804
SLOPE (B) = 0.2977

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	3206.451	0.904
1545.000	1469.871	1.051
575.000	502.436	1.144
150.000	163.193	0.919

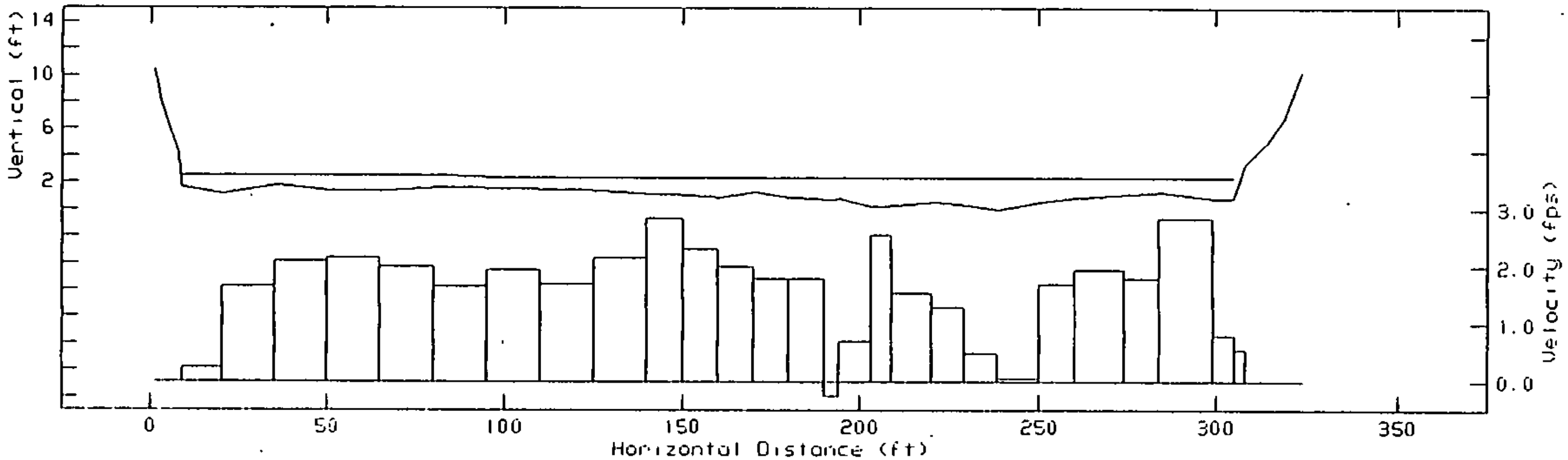
MEAN % ERROR	9.21
VARIANCE	10.85
STANDARD DEVIATION	3.29
SAMPLE SIZE	4

HYDRAULIC SIMULATION RESULTS

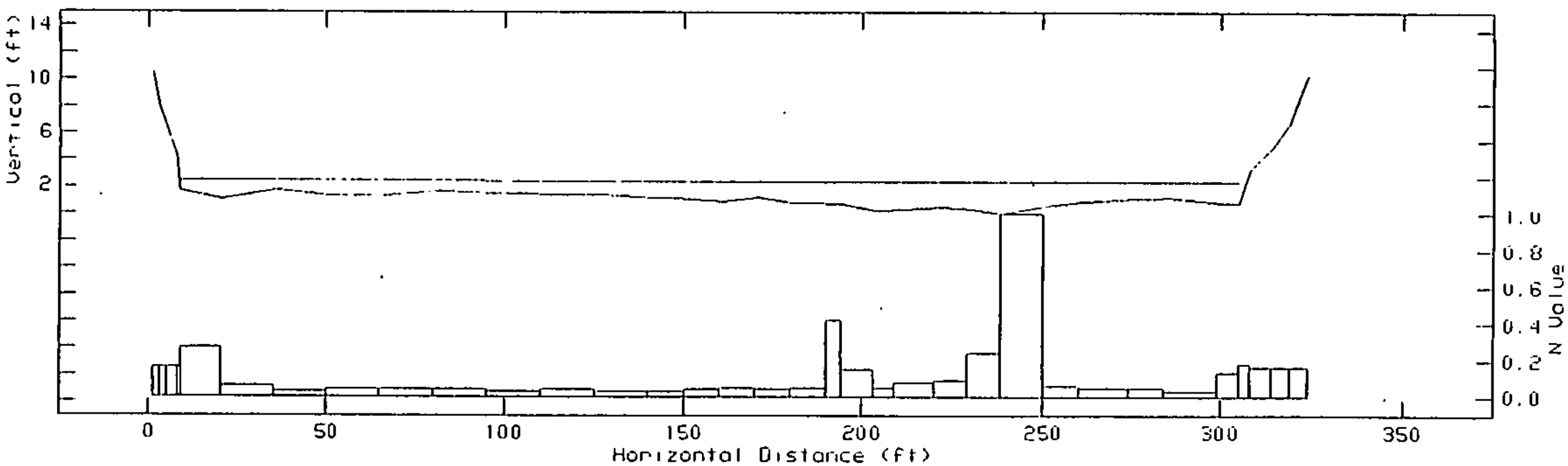
DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 2900 CFS DATA	1545 CFS DATA	575 CFS DATA	150 CFS DATA
50	216.4	0.4	0.52	0.138	0.700	0.841	0.890	1.044
100	282.2	0.5	0.69	0.168	0.724	0.860	0.891	1.005
150	297.1	0.7	0.76	0.165	0.686	0.793	0.823	0.936
200	297.3	0.8	0.84	0.165	0.671	0.760	0.791	0.909
250	297.5	0.9	0.92	0.168	0.666	0.747	0.778	0.902
300	297.7	1.0	0.99	0.172	0.668	0.743	0.774	0.903
350	297.8	1.1	1.06	0.177	0.673	0.743	0.775	0.910
400	298.0	1.2	1.12	0.181	0.679	0.747	0.779	0.919

500	298.2	1.3	1.25	0.190	0.695	0.758	0.792	0.941
700	298.6	1.6	1.48	0.207	0.729	0.788	0.824	0.989
900	298.9	1.8	1.69	0.222	0.763	0.819	0.857	1.038
1100	299.2	2.0	1.88	0.236	0.794	0.849	0.890	1.084
1300	299.4	2.1	2.05	0.249	0.824	0.878	0.921	1.127
1500	299.7	2.3	2.22	0.261	0.852	0.905	0.950	1.168
2000	300.8	2.5	2.63	0.291	0.918	0.969	1.019	1.264
2400	301.7	2.7	2.91	0.311	0.964	1.015	1.068	1.332
2800	302.5	2.9	3.19	0.330	1.007	1.057	1.113	1.395
3200	303.3	3.1	3.44	0.347	1.046	1.096	1.154	1.453
3600	304.1	3.2	3.69	0.362	1.082	1.132	1.193	1.507
4000	304.8	3.3	3.92	0.377	1.116	1.166	1.230	1.558

TUGALO RIVER - TRANSECT Y-21
575 CFS



TUGALO RIVER - TRANSECT Y-21
575 CFS



TUGALO RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT Y-24; RIFFLE/RUN HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 0.2 TO 205.0 FEET

STAGE OF ZERO FLOW (SZF)= 84.93

INTERCEPT (LN(A)) = -0.7096
SLOPE (B) = 0.2678

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	3230.706	0.898
1545.000	1397.865	1.105
575.000	539.171	1.066
150.000	158.707	0.945

MEAN % ERROR	8.24
VARIANCE	7.21
STANDARD DEVIATION	2.68
SAMPLE SIZE	4

TRANSECT SECTION : 215.0 TO 300.1 FEET

STAGE OF ZERO FLOW (SZF)= 85.89

INTERCEPT (LN(A)) = -1.9062
SLOPE (B) = 0.3935

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	3157.717	0.918
1545.000	1399.304	1.104
575.000	566.012	1.016
150.000	154.516	0.971

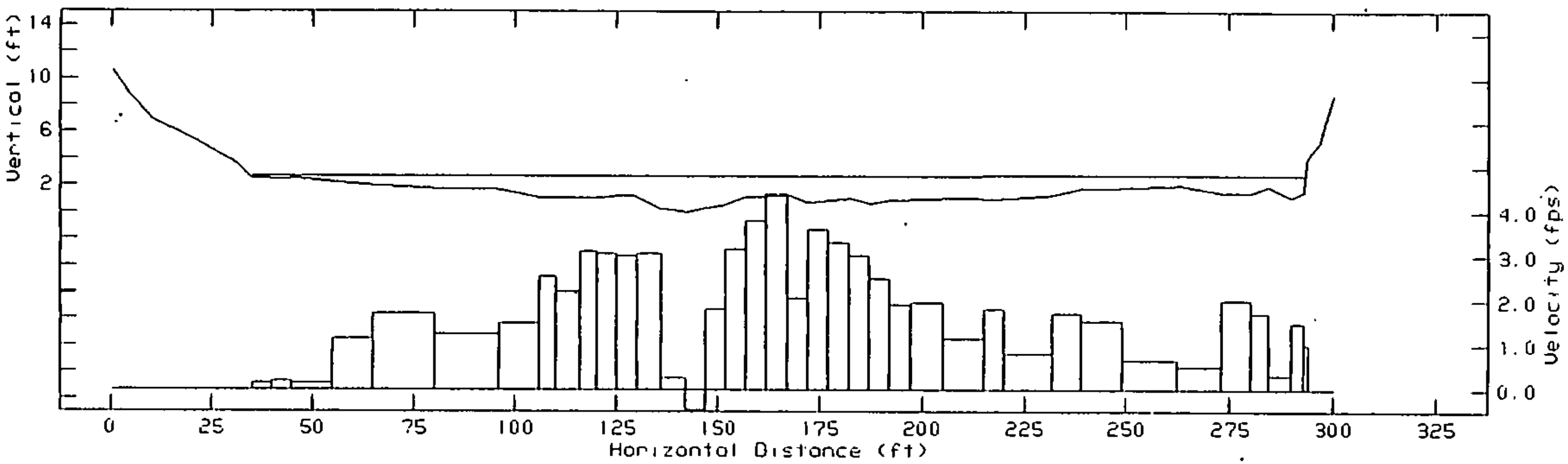
MEAN % ERROR	5.72
VARIANCE	16.14
STANDARD DEVIATION	4.02
SAMPLE SIZE	4

HYDRAULIC SIMULATION RESULTS

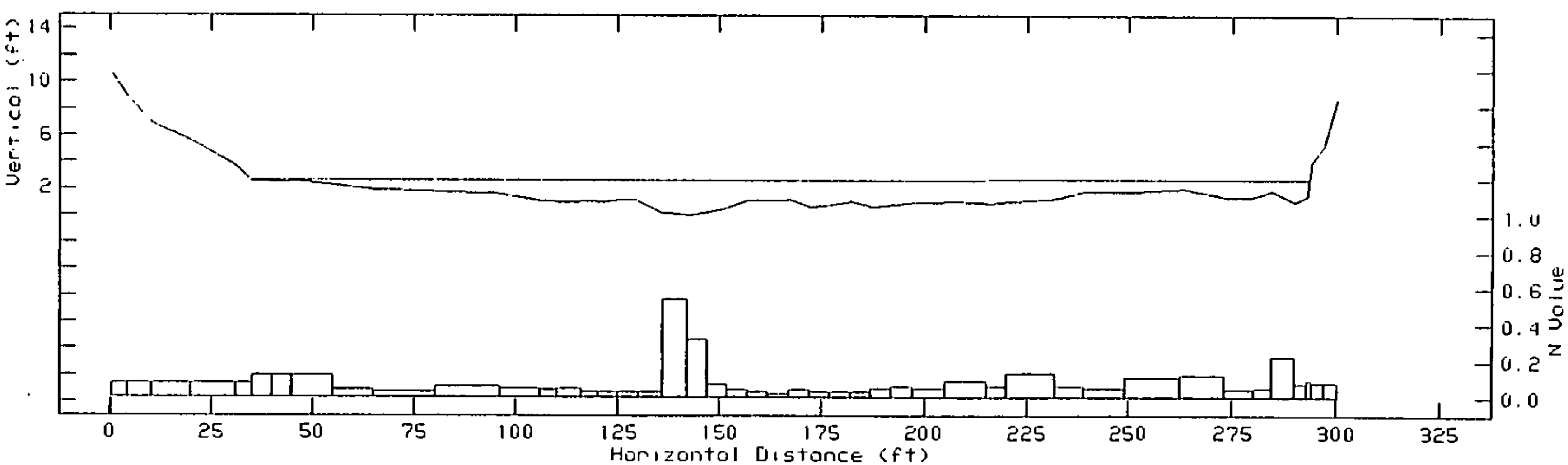
DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 2900 CFS DATA	1545 CFS DATA	575 CFS DATA	150 CFS DATA
50	156.7	0.5	0.64	0.160	0.508	0.658	0.818	0.922
100	195.9	0.6	0.80	0.178	0.524	0.647	0.743	0.853
150	224.2	0.7	0.92	0.191	0.542	0.663	0.744	0.855
200	231.5	0.8	1.05	0.205	0.566	0.692	0.769	0.875
250	236.0	0.9	1.14	0.209	0.581	0.708	0.781	0.900
300	239.8	1.0	1.24	0.217	0.596	0.726	0.797	0.926
350	242.9	1.1	1.32	0.222	0.610	0.743	0.811	0.952

400	245.7	1.2	1.40	0.228	0.623	0.759	0.826	0.978
500	258.7	1.3	1.55	0.244	0.649	0.790	0.857	1.028
700	259.6	1.5	1.81	0.261	0.695	0.844	0.913	1.120
900	260.4	1.7	2.05	0.278	0.735	0.892	0.965	1.203
1100	261.1	1.9	2.27	0.294	0.772	0.937	1.014	1.278
1300	261.6	2.0	2.48	0.309	0.806	0.978	1.059	1.348
1500	262.2	2.1	2.68	0.323	0.838	1.017	1.101	1.413
2000	263.5	2.4	3.15	0.357	0.911	1.104	1.198	1.560
2400	264.7	2.6	3.49	0.382	0.963	1.167	1.269	1.665
2800	266.1	2.8	3.81	0.405	1.011	1.225	1.333	1.762
3200	267.4	2.9	4.12	0.425	1.056	1.279	1.393	1.852
3600	268.6	3.0	4.40	0.445	1.098	1.329	1.448	1.937
4000	269.7	3.2	4.68	0.463	1.138	1.376	1.501	2.017

TUGALO RIVER - TRANSECT Y-24
575 CFS



TUGALO RIVER - TRANSECT Y-24
575 CFS



TUGALO RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT Y-25; RIFFLE HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 0.0 TO 294.0 FEET

STAGE OF ZERO FLOW (SZF)= 93.89

INTERCEPT (LN(A)) = -1.6831
SLOPE (B) = 0.3787

SUMMARY STATISTICS :

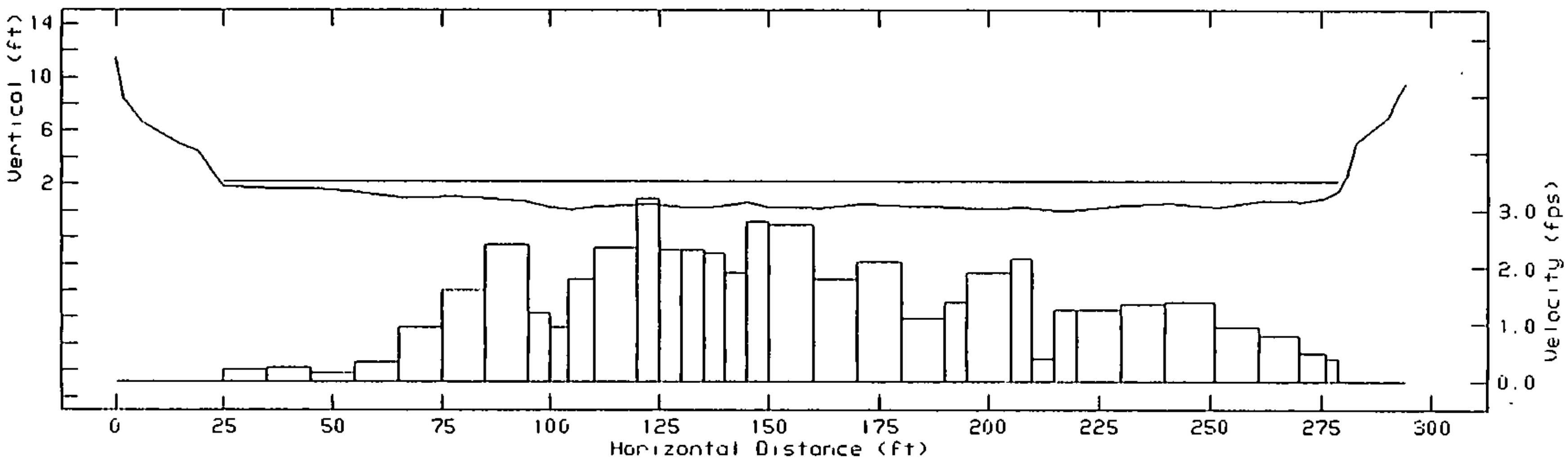
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	2870.597	1.010
1560.000	1481.308	1.053
595.000	666.470	0.893
165.000	156.720	1.053

MEAN % ERROR	5.77
VARIANCE	20.89
STANDARD DEVIATION	4.57
SAMPLE SIZE	4

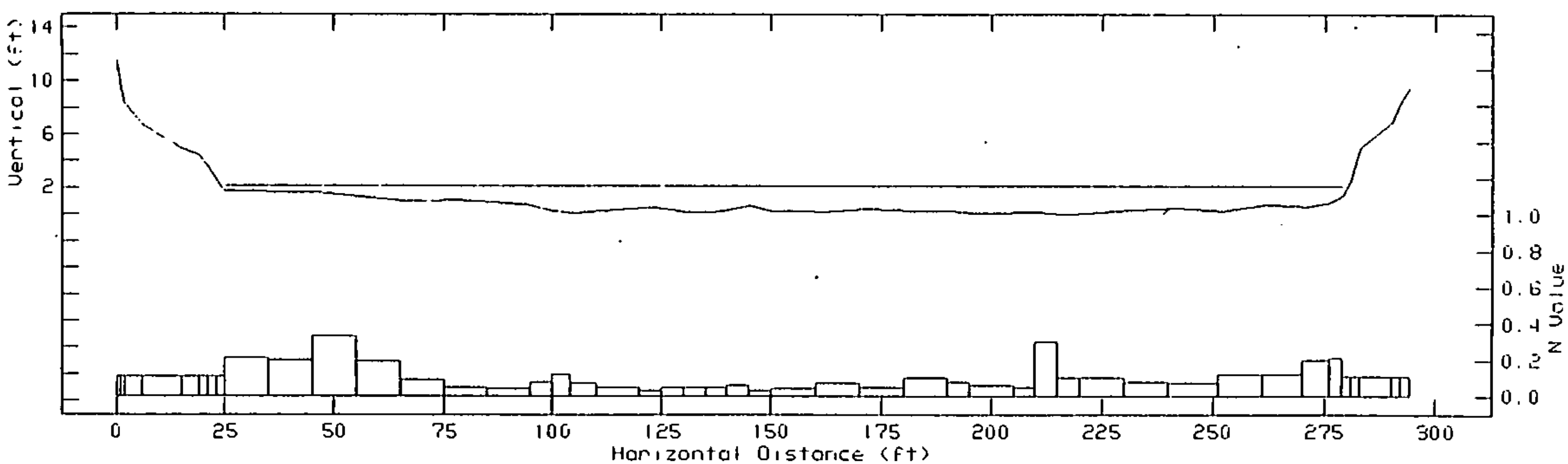
HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 2900 CFS DATA	1560 CFS DATA	595 CFS DATA	165 CFS DATA
50	185.8	0.5	0.57	0.145	0.554	0.585	0.798	1.004
100	212.1	0.6	0.73	0.161	0.583	0.612	0.822	0.983
150	219.7	0.8	0.86	0.170	0.609	0.638	0.851	0.999
200	224.8	0.9	0.97	0.179	0.632	0.662	0.877	1.020
250	229.4	1.0	1.07	0.188	0.653	0.684	0.903	1.043
300	233.3	1.1	1.16	0.194	0.672	0.704	0.926	1.065
350	251.2	1.1	1.24	0.207	0.690	0.723	0.949	1.087
400	254.7	1.2	1.32	0.213	0.705	0.741	0.970	1.108
500	255.4	1.3	1.45	0.220	0.733	0.773	1.008	1.146
700	256.4	1.6	1.70	0.236	0.780	0.828	1.076	1.213
900	257.3	1.8	1.91	0.249	0.821	0.875	1.134	1.273
1100	258.1	2.0	2.12	0.263	0.857	0.917	1.186	1.326
1300	258.6	2.2	2.31	0.276	0.890	0.955	1.234	1.377
1500	259.0	2.3	2.48	0.287	0.920	0.989	1.278	1.422
2000	260.0	2.7	2.89	0.312	0.986	1.065	1.373	1.522
2400	260.6	2.9	3.18	0.329	1.032	1.118	1.440	1.592
2800	261.3	3.1	3.46	0.346	1.075	1.167	1.501	1.657
3200	261.9	3.3	3.72	0.361	1.113	1.211	1.557	1.716
3600	262.4	3.5	3.96	0.375	1.149	1.251	1.608	1.770
4000	263.0	3.6	4.20	0.388	1.183	1.289	1.656	1.821

TUGALO RIVER - TRANSECT Y-25
575 CFS



TUGALO RIVER - TRANSECT Y-25
575 CFS



TUGALO RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT Y-26: RUN/POOL HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 0.0 TO 282.0 FEET

STAGE OF ZERO FLOW (SZF)= 94.44

INTERCEPT (LN(A)) = -1.1156
SLOPE (B) = 0.3130

SUMMARY STATISTICS :

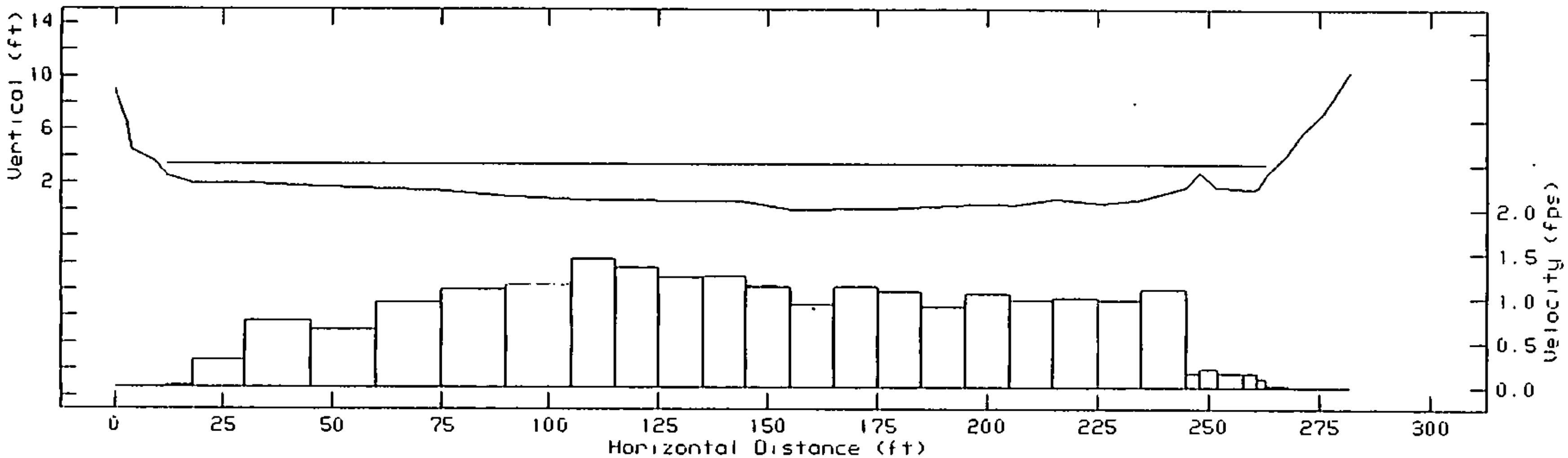
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	2986.259	0.971
1560.000	1525.966	1.022
595.000	579.224	1.027
165.000	168.269	0.981

MEAN % ERROR	2.45
VARIANCE	0.20
STANDARD DEVIATION	0.45
SAMPLE SIZE	4

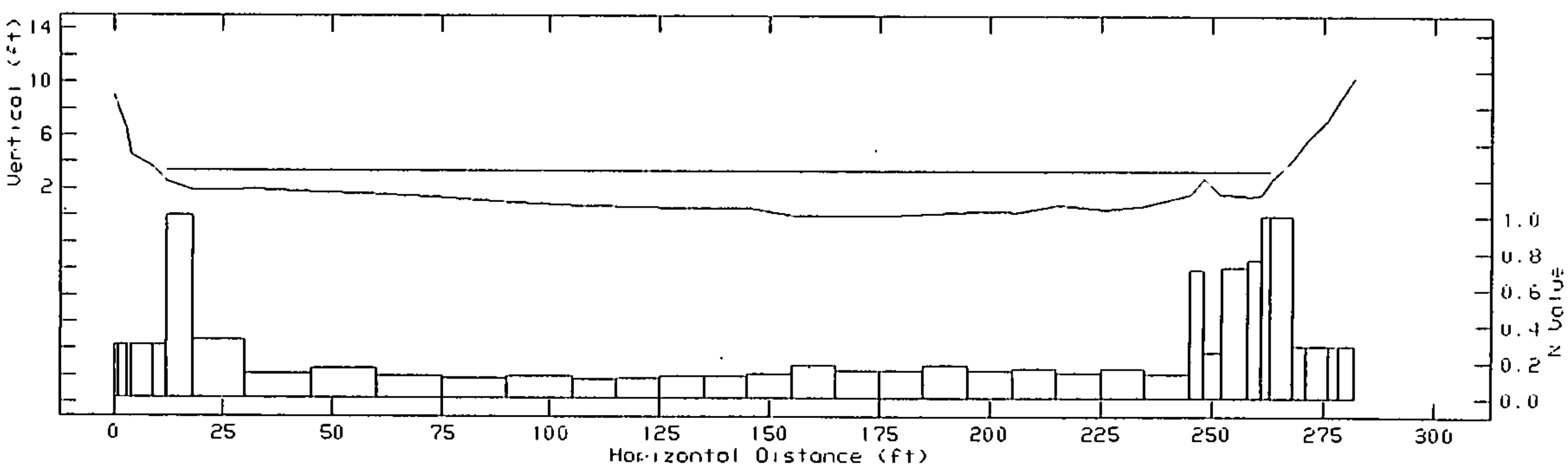
HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 2900 CFS DATA	1560 CFS DATA	595 CFS DATA	165 CFS DATA
50	241.4	1.2	0.17	0.028	0.134	0.166	0.248	0.463
100	246.2	1.5	0.28	0.041	0.200	0.246	0.370	0.694
150	249.4	1.6	0.37	0.051	0.250	0.308	0.464	0.872
200	251.0	1.8	0.45	0.060	0.293	0.360	0.543	1.021
250	252.5	1.9	0.53	0.068	0.330	0.406	0.612	1.152
300	253.1	2.0	0.60	0.076	0.364	0.448	0.675	1.272
350	253.7	2.1	0.67	0.082	0.395	0.486	0.733	1.381
400	254.2	2.1	0.73	0.088	0.424	0.521	0.786	1.482
500	255.0	2.3	0.85	0.099	0.476	0.585	0.884	1.665
700	256.5	2.5	1.07	0.119	0.566	0.695	1.052	1.980
900	258.0	2.7	1.28	0.136	0.644	0.789	1.196	2.253
1100	259.6	2.9	1.46	0.151	0.713	0.873	1.325	2.493
1300	261.0	3.0	1.64	0.165	0.775	0.950	1.442	2.712
1500	262.2	3.2	1.80	0.178	0.833	1.020	1.550	2.912
2000	264.5	3.4	2.20	0.210	0.963	1.178	1.790	3.369
2400	265.1	3.6	2.49	0.230	1.054	1.290	1.961	3.688
2800	265.6	3.8	2.77	0.250	1.138	1.391	2.116	3.980
3200	266.0	4.0	3.03	0.268	1.215	1.486	2.261	4.250
3600	266.5	4.1	3.28	0.284	1.288	1.574	2.396	4.503
4000	266.8	4.3	3.52	0.300	1.357	1.657	2.523	4.741

TUGALO RIVER - TRANSECT Y-26
575 CFS



TUGALO RIVER - TRANSECT Y-26
575 CFS



TUGALO RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT Y-29: RIFFLE HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 1.7 TO 160.0 FEET

STAGE OF ZERO FLOW (SZF)= 92.80

INTERCEPT (LN(A)) = -3.7025
SLOPE (B) = 0.5866

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	3225.637	0.899
1560.000	1543.410	1.011
595.000	477.923	1.245
165.000	186.667	0.884

MEAN % ERROR	11.28
VARIANCE	59.44
STANDARD DEVIATION	7.71
SAMPLE SIZE	4

TRANSECT SECTION : 177.0 TO 275.0 FEET

STAGE OF ZERO FLOW (SZF)= 93.04

INTERCEPT (LN(A)) = -3.1164
SLOPE (B) = 0.4883

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	2834.951	1.023
1560.000	1489.105	1.048
595.000	679.070	0.876
165.000	154.931	1.065

MEAN % ERROR	6.75
VARIANCE	26.68
STANDARD DEVIATION	5.17
SAMPLE SIZE	4

TRANSECT SECTION : 298.0 TO 434.0 FEET

STAGE OF ZERO FLOW (SZF)= 92.59

INTERCEPT (LN(A)) = -1.1238
SLOPE (B) = 0.2640

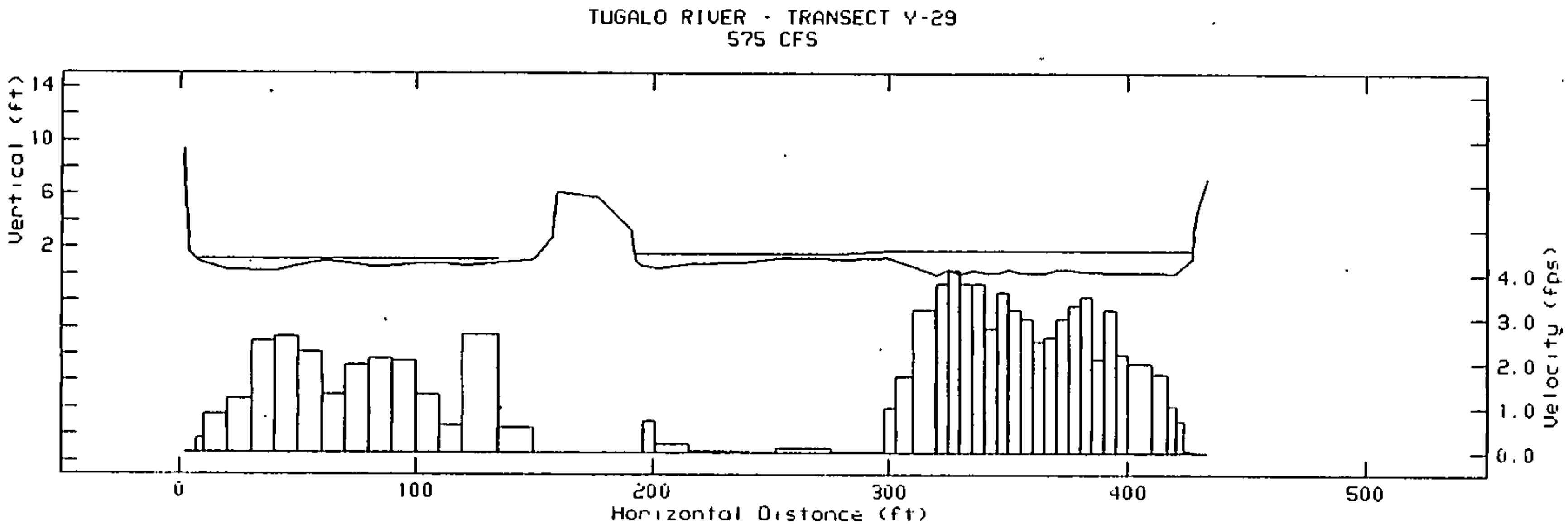
SUMMARY STATISTICS :

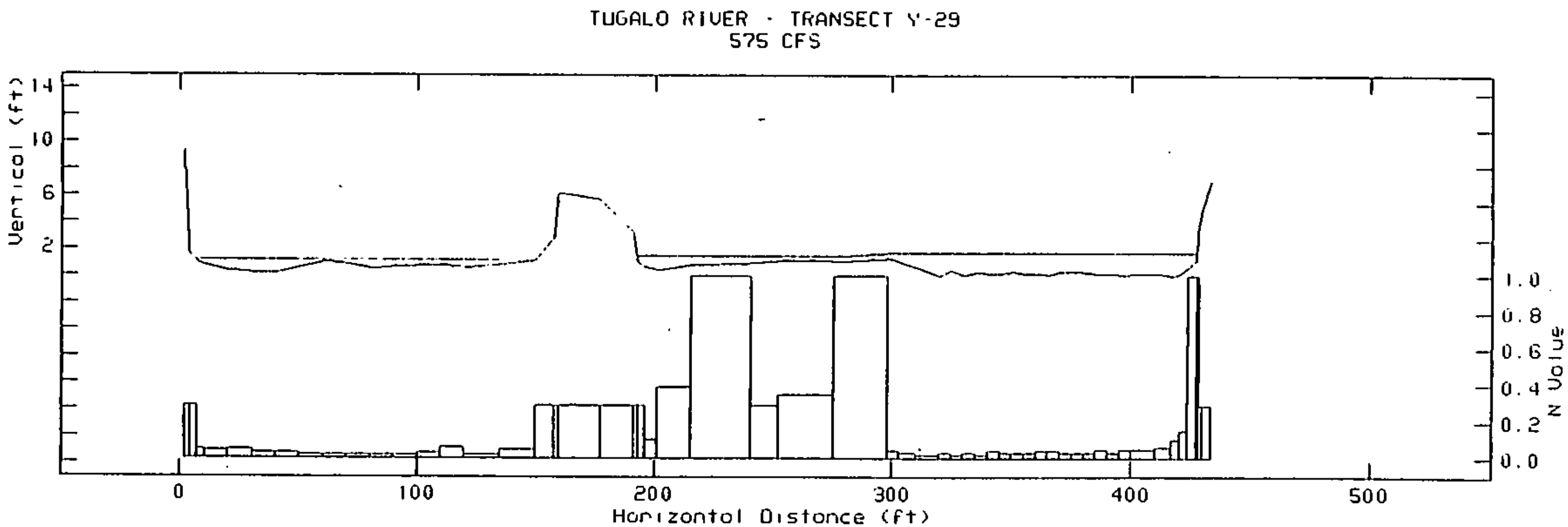
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2900.000	2994.323	0.968
1560.000	1471.662	1.060
595.000	613.468	0.970
165.000	164.295	1.004

MEAN % ERROR	3.11
VARIANCE	4.58
STANDARD DEVIATION	2.14
SAMPLE SIZE	4

HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR			
					2900 CFS DATA	1560 CFS DATA	595 CFS DATA	165 CFS DATA
50	166.1	0.6	0.55	0.130	0.304	0.285	0.370	0.490
100	194.3	0.6	0.83	0.185	0.402	0.377	0.487	0.653
150	236.2	0.6	1.03	0.232	0.474	0.447	0.576	0.773
200	277.8	0.6	1.20	0.273	0.529	0.501	0.638	0.871
250	306.1	0.6	1.32	0.297	0.572	0.543	0.688	0.946
300	341.4	0.6	1.42	0.318	0.608	0.579	0.728	1.008
350	370.2	0.6	1.51	0.337	0.639	0.611	0.763	1.062
400	381.3	0.7	1.57	0.339	0.664	0.636	0.789	1.105
500	379.2	0.8	1.72	0.346	0.708	0.680	0.831	1.180
700	381.4	0.9	1.95	0.354	0.773	0.744	0.888	1.286
900	383.4	1.1	2.16	0.364	0.823	0.793	0.928	1.364
1100	384.6	1.2	2.34	0.374	0.863	0.833	0.960	1.426
1300	385.5	1.3	2.52	0.383	0.897	0.866	0.985	1.477
1500	386.3	1.5	2.67	0.391	0.927	0.894	1.006	1.520
2000	388.2	1.7	3.03	0.409	0.987	0.952	1.047	1.605
2400	389.5	1.9	3.28	0.422	1.025	0.988	1.072	1.657
2800	390.8	2.0	3.51	0.433	1.058	1.019	1.093	1.700
3200	391.4	2.2	3.76	0.449	1.087	1.046	1.111	1.751
3600	391.8	2.3	3.97	0.459	1.112	1.070	1.127	1.787
4000	392.1	2.5	4.16	0.468	1.135	1.091	1.141	1.818


TUGALO RIVER - TRANSECT Y-29
575 CFS
Vertical (ft)
14
10
6
2
4.0
3.0
2.0
1.0
0.0
Velocity (fps)
0
100
200
300
400
500
Horizontal Distance (ft)


TUGALO RIVER - TRANSECT Y-29
575 CFS
Vertical (ft)
14
10
6
2
1.0
0.8
0.6
0.4
0.2
0.0
N Value
0
100
200
300
400
500
Horizontal Distance (ft)

OCMULGEE RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT O-17 AND O-9; DIVIDED CHANNEL SHOAL HABITATS

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 0.0 TO 310.0 FEET

STAGE OF ZERO FLOW (SZF)= 91.53

INTERCEPT (LN(A)) = -0.6308
SLOPE (B) = 0.2813

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	3877.532	0.735
1960.000	1431.370	1.369
650.000	537.410	1.210
375.000	456.491	0.821

MEAN % ERROR	25.52
VARIANCE	64.88
STANDARD DEVIATION	8.05
SAMPLE SIZE	4

TRANSECT SECTION : 340.0 TO 539.0 FEET

STAGE OF ZERO FLOW (SZF)= 92.70

INTERCEPT (LN(A)) = -1.6337
SLOPE (B) = 0.3275

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	3153.472	0.904
1960.000	1868.411	1.049
650.000	516.856	1.258
375.000	447.110	0.839

MEAN % ERROR	13.76
VARIANCE	55.79
STANDARD DEVIATION	7.47
SAMPLE SIZE	4

TRANSECT SECTION : 545.5 TO 697.0 FEET

STAGE OF ZERO FLOW (SZF)= 92.57

INTERCEPT (LN(A)) = -2.1610
SLOPE (B) = 0.4022

SUMMARY STATISTICS :

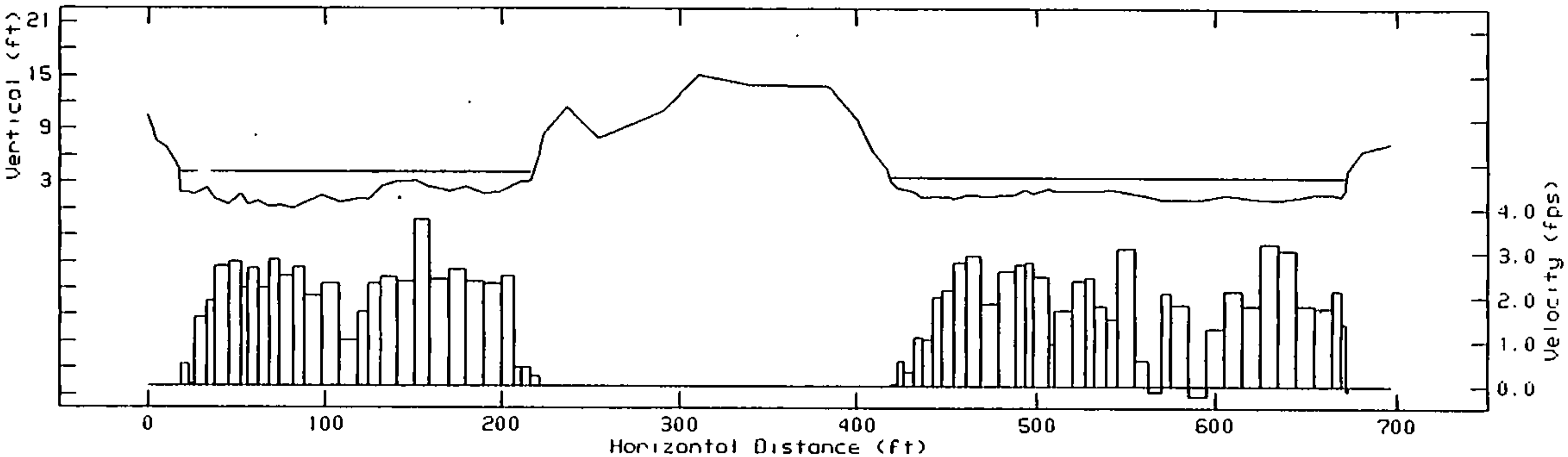
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	3018.492	0.944
1960.000	1961.424	0.999
650.000	524.791	1.239
375.000	438.226	0.856

MEAN % ERROR	10.53
VARIANCE	82.34
STANDARD DEVIATION	9.07
SAMPLE SIZE	4

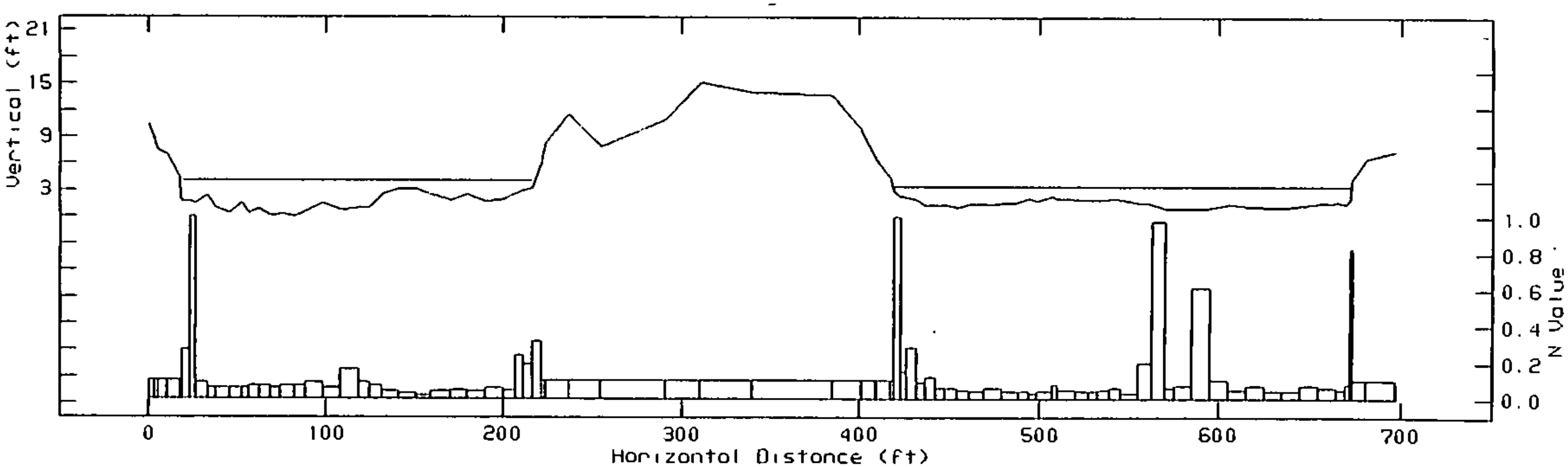
HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 1960 CFS DATA SET	VELOCITY ADJUSTMENT FACTOR 375 CFS DATA SET
50	251.0	0.5	0.37	0.088	0.419	0.588
100	327.7	0.6	0.48	0.107	0.481	0.688
150	372.5	0.7	0.55	0.114	0.512	0.740
200	395.3	0.8	0.61	0.119	0.534	0.775
250	411.8	0.9	0.70	0.132	0.574	0.815
300	416.3	1.0	0.75	0.136	0.594	0.845
350	421.2	1.0	0.80	0.139	0.609	0.868
400	425.7	1.1	0.85	0.142	0.622	0.889
500	434.4	1.2	0.93	0.148	0.644	0.927
700	451.4	1.4	1.10	0.162	0.691	0.997
900	452.9	1.6	1.24	0.172	0.724	1.055
1100	453.7	1.8	1.37	0.181	0.755	1.108
1300	454.4	1.9	1.49	0.190	0.783	1.155
1500	455.0	2.1	1.61	0.198	0.809	1.200
2000	456.5	2.3	1.88	0.217	0.868	1.299
2400	457.8	2.5	2.08	0.230	0.911	1.369
2800	459.0	2.7	2.26	0.243	0.950	1.433
3200	460.1	2.9	2.44	0.254	0.987	1.492
3600	461.1	3.0	2.60	0.265	1.021	1.547
4000	462.0	3.1	2.77	0.275	1.054	1.599

OCMULGEE RIVER - TRANSECT 0-17/0-9
1960 CFS



OCMULGEE RIVER - TRANSECT 0-17/0-9
1960 CFS



OCMULGEE RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT O-32; SINGLE CHANNEL RUN/POOL HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : -4.0 TO 28.0 FEET

STAGE OF ZERO FLOW (SZF)= 90.91

INTERCEPT (LN(A)) = -2.1379
SLOPE (B) = 0.4496

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2875.096	0.991
1960.000	1971.390	0.994
650.000	618.456	1.051
375.000	388.430	0.965

MEAN % ERROR	2.47
VARIANCE	4.34
STANDARD DEVIATION	2.08
SAMPLE SIZE	4

TRANSECT SECTION : 41.0 TO 250.0 FEET

STAGE OF ZERO FLOW (SZF)= 86.62

INTERCEPT (LN(A)) = 0.7102
SLOPE (B) = 0.1786

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2957.508	0.964
1960.000	1933.411	1.014
650.000	590.818	1.100
375.000	403.034	0.930

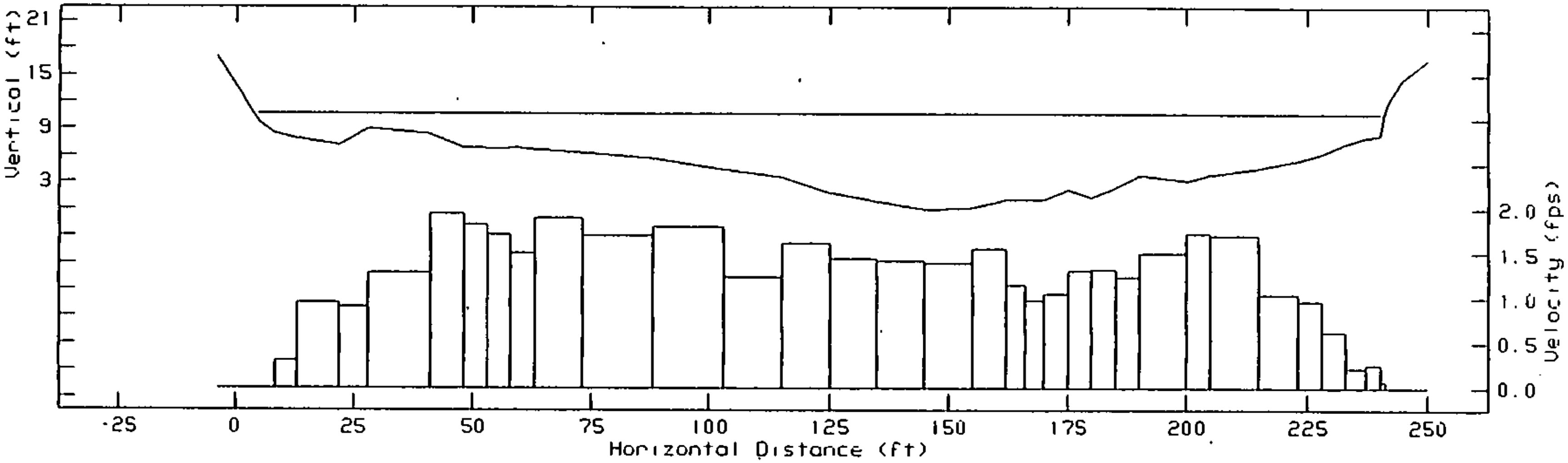
MEAN % ERROR	5.43
VARIANCE	12.34
STANDARD DEVIATION	3.51
SAMPLE SIZE	4

HYDRAULIC SIMULATION RESULTS

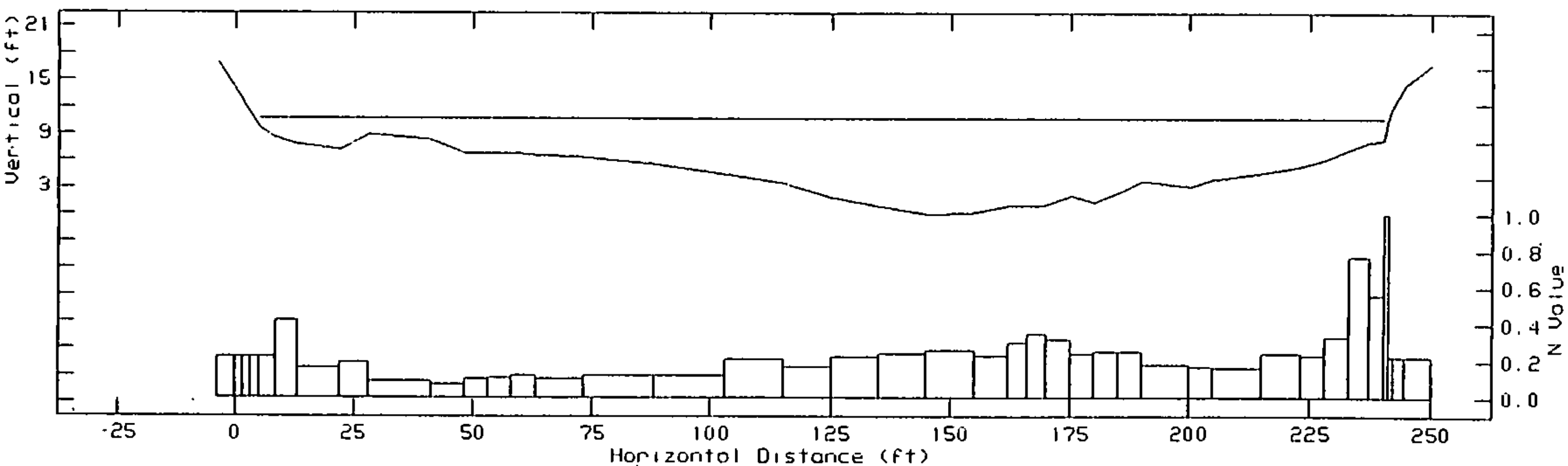
DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR	
					1960 CFS DATA SET	375 CFS DATA SET
50	195.3	3.1	0.08	0.008	0.091	0.243
100	203.0	3.5	0.14	0.013	0.145	0.387
150	208.3	3.8	0.19	0.017	0.190	0.503
200	212.4	4.0	0.24	0.021	0.229	0.602
250	217.3	4.1	0.28	0.025	0.266	0.700
300	222.7	4.1	0.32	0.028	0.300	0.787
350	226.8	4.2	0.36	0.031	0.331	0.868

400	230.4	4.3	0.40	0.034	0.360	0.945
500	233.3	4.5	0.48	0.040	0.417	1.090
700	234.3	4.8	0.62	0.050	0.516	1.349
900	235.2	5.1	0.75	0.059	0.604	1.582
1100	235.8	5.3	0.88	0.067	0.686	1.797
1300	236.2	5.5	0.99	0.074	0.761	1.998
1500	236.5	5.7	1.11	0.082	0.832	2.188
2000	237.3	6.1	1.38	0.098	0.994	2.628
2400	237.9	6.4	1.59	0.111	1.113	2.951
2800	238.4	6.6	1.79	0.123	1.224	3.256
3200	238.8	6.8	1.98	0.134	1.329	3.545
3600	239.2	7.0	2.17	0.145	1.428	3.822
4000	239.6	7.1	2.35	0.155	1.523	4.088

OCMULGEE RIVER - TRANSECT 0-32
1960 CFS



OCMULGEE RIVER - TRANSECT 0-32
1960 CFS



OCMULGEE RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT O-33; SINGLE CHANNEL POOL HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 0.0 TO 257.5 FEET

STAGE OF ZERO FLOW (SZF)= 87.73

INTERCEPT (LN(A)) = 0.7944
SLOPE (B) = 0.1658

SUMMARY STATISTICS :

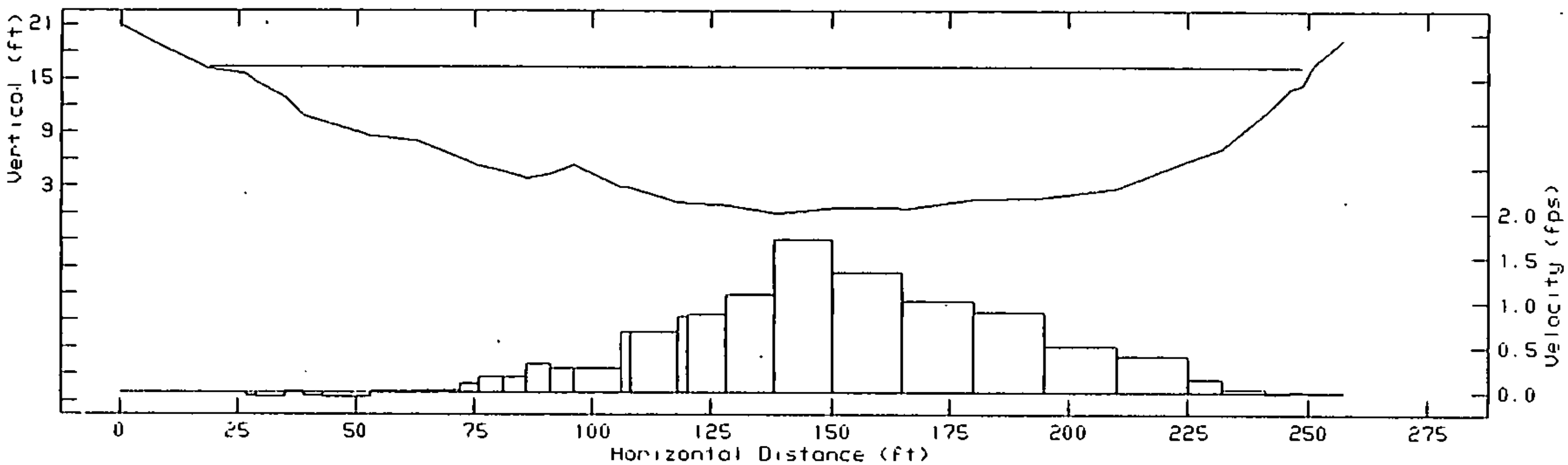
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	3079.308	0.926
1960.000	1848.071	1.061
650.000	583.140	1.115
375.000	410.300	0.914

MEAN % ERROR	8.36
VARIANCE	3.98
STANDARD DEVIATION	1.99
SAMPLE SIZE	4

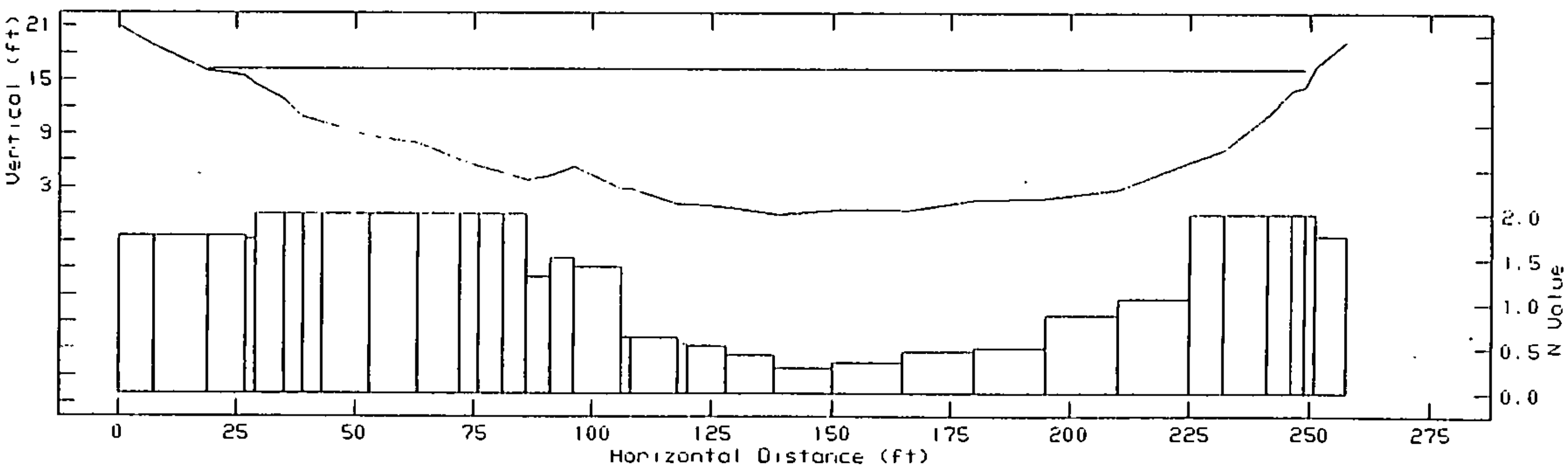
HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 1960 CFS DATA SET	VELOCITY ADJUSTMENT FACTOR 375 CFS DATA SET
50	209.1	8.8	0.03	0.002	0.045	0.165
100	211.8	9.2	0.05	0.003	0.084	0.299
150	213.5	9.5	0.07	0.004	0.120	0.421
200	215.0	9.6	0.10	0.005	0.155	0.537
250	217.0	9.7	0.12	0.007	0.189	0.648
300	218.7	9.8	0.14	0.008	0.221	0.754
350	219.4	10.0	0.16	0.009	0.253	0.858
400	219.9	10.1	0.18	0.010	0.285	0.958
500	220.7	10.2	0.22	0.012	0.346	1.154
700	222.0	10.5	0.30	0.016	0.464	1.523
900	223.3	10.8	0.37	0.020	0.577	1.873
1100	226.3	10.8	0.45	0.024	0.686	2.208
1300	228.9	10.9	0.52	0.028	0.792	2.530
1500	231.2	11.0	0.59	0.031	0.396	2.843
2000	233.3	11.2	0.76	0.040	1.147	3.591
2400	234.7	11.4	0.90	0.047	1.340	4.163
2800	236.1	11.6	1.03	0.053	1.529	4.714
3200	237.2	11.7	1.15	0.059	1.713	5.248
3600	238.3	11.8	1.28	0.066	1.893	5.769
4000	239.2	11.9	1.40	0.072	2.070	6.277

OCMULGEE RIVER - TRANSECT D-33
1960 CFS



OCMULGEE RIVER - TRANSECT D-33
1960 CFS



OCMULGEE RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT O-48 AND O-46; DIVIDED CHANNEL RUN AND DIVIDED CHANNEL POOL HABITATS

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 0.3 TO 251.0 FEET

STAGE OF ZERO FLOW (SZF)= 91.43

INTERCEPT (LN(A)) = -0.6569
SLOPE (B) = 0.2508

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2993.046	0.952
1960.000	1847.376	1.061
650.000	648.282	1.003
375.000	379.851	0.987

MEAN % ERROR	3.08
VARIANCE	7.33
STANDARD DEVIATION	2.71
SAMPLE SIZE	4

TRANSECT SECTION : 268.0 TO 486.2 FEET

STAGE OF ZERO FLOW (SZF)= 91.44

INTERCEPT (LN(A)) = -1.0588
SLOPE (B) = 0.2995

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2957.953	0.964
1960.000	1884.483	1.040
650.000	637.796	1.019
375.000	382.984	0.979

MEAN % ERROR	2.91
VARIANCE	1.11
STANDARD DEVIATION	1.05
SAMPLE SIZE	4

TRANSECT SECTION : 502.2 TO 726.6 FEET

STAGE OF ZERO FLOW (SZF)= 89.39

INTERCEPT (LN(A)) = -1.1456
SLOPE (B) = 0.3174

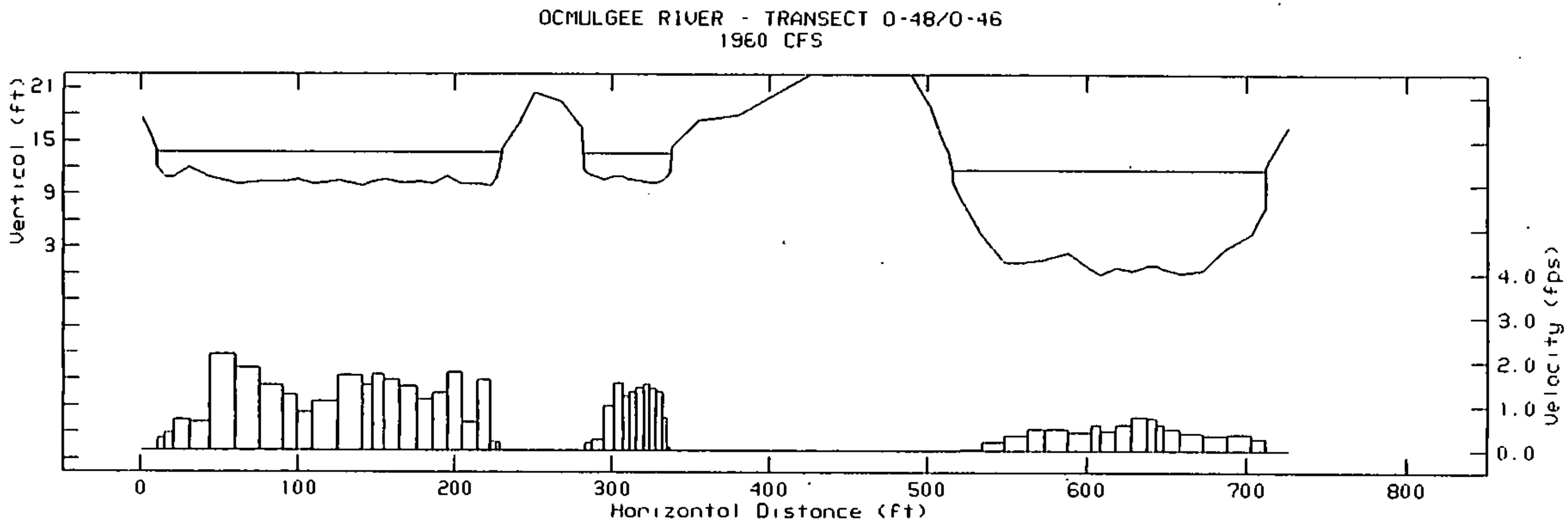
SUMMARY STATISTICS :

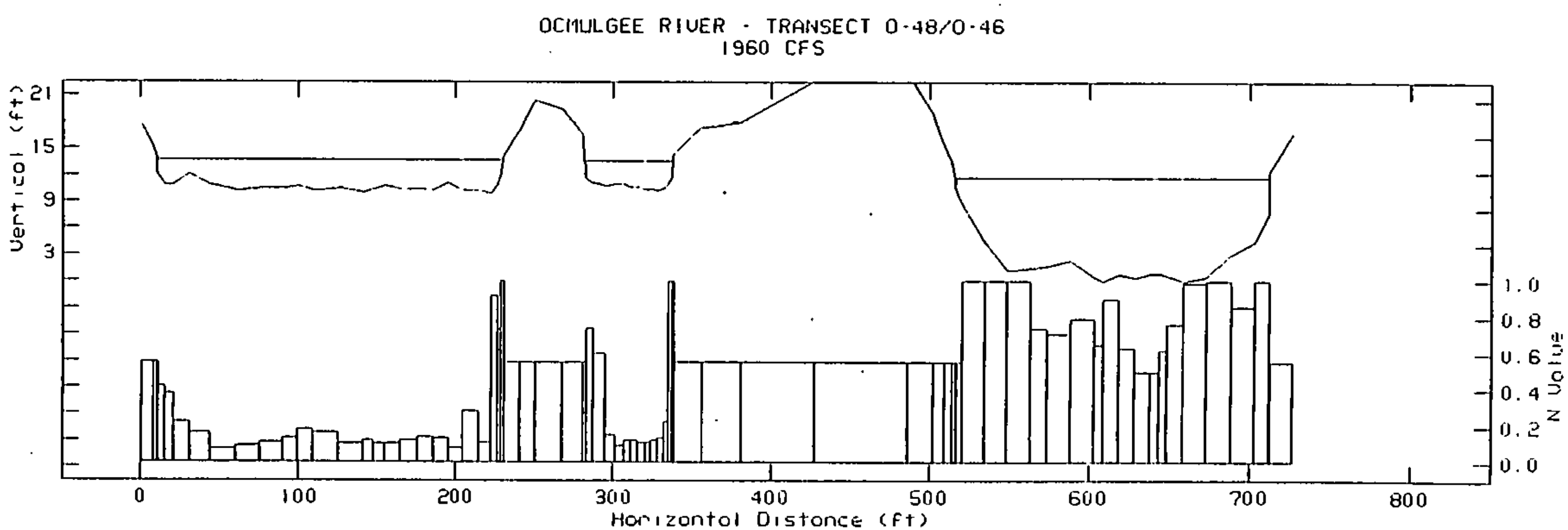
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2962.416	0.962
1960.000	1880.378	1.042
650.000	638.433	1.018
375.000	382.859	0.979

MEAN % ERROR	2.97
VARIANCE	1.44
STANDARD DEVIATION	1.20
SAMPLE SIZE	4

HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 1960 CFS DATA SET	VELOCITY ADJUSTMENT FACTOR 375 CFS DATA SET
50	453.6	3.7	0.03	0.003	0.069	0.243
100	463.2	3.9	0.06	0.005	0.120	0.394
150	467.0	4.0	0.08	0.007	0.166	0.523
200	467.7	4.2	0.10	0.009	0.206	0.634
250	468.2	4.3	0.12	0.011	0.243	0.734
300	468.7	4.4	0.15	0.012	0.278	0.826
350	468.9	4.5	0.17	0.014	0.311	0.912
400	469.1	4.5	0.19	0.015	0.342	0.993
500	469.5	4.7	0.23	0.018	0.401	1.143
700	470.1	4.9	0.30	0.024	0.508	1.411
900	470.6	5.1	0.37	0.029	0.604	1.648
1100	471.0	5.3	0.44	0.034	0.693	1.863
1300	471.4	5.4	0.51	0.039	0.775	2.062
1500	471.7	5.5	0.57	0.043	0.853	2.249
2000	472.5	5.8	0.73	0.053	1.031	2.674
2400	473.1	6.0	0.85	0.061	1.162	2.982
2800	473.9	6.1	0.96	0.068	1.284	3.268
3200	474.7	6.3	1.07	0.075	1.399	3.538
3600	475.4	6.4	1.18	0.082	1.508	3.793
4000	476.8	6.5	1.29	0.089	1.613	4.037


OCMULGEE RIVER - TRANSECT O-48/O-46
1960 CFS
Vertical (ft)
21
15
9
3
Velocity (fps)
4.0
3.0
2.0
1.0
0.0
0
100
200
300
400
500
600
700
800
Horizontal Distance (ft)


OCMULGEE RIVER - TRANSECT O-48/O-46
1960 CFS
Vertical (ft)
21
15
9
3
N Value
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
600
700
800
Horizontal Distance (ft)

OCMULGEE RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT O-51 AND O-47; DIVIDED CHANNEL RUN/POOL AND DIVIDED CHANNEL SHOAL HABITATS

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 0.4 TO 261.1 FEET

STAGE OF ZERO FLOW (SZF)= 88.60

INTERCEPT (LN(A)) = -0.3756
SLOPE (B) = 0.2271

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	3021.179	0.943
1960.000	1843.542	1.063
650.000	630.224	1.031
375.000	387.901	0.967

MEAN % ERROR	4.61
VARIANCE	2.52
STANDARD DEVIATION	1.59
SAMPLE SIZE	4

TRANSECT SECTION : 302.1 TO 406.0 FEET

STAGE OF ZERO FLOW (SZF)= 88.78

INTERCEPT (LN(A)) = -1.2924
SLOPE (B) = 0.3296

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2826.585	1.008
1960.000	1939.768	1.010
650.000	691.309	0.940
375.000	359.221	1.044

MEAN % ERROR	3.10
VARIANCE	7.10
STANDARD DEVIATION	2.66
SAMPLE SIZE	4

TRANSECT SECTION : 418.0 TO 563.4 FEET

STAGE OF ZERO FLOW (SZF)= 88.78

INTERCEPT (LN(A)) = -1.4324
SLOPE (B) = 0.3436

SUMMARY STATISTICS :

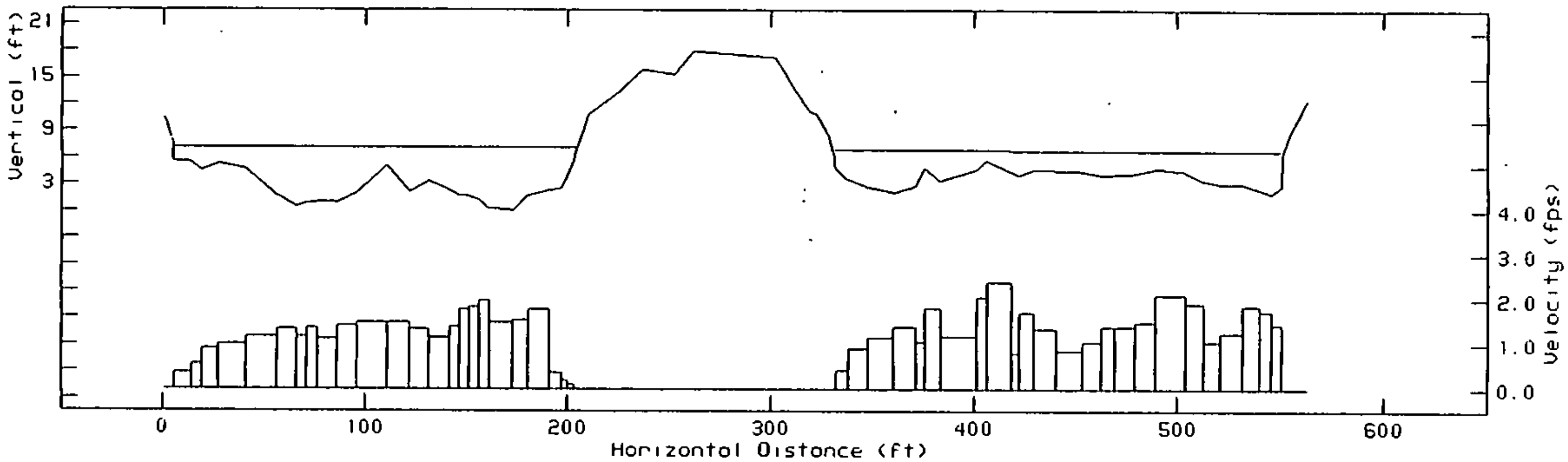
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2799.033	1.018
1960.000	1961.065	0.999
650.000	693.586	0.937
375.000	357.639	1.049

MEAN % ERROR	3.29
VARIANCE	8.73
STANDARD DEVIATION	2.95
SAMPLE SIZE	4

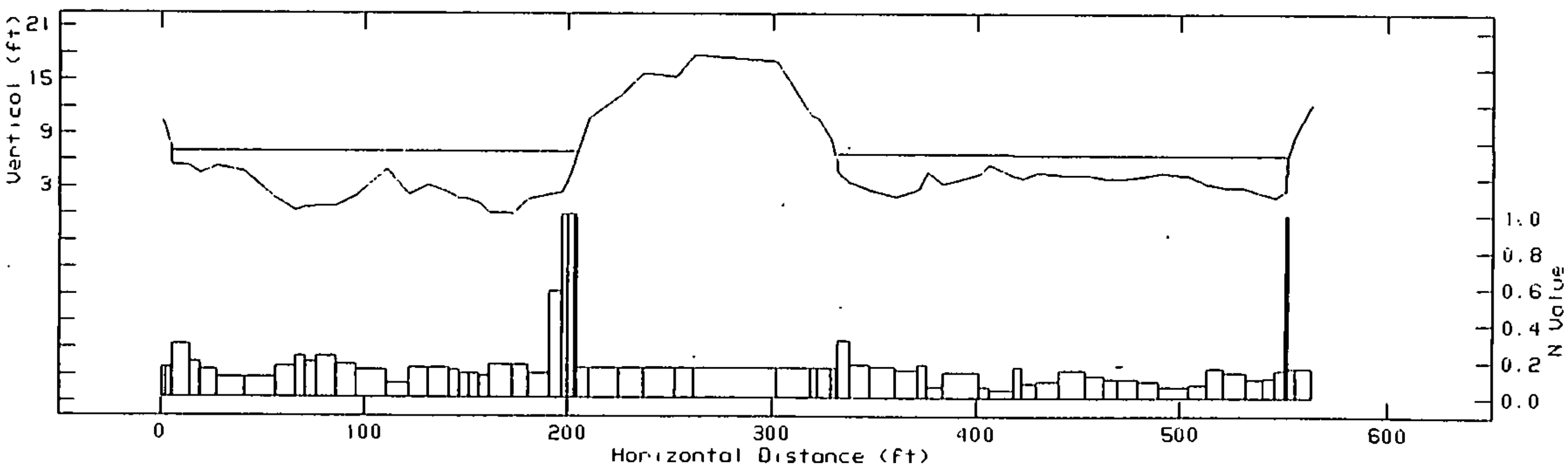
HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR	
					1960 CFS DATA SET	375 CFS DATA SET
50	320.4	2.1	0.07	0.009	0.080	0.254
100	382.5	1.9	0.13	0.017	0.143	0.438
150	402.0	2.0	0.19	0.024	0.195	0.592
200	408.1	2.1	0.23	0.028	0.237	0.714
250	410.2	2.2	0.28	0.033	0.275	0.821
300	412.0	2.3	0.32	0.037	0.310	0.917
350	413.5	2.4	0.36	0.041	0.343	1.004
400	414.9	2.5	0.39	0.044	0.373	1.085
500	423.3	2.6	0.46	0.051	0.429	1.231
700	418.5	2.8	0.60	0.063	0.528	1.491
900	418.9	3.0	0.72	0.073	0.612	1.707
1100	419.3	3.2	0.83	0.082	0.688	1.897
1300	419.7	3.3	0.94	0.091	0.756	2.069
1500	420.1	3.4	1.04	0.099	0.820	2.226
2000	420.9	3.7	1.29	0.118	0.961	2.575
2400	421.8	3.9	1.47	0.132	1.061	2.819
2800	422.5	4.0	1.64	0.144	1.153	3.042
3200	423.2	4.2	1.81	0.156	1.238	3.248
3600	424.0	4.3	1.97	0.167	1.317	3.439
4000	424.7	4.4	2.13	0.178	1.392	3.619

OCMULGEE RIVER - TRANSECT O-51/O-47
1960 CFS



OCMULGEE RIVER - TRANSECT O-51/O-47
1960 CFS



OCMULGEE RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT O-60; SINGLE CHANNEL SHOAL HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 4.9 TO 107.0 FEET

STAGE OF ZERO FLOW (SZF)= 94.34

INTERCEPT (LN(A)) = -1.5965
SLOPE (B) = 0.3611

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2759.903	1.033
1960.000	1945.283	1.008
650.000	748.506	0.868
375.000	338.823	1.107

MEAN % ERROR	7.18
VARIANCE	42.39
STANDARD DEVIATION	6.51
SAMPLE SIZE	4

TRANSECT SECTION : 112.0 TO 196.0 FEET

STAGE OF ZERO FLOW (SZF)= 93.82

INTERCEPT (LN(A)) = -0.3566
SLOPE (B) = 0.2206

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2981.674	0.956
1960.000	1847.291	1.061
650.000	657.537	0.989
375.000	375.950	0.997

MEAN % ERROR	2.95
VARIANCE	7.04
STANDARD DEVIATION	2.65
SAMPLE SIZE	4

TRANSECT SECTION : 209.0 TO 311.5 FEET

STAGE OF ZERO FLOW (SZF)= 94.50

INTERCEPT (LN(A)) = -0.7495
SLOPE (B) = 0.2516

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2925.787	0.974
1960.000	1857.968	1.055
650.000	692.937	0.938
375.000	361.469	1.037

MEAN % ERROR	4.52
VARIANCE	3.04
STANDARD DEVIATION	1.74
SAMPLE SIZE	4

TRANSECT SECTION : 323.0 TO 338.5 FEET

STAGE OF ZERO FLOW (SZF)= 94.75

INTERCEPT (LN(A)) = -2.1985
SLOPE (B) = 0.4136

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2739.252	1.040
1960.000	2013.907	0.973
650.000	693.351	0.937
375.000	355.976	1.053

MEAN % ERROR	4.59
VARIANCE	2.81
STANDARD DEVIATION	1.68
SAMPLE SIZE	4

TRANSECT SECTION : 347.0 TO 390.0 FEET

STAGE OF ZERO FLOW (SZF)= 94.61

INTERCEPT (LN(A)) = -0.7926
SLOPE (B) = 0.2521

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2802.550	1.017
1960.000	1931.787	1.015
650.000	722.323	0.900
375.000	348.178	1.077

MEAN % ERROR	5.35
VARIANCE	21.83
STANDARD DEVIATION	4.67
SAMPLE SIZE	4

TRANSECT SECTION : 404.0 TO 466.0 FEET

STAGE OF ZERO FLOW (SZF)= 94.72

INTERCEPT (LN(A)) = -0.9661
SLOPE (B) = 0.2615

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2828.023	1.008
1960.000	1[illegible]54.283	1.003
650.000	674.720	0.963
375.000	365.133	1.027

MEAN % ERROR	1.87
VARIANCE	2.67
STANDARD DEVIATION	1.63
SAMPLE SIZE	4

TRANSECT SECTION : 476.0 TO 525.4 FEET

STAGE OF ZERO FLOW (SZF)= 95.85

INTERCEPT (LN(A)) = -2.9511
SLOPE (B) = 0.4614

SUMMARY STATISTICS :

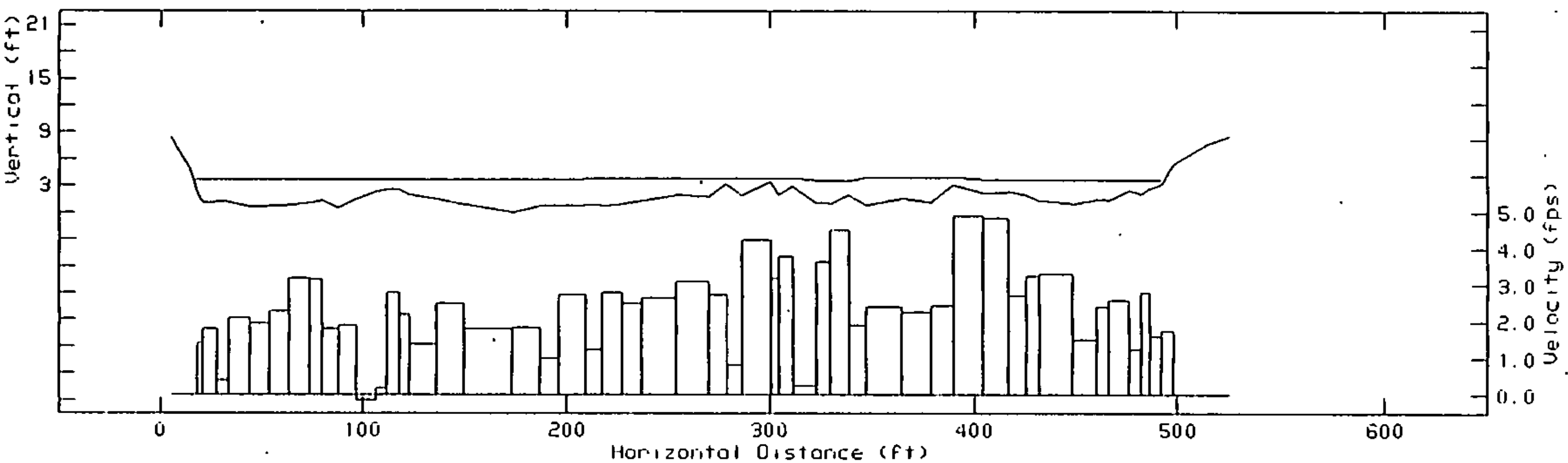
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2959.345	0.963
1960.000	1749.832	1.120
650.000	795.663	0.817
375.000	330.464	1.135

MEAN % ERROR	12.21
VARIANCE	58.82
STANDARD DEVIATION	7.67
SAMPLE SIZE	4

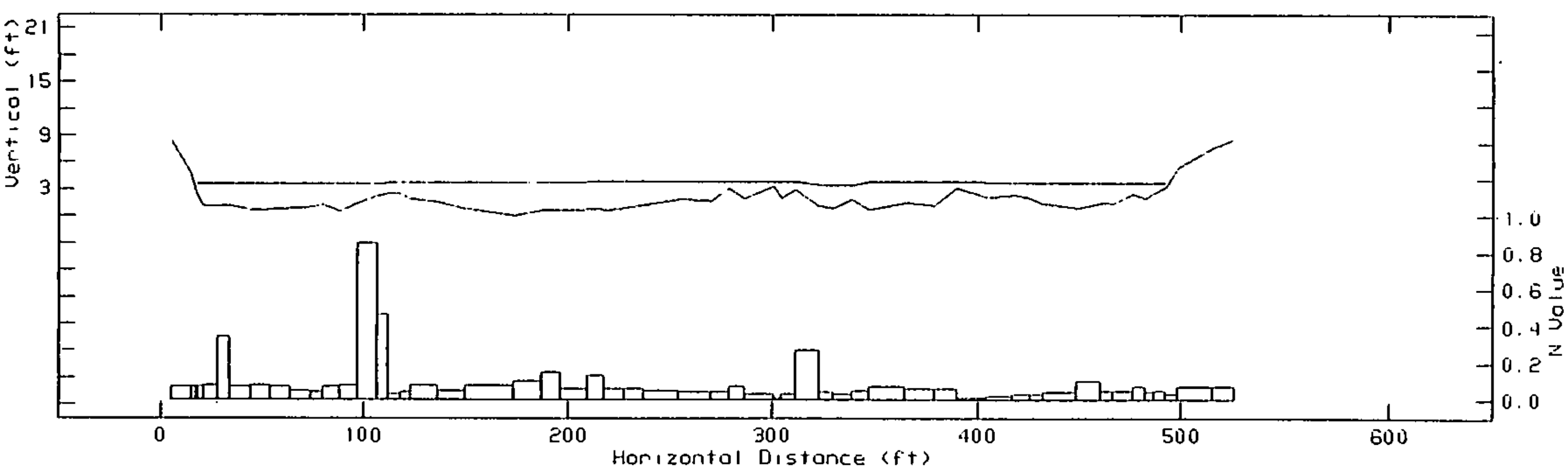
HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 1960 CFS DATA SET	VELOCITY ADJUSTMENT FACTOR 375 CFS DATA SET
50	325.4	0.7	0.22	0.046	0.221	0.326
100	356.7	0.9	0.32	0.061	0.281	0.400
150	390.6	1.0	0.40	0.071	0.316	0.443
200	411.1	1.0	0.47	0.081	0.351	0.488
250	415.6	1.1	0.53	0.088	0.378	0.518
300	423.5	1.2	0.59	0.094	0.398	0.542
350	438.7	1.3	0.63	0.100	0.415	0.563
400	444.8	1.3	0.69	0.106	0.431	0.588
500	455.8	1.4	0.78	0.115	0.457	0.622
700	479.8	1.5	0.95	0.134	0.512	0.701
900	478.4	1.7	1.12	0.151	0.572	0.778
1100	481.1	1.8	1.27	0.167	0.625	0.858
1300	475.9	1.9	1.42	0.181	0.675	0.928
1500	476.3	2.0	1.55	0.192	0.709	0.979
2000	477.3	2.3	1.85	0.216	0.784	1.094
2400	478.0	2.4	2.07	0.234	0.836	1.175
2800	478.6	2.6	2.27	0.250	0.884	1.249
3200	479.1	2.7	2.47	0.265	0.928	1.317
3600	479.6	2.8	2.66	0.279	0.969	1.382
4000	480.1	2.9	2.84	0.293	1.007	1.442

OCMULGEE RIVER - TRANSECT O-60
1960 CFS



OCMULGEE RIVER - TRANSECT O-60
1960 CFS



OCMULGEE RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT O-84; SINGLE CHANNEL GRAVEL RUN HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : 21.0 TO 639.0 FEET

STAGE OF ZERO FLOW (SZF)= 92.90

INTERCEPT (LN(A)) = -1.8502
SLOPE (B) = 0.4243

SUMMARY STATISTICS :

MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	3018.548	0.944
1960.000	1865.452	1.051
650.000	610.187	1.065
375.000	396.278	0.946

MEAN % ERROR	5.63
VARIANCE	0.33
STANDARD DEVIATION	0.57
SAMPLE SIZE	4

TRANSECT SECTION : 738.0 TO 868.0 FEET

STAGE OF ZERO FLOW (SZF)= 91.38

INTERCEPT (LN(A)) = -1.3520
SLOPE (B) = 0.3948

SUMMARY STATISTICS :

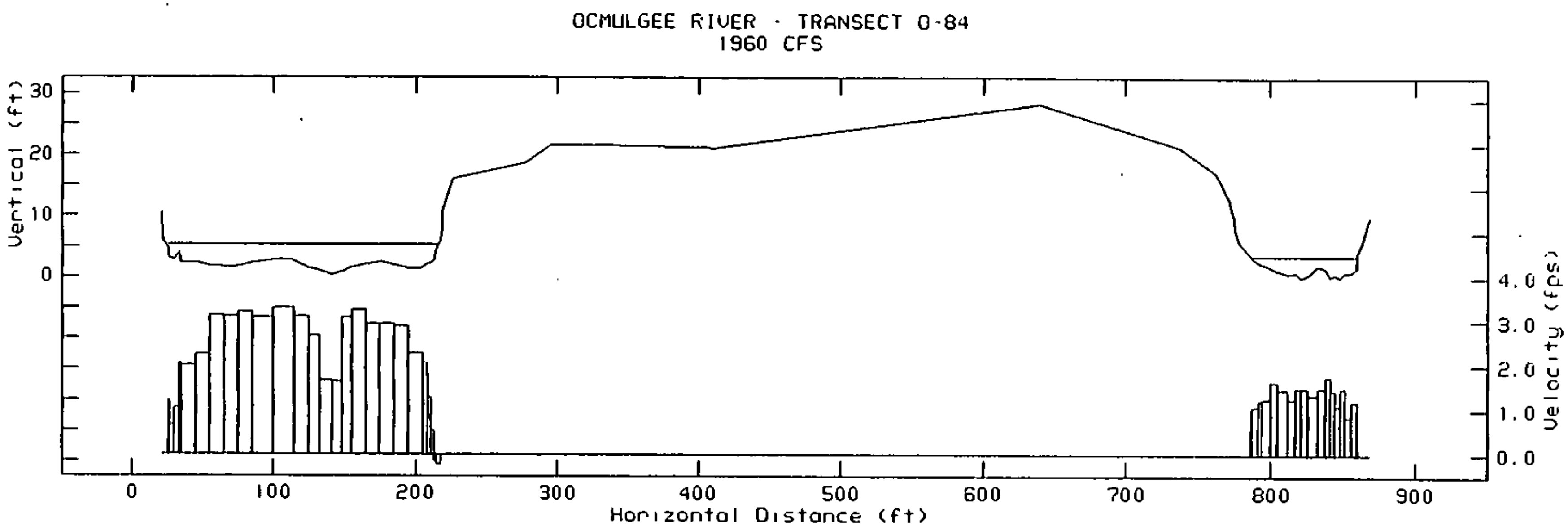
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	2958.963	0.963
1960.000	1894.257	1.035
650.000	627.163	1.036
375.000	387.335	0.968

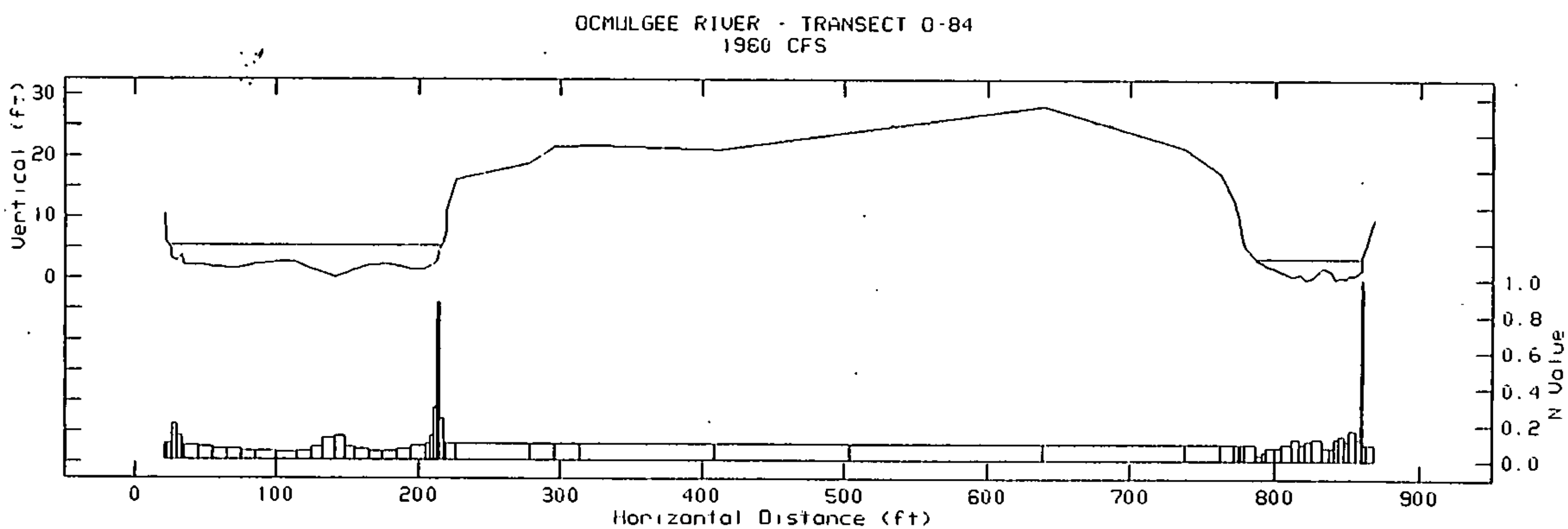
MEAN % ERROR	3.50
VARIANCE	0.06
STANDARD DEVIATION	0.24
SAMPLE SIZE	4

HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 1960 CFS DATA SET	VELOCITY ADJUSTMENT FACTOR 375 CFS DATA SET
50	185.1	0.7	0.39	0.082	0.462	1.076
100	213.9	0.9	0.54	0.102	0.556	1.262
150	237.5	1.0	0.63	0.112	0.594	1.323
200	245.2	1.1	0.72	0.120	0.623	1.382
250	248.9	1.3	0.79	0.124	0.639	1.410
300	250.8	1.4	0.85	0.127	0.651	1.434
350	252.4	1.5	0.91	0.130	0.661	1.456

400	254.1	1.6	0.97	0.133	0.671	1.477
500	257.3	1.8	1.06	0.138	0.688	1.515
700	261.6	2.1	1.25	0.150	0.720	1.587
900	263.3	2.4	1.40	0.158	0.744	1.646
1100	264.8	2.7	1.54	0.165	0.764	1.699
1300	266.9	2.9	1.67	0.172	0.781	1.747
1500	269.5	3.1	1.79	0.178	0.796	1.790
2000	275.4	3.5	2.05	0.191	0.825	1.883
2400	278.8	3.8	2.25	0.203	0.860	1.954
2800	280.6	4.1	2.44	0.212	0.884	2.015
3200	281.6	4.4	2.61	0.220	0.905	2.070
3600	282.6	4.6	2.76	0.227	0.925	2.121
4000	283.5	4.8	2.91	0.233	0.943	2.167


OCMULGEE RIVER · TRANSECT O-84
1960 CFS
Vertical (ft)
30
20
10
0
Velocity (fps)
4.0
3.0
2.0
1.0
0.0
0
100
200
300
400
500
600
700
800
900
Horizontal Distance (ft)


OCMULGEE RIVER · TRANSECT O-84
1960 CFS
Vertical (ft)
30
20
10
0
N Value
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
600
700
800
900
Horizontal Distance (ft)

OCMULGEE RIVER INSTREAM FLOW STUDY-GPC71 1027604
TRANSECT O-95: SINGLE CHANNEL SANDY RUN/POOL HABITAT

STAGE/DISCHARGE REGRESSION ANALYSIS

GENERAL MODEL:

STAGE-SZF = A*DISCHARGE**B OR
LN(STAGE-SZF) = LN(A) + B*LN(DISCHARGE)

TRANSECT SECTION : -2.0 TO 167.0 FEET

STAGE OF ZERO FLOW (SZF)= 89.39

INTERCEPT (LN(A)) = -0.5564
SLOPE (B) = 0.3562

SUMMARY STATISTICS :

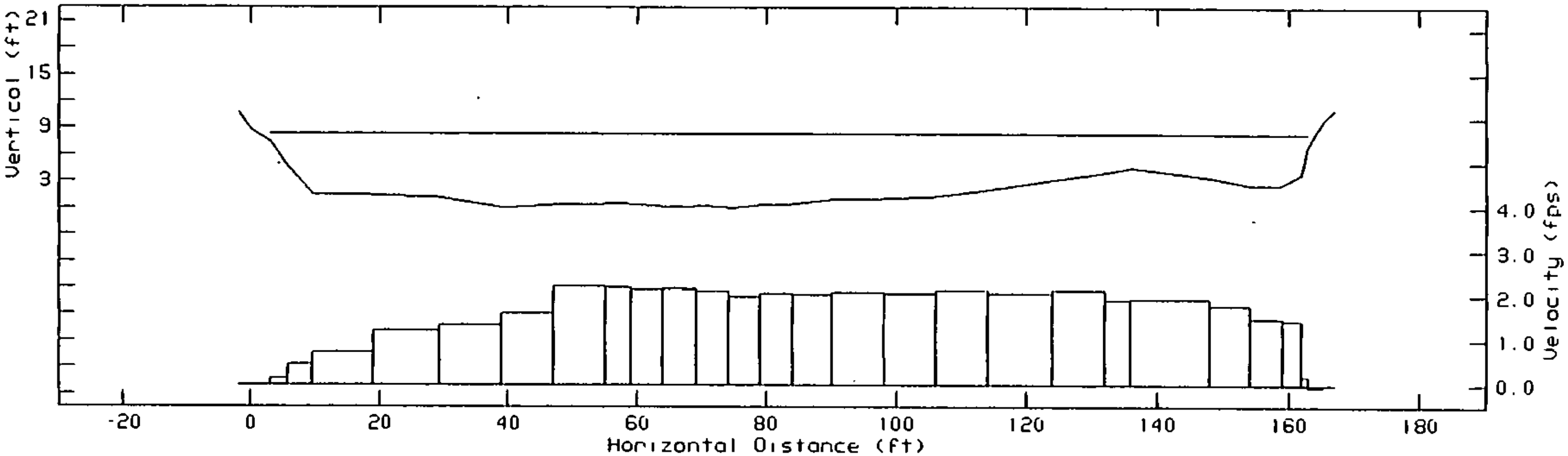
MEASURED DISCHARGE	PREDICTED DISCHARGE	RATIO
2850.000	3078.755	0.926
1960.000	1839.107	1.066
650.000	592.119	1.098
375.000	406.120	0.923

MEAN % ERROR	7.85
VARIANCE	1.39
STANDARD DEVIATION	1.18
SAMPLE SIZE	4

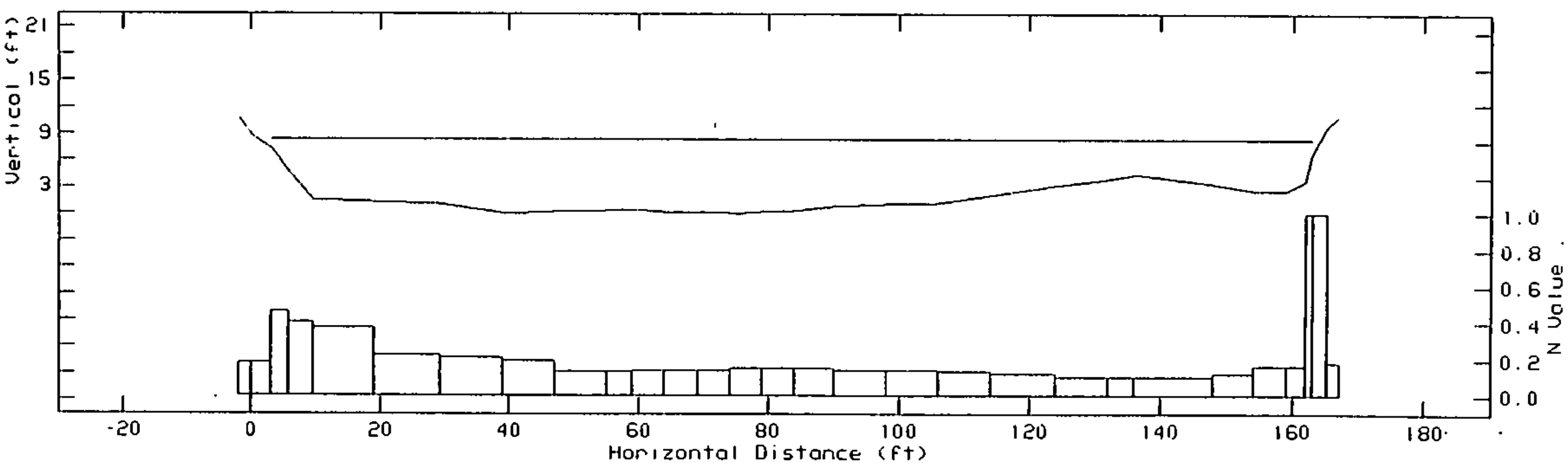
HYDRAULIC SIMULATION RESULTS

DISCHARGE (CFS)	STREAM WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)	FROUDE NUMBER	VELOCITY ADJUSTMENT FACTOR 1960 CFS DATA SET	VELOCITY ADJUSTMENT FACTOR 375 CFS DATA SET
50	107.5	1.5	0.30	0.043	0.431	0.607
100	123.0	2.0	0.41	0.051	0.493	0.700
150	132.8	2.3	0.50	0.058	0.542	0.776
200	141.6	2.5	0.56	0.063	0.575	0.829
250	148.4	2.7	0.62	0.067	0.601	0.874
300	154.1	2.9	0.67	0.070	0.621	0.910
350	156.4	3.1	0.73	0.073	0.645	0.947
400	156.7	3.3	0.78	0.077	0.666	0.984
500	157.3	3.6	0.87	0.081	0.698	1.042
700	158.1	4.3	1.03	0.088	0.751	1.137
900	158.9	4.8	1.17	0.094	0.796	1.218
1100	159.5	5.3	1.30	0.100	0.835	1.288
1300	160.2	5.7	1.42	0.105	0.871	1.352
1500	161.3	6.0	1.54	0.111	0.905	1.412
2000	163.8	6.8	1.80	0.122	0.977	1.539
2400	165.1	7.3	1.99	0.130	1.029	1.627
2800	166.0	7.8	2.17	0.137	1.075	1.707
3200	167.1	8.2	2.34	0.144	1.117	1.782
3600	168.2	8.6	2.50	0.150	1.156	1.850
4000	167.1	9.0	2.65	0.156	1.193	1.914

OCMULGEE RIVER - TRANSECT O-95
1960 CFS



OCMULGEE RIVER - TRANSECT O-95
1960 CFS



APPENDIX G

RESULTS OF PHYSICAL HABITAT SIMULATIONS (RAW WEIGHTED USABLE AREA [WUA] VALUES) FOR EACH SPECIES LIFE STAGE IN THE TUGALO AND OCMULGEE RIVER STUDY AREAS

TABLE G-1 WEIGHTED USABLE AREA (WUA) VALUES FOR ALL SPECIES LIFE STAGES FOR EACH TRANSECT AND TRANSECTS COMBINED (ALL) IN THE TUGALO RIVER. TRANSECTS Y-7 THROUGH Y-29 ARE NUMBERED SEQUENTIALLY

	Simulated Discharge (CFS)																			
	20	40	60	80	100	120	140	160	200	250	300	350	400	500	600	800	1000	1500	2000	3000
SPAWN BLUEHEAD CHUB																				
TRANSECT																				
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	259	326	463	488	449	236
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	141	786	1420	1849	2183	2348	2416	2254	2677	3077	3304	3420	3477	3446	3230	2399	1817	743	70	28
4	4326	25147	38856	43705	47085	49013	50473	51555	50610	49547	46455	44127	41283	34289	24813	4677	302	204	0	476
5	676	1351	1855	2587	3525	3744	5154	5840	6614	7633	8590	8859	8669	7645	6625	4443	2930	457	42	34
6	1130	2993	4179	7318	9748	10431	11732	11842	11552	12259	14145	13896	14175	13842	12945	10839	9406	4775	3510	1481
7	132	1055	2083	2760	3304	3518	3880	4056	4143	4406	4560	4318	4105	3810	3343	2856	2016	1279	871	368
8	1327	7765	8979	9069	9258	9568	9792	9607	9655	8602	7338	6646	6150	5371	5005	3707	2407	210	220	364
9	4889	8314	11106	11797	11880	11975	12093	11657	12495	11050	11523	10104	9705	9752	8110	11542	12024	11457	9335	6813
ALL	12621	47411	68478	79085	86983	90597	95540	96811	97746	96574	95915	91370	87564	78155	64330	40789	31365	19613	14497	9800
YOY BLUEHEAD CHUB																				
TRANSECT																				
1	2575	2182	2719	2597	2368	2193	1886	2916	3364	3169	2988	2727	2467	2064	1674	1253	920	1216	668	246
2	4054	4054	4054	4054	3929	3747	3479	4497	4395	3973	3573	4771	4813	5840	6315	6187	5073	3150	3122	1556
3	2797	2965	2595	3388	3175	2838	2463	2069	1590	1254	961	548	398	281	153	97	73	33	13	0
4	37303	27875	20646	14468	10255	7846	6717	5765	3683	1901	1113	764	611	349	104	0	0	0	469	266
5	703	705	759	553	734	734	666	527	455	408	340	235	210	171	119	69	29	19	68	39
6	945	1136	1024	712	436	1704	2462	1816	1624	1523	1213	1122	741	719	847	453	223	0	0	0
7	608	596	662	469	419	451	445	386	272	309	307	258	644	593	499	303	162	53	21	0
8	8150	7385	6889	5659	4871	4220	3589	2990	2267	1873	1757	1509	1265	1063	921	616	487	280	481	46
9	6260	3604	2948	2392	2125	2034	3217	3287	2890	4804	5832	6341	7687	8101	8617	8140	7222	4687	3427	2130
ALL	63395	50502	42296	34292	28312	25767	24924	24253	20540	19214	18084	18275	18836	19181	19249	17118	14189	9438	8269	4283
ADULT WHITEFIN SHINER																				
TRANSECT																				
1	6753	7875	8840	9457	9900	10251	10516	10890	11464	11814	12033	12463	12825	13218	13443	13653	13635	12887	12013	10560
2	1140	1140	1140	1140	1456	1733	2123	2443	2631	2772	2892	2995	3086	3167	4173	6925	8069	9784	10485	11640
3	4931	6377	7151	7725	8198	8535	8742	8869	8985	9812	9946	9985	9987	9907	9726	9195	8624	7077	5440	3418
4	4392	16017	29447	36126	39408	41634	43289	44580	46433	47578	47967	47913	47720	47015	45922	42909	39210	29800	21759	12491
5	316	834	1404	1718	2232	2764	2975	3224	4308	4940	5586	6166	6373	6609	6447	5860	5255	3969	2933	1533
6	1497	2821	3965	4696	6641	8336	9181	10039	10949	11164	11728	13255	13634	14576	14468	13765	12184	10323	8295	5461
7	0	481	1388	1916	2504	2932	3143	3497	3847	4096	4324	4488	4472	4418	4330	4204	3942	3206	2623	1875
8	9266	11633	13197	13790	14516	14817	15176	15919	16362	16683	16865	16891	16814	16533	16042	14841	13306	9611	7148	3875
9	1103	5145	6440	7644	8084	8249	8277	8271	8342	9091	8906	9011	8928	8925	9565	10700	12560	13646	13722	13287
ALL	29398	52323	72972	84212	92939	99251	103422	107732	113321	117950	120247	123167	123839	124368	124116	122052	116785	100303	84418	64140

YOY NORTHERN HOG SUCKER

TRANSECT																				
1	3076	2750	2077	2639	2692	2549	2385	1957	2560	2942	2788	2588	2172	1920	1678	860	719	497	585	357
2	2271	2271	2271	2271	3618	2445	2411	2378	2267	3456	3571	3604	3471	4029	6792	7063	5897	2746	2050	861
3	1760	1776	1681	1483	1983	2059	1964	1849	1633	1362	1035	827	701	439	216	71	0	0	0	0
4	35197	36195	32009	27906	24162	20994	18202	15390	11100	7263	4168	2474	146	0	0	0	0	0	394	374
5	799	1356	1332	1059	747	853	1126	987	869	275	151	138	125	89	4	0	0	0	0	0
6	1056	2623	2682	2347	1853	1502	1590	2238	2336	2737	2163	1702	1416	1017	1001	1127	831	310	0	0
7	1047	1374	1428	1451	1298	1251	1296	1208	1105	786	736	623	536	646	554	371	279	131	50	0
8	6564	5482	5460	4992	4330	3754	3032	2824	2280	2097	1856	1578	1280	906	623	218	157	100	209	213
9	5810	6057	4811	3636	3350	3042	2241	2092	2927	3061	3062	4470	4968	7296	8998	8843	8378	6512	4635	2061
ALL	57580	59884	53751	47784	44033	38449	34247	30923	27077	23979	19530	18004	14815	16342	19866	18553	16261	10296	7923	3866

JUVENILE NORTHERN HOG SUCKER

TRANSECT																				
1	0	0	164	857	1213	1379	1574	2854	4284	4864	5462	5703	5856	6015	6125	6802	7602	7965	7849	7608
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	575	2248	3658	4487	5284	5880	6371	7060	7926	8537	8841	9019	9377	9507	9465	9124	7550	6309	2955
4	0	3758	12910	23115	28584	31779	34104	36216	39099	42097	43608	44655	45418	46064	45461	43271	41031	35082	23433	12593
5	0	447	724	1109	1279	1579	2086	2321	2689	3935	4545	5186	5741	6320	6425	5855	5554	3668	1892	1246
6	738	1082	2233	3224	3711	5240	6411	7812	9419	10533	10630	11380	12253	13272	13771	13505	12756	10632	7132	5568
7	0	67	529	1281	1772	2232	2620	2960	3422	3792	4025	4254	4469	4482	4453	4143	3884	2989	2789	1830
8	0	2920	7962	9808	11044	12101	12933	13550	14720	15339	15894	16267	16501	16742	16723	16246	15071	12084	8734	2582
9	259	2037	4543	5600	6626	7270	7556	7655	7633	7878	7915	8277	7852	7126	7325	5770	7530	9075	9459	8803
ALL	997	10886	31313	48652	58716	66864	73164	79739	88326	96364	100616	104563	107109	109398	109790	105057	102552	89045	67597	43185

ADULT NORTHERN HOG SUCKER

TRANSECT																				
1	5043	6012	6523	6956	7369	7656	7871	8045	8336	8517	8859	8999	9083	9200	9688	10012	10057	9793	9288	8286
2	619	619	19	619	893	1089	1214	1308	1383	1448	1503	1751	1881	1961	2387	3778	5078	6786	7458	8069
3	3852	4678	5354	6003	6303	6633	6901	7071	7530	7909	8118	8681	8964	9221	9327	9316	9079	8144	7084	5396
4	192	1600	4138	11223	16293	23336	27090	29385	32399	34874	36502	37531	38125	38585	38552	37828	36849	33415	29666	17706
5	76	151	583	730	999	1309	1413	1624	2128	2646	3088	3797	4294	5008	5638	6012	5960	5099	4020	1979
6	541	1111	1251	1872	2586	3061	3812	4440	6304	8113	9384	10047	10311	10804	12535	13333	12358	11860	9593	6110
7	0	0	0	150	548	875	1542	1757	2417	2927	3351	3637	3826	4128	4282	4257	4149	3658	3178	2429
8	6055	8030	8956	9724	10151	10763	11152	11423	12247	12869	13733	14086	14323	14585	14661	14472	13893	12225	10481	6493
9	0	0	345	1165	3121	3973	4484	4916	5767	6261	6404	6471	6703	7511	7965	7818	8120	9090	11225	11650
ALL	16378	22201	27769	38442	48263	58695	65479	69969	78511	85564	90942	95000	97510	101003	105035	106826	105543	100070	91993	68118

ADULT SILVER REDHORSE

TRANSECT																				
1	6771	8258	9204	9839	10294	10818	11341	11691	12112	12597	13200	13603	13940	14547	15185	15953	16148	16211	14996	13089
2	93	93	93	93	524	726	850	942	1017	1254	1360	1439	1507	1566	1931	3080	3493	6028	7714	10197
3	1944	3166	3667	3896	4046	4168	4269	4439	4708	5244	5531	5821	6064	6555	6896	7332	7195	5952	4026	1380
4	0	0	0	0	0	727	1870	2247	4856	11763	18773	25609	29719	33389	35119	35493	33516	23526	15939	8723
5	0	0	0	0	0	77	94	105	193	494	655	885	962	1336	1674	1934	2095	1434	1219	1069
6	0	0	0	241	290	565	860	949	1053	1246	1474	1482	1779	2818	3124	3551	3311	3400	3345	3434
7	0	0	0	0	0	0	0	0	0	26	175	442	918	1282	1473	1738	1766	1607	1371	1080
8	1638	2984	4077	4910	5980	6432	7035	7365	7889	8410	9159	9655	10427	11328	11639	12255	11548	8173	3949	1324
9	0	0	0	0	0	0	0	0	0	0	0	0	181	1143	1492	1417	1394	1442	1876	4538
ALL	10446	14501	17041	18979	21134	23513	26319	27738	31828	41034	50327	58936	65497	73964	78533	82753	80466	67773	54435	44834

YOY STRIPED JUMPROCK

TRANSECT																				
1	3516	2905	2974	3303	3495	3413	3306	3274	3621	4242	4285	4149	3723	3583	3330	2495	2208	1954	1839	1018
2	1952	1952	1952	1952	2999	3185	3204	3184	3157	3749	4179	4315	4369	4394	8593	9678	9294	7861	7910	6466
3	6012	6122	6057	5804	5361	5010	4621	4331	3613	3141	2788	2521	2156	1688	1473	898	570	144	73	23
4	30153	36072	33682	30990	28515	26186	24352	22836	20435	17978	15077	12469	10323	7061	6051	1279	832	0	187	320
5	1243	1551	1911	1950	1689	1379	1301	1546	1466	1257	956	908	817	736	684	494	344	129	84	85
6	1533	2583	2980	3269	2980	2772	2536	2349	2414	2216	2554	2370	2268	2178	1846	1957	1689	950	564	305
7	1368	1752	1948	1959	1947	1665	1515	1462	1332	1114	760	661	567	454	331	209	179	89	34	11
8	7261	8527	8591	8435	7953	7487	7100	6724	5891	4729	4156	3715	3317	2599	2073	1737	1306	1062	579	558
9	2974	2513	2576	2235	1890	2194	2085	1674	1406	2467	2859	2855	3498	5073	7089	8467	7710	7177	6090	5091
ALL	56012	63977	62671	59897	56829	53291	50020	47380	43335	40893	37614	33963	31038	27766	31470	27214	24132	19366	17360	13877

ADULT STRIPED JUMPROCK

TRANSECT																				
1	2152	2432	2431	2519	2548	2664	2694	2653	2026	2114	2247	2359	2440	2491	2320	2478	2459	2541	2341	1882
2	553	553	553	553	725	1012	1150	1255	1340	1415	1477	1532	1586	1730	2579	3820	4587	5594	5806	5721
3	3977	4907	5507	5928	6161	6388	6691	6933	7267	7504	7588	7474	7401	7218	7059	6531	5850	4105	3168	1415
4	7978	17704	22511	25376	27607	29656	31396	33034	35701	37946	39494	40200	40479	40050	39046	36201	32667	24863	18615	6405
5	528	1085	1512	1941	2499	2912	3212	3577	4046	4839	5353	5601	5761	5924	5989	5951	5760	4636	2976	1246
6	1677	2881	4303	5789	6882	7637	8021	8296	8975	10392	11118	12021	12471	12606	12604	12313	11478	10246	7915	4559
7	433	1184	1701	2063	2342	2512	2702	2824	3132	3477	3662	3785	3930	4043	4143	4016	3792	2917	2345	1623
8	6412	8298	9756	10679	11626	12279	12747	13009	13307	13521	13640	13719	13666	13397	12932	11751	10524	7667	5322	2352
9	2693	4025	4493	4742	5239	5769	6017	6161	6541	6813	6926	7471	8333	9140	10824	11859	11251	10439	10855	11500
ALL	26403	43069	52767	59590	65629	70829	74630	77742	82335	88021	91505	94162	96067	96599	97496	94920	88368	73008	59343	36703

YOY MARGINED MADTOM

TRANSECT																				
1	188	214	317	357	382	398	444	486	522	539	546	515	486	478	433	374	306	113	20	0
2	1117	1117	1117	1117	1330	1447	1442	1608	1646	1657	2067	2184	2200	2276	2948	3232	3051	2193	1386	234
3	2116	2570	2563	3301	3412	3497	3516	3452	3291	3226	3087	2941	2811	2508	2043	1457	980	303	19	0
4	40402	44077	44313	43740	42898	41978	41002	39953	37371	33790	29588	25171	20468	13094	7225	564	0	0	0	0
5	3641	5260	6222	7458	8226	8844	9335	9381	9188	8674	8080	7453	6774	5493	4376	2679	1822	259	0	0
6	6516	12115	13081	13001	13680	15127	15413	15282	16232	16028	15211	15346	14369	13287	11437	8908	7092	3899	2203	863
7	2756	3468	3726	3940	4107	4290	4282	4207	4014	3932	3659	3584	3504	3114	2673	1968	1482	936	615	79
8	8145	9462	9672	9277	9030	8614	8217	7896	7334	6285	5640	5184	4820	3953	3281	2059	1080	99	72	23
9	13700	16242	16950	16993	17102	17809	17394	18610	19570	20583	22243	22789	23099	22253	21290	17365	15040	11567	8677	4883
ALL	78581	94525	97961	99184	100167	102004	101045	100875	99168	94714	90121	85167	78531	66456	55706	38606	30853	19369	12992	6082

ADULT MARGINED MADTOM

TRANSECT																				
1	3145	3556	3837	3682	3683	3713	3794	3926	4012	4093	4102	4033	3841	3849	3758	3705	3558	2791	2101	1355
2	1444	1444	1444	1444	1828	2098	2240	2455	2572	2644	2694	3148	3313	3648	4839	6083	6420	6532	6370	6046
3	4331	5311	5667	6576	7060	7287	7355	7389	7538	7662	7703	7696	7619	7395	7114	6559	5944	4539	3640	1884
4	43641	47786	49397	50502	51304	51807	52097	51909	51111	49332	47323	45191	42987	38218	33437	27732	25030	20264	13472	5932
5	2842	5529	6667	7348	8375	9398	10154	10590	10706	10522	10204	9856	9468	8676	7911	6463	5435	3013	1575	1050
6	6948	14281	15922	16024	15819	17722	19463	20151	21013	22222	21956	21928	21425	20041	19329	16528	14469	10126	6581	4215
7	3173	4101	4547	4690	4988	5222	5480	5539	5498	5516	5400	5191	5318	5142	4816	4019	3312	2497	2097	1385
8	11265	13116	14355	14666	14811	14908	14918	14923	14772	14475	14270	14100	13912	13433	12794	11303	9937	7608	5741	2318
9	14544	16965	18788	19164	19131	18883	20152	20163	22091	23213	25849	26911	27594	27599	27136	22622	19159	16504	14825	10943
ALL	91333	112089	120624	124096	126999	131038	135653	137045	139313	139679	139501	138054	135477	128001	121134	105014	93264	73874	56402	35128

SPAWN REDBREAST SUNFISH

TRANSECT																				
1	9065	8936	8740	8542	8249	8562	8290	8212	7898	7583	8165	7281	7021	6696	6556	6163	5644	5197	5310	4321
2	3523	3523	3523	3523	3544	4654	4838	4920	4936	4954	4975	4986	5030	5966	8580	11434	13516	13215	12515	12266
3	6011	6238	6480	6774	6865	6870	7016	7139	6997	6774	6505	6239	5949	5285	4612	3721	3195	2173	1552	883
4	14791	31923	37439	38666	38882	38556	38023	37363	36071	33759	31324	29216	27517	25085	22519	19006	17044	13615	10835	6414
5	707	1124	1463	1780	2043	2275	2456	2608	2796	3136	3228	3189	3101	2857	2691	2469	2303	1839	1410	805
6	1246	2078	2976	3711	4156	4445	4450	4355	4425	5119	5319	5624	5649	5329	5184	4978	4572	3782	2845	1794
7	429	1192	1574	1858	2077	2127	2325	2339	2376	2340	2246	2152	2115	1995	1976	1802	1658	1328	1077	764
8	10168	10684	11562	11737	12348	12492	12483	12391	12066	11585	11068	10589	9939	8649	7782	6723	5733	4487	3741	2493
9	3830	4765	4512	4305	4390	4500	4310	4120	4071	4270	4169	4348	5167	5727	7276	10645	11918	11318	10924	10311
ALL	49770	70463	78269	80896	82554	84481	84191	83447	81636	79520	76999	73624	71488	67589	67176	66941	65583	56954	50209	40051

ADULT REDBREAST SUNFISH

TRANSECT																				
1	13137	13234	13185	13567	13793	13791	13859	13826	14211	14269	14159	14109	13996	14242	14061	14117	14141	12563	11552	8969
2	2263	2263	2263	2263	2580	2795	3712	3912	4034	4124	4196	4256	4368	4435	5524	6418	7592	10522	12189	12699
3	4757	5329	5542	5629	5792	5927	6293	6550	6704	6947	6976	7113	7128	6969	7267	6908	6507	4978	2661	1016
4	0	0	816	2451	3222	5908	8037	12929	20459	27680	30426	31665	32242	32289	31568	29638	26054	15026	12000	4681
5	0	0	161	259	297	391	678	756	982	1294	1547	1775	2085	2316	2496	2589	1970	1403	1229	984
6	0	344	749	1160	1309	1398	1543	1740	1903	2161	2800	3416	3563	3834	4204	3737	3675	3460	3310	2949
7	0	0	0	0	0	0	0	48	265	778	1236	1583	1742	1786	1781	1657	1579	1337	1041	758
8	4363	6911	8530	9550	9872	9988	10043	10067	10630	10976	11052	11296	11200	11773	11607	10806	9372	4639	1997	1223
9	0	0	0	0	0	0	0	0	255	572	1791	1980	1933	1753	1735	1508	1807	1804	4002	7999
ALL	24520	28081	31246	34879	36865	40198	44165	49828	59443	68801	74183	77193	78257	79397	80243	77378	72697	55732	49981	41278

YOY REDEYE BASS

TRANSECT																				
1	11465	11086	10922	11412	11397	11274	11136	10997	11631	11911	11674	11367	11074	10582	10116	9228	8581	7678	6774	5357
2	4869	4869	4869	4869	6602	6616	6543	6479	6487	7652	7839	7932	7986	8836	11701	13574	13334	12509	12541	11159
3	8045	8511	8690	8548	9232	9327	9300	9143	8838	8468	8067	7664	7277	6561	6011	5120	4342	2985	2329	997
4	42335	49111	49000	48448	47617	46728	46038	45168	43438	41254	39030	36850	34708	30902	27327	22198	19023	12695	8182	5064
5	1765	2982	3571	4217	4444	4836	5449	5565	5969	5792	5534	5270	4983	4502	4153	3534	3126	1723	1014	713
6	4435	8215	10654	10975	10691	10336	10757	12401	13222	14282	14103	13426	13031	11770	10626	9903	8830	5804	3780	2769
7	2223	3186	3563	3744	3729	3764	3868	3870	3880	3667	3628	3532	3410	3510	3261	2689	2304	1680	1310	828
8	14550	15725	16707	16864	16589	16159	15721	15297	14477	13765	12993	12261	11689	10520	9489	7774	6502	4840	3407	1688
9	10836	12255	12206	11702	11888	11367	10858	10432	11200	11699	11944	13522	14200	16405	17446	16654	15604	14377	13321	11796
ALL	100523	115940	120182	120779	122189	120407	119670	119352	119142	118490	114812	111824	108358	103588	100130	90674	81646	64291	52658	40371

JUVENILE REDEYE BASS

TRANSECT																				
1	14045	14349	14467	14878	14904	14875	14815	14872	14746	15141	15074	14946	14805	15519	15514	15062	14308	12600	11330	9841
2	3944	3944	3944	3944	4205	4412	4473	4512	5138	5596	5778	5887	5967	6030	6313	10038	11706	13786	13867	14287
3	6745	7533	8435	8678	9185	9340	9671	9867	10077	10178	10949	11092	11139	11120	10985	10562	9777	7956	5711	2273
4	2590	7084	18143	28330	36545	40198	42259	43674	45420	46477	46941	47237	47052	46224	45066	42106	39064	27004	16878	9993
5	291	834	1024	1579	1744	2043	2503	2998	3311	4352	4949	5324	5718	6284	6083	5647	4535	2410	1859	1515
6	1283	1576	2514	3264	4596	5448	7071	8132	9438	10753	10557	10898	10498	11817	12902	12589	11259	7533	6471	5080
7	0	33	357	947	1838	2151	2681	2977	3484	3910	4053	4134	4247	4203	3982	3402	3326	2768	2139	1470
8	11345	12042	12886	13243	13952	14331	15014	15204	16123	16642	16859	16944	16968	16856	16725	15784	14441	10386	5776	2186
9	0	1126	4481	5954	6691	7523	7964	8063	8008	7743	6943	7162	7045	6215	5640	5851	7789	12483	13264	12001
ALL	40243	48521	66251	80817	93660	100321	106451	110299	115745	120792	122103	123624	123439	124268	123210	121041	116205	96926	77295	58646

ADULT REDEYE BASS

TRANSECT																				
1	7763	9100	10099	11026	11585	12080	12455	12735	13474	13919	14209	14486	14619	15385	15521	16104	16415	15816	14793	12683
2	729	729	729	729	904	1314	1576	1731	1823	1901	1970	2066	2130	2186	3220	4020	5926	8939	10929	12091
3	4360	5262	5723	6114	6437	7000	7515	7956	8210	8806	9220	9524	9672	9709	10525	10313	9757	7992	6668	4434
4	0	0	968	2995	5938	7779	17368	21593	36044	43919	45780	46288	46463	46229	45627	43504	40491	34281	28922	15651
5	0	0	145	185	293	692	839	907	1393	1594	1974	2592	2901	3529	4262	4840	4781	4022	2987	1746
6	0	462	933	1430	1511	1532	1807	2286	2497	3622	5460	7098	8182	9143	8840	8448	9706	9857	8307	5719
7	0	0	0	0	0	0	54	95	717	1806	2301	2624	2896	3307	3350	3481	3233	3002	2515	1955
8	5196	8238	9807	10909	11384	11589	11683	12297	12670	13688	14692	15059	15445	16373	16163	15152	14087	11382	9225	4942
9	0	0	0	0	0	0	0	339	1088	3936	5011	5377	5587	5549	4805	4784	4701	5013	8827	12824
ALL	18048	23791	28404	33388	38052	41986	53297	59939	77916	93191	100617	105114	107895	111410	112313	110646	109097	100304	93173	72045

SPAWN WALLEYE (Bechtel 1986)

TRANSECT																				
1	269	287	278	151	174	188	196	203	215	324	359	373	382	475	515	534	449	471	426	165
2	425	425	425	425	574	696	776	849	906	1097	1191	1245	1285	1317	1451	2234	2967	3521	3651	2759
3	1433	1687	1955	2078	2220	2356	2435	2680	2848	2908	3364	3673	3786	3921	3836	3756	3581	2846	1863	575
4	260	2511	11910	19257	28805	34734	38544	41613	47113	52396	56041	57982	58575	57994	55614	46666	37088	11127	0	0
5	73	325	697	991	1230	1418	1761	2410	3428	4216	5600	6657	7625	9123	9984	10412	10067	7076	4208	82
6	173	335	672	1210	1893	2680	3996	6081	8582	10147	11030	11530	12750	15230	15665	17267	17472	14521	11047	5334
7	0	0	91	395	949	1488	1793	2045	2524	3077	3451	3817	4041	4571	4658	4526	4373	3216	2132	1197
8	4322	5448	6642	7759	8923	9688	10565	11083	11748	12916	13232	12818	12624	12120	11343	9085	7257	4995	2855	182
9	0	542	2305	4703	5790	6765	7979	8864	9677	10132	10797	11071	12655	13750	14059	15801	16516	17489	17552	16083
ALL	6955	11560	24975	36969	50558	60013	68045	75828	87041	97213	105065	109166	113723	118501	117125	110281	99770	65262	43734	26377

TABLE G-2 WEIGHTED USABLE AREA (WUA) VALUES FOR ALL SPECIES LIFE STAGES FOR EACH TRANSECT AND TRANSECTS COMBINED (ALL) IN THE OCMULGEE RIVER. TRANSECTS O-9 THROUGH O-95 ARE NUMBERED SEQUENTIALLY

	Simulated Discharge (CFS)																			
	50	75	100	125	150	175	200	250	300	350	400	450	600	800	1000	1300	1500	2000	2500	3500
YOY STRIPED JUMPROCK																				
TRANSECT																				
1	2113	2231	2211	2337	2313	2305	2191	1891	1809	2141	1955	1516	831	744	463	395	364	276	275	193
2	3347	3657	3779	4003	4179	4489	4506	4087	3941	3644	3517	3414	2717	1910	1543	1346	1212	1039	769	445
3	7404	7845	7342	7400	7126	6734	6320	5156	4446	5590	5478	5033	4552	3254	2396	1373	1189	532	272	233
4	1675	1480	1622	1476	1210	1069	582	756	996	1017	1209	1316	1785	1690	1451	1754	1721	2600	2465	2425
5	16562	16027	15474	15064	14640	14298	13940	13313	12569	11850	11042	10265	8085	4739	2572	1604	1170	657	428	217
6	412	410	410	396	377	368	359	340	322	311	298	312	267	262	250	201	124	42	86	80
7	1877	1767	2231	2461	2555	2523	2903	3069	3006	2803	2565	2276	1990	1629	1358	854	725	390	303	238
8	3396	3471	4178	4650	5548	5763	6062	6641	6339	5896	5434	4976	3891	3016	1891	902	601	343	93	48
9	14080	14629	14729	15073	14701	14318	13785	12890	11869	10633	9506	8397	5931	4579	3534	2968	2406	1884	1523	699
10	2737	2801	2966	2892	2682	2638	2603	2376	1942	1630	1150	1005	472	158	152	82	86	83	32	143
11	2432	2294	1879	1451	1277	1429	1470	953	938	815	853	842	524	218	46	61	102	104	145	66
ALL	56035	56612	56821	57203	56608	55934	54721	51472	48177	46330	43007	39352	31045	22199	15656	11540	9700	7950	6391	4787
ADULT STRIPED JUMPROCK																				
TRANSECT																				
1	2098	2438	2882	3175	3518	3733	4095	4403	4571	4746	5126	5388	5613	5490	5615	5207	4907	3961	3069	904
2	1192	1664	2171	2522	2771	2955	3289	3819	4366	4743	5116	5392	6075	6556	6796	6913	6911	6660	6191	4692
3	5358	6377	6739	7046	7331	7561	7562	7596	7801	7356	7835	7513	7514	7803	6769	6292	5798	4337	2811	1161
4	288	303	330	342	349	346	347	345	340	241	250	254	281	314	299	389	436	505	698	864
5	7739	9423	10652	11634	12440	13117	13695	14649	15440	16112	16532	16773	16830	16338	15649	14338	13387	11110	9313	5852
6	39	47	53	56	60	64	67	73	79	83	85	87	96	101	106	108	107	103	78	80
7	3084	2956	3056	3111	3346	3355	3416	3561	3530	3481	3127	3157	2900	2711	2529	2521	2501	2362	2091	1530
8	1658	2083	2348	2645	3054	3419	3889	4358	5086	5514	5833	6094	6681	7077	7351	6970	6718	5934	4990	2936
9	8066	9840	11804	12959	14408	15517	16395	17677	18778	19534	20034	20812	21667	22378	22137	21295	20525	18047	15903	10789
10	2086	2507	2886	3384	3700	3956	4218	4709	5064	5233	5366	5418	5391	4999	4556	3749	3215	2095	1156	160
11	1932	2247	2313	2305	2283	2293	2320	2209	1891	1660	1564	1576	1096	949	711	383	223	101	56	80
ALL	33540	39885	45234	49179	53260	56316	59293	63399	66946	68703	70868	72464	74144	74716	72518	68165	64728	55215	46356	29048
ADULT SILVER REDHORSE																				
TRANSECT																				
1	111	288	443	660	876	1068	1222	1502	1885	2016	2095	2145	2545	3062	3042	3198	3089	1928	1351	1000
2	0	0	0	0	0	0	0	0	0	0	0	0	230	1224	1906	2644	2981	2937	2764	2148
3	10880	13216	14311	14856	15814	16231	16497	17332	18582	19154	19606	20001	20977	22070	23040	23309	22808	20623	16654	8048
4	19175	21123	22621	23844	24810	25618	26323	27383	28095	28705	29228	29712	28340	29411	24486	23517	23874	22682	19720	16864
5	319	1982	3103	4679	5786	6416	7206	8292	9285	9833	10511	10966	12397	13520	14188	14438	14165	12837	10255	4455
6	3770	4104	4353	4557	4729	4878	5008	5222	5394	5526	5634	5717	5874	5962	6031	6128	6185	6328	6451	6651
7	5124	5650	5934	6058	6134	6193	6241	6328	6408	6487	6568	6651	7288	7760	8330	8749	8903	8484	7608	5137
8	535	617	866	955	1009	1219	1291	1535	1629	1701	1759	1813	2233	2810	3914	4932	5182	5010	4173	2755
9	496	594	775	1117	1505	2008	2831	3797	4840	5352	6239	6622	8363	10679	11342	11372	11033	9289	7421	4884
10	218	388	518	616	658	872	1164	1656	2002	2355	2699	2878	3628	4263	4405	3998	3282	2127	1610	909
11	1715	2533	3303	3622	3840	4142	4383	4649	4816	4912	5236	5590	5935	6174	6028	5451	4978	3798	1967	778
ALL	42343	50495	56227	60964	65161	68645	72166	77696	82936	86041	89575	92095	97810	106935	106712	107736	106480	96043	79974	53629

TABLE G-2 (Cont.)

YOY REDEYE BASS

TRANSECT																				
1	2703	3143	3280	3485	3845	3845	3763	3524	3664	4155	4203	4038	3618	3635	3121	2627	2467	1868	1181	707
2	3854	4229	4767	5139	5555	6092	6242	6592	6608	6661	6699	6603	6164	5659	5212	4671	4390	3500	2845	1906
3	13685	14688	14433	14247	13915	13476	12957	12060	11976	12210	11697	10956	10223	8781	7494	6117	5241	3951	3129	1424
4	4803	4504	4085	3744	3561	3364	3138	2965	2930	2854	2929	2905	3036	2766	2606	2765	2418	2867	2718	2706
5	18039	18086	17946	17794	17669	17585	17403	17686	17315	16783	16232	15687	14108	12210	10725	9019	8029	6202	4976	3145
6	1053	984	902	863	801	790	781	760	740	718	686	630	605	556	434	406	389	358	351	205
7	5616	5603	5948	5963	5910	6333	6502	6574	6492	6345	6199	6057	5642	5099	4622	4024	3725	3040	2534	1900
8	3640	3980	4841	5573	5887	6146	6660	6951	6933	6801	6646	6488	5997	5588	4960	4118	3596	2799	2098	1146
9	15525	16831	18034	18977	18853	18907	19073	18675	18642	18147	17734	17065	16055	14567	13449	11444	10406	8324	6512	4019
10	3643	4066	4540	4497	4708	4734	5026	4989	4742	4600	4353	4097	3470	2899	2496	2009	1747	1021	700	523
11	4590	4467	4256	3904	3942	4139	4022	3637	3569	3275	3317	3148	2523	1924	1494	1128	996	614	367	172
ALL	77151	80581	83032	84186	84646	85411	85567	84413	83611	82549	80695	77674	71441	63684	56613	48328	43404	34544	27411	17853

JUVENILE REDEYE BASS

TRANSECT																				
1	1870	2394	2955	3098	3175	3533	3793	4152	4441	4900	5005	5045	5476	5942	5680	5489	5104	2949	1860	1293
2	0	137	171	887	1615	2015	2232	2994	3477	3970	4343	4868	5761	6783	7125	7146	6863	5447	4521	3436
3	16045	17763	18249	19388	19490	19307	18897	18303	18203	17900	17531	16847	16687	16088	16025	14822	13897	11401	8539	3066
4	8619	8110	7290	6661	6567	6352	5949	5319	5194	5071	4940	4945	4773	4469	4392	3965	3164	3023	2180	2498
5	14842	16106	17194	17600	18480	18846	19043	19278	19399	19434	19451	19530	19992	20129	19973	19334	18600	16141	13158	6561
6	1728	1636	1552	1494	1365	1352	1335	1296	1250	1201	1136	924	884	815	626	616	605	576	536	299
7	7976	7859	7749	7739	7962	8226	8260	8248	8732	8797	8796	9070	9398	9427	9295	8934	8659	7860	6985	5019
8	3206	3340	3412	3446	3466	4003	4145	4496	5306	6090	6556	6799	8077	8414	8462	8452	8191	7218	5664	3700
9	7864	9648	11067	12966	13743	14504	16177	17276	18565	20252	20901	21772	22327	22571	22277	21041	19897	16427	13511	8500
10	1599	2201	2745	3218	3414	3740	4080	4540	4960	5356	5772	5928	6034	5727	5304	4664	3813	2397	1804	1075
11	4112	4338	4669	4761	4857	4871	4830	5050	5360	5315	5363	5301	5258	4745	4229	3465	3025	1708	651	175
ALL	67861	73532	77053	81258	84134	86749	88741	90952	94887	98286	99794	101029	104667	105110	103388	97928	91818	75147	59409	35622

ADULT REDEYE BASS

TRANSECT																				
1	668	1282	1482	1962	2130	2611	2838	2938	2942	3469	3618	3862	4445	4339	4901	4818	4569	4469	4008	2266
2	0	0	0	0	0	0	0	0	165	447	1406	1950	2973	4071	5053	5500	5804	5890	5597	4292
3	13109	14315	15779	16734	17473	18249	20032	20901	21040	21008	20927	20828	20759	21179	20856	19660	18682	15447	12760	8223
4	5131	4999	4393	4542	4650	4739	4805	4913	4773	4822	4837	4747	4426	4463	4372	3903	3943	3484	3690	3809
5	4987	7980	9703	11025	12709	13517	14091	15409	16079	17175	17634	17885	18261	18558	18566	18531	17852	15733	13729	10288
6	2651	2813	2923	3007	3068	3115	3171	3241	3261	3237	3147	3020	2895	2316	2092	1859	1808	1450	1121	1023
7	6260	6795	7134	7354	7523	7651	7738	7820	7898	8302	8618	8712	9188	9312	9871	9780	9504	8660	7795	6327
8	1492	1715	2152	2535	2691	2799	2875	2984	3057	3117	3772	3937	5168	6543	7603	7585	7383	6811	6095	4414
9	1813	2785	5006	6279	7634	8361	9083	10088	11308	12764	13717	15222	17034	18326	18680	17775	17403	16194	14909	12091
10	751	936	1113	1783	2249	2510	2935	3499	3769	4090	4614	5013	5668	5931	5610	5112	4841	4251	3480	1865
11	3091	4175	4403	4495	4920	5007	5082	5181	5270	5806	5869	5807	5722	5654	5195	4493	4050	3180	2626	1530
ALL	39953	47795	54088	59716	65047	68559	72650	76974	79562	84237	88159	90983	96539	100692	102799	99016	95839	85569	75810	56128

TABLE G-2 (Cont.)

SPAWN REDBREAST SUNFISH

TRANSECT																				
1	1681	1704	1859	1875	1985	2103	2333	2360	2249	2166	2314	2399	2325	2195	2244	2013	1907	1622	1444	1049
2	2019	2553	3041	3300	3461	3515	3817	4204	4557	4642	4677	4644	4431	4100	3831	3466	3253	2910	2712	2253
3	10693	11365	11397	11061	11114	10942	10224	9696	9015	8764	9275	9201	7798	7126	5991	4630	3972	2938	2187	1444
4	3913	3467	3095	3187	3173	3097	3008	2821	2996	3041	2968	2799	2490	2817	2516	2460	2614	2611	3660	4032
5	14284	15013	15064	15031	14961	14885	14799	14791	14694	15057	15018	14874	14070	12460	10894	9187	8350	6648	5483	3956
6	430	461	469	470	468	468	468	468	465	461	456	452	479	484	483	470	454	419	416	321
7	4613	4984	5103	5046	5194	4908	4877	5110	5346	5293	5309	5225	4806	3965	3482	2857	2380	1951	1742	1311
8	2315	2728	2878	3160	3620	3993	4524	4848	5582	5802	5878	5886	5632	5014	4459	3638	3155	2410	1927	1305
9	9540	10414	12188	12779	13632	14078	14256	14240	13848	13192	12497	12261	11076	10101	9231	8366	7917	6983	6003	4635
10	2997	3277	3437	4016	4162	4157	4264	4520	4507	4244	4162	3947	3389	2790	2588	2195	1944	1497	1092	502
11	4240	4500	4382	4385	4251	4336	4489	4248	3825	3491	2961	2775	2101	1143	829	548	408	250	175	211
ALL	56725	60466	62913	64310	66021	66482	67059	67306	67084	66153	65515	64463	58597	52195	46548	39830	36354	30239	26841	21019

ADULT REDBREAST SUNFISH

TRANSECT																				
1	480	816	1070	1341	1552	1716	2030	2181	2229	2417	2597	2625	3103	3087	3152	2732	2085	1277	1038	775
2	0	0	0	0	0	0	0	0	58	87	436	802	1395	1907	2544	2642	2723	2497	2178	1481
3	15136	15613	15570	16428	16510	16916	18053	18454	18299	18081	17778	17473	16540	15717	14927	13533	13144	10459	5467	2229
4	12880	12381	11892	11368	9974	9553	9393	9203	8975	8746	8522	8281	7650	6923	6400	6074	5790	4898	4567	3846
5	4979	7890	9129	10456	11335	12164	12551	13284	13592	14008	14211	14242	14068	13519	12897	12481	11927	9756	6584	2567
6	4367	4252	4166	4100	4045	3997	3949	3977	3928	3868	3807	3747	3550	3166	2870	2279	2029	1654	1485	1049
7	7172	7158	7137	7111	7064	7005	6932	6755	6588	6544	6917	6946	6778	6983	7109	7029	6823	6149	5078	2970
8	1477	1623	1957	2255	2405	2490	2537	2595	2626	2626	2832	3070	3525	4746	5396	5441	5287	4389	3274	1765
9	1195	2133	3225	4245	5353	6051	6490	7447	7763	8505	9411	9854	11417	12267	12304	11140	10048	7961	5940	4599
10	391	561	633	994	1168	1483	1583	1977	2153	2389	2583	2805	3206	3376	2978	2112	1905	1381	915	469
11	2459	3753	4083	4137	4369	4426	4409	4394	4273	4563	4655	4601	4469	4275	3835	3220	2812	1140	628	326
ALL	50536	56180	58862	62435	63775	65801	67927	70267	70484	71834	73749	74446	75701	75966	74412	68683	64573	51561	37154	22076

YOY SHOAL BASS

TRANSECT																				
1	2321	2247	2508	2604	2614	2856	2796	2556	2426	2469	2528	2494	2015	1215	838	598	500	369	340	249
2	2617	3084	3227	3431	3680	3878	4174	4393	4396	4393	4235	3909	3666	3077	2528	1908	1585	1382	1134	821
3	9335	10092	9586	9400	9054	8582	7714	6972	6188	6566	6570	6210	5482	4554	3697	2109	1820	882	496	413
4	2202	2001	2417	2326	2226	2054	1697	1581	1881	1783	1605	1792	1928	2011	1959	2409	2395	2926	3117	3192
5	18143	18110	17925	17630	17199	16721	16215	15078	14408	13460	12659	11886	9946	8120	6640	4434	3147	1492	851	495
6	440	444	449	450	449	445	441	432	428	416	401	394	426	393	359	325	269	221	228	86
7	3585	3945	3689	3998	3640	3587	3473	3611	3467	3368	3106	2895	2572	2180	1906	1572	1280	917	600	290
8	3526	3987	4437	5209	5837	6310	6420	7044	7030	6800	6472	6137	5082	4318	3627	2101	1612	790	477	121
9	13812	14955	14981	15494	15742	15324	15088	14377	13562	13221	12710	11880	9946	7097	5605	4815	4077	3003	2256	1644
10	2551	2593	2907	2964	2912	2958	2930	2957	2719	2464	2228	2011	1119	760	349	118	90	90	54	124
11	2602	2531	2339	2094	1809	1822	1829	1471	1382	1190	1125	987	722	461	263	58	46	113	150	107
ALL	61134	63989	64465	65600	65162	64537	62777	60472	57887	56130	53639	50595	42904	34186	27771	20447	16821	12185	9703	7542

ADULT SHOAL BASS

TRANSECT																				
1	0	189	459	647	835	1049	1110	1546	1762	2110	2215	2244	2489	2678	2865	2316	2082	1167	1037	945
2	0	0	0	0	0	0	0	0	0	0	0	0	0	452	1316	1814	2122	2711	2409	1757
3	11313	12471	14413	14989	15337	16504	16937	17974	19419	20307	21205	21567	22075	21340	19035	17425	16176	13512	8995	4599
4	13365	14376	15037	15479	15749	15846	15527	15633	14841	14144	14221	13794	13530	13258	12353	11704	11830	11867	11009	10424
5	412	662	2782	3917	5529	7232	8526	9948	11873	13755	15052	15847	17527	18385	17168	15110	14007	11752	8771	4212
6	3187	3489	3696	3852	3985	4097	4189	4347	4472	4565	4643	4748	4890	4975	5018	5043	5053	5035	4943	4627
7	5975	6606	6958	7153	7291	7417	7518	7670	7784	7863	7908	7940	7962	8113	7513	7008	6440	6094	5205	3241
8	851	1126	1253	1520	1848	1969	2057	2481	2943	3130	3270	3358	3532	4014	4477	5162	5352	4725	3400	1961
9	385	803	936	1022	1309	1842	2413	3779	5290	6144	7128	7439	8966	9843	10945	10409	9544	7577	5602	3982
10	188	272	406	579	726	789	916	1412	1852	2185	2491	2677	2997	3466	3509	2411	2093	1600	1164	746
11	1834	2291	3231	3771	3983	4075	4308	4414	4454	4268	4255	4459	4355	4134	3714	3169	2855	1361	878	583
ALL	37510	42285	49171	52929	56592	60820	63501	69204	74690	78471	82388	84073	88323	90658	87913	81571	77554	67401	53413	37077

YOY ALTAMAHA SHINER

TRANSECT																				
1	1053	1385	1702	2108	2200	2213	2188	2574	2659	2934	3043	3190	3095	3135	2878	1765	1265	990	767	567
2	0	0	0	0	109	124	419	1287	1782	2114	2490	2681	3206	3798	3757	3703	3576	2924	2005	1774
3	7100	7986	8486	9309	10134	10432	10098	9889	9297	9056	8992	8685	7103	6945	6194	5888	5118	2807	1880	701
4	839	819	626	647	657	710	741	764	767	757	732	700	584	639	666	647	681	869	994	1435
5	8672	11421	13253	14276	15453	16006	16654	17507	17865	18080	18107	18015	16993	15343	14015	12522	11121	7458	4185	1832
6	53	59	65	98	118	130	138	149	158	165	171	175	182	190	192	211	208	201	190	126
7	5073	5006	4943	4805	4577	4168	4117	4430	4370	4163	4511	4484	4032	3616	3143	2626	2392	2026	1412	766
8	2055	2644	2874	2995	3059	3101	3137	3681	3925	4248	4810	5340	6339	6714	6245	5611	5272	3322	2497	1039
9	4764	7121	8278	9444	9839	10703	11730	12197	13722	13988	14205	14694	14947	14609	13138	10855	9454	6233	5529	3968
10	880	1474	1805	2078	2423	2619	2666	2941	3273	3506	3588	3718	3921	3048	2015	1525	1102	322	169	141
11	2835	3169	3152	3315	3224	3182	3050	2701	2889	2607	2226	1990	1656	1098	842	566	362	93	67	89
ALL	33324	41084	45184	49075	51793	53388	54938	58120	60707	61618	62875	63672	62058	59135	53085	45919	40551	27245	19695	12438

ADULT ALTAMAHA SHINER

TRANSECT																				
1	1738	2266	2876	2967	2985	2972	3516	3585	3946	4275	4306	4164	4020	4413	3911	3797	3395	2535	2034	1088
2	0	85	202	420	1255	1825	2133	2478	3129	3322	3683	3931	4905	5313	5468	5347	5133	4573	4026	3187
3	4787	6250	6718	7958	8047	8136	7829	7548	7636	7438	6703	6405	7054	6717	6829	5620	5058	3396	2299	1083
4	385	299	307	300	328	342	348	349	331	300	202	236	251	220	164	171	172	159	153	81
5	8719	10625	12119	13020	13801	14411	14772	15077	15184	15244	15162	15028	14376	13975	13159	11501	10369	7959	6341	3904
6	34	37	69	76	81	84	88	95	100	101	102	104	108	111	109	101	99	95	72	52
7	3280	3248	3051	3037	3073	3283	3262	3167	3530	3608	3488	3107	3367	2964	2804	2519	2354	1951	1591	1025
8	1923	2140	2282	2415	2524	2860	3290	3462	4028	4883	5746	6001	7246	7427	7088	6448	5953	4616	3622	2171
9	7205	8880	9836	11437	13213	13725	14602	16729	17254	18616	19516	19485	19655	18641	17738	16376	15294	13274	11778	8874
10	1417	1951	2481	2860	3021	3065	3378	3819	4087	4180	4271	4482	4209	3599	3022	2283	1914	1183	754	246
11	2139	2204	2299	2256	2242	2187	2073	2101	2009	1719	1585	1516	1132	892	605	354	187	74	16	11
ALL	31627	37985	42240	46746	50570	52890	55291	58410	61234	63686	64764	64459	66323	64272	60897	54517	49928	39815	32686	21722

APPENDIX H

HABITAT DURATION TABLES FOR EACH TARGET SPECIES
LIFE STAGE IN THE TUGALO AND OCMULGEE RIVER STUDY AREAS
BASED ON ANALYSIS OF REGULATED AND UNREGULATED STREAM FLOWS.
TABLE ENTRIES ARE PERCENT MAXIMUM WEIGHTED USABLE AREAS (PMWUA)
VALUES THAT ARE REACHED OR EXCEEDED FOR SPECIFIED
PERCENTAGES OF TIME.

TABLE H-1 HABITAT DURATION TABLES FOR EACH SPECIES LIFE STAGE IN THE TUGALO RIVER STUDY AREA BASED ON ANALYSIS OF HOURLY REGULATED FLOWS AT YONAH DAM FOR THE PERIOD OF RECORD 1978 TO 1986

BLUEHEAD CHUB SPAWN

Percent of Time Reached Or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	3.9	3.9	3.9	3.9	3.9	3.9
95	3.9	8.1	8.1	8.1	8.1	8.1
90	8.1	8.1	8.5	8.1	11.0	9.2
85	8.1	8.1	12.1	11.4	12.1	12.1
80	8.1	11.4	12.1	12.1	16.6	12.1
75	9.2	12.1	16.6	13.3	26.2	16.6
70	12.1	16.6	26.2	22.0	95.6	26.2
65	12.1	26.2	80.7	37.9	95.6	80.7
60	18.9	95.6	95.6	95.6	95.6	95.6
55	37.9	95.6	95.6	95.6	95.6	95.6
50	95.6	95.6	95.6	95.6	95.6	95.6
45	95.6	95.6	95.6	95.6	95.6	95.6
40	95.6	95.6	95.6	95.6	95.6	95.6
35	95.6	95.6	95.6	95.6	95.6	95.6
30	95.6	95.6	95.6	95.6	95.6	95.6
25	95.6	95.6	95.6	95.6	95.6	95.6
20	95.6	95.6	95.6	95.6	95.6	95.6
15	95.6	95.6	95.6	95.6	95.6	95.6
10	95.6	95.6	95.6	95.6	95.6	95.6
5	95.6	95.6	95.6	95.6	95.6	95.6
1	95.6	95.6	95.6	95.6	95.6	95.6

BLUEHEAD CHUB YOY

Percent of Time Reached Or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	7.5	7.5	7.5	7.5	7.5	7.5
95	8.7	8.9	8.9	8.9	8.9	8.9
90	8.9	8.9	11.2	10.7	16.1	13.2
85	8.9	11.1	19.2	17.2	19.2	19.2
80	8.9	17.2	19.2	19.2	30.0	19.2
75	13.2	19.2	30.0	22.0	38.1	30.0
70	19.2	30.0	38.1	35.4	97.2	38.1
65	19.2	38.1	66.8	54.7	97.2	66.8
60	33.2	97.2	97.2	97.2	97.2	97.2
55	54.7	97.2	97.2	97.2	97.2	97.2
50	97.2	97.2	97.2	97.2	97.2	97.2
45	97.2	97.2	97.2	97.2	97.2	97.2
40	97.2	97.2	97.2	97.2	97.2	97.2
35	97.2	97.2	97.2	97.2	97.2	97.2
30	97.2	97.2	97.2	97.2	97.2	97.2
25	97.2	97.2	97.2	97.2	97.2	97.2
20	97.2	97.2	97.2	97.2	97.2	97.2
15	97.2	97.2	97.2	97.2	97.2	97.2
10	97.2	97.2	97.2	97.2	97.2	97.2
5	97.2	97.2	97.2	97.2	97.2	97.2
1	97.2	97.2	97.2	97.2	97.2	97.2

MARGINED MADTOM YOY

Percent of Time Reached Or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	1.2	1.2	1.2	1.2	1.2	1.2
95	1.2	4.1	4.1	4.1	4.1	4.1
90	4.1	4.1	4.7	4.1	6.9	5.3
85	4.1	4.1	9.1	7.9	9.1	9.1
80	4.1	7.9	9.1	9.1	13.8	9.1
75	5.3	9.1	13.8	10.5	23.1	13.8
70	9.1	13.8	23.1	19.3	98.8	23.1
65	9.1	23.1	65.8	34.3	98.8	65.8
60	16.2	98.8	98.8	98.8	98.8	98.8
55	34.3	98.8	98.8	98.8	98.8	98.8
50	98.8	98.8	98.8	98.8	98.8	98.8
45	98.8	98.8	98.8	98.8	98.8	98.8
40	98.8	98.8	98.8	98.8	98.8	98.8
35	98.8	98.8	98.8	98.8	98.8	98.8
30	98.8	98.8	98.8	98.8	98.8	98.8
25	98.8	98.8	98.8	98.8	98.8	98.8
20	98.8	98.8	98.8	98.8	98.8	98.8
15	98.8	98.8	98.8	98.8	98.8	98.8
10	98.8	98.8	98.8	98.8	98.8	98.8
5	98.8	98.8	98.8	98.8	98.8	98.8
1	98.8	98.8	98.8	98.8	98.8	98.8

TABLE H-1 (Cont.)

MARGINED MADTOM ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
95	18.7	17.7	16.3	16.3	16.3	22.1	22.1	22.1	22.1	22.1	22.1	17.7
90	22.1	22.1	19.7	17.7	22.1	22.1	23.1	22.1	22.1	24.1	22.1	22.1
85	22.1	22.1	22.1	22.1	22.1	22.1	31.6	28.7	28.7	31.6	24.1	22.1
80	22.1	22.1	22.1	22.1	22.1	28.7	31.6	31.6	31.6	31.6	31.6	22.1
75	24.1	22.1	22.1	22.1	24.1	31.6	43.8	34.9	34.9	43.8	31.6	24.1
70	26.3	24.1	24.1	25.0	31.6	43.8	58.5	53.7	53.7	58.5	34.9	31.6
65	31.6	31.6	31.6	31.6	31.6	58.5	92.0	71.4	71.4	92.0	43.8	31.6
60	43.8	31.6	31.6	34.9	49.0	92.6	92.6	92.6	92.6	92.6	58.5	34.9
55	58.5	49.0	49.0	53.7	71.4	92.6	92.6	92.6	92.6	92.6	64.5	43.8
50	81.4	58.5	58.5	92.0	92.6	92.6	92.6	92.6	92.6	92.6	92.6	58.5
45	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	71.4
40	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6
35	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6
30	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6
25	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6
20	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6
15	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6
10	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6
5	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6
1	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6	92.6

NORTHERN HOG SUCKER YOY

Percent of Time Reached Or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	2.5	2.5	2.5	2.5	2.5	2.5
95	3.4	3.9	3.9	3.9	3.9	3.9
90	3.9	3.9	5.7	3.9	9.6	7.4
85	3.9	3.9	13.6	11.5	13.6	13.6
80	3.9	11.5	13.6	13.6	18.0	13.6
75	7.4	13.6	18.0	15.6	28.2	18.0
70	13.6	18.0	28.2	23.2	95.3	28.2
65	13.6	28.2	43.6	39.5	95.3	43.6
60	19.8	95.3	95.3	95.3	95.3	95.3
55	39.5	95.3	95.3	95.3	95.3	95.3
50	95.3	95.3	95.3	95.3	95.3	95.3
45	95.3	95.3	95.3	95.3	95.3	95.3
40	95.3	95.3	95.3	95.3	95.3	95.3
35	95.3	95.3	95.3	95.3	95.3	95.3
30	95.3	95.3	95.3	95.3	95.3	95.3
25	95.3	95.3	95.3	95.3	95.3	95.3
20	95.3	95.3	95.3	95.3	95.3	95.3
15	95.3	95.3	95.3	95.3	95.3	95.3
10	95.3	95.3	95.3	95.3	95.3	95.3
5	95.3	95.3	95.3	95.3	95.3	95.3
1	95.3	95.3	95.3	95.3	95.3	95.3

NORTHERN HOG SUCKER JUVENILE

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8
95	27.1	25.7	24.8	24.8	24.8	33.6	33.6	33.6	33.6	33.6	33.6	25.7
90	33.6	33.6	29.3	25.7	33.6	33.6	35.9	33.6	33.6	37.8	33.6	33.6
85	33.6	33.6	33.6	33.6	33.6	33.6	47.6	43.4	43.4	47.6	37.8	33.6
80	33.6	33.6	33.6	33.6	33.6	43.4	47.6	47.6	47.6	47.6	47.6	33.6
75	37.8	33.6	33.6	33.6	37.8	47.6	56.8	52.9	52.9	56.8	47.6	37.8
70	40.6	37.8	37.8	39.0	47.6	56.8	56.8	56.8	56.8	56.8	52.9	47.6
65	47.6	47.6	47.6	47.6	47.6	56.8	56.8	56.8	56.8	56.8	56.8	47.6
60	56.8	47.6	47.6	52.9	56.8	56.8	56.8	56.8	56.8	56.8	56.8	52.9
55	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8
50	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8
45	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8
40	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8
35	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8
30	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8
25	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8
20	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8
15	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	65.5	58.8
10	65.6	65.5	58.8	56.8	65.5	58.8	65.5	65.5	65.5	65.5	80.7	80.7
5	85.9	85.9	85.9	85.9	85.9	85.9	85.9	85.9	85.9	85.9	85.9	85.9
1	97.9	97.9	94.3	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9

TABLE H-1 (Cont.)

NORTHERN HOG SUCKER ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4
95	46.9	45.5	43.4	43.4	43.4	48.8	48.8	48.8	48.8	48.8	48.8	45.5
90	48.8	48.8	48.6	45.5	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
85	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
80	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
75	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
70	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
65	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
60	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
55	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
50	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
45	50.6	53.6	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	50.6	53.6
40	53.6	53.6	53.6	48.8	48.8	48.8	48.8	48.8	48.8	48.8	53.6	53.6
35	53.6	53.6	53.6	53.6	53.6	53.6	48.8	48.8	48.8	48.8	59.6	59.6
30	53.7	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	72.0	66.8
25	59.6	59.6	56.7	53.6	53.6	53.6	59.6	59.6	59.6	59.6	76.9	76.9
20	76.9	76.9	66.8	62.6	66.8	66.8	76.9	76.9	76.9	76.9	81.4	76.9
15	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	88.6	85.1
10	88.6	88.6	85.1	81.4	88.6	85.1	88.6	88.6	88.6	88.6	93.9	91.6
5	95.8	95.8	95.8	95.2	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8
1	99.2	99.6	99.2	99.2	99.2	99.6	99.6	99.6	99.6	99.6	99.6	99.6

REDBREAST SUNFISH SPAWN

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	33.9	33.9	33.9	33.9	33.9	33.9
95	33.9	41.3	41.3	41.3	41.3	41.3
90	41.3	41.3	43.1	41.3	50.4	45.3
85	41.3	41.3	55.9	53.2	55.9	55.9
80	41.3	53.2	55.9	55.9	62.6	55.9
75	45.3	55.9	62.6	58.4	73.1	62.6
70	55.9	62.6	73.1	69.1	99.1	73.1
65	55.9	73.1	84.1	80.6	99.1	84.1
60	65.6	99.1	99.1	99.1	99.1	99.1
55	80.6	99.1	99.1	99.1	99.1	99.1
50	99.1	99.1	99.1	99.1	99.1	99.1
45	99.1	99.1	99.1	99.1	99.1	99.1
40	99.1	99.1	99.1	99.1	99.1	99.1
35	99.1	99.1	99.1	99.1	99.1	99.1
30	99.1	99.1	99.1	99.1	99.1	99.1
25	99.1	99.1	99.1	99.1	99.1	99.1
20	99.1	99.1	99.1	99.1	99.1	99.1
15	99.1	99.1	99.1	99.1	99.1	99.1
10	99.1	99.1	99.1	99.1	99.1	99.1
5	99.1	99.1	99.1	99.1	99.1	99.1
1	99.1	99.1	99.1	99.1	99.1	99.1

REDBREAST SUNFISH ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7
95	48.6	48.4	47.7	47.7	47.7	49.5	49.5	49.5	49.5	49.5	49.5	48.4
90	49.5	49.5	48.6	48.4	49.5	49.5	49.9	49.5	49.5	50.0	49.5	49.5
85	49.5	49.5	49.5	49.5	49.5	49.5	50.0	50.0	50.0	50.0	50.0	49.5
80	49.5	49.5	49.5	49.5	49.5	50.0	50.0	50.0	50.0	50.0	50.0	49.5
75	50.0	49.5	49.5	49.5	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
70	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
65	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
60	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
55	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
50	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
45	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
40	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
35	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.4	50.4
30	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	53.2	51.9
25	50.4	50.4	50.0	50.0	50.0	50.0	50.4	50.4	50.4	50.4	55.1	55.1
20	55.1	55.1	51.9	51.0	51.9	51.9	55.1	55.1	55.1	55.1	57.9	55.1
15	55.1	55.1	55.1	55.1	55.1	55.1	55.1	55.1	55.1	55.1	63.5	61.2
10	63.5	63.5	61.2	57.9	63.5	61.2	63.5	63.5	63.5	63.5	70.3	70.3
5	78.3	78.3	78.3	78.3	78.3	78.3	78.3	78.3	78.3	78.3	78.3	78.3
1	98.3	98.3	94.0	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3

TABLE H-1 (Cont.)

REDEYE BASS YOY

Percent of Time Reached Or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	23.8	23.8	23.8	23.8	23.8	23.8
95	23.8	28.2	28.2	28.2	28.2	28.2
90	28.2	28.2	29.6	28.2	34.0	31.1
85	28.2	28.2	37.4	35.6	37.4	37.4
80	28.2	35.6	37.4	37.4	44.4	37.4
75	31.1	37.4	44.4	39.5	57.6	44.4
70	37.4	44.4	57.6	52.5	99.3	57.6
65	37.4	57.6	85.3	70.0	99.3	85.3
60	48.1	99.3	99.3	99.3	99.3	99.3
55	70.0	99.3	99.3	99.3	99.3	99.3
50	99.3	99.3	99.3	99.3	99.3	99.3
45	99.3	99.3	99.3	99.3	99.3	99.3
40	99.3	99.3	99.3	99.3	99.3	99.3
35	99.3	99.3	99.3	99.3	99.3	99.3
30	99.3	99.3	99.3	99.3	99.3	99.3
25	99.3	99.3	99.3	99.3	99.3	99.3
20	99.3	99.3	99.3	99.3	99.3	99.3
15	99.3	99.3	99.3	99.3	99.3	99.3
10	99.3	99.3	99.3	99.3	99.3	99.3
5	99.3	99.3	99.3	99.3	99.3	99.3
1	99.3	99.3	99.3	99.3	99.3	99.3

REDEYE BASS JUVENILE

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0
95	38.7	38.2	37.0	37.0	37.0	40.5	40.5	40.5	40.5	40.5	40.5	38.2
90	40.5	40.5	39.4	38.2	40.5	40.5	41.7	40.5	40.5	43.7	40.5	40.5
85	40.5	40.5	40.5	40.5	40.5	40.5	54.3	51.7	51.7	54.3	43.7	40.5
80	40.5	40.5	40.5	40.5	40.5	51.7	54.3	54.3	54.3	54.3	54.3	40.5
75	43.7	40.5	40.5	40.5	43.7	54.3	66.1	56.9	56.9	66.1	54.3	43.7
70	48.8	43.7	43.7	46.3	54.3	66.1	77.7	77.7	77.7	77.7	56.9	54.3
65	54.3	54.3	54.3	54.3	54.3	77.7	77.7	77.7	77.7	77.7	66.1	54.3
60	66.1	54.3	54.3	56.9	72.3	77.7	77.7	77.7	77.7	77.7	77.7	56.9
55	77.7	72.3	72.3	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	66.1
50	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7
45	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7
40	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7
35	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7
30	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7
25	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7
20	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7
15	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7
10	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	79.0	79.0
5	85.6	85.6	85.6	85.6	85.6	85.6	85.6	85.6	85.6	85.6	85.6	85.6
1	98.7	98.7	96.8	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7

REDEYE BASS ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
95	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
90	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
85	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
80	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
75	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
70	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
65	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
60	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
55	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	48.6
50	48.6	52.1	48.6	48.6	38.7	38.7	38.7	38.7	38.7	38.7	38.7	54.4
45	55.1	56.4	48.6	48.6	48.6	38.7	38.7	38.7	38.7	38.7	55.1	56.4
40	56.4	56.4	56.4	52.1	52.1	38.7	38.7	38.7	38.7	38.7	56.4	56.4
35	56.4	56.4	56.4	56.4	56.4	56.4	48.6	52.1	52.1	48.6	60.0	60.0
30	56.4	56.4	56.4	56.4	56.4	56.4	56.4	56.4	56.4	56.4	69.9	66.4
25	60.0	60.0	58.0	56.4	56.4	56.4	60.0	60.0	60.0	60.0	73.7	73.7
20	73.7	73.7	66.4	62.5	66.4	66.4	73.7	73.7	73.7	73.7	77.5	73.7
15	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	84.9	81.1
10	85.0	84.9	81.1	77.5	84.9	81.1	84.9	84.9	84.9	84.9	89.5	87.0
5	92.8	92.8	92.8	92.8	92.8	92.8	92.8	92.8	92.8	92.8	92.8	92.8
1	98.4	98.4	98.4	98.4	98.4	98.4	98.4	98.4	98.4	98.4	98.4	98.4

SILVER REDHORSE ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
95	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
90	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
85	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
80	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
75	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
70	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
65	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
60	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
55	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
50	48.9	49.1	48.9	48.9	29.2	29.2	29.2	29.2	29.2	29.2	29.2	48.9
45	49.3	49.5	48.9	48.9	48.9	29.2	29.2	29.2	29.2	29.2	49.3	49.5
40	49.5	49.5	49.5	49.1	49.1	29.2	29.2	29.2	29.2	29.2	49.5	49.5
35	49.5	49.5	49.5	49.5	49.5	49.5	48.9	49.1	49.1	48.9	51.4	51.4
30	49.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5	58.4	55.7
25	51.4	51.4	49.9	49.5	49.5	49.5	51.4	51.4	51.4	51.4	60.3	60.3
20	60.3	60.3	55.7	53.9	55.7	55.7	60.3	60.3	60.3	60.3	62.1	60.3
15	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	69.8	64.9
10	69.9	69.8	64.9	62.1	69.8	64.9	69.8	69.8	69.8	69.8	82.2	76.1
5	88.4	88.4	88.4	86.8	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4
1	97.2	99.0	97.2	97.2	97.2	99.0	99.0	99.0	99.0	99.0	99.0	99.0

STRIPED JUMPROCK YOY

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN
100	16.3	16.3	16.3	16.3	16.3	16.3
95	16.3	19.7	19.7	19.7	19.7	19.7
90	19.7	19.7	21.3	19.7	25.9	22.7
85	19.7	19.7	28.2	27.1	28.2	28.2
80	19.7	27.1	28.2	28.2	30.9	28.2
75	22.7	28.2	30.9	29.1	36.6	30.9
70	28.2	30.9	36.6	34.0	96.8	36.6
65	28.2	36.6	56.9	45.5	96.8	56.9
60	32.3	96.8	96.8	96.8	96.8	96.8
55	45.5	96.8	96.8	96.8	96.8	96.8
50	96.8	96.8	96.8	96.8	96.8	96.8
45	96.8	96.8	96.8	96.8	96.8	96.8
40	96.8	96.8	96.8	96.8	96.8	96.8
35	96.8	96.8	96.8	96.8	96.8	96.8
30	96.8	96.8	96.8	96.8	96.8	96.8
25	96.8	96.8	96.8	96.8	96.8	96.8
20	96.8	96.8	96.8	96.8	96.8	96.8
15	96.8	96.8	96.8	96.8	96.8	96.8
10	96.8	96.8	96.8	96.8	96.8	96.8
5	96.8	96.8	96.8	96.8	96.8	96.8
1	96.8	96.8	96.8	96.8	96.8	96.8

STRIPED JUMPROCK ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6
95	23.9	23.0	21.6	21.6	21.6	28.7	28.7	28.7	28.7	28.7	28.7	23.0
90	28.7	28.7	25.2	23.0	28.7	28.7	30.5	28.7	28.7	33.1	28.7	28.7
85	28.7	28.7	28.7	28.7	28.7	28.7	47.9	43.9	43.9	47.9	33.1	28.7
80	28.7	28.7	28.7	28.7	28.7	43.9	47.9	47.9	47.9	47.9	47.9	28.7
75	33.1	28.7	28.7	28.7	33.1	47.9	63.5	52.6	52.6	63.5	47.9	33.1
70	40.4	33.1	33.1	36.5	47.9	63.5	69.7	69.7	69.7	69.7	52.6	47.9
65	47.9	47.9	47.9	47.9	47.9	69.7	69.7	69.7	69.7	69.7	63.5	47.9
60	63.5	47.9	47.9	52.6	69.1	69.7	69.7	69.7	69.7	69.7	69.7	52.6
55	69.7	69.1	69.1	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	63.5
50	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7
45	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7
40	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7
35	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7
30	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7
25	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7
20	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7
15	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7
10	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	74.9	74.9
5	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7
1	98.2	98.2	93.9	98.2	98.2	98.2	98.2	98.2	98.2	98.2	98.2	98.2

WALLEYE SPAWN

Percent of Time Reached or Exceeded	JAN	FEB	MAR
100	10.8	10.8	10.8
95	12.9	10.8	10.8
90	18.2	15.5	12.9
85	18.2	18.2	18.2
80	18.2	18.2	18.2
75	18.2	18.2	18.2
70	20.7	20.7	22.0
65	28.8	28.8	28.8
60	28.8	28.8	31.9
55	46.6	46.6	47.2
50	47.2	47.2	47.2
45	47.2	47.2	47.2
40	47.2	47.2	47.2
35	47.2	47.2	47.2
30	47.2	47.2	47.2
25	47.2	47.2	47.2
20	47.2	47.2	47.2
15	47.2	47.2	47.2
10	47.2	47.2	47.2
5	68.4	68.4	68.4
1	96.4	89.3	96.4

WHITEFIN SHINER ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4
95	41.8	41.0	39.4	39.4	39.4	45.2	45.2	45.2	45.2	45.2	45.2	41.0
90	45.2	45.2	42.7	41.0	45.2	45.2	47.1	45.2	45.2	49.1	45.2	45.2
85	45.2	45.2	45.2	45.2	45.2	45.2	59.2	56.1	56.1	59.2	49.1	45.2
80	45.2	45.2	45.2	45.2	45.2	56.1	59.2	59.2	59.2	59.2	59.2	45.2
75	49.1	45.2	45.2	45.2	49.1	59.2	70.8	62.8	62.8	70.8	59.2	49.1
70	53.5	49.1	49.1	51.1	59.2	70.8	76.8	76.8	76.8	76.8	62.8	59.2
65	59.2	59.2	59.2	59.2	59.2	76.8	76.8	76.8	76.8	76.8	70.8	59.2
60	70.8	59.2	59.2	62.8	75.7	76.8	76.8	76.8	76.8	76.8	76.8	62.8
55	76.8	75.7	75.7	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	70.8
50	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8
45	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8
40	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8
35	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8
30	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8
25	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8
20	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8
15	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8
10	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	81.0	81.0
5	86.4	86.4	86.4	86.4	86.4	86.4	86.4	86.4	86.4	86.4	86.4	86.4
1	99.1	99.1	96.6	99.1	99.1	99.1	99.1	99.1	99.1	99.1	99.1	99.1

TABLE H-2 HABITAT DURATION TABLES FOR EACH SPECIES LIFE STAGE IN THE TUGALO RIVER STUDY AREA BASED ON ANALYSIS OF AVERAGE DAILY UNREGULATED FLOWS AT YONAH DAM FOR THE PERIOD OF RECORD 1978 TO 1986

BLUEHEAD CHUB SPAWN

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	3.3	7.1	9.7	4.4	3.3	9.5
95	9.0	13.1	17.5	16.7	16.6	17.2
90	11.3	17.3	21.9	21.1	27.8	21.9
85	12.3	19.3	26.1	24.5	35.3	25.4
80	13.4	21.7	30.4	27.1	39.0	36.7
75	14.5	23.0	32.4	29.7	45.9	46.6
70	15.4	24.6	34.0	32.2	51.2	57.1
65	15.9	26.0	36.6	34.6	54.9	62.8
60	17.1	27.8	37.9	37.3	60.5	67.4
55	18.5	29.2	39.5	39.4	63.6	73.5
50	21.7	31.3	44.3	45.7	65.7	76.3
45	26.4	32.9	49.1	52.3	69.8	79.4
40	28.4	35.4	55.7	62.4	71.7	81.4
35	31.8	37.9	63.0	69.3	74.1	83.7
30	34.0	40.6	70.2	75.0	76.2	85.4
25	36.5	50.6	75.3	79.6	79.9	87.7
20	42.9	60.9	78.1	84.4	86.0	90.1
15	52.8	67.0	79.8	92.8	92.2	93.4
10	58.4	72.8	85.9	98.6	98.6	98.6
5	73.0	81.5	98.6	99.4	99.3	99.2
1	77.0	92.9	99.8	99.8	99.8	99.8

BLUEHEAD CHUB YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	7.7	9.6	14.0	9.1	8.3	13.7
95	13.0	21.7	31.5	30.5	30.2	31.2
90	16.9	31.4	35.4	35.0	39.7	35.4
85	19.8	33.7	38.1	36.6	50.0	37.3
80	22.2	35.3	42.2	39.0	56.8	52.5
75	24.3	35.9	44.6	41.6	60.0	60.2
70	26.5	36.6	47.6	44.2	61.7	63.6
65	28.2	38.0	52.3	48.6	62.9	64.9
60	31.1	39.7	54.7	53.7	64.6	65.5
55	32.7	41.0	57.7	57.6	65.1	65.8
50	35.3	43.1	59.4	59.9	65.6	66.0
45	38.3	45.4	61.0	62.1	65.9	66.1
40	40.3	50.1	63.2	64.6	66.2	66.4
35	43.6	54.7	64.9	65.2	66.8	66.6
30	47.6	58.2	65.9	65.9	67.0	66.8
25	52.2	61.5	66.5	66.4	67.3	67.0
20	59.0	64.9	66.9	66.9	67.5	67.2
15	62.2	65.9	67.1	67.3	67.7	67.6
10	64.1	66.8	67.3	67.6	67.9	68.5
5	67.5	67.4	67.8	67.9	69.9	72.9
1	67.8	67.9	72.8	73.8	76.3	80.9

MARGINED MADTOM YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	1.1	3.1	5.7	1.2	1.1	5.5
95	5.2	10.3	14.7	14.0	13.9	14.5
90	7.6	14.6	19.2	18.4	24.4	19.2
85	9.4	16.7	23.0	21.7	31.5	22.4
80	10.6	19.0	26.5	23.8	35.5	33.0
75	11.6	20.2	28.2	25.9	40.2	40.6
70	12.4	21.8	30.0	28.0	43.5	47.2
65	13.1	22.9	32.8	30.6	45.8	50.8
60	14.4	24.3	34.3	33.7	49.4	53.7
55	15.8	25.5	36.1	36.0	51.3	58.7
50	19.0	27.2	39.1	40.1	52.7	61.5
45	23.3	28.7	42.2	44.2	55.2	64.6
40	24.9	31.5	46.4	50.6	56.9	66.6
35	27.6	34.3	51.0	54.9	59.3	68.8
30	30.0	36.8	55.5	60.2	61.4	70.6
25	32.8	43.1	60.4	64.8	65.0	72.8
20	38.3	49.6	63.3	69.5	71.1	75.1
15	44.5	53.4	64.9	77.8	77.3	78.4
10	48.1	58.0	71.0	83.6	85.3	86.7
5	58.2	66.7	85.5	86.3	87.3	88.6
1	62.2	78.0	88.5	88.9	90.0	91.9

TABLE H-2 (Cont.)

MARGINED MADTOM ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	17.3	17.0	16.3	16.1	16.1	20.2	24.5	16.6	16.6	24.3	16.7	16.6
95	24.7	23.2	21.0	20.9	24.0	34.5	46.0	44.4	44.4	45.5	28.2	25.0
90	28.2	26.7	24.6	23.3	27.9	45.7	53.6	52.6	52.6	53.6	42.3	28.7
85	32.9	30.8	28.9	24.7	32.4	49.9	58.4	56.7	56.7	57.6	51.9	33.4
80	36.3	33.6	31.7	26.3	35.1	53.4	62.9	59.4	59.4	70.0	56.3	35.7
75	40.9	36.6	34.0	28.6	37.3	54.9	65.1	62.2	62.2	76.6	62.0	41.5
70	45.0	39.4	36.9	30.3	39.7	56.9	67.0	64.8	64.8	81.5	65.8	45.5
65	46.9	42.2	40.3	32.7	41.7	58.3	69.9	67.6	67.6	84.2	68.7	49.6
60	49.3	44.8	43.6	36.1	45.3	60.2	71.4	70.8	70.8	86.4	71.3	52.4
55	51.5	47.9	46.3	42.5	48.2	61.6	73.2	73.2	73.2	89.0	74.8	54.4
50	53.8	51.5	49.3	53.9	53.3	63.9	75.5	76.2	76.2	90.2	77.3	56.8
45	55.7	53.1	51.3	58.2	58.7	65.6	77.8	79.3	79.3	91.5	80.6	63.0
40	57.4	54.1	53.8	60.7	60.8	68.5	80.9	84.0	84.0	92.3	83.1	65.8
35	59.7	55.0	56.0	63.2	64.3	71.4	84.3	87.2	87.2	93.2	85.9	70.1
30	69.8	55.9	60.2	66.0	67.0	73.8	87.6	89.7	89.7	94.0	87.8	72.3
25	73.9	57.3	64.2	67.7	69.8	78.5	89.8	91.6	91.6	94.9	90.6	74.3
20	77.0	60.0	67.8	69.0	74.9	83.3	90.9	93.5	93.5	95.9	92.7	77.2
15	79.9	64.1	70.1	71.6	79.5	86.1	91.6	97.0	97.0	96.7	95.9	82.3
10	92.6	73.0	75.8	74.7	82.2	88.7	94.2	98.4	98.4	98.1	97.4	88.3
5	94.7	79.9	80.1	80.3	88.8	92.4	98.6	99.4	99.4	98.8	98.4	90.8
1	95.7	89.2	83.0	83.4	90.5	97.1	99.6	99.8	99.8	99.7	99.9	93.1

NORTHERN HOG SUCKER YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	2.6	2.6	8.0	3.5	3.3	7.7
95	7.2	15.5	18.7	18.1	18.0	18.5
90	10.9	18.5	23.1	22.1	29.9	23.0
85	14.3	20.2	28.1	26.3	37.4	27.2
80	15.7	22.9	32.9	29.1	40.4	38.5
75	16.5	24.4	35.0	32.1	41.2	41.3
70	17.1	26.4	36.3	34.8	41.9	42.0
65	17.5	28.0	38.4	36.7	42.3	42.3
60	18.4	29.9	39.5	39.0	42.6	42.6
55	19.5	31.5	40.8	40.7	42.9	42.8
50	22.8	33.9	41.4	41.2	43.3	43.1
45	28.4	35.3	41.9	41.7	43.7	43.3
40	30.6	37.4	42.4	42.1	44.0	43.5
35	34.4	39.5	42.9	42.7	44.2	43.7
30	36.3	41.0	43.6	43.1	44.3	44.0
25	38.4	42.0	43.8	43.6	44.5	44.3
20	41.3	43.0	44.0	44.1	44.7	44.6
15	42.7	43.7	44.2	44.4	44.9	44.7
10	43.5	44.1	44.6	44.9	45.0	47.5
5	44.5	44.7	45.1	46.1	49.9	54.8
1	44.9	45.0	54.6	56.3	60.5	68.1

NORTHERN HOG SUCKER JUVENILE

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	25.6	25.4	24.8	24.5	24.5	30.3	38.4	25.1	25.1	38.1	25.2	25.1
95	38.6	36.2	31.9	31.8	37.7	52.3	68.9	66.3	66.3	68.0	42.8	39.0
90	42.9	41.1	38.5	36.4	42.5	68.4	80.5	79.4	79.4	78.6	63.5	43.4
85	49.7	46.4	43.7	38.6	48.9	75.5	85.0	84.2	84.2	82.0	78.5	50.6
80	55.1	50.8	47.8	40.7	53.3	80.3	87.9	86.3	86.3	85.4	83.7	54.1
75	61.7	55.6	51.5	43.3	56.7	82.0	90.8	88.0	88.0	89.4	89.1	62.5
70	67.1	59.8	56.1	45.5	60.1	84.4	91.8	90.2	90.2	93.6	92.0	68.0
65	70.4	63.4	60.9	49.5	62.7	85.7	92.5	91.6	91.6	95.5	92.9	75.0
60	74.4	66.7	65.2	54.9	67.6	87.4	93.8	92.3	92.3	96.3	93.8	79.1
55	78.1	72.0	69.3	63.8	72.6	88.7	94.3	93.6	93.6	96.7	95.1	81.5
50	80.8	78.1	74.3	80.9	80.2	90.8	95.1	94.5	94.5	97.0	95.7	84.3
45	83.0	80.0	77.9	85.6	86.1	91.9	95.8	95.3	95.3	97.3	96.1	90.0
40	84.9	81.1	80.8	87.9	88.0	93.1	96.3	95.8	95.8	97.6	96.4	92.0
35	86.9	82.2	83.3	90.2	91.2	94.3	96.9	96.2	96.2	97.9	96.7	93.8
30	93.6	83.3	87.4	92.0	92.4	95.3	97.6	97.0	97.0	98.1	97.4	94.7
25	95.3	84.8	91.0	92.8	93.7	96.5	98.3	97.5	97.5	98.3	97.8	95.5
20	96.4	87.2	92.8	93.3	95.7	97.6	98.6	98.0	98.0	98.7	98.2	96.5
15	97.0	91.0	93.8	94.4	97.2	98.4	98.8	98.5	98.5	99.0	98.7	97.9
10	97.3	95.0	96.0	95.6	98.1	98.9	99.1	99.1	99.1	99.3	99.3	98.7
5	97.8	97.3	97.4	97.5	99.4	99.6	99.4	99.7	99.7	99.5	99.7	99.4
1	98.7	99.8	98.4	98.5	99.8	99.9	100.0	99.9	99.9	99.9	100.0	99.9

NORTHERN HOG SUCKER ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	45.1	44.8	43.3	42.8	42.8	49.5	61.0	44.0	44.0	60.5	44.2	44.1
95	61.7	57.0	51.1	50.9	59.3	81.0	82.8	80.2	80.2	76.3	70.9	62.7
90	71.0	67.8	61.4	57.2	70.3	89.8	89.5	86.1	86.1	81.2	86.6	72.0
85	78.9	75.8	72.5	61.6	78.2	91.8	92.1	89.5	89.5	86.8	89.4	79.8
80	82.8	80.0	77.1	66.8	81.6	93.4	93.6	90.8	90.8	90.9	91.0	82.2
75	86.6	83.1	80.5	71.8	83.8	94.0	94.8	92.8	92.8	91.9	91.6	87.1
70	89.4	85.6	83.4	75.0	85.8	94.6	95.6	93.9	93.9	92.7	93.2	89.7
65	90.5	87.5	86.2	78.8	87.1	95.2	96.0	94.6	94.6	93.2	94.1	92.0
60	91.8	89.2	88.4	82.7	89.5	95.6	96.4	95.5	95.5	93.7	94.7	93.4
55	92.7	91.0	90.1	87.7	91.2	96.1	97.1	96.1	96.1	94.2	96.0	94.2
50	93.1	93.0	91.8	94.0	93.8	96.6	97.8	96.7	96.7	94.6	96.9	94.8
45	93.7	93.7	93.0	95.7	95.9	97.2	98.3	97.2	97.2	95.0	97.8	95.8
40	94.2	94.1	94.0	96.6	96.5	97.8	98.5	97.9	97.9	95.5	98.4	96.4
35	94.7	94.4	94.8	97.6	97.2	98.2	98.8	98.4	98.4	96.5	98.6	97.7
30	95.3	94.8	96.4	98.4	97.9	98.5	99.0	98.6	98.6	97.4	98.8	98.5
25	96.1	95.4	97.9	98.8	98.4	98.7	99.2	98.8	98.8	98.6	99.0	98.7
20	98.7	96.4	98.8	99.0	98.8	99.0	99.4	99.2	99.2	98.8	99.2	99.1
15	99.3	97.8	99.1	99.2	99.2	99.2	99.6	99.4	99.4	99.0	99.4	99.4
10	99.5	99.2	99.3	99.5	99.4	99.6	99.7	99.6	99.6	99.2	99.6	99.7
5	99.7	99.5	99.5	99.7	99.7	99.8	99.8	99.8	99.8	99.6	99.8	99.9
1	99.9	99.9	99.8	99.9	100.0	100.0	99.9	100.0	100.0	99.9	100.0	100.0

REDBREAST SUNFISH SPAWN

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	33.7	38.7	46.6	34.2	33.7	46.1
95	45.0	58.2	63.8	62.9	62.7	63.5
90	52.3	63.6	69.0	68.2	74.3	69.0
85	56.6	66.1	73.1	71.8	79.2	72.5
80	58.5	68.9	76.2	73.8	81.2	79.9
75	59.8	70.2	77.6	75.7	81.4	81.4
70	60.9	72.0	78.5	77.5	81.4	81.4
65	61.7	73.0	79.8	78.7	81.4	81.4
60	63.3	74.3	80.6	80.3	81.4	81.5
55	65.1	75.3	81.4	81.4	81.4	82.2
50	68.8	76.8	81.4	81.4	81.4	82.9
45	73.3	77.8	81.4	81.4	81.5	83.7
40	74.7	79.2	81.4	81.5	81.7	84.3
35	77.2	80.6	81.5	81.5	82.3	84.9
30	78.5	81.4	81.5	82.6	82.9	85.3
25	79.8	81.4	82.7	83.8	83.9	85.9
20	81.4	81.4	83.4	85.1	85.5	86.6
15	81.4	81.5	83.8	87.3	87.1	87.4
10	81.5	82.0	85.5	88.8	89.4	90.4
5	82.1	84.3	89.5	90.1	90.8	91.7
1	83.1	87.3	91.7	92.0	92.8	94.2

REDBREAST SUNFISH ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	48.3	48.1	47.7	47.5	47.5	48.7	50.7	47.9	47.9	50.6	48.0	47.9
95	50.8	50.0	48.9	48.8	50.3	57.5	64.3	63.7	63.7	64.2	52.9	51.0
90	52.9	52.1	50.8	50.0	52.8	64.2	70.1	68.3	68.3	70.1	62.8	53.2
85	56.1	54.6	53.3	50.8	55.8	65.6	78.2	75.9	75.9	74.7	66.9	56.6
80	59.2	56.7	55.2	51.9	58.1	69.8	82.2	79.5	79.5	83.7	75.1	58.6
75	62.2	59.5	57.1	53.1	60.1	72.4	85.8	83.0	83.0	88.4	83.0	62.5
70	64.0	61.5	59.7	54.2	61.7	76.1	88.3	85.7	85.7	92.4	87.7	64.1
65	64.6	62.8	61.9	56.0	62.5	78.1	90.3	88.3	88.3	96.5	90.9	65.5
60	65.4	63.9	63.4	59.0	64.1	80.5	92.6	90.6	90.6	97.1	93.4	67.9
55	66.2	64.9	64.4	62.9	65.0	82.5	94.3	92.7	92.7	97.4	95.9	71.6
50	70.5	66.3	65.4	70.6	69.6	85.4	95.9	94.5	94.5	97.6	96.6	75.9
45	74.0	69.2	66.1	77.9	78.6	87.5	96.6	96.3	96.3	97.9	96.9	84.3
40	76.8	71.0	70.5	81.3	81.4	90.7	97.1	96.6	96.6	98.1	97.1	87.8
35	79.9	72.7	74.5	84.6	86.0	94.0	97.5	97.0	97.0	98.3	97.4	92.5
30	92.2	74.4	80.5	88.0	89.0	96.3	98.1	97.6	97.6	98.5	97.9	95.0
25	96.3	76.8	85.8	89.8	92.2	97.2	98.6	98.0	98.0	98.7	98.3	96.4
20	97.2	80.3	89.9	91.3	96.6	98.1	98.9	98.4	98.4	99.0	98.6	97.2
15	97.6	85.8	92.5	94.2	97.8	98.7	99.0	98.8	98.8	99.2	99.0	98.3
10	97.9	95.7	96.8	96.5	98.5	99.1	99.3	99.3	99.3	99.5	99.4	99.0
5	98.2	97.9	98.0	98.0	99.5	99.7	99.6	99.7	99.7	99.6	99.8	99.6
1	99.0	99.9	98.7	98.8	99.8	99.9	100.0	99.9	99.9	99.9	100.0	99.9

REDEYE BASS YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	23.4	26.2	32.0	24.1	23.4	31.6
95	30.9	39.2	45.8	44.7	44.6	45.5
90	35.1	45.6	52.4	51.3	59.2	52.3
85	37.9	48.8	57.6	55.9	67.2	56.8
80	39.6	52.2	61.8	58.5	71.2	68.7
75	41.0	53.8	63.9	61.2	74.0	74.2
70	42.3	56.1	65.7	63.6	75.7	77.6
65	43.3	57.5	68.5	66.3	76.9	79.5
60	45.3	59.2	70.0	69.4	78.7	81.0
55	47.5	60.6	71.8	71.7	79.7	82.9
50	52.1	62.7	73.5	73.9	80.4	83.9
45	57.9	64.4	75.0	76.1	81.7	84.9
40	59.8	67.2	77.2	79.3	82.4	85.5
35	63.2	70.0	79.5	81.6	83.1	86.2
30	65.7	72.2	81.9	83.4	83.8	86.8
25	68.5	75.5	83.5	84.9	85.0	87.5
20	73.0	78.9	84.4	86.5	87.0	88.3
15	76.2	80.8	85.0	89.2	89.0	89.4
10	78.1	82.7	87.0	91.1	91.7	92.5
5	82.8	85.5	91.8	92.3	92.8	93.5
1	84.1	89.2	93.5	93.7	94.3	95.4

REDEYE BASS JUVENILE

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	38.1	37.9	37.0	36.6	36.6	39.6	45.1	37.4	37.4	44.5	37.6	37.5
95	45.7	41.8	40.0	39.9	43.4	56.6	68.7	66.8	66.8	68.1	51.1	46.4
90	51.1	49.4	45.4	41.9	50.8	68.4	78.8	77.2	77.2	78.7	64.3	51.7
85	55.3	53.7	51.9	45.6	54.9	73.4	85.6	83.9	83.9	84.8	76.0	55.7
80	58.0	55.8	54.4	48.9	57.1	78.5	89.6	86.5	86.5	93.2	83.2	57.5
75	62.6	58.3	56.2	51.6	58.8	80.9	91.5	89.0	89.0	95.0	88.8	63.4
70	67.5	61.0	58.5	53.3	61.2	84.1	92.7	91.3	91.3	96.5	92.0	68.1
65	69.8	64.2	62.0	55.2	63.6	85.5	94.4	93.3	93.3	98.0	94.1	73.1
60	72.7	67.2	65.9	57.9	67.9	87.1	95.9	95.1	95.1	98.7	96.0	76.8
55	75.4	71.0	69.0	64.5	71.4	88.5	96.9	96.3	96.3	99.1	97.7	80.1
50	79.1	75.4	72.7	79.2	78.3	90.5	97.7	97.5	97.5	99.4	98.1	83.9
45	82.2	78.0	75.2	85.3	85.8	91.9	98.0	97.9	97.9	99.7	98.5	89.7
40	84.6	79.6	79.1	87.7	87.7	94.0	98.2	98.3	98.3	99.7	98.8	92.1
35	86.7	81.0	82.6	89.9	90.9	96.1	98.7	98.8	98.8	99.8	99.2	95.1
30	94.9	82.6	87.1	92.2	92.9	97.6	99.1	99.4	99.4	99.8	99.6	96.8
25	97.6	84.6	90.8	93.4	94.9	98.3	99.6	99.7	99.7	99.8	99.7	97.6
20	98.1	87.0	93.5	94.4	97.7	99.0	99.7	99.7	99.7	99.8	99.8	98.1
15	98.5	90.7	95.1	96.2	98.4	99.4	99.8	99.8	99.8	99.9	99.8	98.8
10	99.8	97.2	97.9	97.7	98.8	99.7	99.8	99.8	99.8	99.9	99.9	99.7
5	99.9	98.5	98.5	98.5	99.7	99.8	99.8	99.9	99.9	99.9	99.9	99.7
1	99.9	99.7	99.0	99.0	99.7	99.9	100.0	100.0	100.0	100.0	100.0	99.8

REDEYE BASS ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	51.6	51.0	48.5	47.6	47.6	54.7	61.1	49.7	49.7	60.7	50.1	49.9
95	61.7	58.2	55.3	55.2	59.8	77.1	83.1	80.2	80.2	74.8	69.2	62.5
90	69.3	67.2	61.4	58.3	68.8	86.0	87.5	86.5	86.5	82.8	83.8	69.9
85	75.3	72.7	70.2	61.6	74.7	87.3	89.8	88.7	88.7	86.6	88.1	76.0
80	78.9	76.2	73.8	66.4	77.7	89.2	92.8	90.7	90.7	89.1	90.3	78.3
75	82.8	79.2	76.6	69.8	79.9	90.3	94.4	92.7	92.7	91.4	93.4	83.3
70	85.7	81.7	79.5	72.0	81.9	91.9	95.8	93.8	93.8	94.6	94.7	85.9
65	86.3	83.7	82.3	75.1	83.3	92.7	96.5	94.6	94.6	95.5	94.9	87.2
60	87.1	85.6	84.8	78.7	85.8	93.8	96.9	95.0	95.0	96.1	95.4	88.5
55	87.8	86.6	86.1	83.9	86.7	94.6	97.5	96.2	96.2	96.5	96.5	90.0
50	89.5	87.8	87.1	89.6	89.2	95.5	97.9	96.8	96.8	97.1	97.1	91.8
45	91.0	89.0	87.7	92.6	92.9	96.4	98.2	97.1	97.1	97.4	97.5	95.4
40	92.2	89.7	89.5	94.1	94.2	96.9	98.4	97.5	97.5	97.7	98.0	96.5
35	93.5	90.4	91.2	95.5	96.2	97.5	98.6	98.2	98.2	98.0	98.5	97.5
30	96.1	91.1	93.8	96.8	97.0	98.2	98.9	98.6	98.6	98.5	99.0	98.2
25	96.6	92.1	96.1	97.3	97.9	98.7	99.1	99.0	99.0	99.1	99.2	98.5
20	97.7	93.7	97.3	97.7	98.9	99.1	99.2	99.2	99.2	99.3	99.4	99.0
15	98.8	96.1	98.0	98.4	99.2	99.4	99.4	99.3	99.3	99.5	99.5	99.1
10	99.2	98.8	99.1	99.1	99.4	99.7	99.6	99.6	99.6	99.7	99.7	99.4
5	99.4	99.4	99.5	99.5	99.6	99.8	99.8	99.8	99.8	99.9	99.9	99.7
1	99.6	100.0	99.7	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0

SILVER REDHORSE ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	49.0	49.0	48.9	48.9	48.9	49.3	52.7	48.9	48.9	48.8	48.9	48.9
95	53.4	50.0	49.3	49.3	51.1	61.8	64.8	62.0	62.0	59.3	57.8	53.9
90	57.9	56.2	53.1	50.0	57.5	72.0	71.4	67.9	67.9	63.1	68.1	58.4
85	60.9	60.0	58.6	53.2	60.6	77.0	78.1	72.4	72.4	69.0	72.1	61.1
80	63.1	61.2	60.3	55.7	62.3	80.8	82.7	75.4	75.4	75.2	76.1	62.7
75	67.0	63.3	61.5	58.3	63.9	82.7	85.5	78.8	78.8	78.2	76.9	67.7
70	71.0	65.7	63.6	59.7	65.9	84.8	87.8	83.0	83.0	80.2	80.7	71.7
65	73.5	68.3	66.5	60.8	67.8	86.3	88.9	84.8	84.8	81.4	83.6	76.9
60	76.5	70.7	69.6	63.0	71.4	87.8	90.1	87.4	87.4	82.6	85.4	80.5
55	79.3	74.7	72.6	68.6	75.1	89.2	92.0	89.1	89.1	84.0	88.8	83.1
50	80.8	79.3	76.5	82.5	81.7	91.0	94.3	91.0	91.0	84.9	91.4	85.2
45	82.2	81.4	79.1	88.0	88.6	92.8	95.4	92.6	92.6	86.3	93.9	88.2
40	83.6	82.7	82.3	91.0	90.5	94.2	96.1	94.1	94.1	87.6	95.3	90.2
35	85.0	83.9	85.2	94.0	92.5	95.2	96.5	95.4	95.4	90.0	95.7	93.9
30	86.8	85.2	90.3	96.0	94.7	96.0	97.1	96.2	96.2	92.3	96.4	95.6
25	89.2	87.0	95.1	96.9	95.8	96.5	97.7	96.8	96.8	95.3	97.2	96.5
20	96.4	90.1	96.8	97.3	96.9	97.0	98.4	97.6	97.6	96.0	97.7	97.6
15	97.8	94.6	97.6	97.8	97.4	98.0	98.7	98.4	98.4	97.0	98.3	98.5
10	98.7	97.5	98.1	98.5	98.2	98.9	99.2	99.0	99.0	97.8	98.9	99.2
5	99.2	98.6	98.6	99.4	99.2	99.5	99.5	99.4	99.4	98.7	99.5	99.5
1	99.8	99.7	99.5	99.8	100.0	99.8	99.9	99.9	99.9	99.6	99.9	99.9

STRIPED JUMPROCK YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	16.2	17.1	23.3	16.5	16.2	23.1
95	22.5	29.0	31.4	31.0	30.9	31.2
90	26.8	31.3	34.0	33.6	37.7	34.0
85	28.4	32.5	36.5	35.5	43.4	36.0
80	29.2	33.9	39.5	37.2	46.4	44.5
75	29.8	34.6	40.9	39.0	48.7	48.9
70	30.3	35.5	42.3	40.7	50.1	51.7
65	30.6	36.5	44.4	42.7	51.1	53.3
60	31.2	37.7	45.5	45.0	52.7	54.6
55	32.0	38.6	46.8	46.8	53.5	55.8
50	33.9	40.1	48.2	48.6	54.1	56.3
45	36.7	41.3	49.5	50.4	55.2	56.7
40	38.1	43.4	51.4	53.2	55.6	57.0
35	40.4	45.5	53.3	55.1	55.9	57.3
30	42.3	47.2	55.3	56.1	56.2	57.6
25	44.4	49.9	56.1	56.7	56.8	57.9
20	47.8	52.8	56.5	57.4	57.7	58.3
15	50.5	54.4	56.8	58.7	58.6	58.8
10	52.1	55.7	57.7	59.6	60.6	64.3
5	53.8	57.0	61.1	63.3	65.9	69.3
1	56.4	58.7	69.1	70.2	73.1	78.3

STRIPED JUMPROCK ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	22.8	22.6	21.6	21.2	21.2	26.1	34.8	22.0	22.0	34.1	22.2	22.1
95	35.6	30.7	27.5	27.4	32.8	52.0	65.9	64.1	64.1	65.3	43.2	36.6
90	43.3	41.2	35.3	30.9	42.8	65.5	74.8	73.5	73.5	74.7	61.9	43.9
85	49.6	46.8	44.2	35.5	49.0	70.2	80.6	78.9	78.9	79.8	72.5	50.4
80	54.7	50.6	48.0	40.4	52.9	74.5	85.0	81.6	81.6	88.9	78.3	53.8
75	60.4	55.2	51.3	43.8	56.3	76.4	86.9	84.3	84.3	91.3	84.1	61.1
70	64.7	58.9	55.6	46.1	59.2	79.1	88.5	86.8	86.8	93.3	87.9	65.3
65	66.9	61.8	59.8	49.5	61.3	80.5	91.0	89.1	89.1	96.4	91.0	69.9
60	69.5	64.5	63.2	54.5	65.0	82.3	93.0	91.0	91.0	97.1	93.8	73.2
55	72.0	67.9	66.1	62.1	68.3	83.7	94.5	93.9	93.9	97.6	95.8	75.8
50	75.0	72.0	69.5	75.1	74.4	85.9	95.7	94.7	94.7	97.8	96.7	78.9
45	77.6	74.1	71.8	80.4	80.9	87.7	96.6	96.3	96.3	98.0	97.1	85.1
40	79.6	75.4	75.0	82.9	83.0	90.8	97.0	96.8	96.8	98.3	97.3	87.9
35	81.8	76.6	77.9	85.3	86.4	93.9	97.7	97.2	97.2	98.4	97.5	92.5
30	92.1	77.8	82.3	88.1	89.1	96.1	98.1	97.5	97.5	98.6	97.9	94.9
25	96.1	79.6	86.2	89.9	92.2	97.2	98.6	98.2	98.2	98.8	98.3	96.2
20	97.0	82.1	90.0	91.3	96.4	98.2	98.9	98.5	98.5	99.0	98.6	97.0
15	97.7	86.1	92.4	94.1	97.7	98.7	99.1	98.9	98.9	99.2	99.0	98.3
10	98.0	95.5	96.6	96.3	98.4	99.1	99.3	99.4	99.4	99.5	99.5	99.1
5	98.3	97.8	97.9	97.9	99.5	99.7	99.6	99.7	99.7	99.6	99.7	99.6
1	98.9	99.9	98.7	98.8	99.8	99.9	100.0	99.9	99.9	99.9	100.0	99.9

WALLEYE SPAWN

Percent of Time Reached or Exceeded	MAY	JUN	JUL
100	12.1	10.7	10.3
95	19.6	16.9	16.8
90	24.3	21.4	19.7
85	28.2	26.4	21.5
80	30.6	28.9	23.8
75	33.6	31.0	26.1
70	36.2	33.8	27.7
65	38.5	36.9	29.9
60	40.7	39.7	33.1
55	45.0	42.8	38.8
50	50.3	47.0	56.9
45	54.7	49.9	67.8
40	57.4	56.6	72.7
35	60.0	62.7	77.5
30	62.6	71.6	82.1
25	66.1	79.3	84.3
20	71.3	84.4	86.1
15	79.3	87.5	89.5
10	91.4	93.3	92.6
5	95.6	95.7	95.8
1	99.7	97.3	97.5

WHITEFIN SHINER ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	40.8	40.5	39.4	38.9	38.9	43.1	50.1	39.9	39.9	49.7	40.1	40.0
95	50.6	47.3	43.9	43.7	48.9	62.4	72.8	71.3	71.3	72.3	55.6	51.2
90	55.6	54.1	50.4	47.4	55.3	72.5	80.8	79.6	79.6	80.8	69.5	56.1
85	60.7	58.4	56.4	50.5	60.1	76.7	86.3	84.7	84.7	85.6	78.7	61.3
80	64.2	61.4	59.4	53.5	63.0	80.6	90.4	87.2	87.2	92.8	84.2	63.6
75	68.4	64.5	61.9	56.0	65.2	82.4	91.8	89.8	89.8	94.9	89.6	68.9
70	71.8	67.2	64.8	57.8	67.4	84.9	93.1	92.1	92.1	96.2	92.7	72.3
65	73.7	69.5	67.9	60.5	69.0	86.2	94.7	93.5	93.5	98.2	94.7	76.4
60	76.1	71.6	70.6	64.1	72.1	87.9	96.1	94.7	94.7	98.8	96.5	79.3
55	78.2	74.6	73.1	69.7	75.0	89.2	97.2	96.6	96.6	99.3	98.0	81.8
50	81.1	78.2	76.0	81.2	80.5	91.3	97.9	97.3	97.3	99.4	98.3	84.7
45	83.5	80.2	78.1	86.1	86.6	92.6	98.2	98.1	98.1	99.5	98.7	90.5
40	85.4	81.4	81.1	88.4	88.5	94.6	98.5	98.5	98.5	99.5	99.1	92.8
35	87.4	82.5	83.8	90.7	91.7	96.6	99.0	98.9	98.9	99.6	99.3	95.7
30	95.4	83.7	87.9	92.9	93.5	98.0	99.3	99.3	99.3	99.6	99.4	97.2
25	98.0	85.3	91.5	94.0	95.5	98.6	99.6	99.4	99.4	99.7	99.4	98.0
20	98.4	87.7	94.1	94.9	98.1	99.3	99.7	99.6	99.6	99.7	99.6	98.5
15	98.9	91.5	95.6	96.7	98.8	99.6	99.8	99.7	99.7	99.8	99.7	99.2
10	99.5	97.6	98.2	98.1	99.2	99.7	99.8	99.8	99.8	99.8	99.8	99.8
5	99.6	98.8	98.9	98.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.8
1	99.7	99.9	99.3	99.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE H-3 HABITAT DURATION TABLES FOR EACH SPECIES LIFE STAGE IN THE OCMULGEE RIVER STUDY AREA BASED ON ANALYSIS OF HOURLY REGULATED FLOWS AT LLOYD SHOALS DAM FOR THE PERIOD OF RECORD 1978 TO 1986

ALTAMAHA SHINER YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	20.4	22.1	23.7	23.7	23.7	20.4
95	22.1	28.7	40.0	28.7	43.8	27.0
90	23.7	33.1	62.0	43.8	98.2	43.8
85	25.4	40.0	98.2	62.0	98.2	79.4
80	27.0	49.9	98.2	98.2	98.2	98.2
·75	30.3	85.1	98.2	98.2	98.2	98.2
70	33.1	95.8	98.2	98.2	98.7	98.2
65	33.1	95.8	98.7	98.2	98.7	98.2
60	43.8	95.8	98.7	98.7	98.7	98.2
55	85.1	98.7	98.7	98.7	98.7	98.2
50	85.1	98.7	98.7	98.7	98.7	98.2
45	95.8	98.7	98.7	98.7	98.7	98.7
40	95.8	98.7	98.7	98.7	98.7	98.7
35	98.7	98.7	98.7	98.7	98.7	98.7
30	98.7	98.7	98.7	98.7	98.7	98.7
25	98.7	98.7	98.7	98.7	98.7	98.7
20	98.7	98.7	98.7	98.7	98.7	98.7
15	98.7	98.7	98.7	98.7	98.7	98.7
10	98.7	98.7	98.7	98.7	98.7	98.7
5	98.7	98.7	98.7	98.7	98.7	98.7
1	98.7	98.7	98.7	98.7	98.7	98.7

ALTAMAHA SHINER ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	34.1	34.1	34.1	34.1	34.1	36.5	38.9	38.9	38.9	34.1	34.1	41.2
95	41.2	41.2	38.9	38.9	36.5	46.0	57.5	46.0	46.0	43.6	43.6	46.0
90	43.6	43.6	41.2	38.9	38.9	51.2	74.0	60.8	60.8	60.8	57.5	46.0
85	46.0	43.6	43.6	41.2	41.2	57.5	97.2	74.0	74.0	88.4	65.2	48.4
80	48.4	46.0	43.6	41.2	43.6	65.2	97.2	97.2	97.2	97.2	74.0	51.2
75	48.4	46.0	43.6	43.6	48.4	92.8	97.2	97.2	97.2	97.2	88.4	54.4
70	51.2	48.4	46.0	43.6	51.2	98.7	97.2	97.2	97.2	97.2	92.8	57.5
65	51.2	48.4	46.0	46.0	51.2	98.7	98.7	97.2	97.2	97.2	97.2	88.4
60	54.4	48.4	48.4	48.4	60.8	98.7	98.7	98.7	98.7	97.2	97.2	92.8
55	57.5	51.2	51.2	51.2	92.8	98.7	98.7	98.7	98.7	97.2	97.2	92.8
50	60.8	54.4	54.4	54.4	92.8	98.7	98.7	98.7	98.7	97.2	97.2	92.8
45	83.7	54.4	57.5	57.5	98.7	98.7	98.7	98.7	98.7	98.7	97.2	97.2
40	92.8	57.5	60.8	60.8	98.7	98.7	98.7	98.7	98.7	98.7	97.2	97.2
35	98.7	60.8	69.6	88.4	98.7	98.7	98.7	98.7	98.7	98.7	97.2	98.7
30	98.7	65.2	88.4	92.8	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7
25	98.7	87.1	92.8	92.8	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7
20	98.7	96.4	96.4	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7
15	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7
10	98.7	98.7	98.7	98.7	98.9	98.9	98.7	98.7	98.7	98.7	98.7	98.7
5	98.7	98.7	98.7	98.7	98.9	98.9	98.7	98.7	98.7	98.7	98.9	98.7
1	98.7	98.7	98.7	98.9	98.9	98.9	98.9	98.9	98.9	98.7	98.9	98.7

REDBREAST SUNFISH SPAWN

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	31.9	33.2	34.4	34.4	34.4	31.9
95	33.2	38.2	43.7	38.2	45.4	36.9
90	34.4	40.8	53.3	45.4	91.2	45.4
85	35.7	43.7	91.2	53.3	91.2	65.6
80	36.9	48.0	91.2	91.2	91.2	91.2
75	39.4	70.7	91.2	91.2	91.2	91.2
70	40.8	83.5	91.2	91.2	91.2	91.2
65	40.8	83.5	91.2	91.2	91.2	91.2
60	45.4	83.5	91.2	91.2	91.2	91.2
55	70.7	91.2	91.2	91.2	91.2	91.2
50	70.7	91.2	91.2	91.2	91.2	91.2
45	83.5	91.2	91.2	91.2	91.2	91.2
40	83.5	91.2	91.2	91.2	91.2	91.2
35	91.2	91.2	91.2	91.2	91.2	91.2
30	91.2	91.2	91.2	91.2	91.2	97.6
25	91.2	91.2	91.2	91.2	91.2	97.6
20	91.2	91.2	91.2	97.6	97.6	97.6
15	91.2	91.2	97.6	97.6	97.6	97.6
10	91.2	91.2	97.6	97.6	97.6	97.6
5	91.2	91.2	97.6	97.6	97.6	97.6
1	91.2	97.6	97.6	97.6	97.6	97.6

REDBREAST SUNFISH ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	30.6	30.6	30.6	30.6	30.6	33.5	36.4	36.4	36.4	30.6	30.6	39.2
95	39.2	39.2	36.4	36.4	33.5	45.0	63.4	45.0	45.0	42.1	42.1	45.0
90	42.1	42.1	39.2	36.4	36.4	52.4	83.6	68.7	68.7	68.7	63.4	45.0
85	45.0	42.1	42.1	39.2	39.2	63.4	96.3	83.6	83.6	95.3	73.7	47.9
80	47.9	45.0	42.1	39.2	42.1	73.7	96.3	96.3	96.3	96.3	83.6	52.4
75	47.9	45.0	42.1	42.1	47.9	98.3	96.3	96.3	96.3	96.3	95.3	57.9
70	52.4	47.9	45.0	42.1	52.4	98.9	96.3	96.3	96.3	96.3	96.3	63.4
65	52.4	47.9	45.0	45.0	52.4	98.9	98.9	96.3	96.3	96.3	96.3	95.3
60	57.9	47.9	47.9	47.9	68.7	98.9	98.9	98.9	98.9	96.3	96.3	96.3
55	63.4	52.4	52.4	52.4	98.3	98.9	98.9	98.9	98.9	96.3	96.3	98.3
50	68.7	57.9	57.9	57.9	98.3	98.9	98.9	98.9	98.9	96.3	96.3	98.3
45	91.6	57.9	63.4	63.4	98.9	98.9	98.9	98.9	98.9	98.9	96.3	98.3
40	98.3	63.4	68.7	68.7	98.9	98.9	98.9	98.9	98.9	98.9	98.3	98.3
35	98.9	68.7	78.6	95.3	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9
30	98.9	73.7	95.3	98.3	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9
25	98.9	91.9	98.3	98.3	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9
20	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9
15	98.9	98.9	98.9	98.9	98.9	99.8	98.9	98.9	98.9	98.9	98.9	98.9
10	98.9	98.9	98.9	98.9	99.8	99.8	98.9	98.9	98.9	98.9	98.9	98.9
5	98.9	98.9	98.9	98.9	99.8	99.8	98.9	98.9	98.9	98.9	99.8	98.9
1	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8	98.9	99.8	99.8

REDEYE BASS YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	21.7	23.4	25.0	25.0	25.0	21.7
95	23.4	29.8	38.4	29.8	40.9	28.2
90	25.0	33.6	49.9	40.9	86.9	40.9
85	26.6	38.4	86.9	49.9	86.9	62.7
80	28.2	43.9.	86.9	86.9	86.9	86.9
75	31.4	67.7	86.9	86.9	86.9	86.9
70	33.6	80.1	86.9	86.9	86.9	86.9
65	33.6	80.1	86.9	86.9	86.9	86.9
60	40.9	80.1	86.9	86.9	86.9	86.9
55	67.7	86.9	86.9	86.9	86.9	86.9
50	67.7	86.9	86.9	86.9	86.9	86.9
45	80.1	86.9	86.9	86.9	86.9	86.9
40	80.1	86.9	86.9	86.9	86.9	86.9
35	86.9	86.9	86.9	86.9	86.9	86.9
30	86.9	86.9	86.9	86.9	86.9	95.0
25	86.9	86.9	86.9	86.9	86.9	95.0
20	86.9	86.9	86.9	95.0	95.0	95.0
15	86.9	86.9	95.0	95.0	95.0	95.0
10	86.9	86.9	95.0	95.0	95.0	95.0
5	86.9	86.9	95.0	95.0	95.0	95.0
1	86.9	95.0	95.0	95.0	95.0	95.0

REDEYE BASS JUVENILE

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	35.7	35.7	35.7	35.7	35.7	39.0	42.2	42.2	42.2	35.7	35.7	45.5
95	45.5	45.5	42.2	42.2	39.0	52.0	67.9	52.0	52.0	48.8	48.8	52.0
90	48.8	48.8	45.5	42.2	42.2	59.2	86.1	72.3	72.3	72.3	67.9	52.0
85	52.0	48.8	48.8	45.5	45.5	67.9	94.5	86.1	86.1	94.5	76.9	55.3
80	55.3	52.0	48.8	45.5	48.8	76.9	94.5	94.5	94.5	94.5	86.1	59.2
75	55.3	52.0	48.8	48.8	55.3	97.9	94.5	94.5	94.5	94.5	94.5	63.6
70	59.2	55.3	52.0	48.8	59.2	97.9	94.5	94.5	94.5	94.5	94.5	67.9
65	59.2	55.3	52.0	52.0	59.2	97.9	97.9	94.5	94.5	94.5	94.5	94.5
60	63.6	55.3	55.3	55.3	72.3	97.9	97.9	97.9	97.9	94.5	94.5	94.5
55	67.9	59.2	59.2	59.2	97.9	97.9	97.9	97.9	97.9	94.5	94.5	97.9
50	72.3	63.6	63.6	63.6	97.9	97.9	97.9	97.9	97.9	96.5	94.5	97.9
45	94.0	63.6	67.9	67.9	97.9	97.9	97.9	97.9	97.9	97.9	94.5	97.9
40	97.9	67.9	72.3	72.3	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9
35	97.9	72.3	81.5	96.5	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9
30	97.9	76.9	96.5	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9
25	97.9	86.1	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9
20	97.9	97.9	97.9	97.9	98.7	97.9	97.9	97.9	97.9	97.9	97.9	98.7
15	97.9	97.9	97.9	97.9	98.7	99.7	97.9	97.9	97.9	97.9	97.9	98.7
10	97.9	97.9	97.9	98.7	99.7	99.7	97.9	97.9	97.9	97.9	98.7	98.7
5	98.7	98.7	98.7	98.7	99.7	99.7	97.9	97.9	97.9	97.9	99.7	98.7
1	99.9	99.9	99.9	99.7	99.7	99.9	99.7	99.7	99.7	97.9	99.9	99.9

TABLE H-3 (Cont.)

REDEYE BASS ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	56.1	56.1	56.1	56.1	56.1	58.9	61.7	61.7	61.7	56.1	56.1	64.4
95	64.4	64.4	61.7	61.7	58.9	70.0	81.0	70.0	70.0	67.2	67.2	70.0
90	67.2	67.2	64.4	61.7	61.7	75.5	84.6	83.7	83.7	83.7	78.2	70.0
85	70.0	67.2	67.2	64.4	64.4	81.0	84.6	84.6	84.6	84.6	84.6	72.7
80	72.7	70.0	67.2	64.4	67.2	84.6	84.6	84.6	84.6	84.6	84.6	75.5
75	72.7	70.0	67.2	67.2	72.7	91.4	84.6	84.6	84.6	84.6	84.6	78.2
70	75.5	72.7	70.0	67.2	75.5	91.4	91.4	84.6	84.6	84.6	84.6	81.0
65	75.5	72.7	70.0	70.0	75.5	91.4	91.4	91.4	91.4	84.6	84.6	84.6
60	78.2	72.7	72.7	72.7	83.7	91.4	91.4	91.4	91.4	84.6	84.6	89.5
55	81.0	75.5	75.5	75.5	91.4	91.4	91.4	91.4	91.4	89.5	84.6	91.4
50	83.7	75.5	78.2	78.2	91.4	91.4	91.4	91.4	91.4	91.4	89.5	91.4
45	91.4	78.2	81.0	81.0	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4
40	91.4	78.2	83.7	83.7	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4
35	91.4	81.0	89.5	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4
30	91.4	83.7	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4
25	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4
20	91.4	91.4	91.4	91.4	95.4	92.4	91.4	91.4	91.4	91.4	92.4	98.1
15	91.4	91.4	92.4	95.4	95.4	95.4	91.4	91.4	91.4	91.4	95.4	99.6
10	92.4	91.4	98.1	99.6	95.4	95.4	91.4	91.4	91.4	91.4	98.1	99.6
5	99.6	98.1	98.7	99.6	99.6	98.1	91.4	92.4	92.4	96.9	98.7	99.6
1	99.6	99.6	99.6	99.6	99.6	99.6	95.4	98.7	98.7	98.7	99.6	99.6

SHOAL BASS YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	11.8	12.2	12.7	12.7	12.7	11.8
95	12.2	14.1	17.7	14.1	18.9	13.7
90	12.7	15.5	25.1	18.9	71.0	18.9
85	13.2	17.7	71.0	25.1	71.0	38.4
80	13.7	21.0	71.0	71.0	71.0	71.0
75	14.6	44.1	71.0	71.0	71.0	71.0
70	15.5	60.5	71.0	71.0	71.0	71.0
65	15.5	60.5	71.0	71.0	71.0	71.0
60	18.9	60.5	71.0	71.0	71.0	71.0
55	44.1	71.0	71.0	71.0	71.0	71.0
50	44.1	71.0	71.0	71.0	71.0	71.0
45	60.5	71.0	71.0	71.0	71.0	71.0
40	60.5	71.0	71.0	71.0	71.0	71.0
35	71.0	71.0	71.0	71.0	71.0	71.0
30	71.0	71.0	71.0	71.0	71.0	82.9
25	71.0	71.0	71.0	71.0	71.0	82.9
20	71.0	71.0	71.0	82.9	82.9	82.9
15	71.0	71.0	82.9	82.9	82.9	82.9
10	71.0	71.0	82.9	82.9	82.9	82.9
5	71.0	71.0	82.9	82.9	82.9	82.9
1	71.0	82.9	82.9	82.9	82.9	82.9

SHOAL BASS ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	42.3	42.3	42.3	42.3	42.3	44.9	47.5	47.5	47.5	42.3	42.3	50.1
95	50.1	50.1	47.5	47.5	44.9	55.3	70.7	55.3	55.3	52.8	52.8	55.3
90	52.8	52.8	50.1	47.5	47.5	61.7	84.6	74.9	74.9	74.9	70.7	55.3
85	55.3	52.8	52.8	50.1	50.1	70.7	89.6	84.6	84.6	89.6	78.2	58.0
80	58.0	55.3	52.8	50.1	52.8	78.2	89.6	89.6	89.6	89.6	84.6	61.7
75	58.0	55.3	52.8	52.8	58.0	95.2	89.6	89.6	89.6	89.6	89.6	66.2
70	61.7	58.0	55.3	52.8	61.7	95.2	91.1	89.6	89.6	89.6	89.6	70.7
65	61.7	58.0	55.3	55.3	61.7	95.2	95.2	89.6	89.6	89.6	89.6	89.6
60	66.2	58.0	58.0	58.0	74.9	95.2	95.2	95.2	95.2	89.6	89.6	89.6
55	70.7	61.7	61.7	61.7	95.2	95.2	95.2	95.2	95.2	89.6	89.6	95.2
50	74.9	66.2	66.2	66.2	95.2	95.2	95.2	95.2	95.2	94.5	89.6	95.2
45	91.1	66.2	70.7	70.7	95.2	95.2	95.2	95.2	95.2	95.2	89.6	95.2
40	95.2	70.7	74.9	74.9	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2
35	95.[illegible]	74.9	81.4	94.5	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2
30	95.2	75.1	94.5	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2
25	95.2	84.6	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2
20	95.2	95.2	95.2	95.2	97.5	95.2	95.2	95.2	95.2	95.2	95.2	97.5
15	95.2	95.2	95.2	95.2	97.5	98.4	95.2	95.2	95.2	95.2	95.2	97.5
10	95.2	95.2	95.2	97.5	98.4	98.4	95.2	95.2	95.2	95.2	97.5	97.5
5	97.5	97.5	97.5	97.5	98.4	98.4	95.2	95.2	95.2	95.2	98.4	97.5
1	99.7	99.7	99.7	98.4	98.4	99.7	98.4	98.4	98.4	95.2	99.7	99.7

TABLE H-3 (Cont.)

SILVER REDHORSE ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	51.7	51.7	51.7	51.7	51.7	55.3	58.8	58.8	58.8	51.7	51.7	62.3
95	62.3	62.3	58.8	58.8	55.3	69.4	82.2	69.4	69.4	65.9	65.9	69.4
90	65.9	65.9	62.3	58.8	58.8	76.9	82.2	82.2	82.2	82.2	81.3	69.4
85	69.4	65.9	65.9	62.3	62.3	85.6	82.2	82.2	82.2	82.2	82.2	72.9
80	72.9	69.4	65.9	62.3	65.9	88.3	82.2	82.2	82.2	82.2	82.2	76.9
75	72.9	69.4	65.9	65.9	72.9	88.3	88.3	82.2	82.2	82.2	82.2	81.3
70	76.9	72.9	69.4	65.9	76.9	88.3	88.3	88.3	88.3	82.2	82.2	82.2
65	76.9	72.9	69.4	69.4	76.9	88.3	88.3	88.3	88.3	82.2	82.2	82.2
60	81.3	72.9	72.9	72.9	88.3	88.3	88.3	88.3	88.3	82.2	82.2	88.3
55	85.6	76.9	76.9	76.9	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3
50	88.3	76.9	81.3	81.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3
45	88.3	81.3	85.6	85.6	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3
40	88.3	81.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3
35	88.3	85.6	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3
30	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3
25	88.3	88.3	88.3	88.3	88.3	89.6	88.3	88.3	88.3	88.3	89.6	89.6
20	88.3	88.3	89.6	89.6	93.9	93.9	88.3	88.3	88.3	88.3	93.9	99.1
15	89.6	89.6	98.0	93.9	93.9	93.9	88.3	88.3	88.3	88.3	95.2	99.1
10	98.0	93.9	99.1	99.1	95.2	93.9	88.3	88.3	88.3	89.6	99.1	99.1
5	99.1	99.1	99.4	99.1	99.1	99.1	93.9	95.2	95.2	99.4	99.2	99.2
1	99.4	99.2	99.4	99.4	99.4	99.2	98.0	99.4	99.4	99.4	99.4	99.4

STRIPED JUMPROCK YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	8.6	9.0	9.4	9.4	9.4	8.6
95	9.0	10.6	13.2	10.6	14.1	10.2
90	9.4	11.7	16.7	14.1	61.1	14.1
85	9.8	13.2	61.1	16.7	61.1	24.8
80	10.2	14.9	61.1	61.1	61.1	61.1
75	11.0	29.5	61.1	61.1	61.1	61.1
70	11.7	48.5	61.1	61.1	61.1	61.1
65	11.7	48.5	61.1	61.1	61.1	61.1
60	14.1	48.5	61.1	61.1	61.1	61.1
55	29.5	61.1	61.1	61.1	61.1	61.1
50	29.5	61.1	61.1	61.1	61.1	61.1
45	48.5	61.1	61.1	61.1	61.1	61.1
40	48.5	61.1	61.1	61.1	61.1	61.1
35	61.1	61.1	61.1	61.1	61.1	61.1
30	61.1	61.1	61.1	61.1	61.1	76.9
25	61.1	61.1	61.1	61.1	61.1	76.9
20	61.1	61.1	61.1	76.9	76.9	76.9
15	61.1	61.1	76.9	76.9	76.9	76.9
10	61.1	61.1	76.9	76.9	76.9	76.9
5	61.1	61.1	76.9	76.9	76.9	76.9
1	61.1	76.9	76.9	76.9	76.9	76.9

STRIPED JUMPROCK ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	40.7	40.7	40.7	40.7	40.7	44.1	47.4	47.4	47.4	40.7	40.7	50.8
95	50.8	50.8	47.4	47.4	44.1	57.5	71.1	57.5	57.5	54.1	54.1	57.5
90	54.1	54.1	50.8	47.4	47.4	64.2	85.6	74.5	74.5	74.5	71.1	57.5
85	57.5	54.1	54.1	50.8	50.8	71.1	94.0	85.6	85.6	94.0	78.2	60.8
80	60.8	57.5	54.1	50.8	54.1	78.2	94.0	94.0	94.0	94.0	85.6	64.2
75	60.8	57.5	54.1	54.1	60.8	97.6	94.0	94.0	94.0	94.0	94.0	67.6
70	64.2	60.8	57.5	54.1	64.2	98.2	94.0	94.0	94.0	94.0	94.0	71.1
65	64.2	60.8	57.5	57.5	64.2	98.2	98.2	94.0	94.0	94.0	94.0	94.0
60	67.6	60.8	60.8	60.8	74.5	98.2	98.2	98.2	98.2	94.0	94.0	94.0
55	71.1	64.2	64.2	64.2	97.6	98.2	98.2	98.2	98.2	94.0	94.0	97.6
50	74.5	67.6	67.6	67.6	97.6	98.2	98.2	98.2	98.2	95.0	94.0	97.6
45	92.2	67.6	71.1	71.1	98.2	98.2	98.2	98.2	98.2	98.2	94.0	97.6
40	97.6	71.1	74.5	74.5	98.2	98.2	98.2	98.2	98.2	98.2	97.6	97.6
35	98.2	74.5	81.9	95.0	98.2	98.2	98.2	98.2	98.2	98.2	98.2	98.2
30	98.2	78.2	95.0	97.6	98.2	98.2	98.2	98.2	98.2	98.2	98.2	98.2
25	98.2	85.6	97.6	97.6	98.2	98.2	98.2	98.2	98.2	98.2	98.2	98.2
20	98.2	98.2	98.2	98.2	98.2	98.2	98.2	98.2	98.2	98.2	98.2	98.2
15	98.2	98.2	98.2	98.2	98.2	99.5	98.2	98.2	98.2	98.2	98.2	98.2
10	98.2	98.2	98.2	98.2	99.5	99.5	98.2	98.2	98.2	98.2	98.2	98.2
5	98.2	98.2	98.2	98.2	99.5	99.5	98.2	98.2	98.2	98.2	99.5	98.2
1	99.7	99.7	99.7	99.5	99.5	99.7	99.5	99.5	99.5	98.2	99.7	99.7

TABLE H-4 HABITAT DURATION TABLES FOR EACH SPECIES LIFE STAGE IN THE OCMULGEE RIVER STUDY AREA BASED ON ANALYSIS OF AVERAGE DAILY UNREGULATED FLOWS AT LLOYD SHOALS DAM FOR THE PERIOD OF RECORD 1978 TO 1986

ALTAMAHA SHINER YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	21.5	22.5	24.4	23.2	25.4	29.6
95	29.5	40.0	65.5	42.2	43.9	68.2
90	36.4	46.9	77.5	54.2	76.4	76.2
85	41.0	54.4	81.2	75.1	85.0	83.7
80	42.0	61.7	84.8	79.7	89.2	85.9
75	47.0	68.2	87.4	85.7	91.8	86.6
70	51.9	71.7	90.0	90.3	93.3	89.1
65	54.0	77.0	91.6	94.2	94.5	90.9
60	57.8	80.8	93.0	95.3	95.5	93.3
55	60.8	82.4	93.8	95.6	96.7	94.0
50	62.1	85.6	94.1	96.4	97.6	94.6
45	65.3	88.7	95.1	97.0	98.1	96.2
40	67.9	90.5	95.7	97.4	98.4	97.1
35	71.8	92.2	96.4	97.9	98.5	98.0
30	76.1	93.5	96.8	98.0	98.9	98.3
25	79.0	94.4	97.5	98.5	99.0	98.5
20	82.0	95.4	97.9	98.7	99.3	98.8
15	89.7	96.2	98.7	98.9	99.5	99.4
10	94.4	97.3	99.4	99.2	99.7	99.5
5	96.0	98.7	99.8	99.4	99.8	99.7
1	98.9	99.8	99.9	99.9	100.0	100.0

ALTAMAHA SHINER ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	34.5	33.6	33.5	33.1	35.6	37.0	39.8	38.1	38.1	47.3	33.3	44.6
95	39.2	40.4	39.5	35.1	47.1	57.5	76.8	59.5	59.5	79.0	51.2	57.0
90	45.7	46.0	46.7	40.4	54.2	63.1	86.8	68.4	68.4	83.0	71.7	69.5
85	49.1	48.3	48.2	43.5	58.4	68.5	89.3	84.7	84.7	83.9	80.2	75.9
80	53.8	50.6	53.1	45.9	59.3	73.8	91.0	88.7	88.7	87.7	84.3	80.8
75	57.0	53.6	56.5	48.0	63.1	79.0	92.6	92.4	92.4	90.2	86.9	84.0
70	59.3	55.7	59.6	49.3	66.7	81.8	93.9	94.4	94.4	91.4	92.3	86.8
65	63.3	58.5	62.4	52.6	68.2	86.4	95.1	95.5	95.5	93.0	94.1	87.8
60	67.5	59.7	64.9	56.7	70.9	89.6	95.7	97.2	97.2	94.9	95.4	90.0
55	70.3	61.5	66.4	58.6	73.2	91.0	96.4	97.4	97.4	95.5	96.7	91.0
50	73.3	62.4	68.1	59.5	74.2	92.9	96.9	97.9	97.9	97.0	96.9	91.9
45	76.3	65.2	69.2	66.3	76.6	94.3	97.3	98.2	98.2	97.2	97.2	93.6
40	78.9	67.6	70.7	71.9	78.7	94.9	97.4	98.4	98.4	97.3	97.4	94.9
35	80.3	68.7	71.6	76.5	82.0	95.8	97.6	98.5	98.5	97.4	97.6	95.7
30	82.3	70.9	73.9	78.6	85.6	96.5	97.7	98.7	98.7	97.5	97.6	96.0
25	92.3	74.3	76.7	80.4	88.1	97.1	97.9	98.8	98.8	97.8	98.0	96.6
20	97.2	76.3	80.3	84.2	90.6	97.4	98.6	99.2	99.2	98.5	98.1	96.9
15	97.7	79.1	84.2	87.0	95.2	98.0	98.8	99.4	99.4	98.8	98.9	97.3
10	98.1	81.0	89.1	92.1	98.0	98.6	99.3	99.6	99.6	99.1	99.2	97.6
5	98.4	89.3	91.3	94.9	99.0	99.1	99.7	99.8	99.8	99.5	99.8	99.2
1	98.7	98.1	93.9	97.2	99.7	99.9	100.0	100.0	100.0	99.8	100.0	100.0

REDBREAST SUNFISH SPAWN

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	32.7	33.5	34.9	34.0	35.7	38.8
95	38.8	43.7	55.1	44.7	45.4	56.8
90	42.2	46.7	63.9	49.9	62.9	62.8
85	44.2	50.0	67.2	61.8	70.6	69.5
80	44.6	53.2	70.5	65.9	76.7	72.6
75	46.7	56.8	72.7	71.2	81.0	74.6
70	48.9	58.9	75.0	75.2	84.3	77.8
65	49.8	63.5	76.6	81.9	87.6	83.3
60	51.4	66.9	78.7	82.9	89.9	85.5
55	52.8	68.3	79.6	84.6	90.5	88.6
50	53.3	71.1	81.8	86.1	91.7	90.5
45	55.0	73.9	83.4	87.4	92.6	91.6
40	56.6	75.5	85.2	88.9	93.9	95.6
35	59.0	76.9	87.7	90.5	95.2	96.2
30	62.7	78.9	91.2	91.2	96.1	96.4
25	65.3	80.9	93.8	92.1	96.5	97.5
20	67.9	83.1	95.6	92.9	97.2	97.7
15	74.8	86.6	97.2	94.4	97.9	99.6
10	80.8	93.8	98.0	97.5	99.8	99.7
5	84.1	98.3	99.3	98.2	99.9	99.8
1	91.8	99.7	100.0	99.8	100.0	99.9

TABLE H-4 (Cont.)

REDBREAST SUNFISH ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	31.2	30.1	29.9	29.5	32.4	34.2	37.6	35.5	35.5	46.5	29.8	43.3
95	36.8	38.3	37.1	31.9	46.3	63.4	86.2	66.9	66.9	87.9	52.3	62.6
90	44.6	45.0	45.8	38.2	57.6	71.3	92.6	77.2	77.2	89.3	81.0	78.5
85	48.7	47.7	47.6	41.9	65.0	77.4	93.7	92.4	92.4	90.2	88.8	85.5
80	56.9	51.2	55.7	44.8	66.5	83.4	95.2	93.6	93.6	92.6	92.1	89.3
75	62.5	56.5	61.6	47.3	71.3	87.9	95.9	95.1	95.1	92.7	94.1	91.8
70	66.6	60.3	67.1	48.9	75.3	90.1	96.9	96.6	96.6	94.3	96.0	94.1
65	71.5	65.1	70.5	54.8	77.1	92.8	97.6	98.0	98.0	96.2	96.5	94.8
60	76.2	67.3	73.3	62.1	80.1	94.5	98.1	98.4	98.4	97.3	97.0	96.5
55	79.4	69.5	75.0	65.3	82.7	95.9	98.3	98.5	98.5	97.6	97.2	97.3
50	82.7	70.5	76.9	66.9	83.7	96.9	98.6	98.7	98.7	97.7	97.5	97.9
45	85.8	73.7	78.2	74.9	86.0	97.6	98.9	98.9	98.9	98.0	98.3	98.1
40	87.8	76.3	79.9	81.2	87.7	98.4	99.2	99.0	99.0	98.4	98.5	98.7
35	88.9	77.6	80.9	85.9	90.2	98.9	99.5	99.3	99.3	98.8	98.9	99.2
30	90.5	80.1	83.4	87.6	93.1	99.2	99.7	99.4	99.4	98.9	99.3	99.5
25	98.2	83.9	86.1	89.0	95.0	99.5	99.7	99.6	99.6	99.1	99.6	99.6
20	99.8	85.8	88.9	92.0	97.0	99.7	99.8	99.7	99.7	99.3	99.7	99.7
15	99.8	88.0	91.9	94.2	99.0	99.8	99.8	99.7	99.7	99.5	99.7	99.8
10	99.9	89.5	95.8	98.1	99.8	99.9	99.9	99.8	99.8	99.7	99.8	99.9
5	99.9	96.0	97.5	99.2	99.9	99.9	99.9	99.8	99.8	99.8	99.9	100.0
1	100.0	99.9	98.8	100.0	100.0	100.0	100.0	99.9	99.9	100.0	100.0	100.0

REDEYE BASS YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	22.8	23.7	25.7	24.5	26.7	30.7
95	30.6	38.4	52.0	40.0	40.9	53.8
90	35.9	42.4	61.1	46.0	60.1	60.0
85	39.1	46.1	64.3	59.0	67.6	66.5
80	39.8	49.8	67.4	63.0	73.6	69.5
75	42.4	53.8	69.6	68.2	77.7	71.5
70	44.9	56.2	71.9	72.2	80.9	74.7
65	45.9	60.7	73.5	78.6	83.9	79.9
60	47.8	63.9	75.6	79.5	85.9	82.0
55	49.3	65.3	76.4	81.2	86.4	84.8
50	50.0	68.1	78.5	82.5	87.3	86.4
45	51.8	70.8	80.0	83.8	88.2	87.3
40	53.6	72.4	81.7	85.0	89.2	90.6
35	56.3	73.8	84.0	86.4	90.3	91.8
30	59.9	75.7	86.9	86.9	91.5	92.2
25	62.4	77.6	89.1	87.7	92.5	94.7
20	65.0	79.7	90.6	88.4	94.0	95.1
15	71.7	83.1	94.0	89.6	95.7	97.9
10	77.5	89.1	95.9	94.7	98.0	98.2
5	80.7	96.5	97.4	96.3	98.9	99.9
1	87.5	97.9	98.6	98.0	99.6	100.0

REDEYE BASS JUVENILE

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	36.3	35.1	34.9	34.3	37.7	39.7	43.6	41.2	41.2	53.8	34.7	50.1
95	42.7	44.4	43.1	37.1	53.6	67.9	86.3	70.7	70.7	84.1	59.2	67.3
90	51.6	52.1	53.0	44.3	63.4	74.6	89.9	80.2	80.2	84.7	83.7	81.3
85	56.3	55.1	55.0	48.6	69.2	80.3	92.7	90.0	90.0	88.4	91.5	87.9
80	62.9	58.3	61.9	51.9	70.4	85.9	94.3	93.6	93.6	89.5	94.1	92.0
75	67.2	62.5	66.6	54.7	74.7	90.1	95.4	94.7	94.7	92.3	94.3	94.2
70	70.5	65.5	70.9	56.6	78.4	91.3	96.2	95.6	95.6	94.4	94.6	95.7
65	74.9	69.3	73.9	61.2	80.0	92.9	96.5	96.7	96.7	95.1	94.9	96.0
60	79.2	71.1	76.5	66.9	82.8	94.6	97.1	97.2	97.2	95.6	95.0	96.4
55	82.2	73.0	78.1	69.5	85.2	96.0	97.8	97.5	97.5	95.7	95.3	97.4
50	85.3	74.0	79.8	70.7	86.2	97.1	98.5	97.9	97.9	96.1	96.5	97.8
45	88.2	76.9	81.1	78.0	88.5	97.8	98.9	98.1	98.1	96.5	97.7	98.4
40	90.4	79.3	82.6	83.9	90.3	98.4	99.2	98.7	98.7	[illegible]	98.5	98.6
35	91.6	80.5	83.5	88.3	93.0	99.1	99.5	98.9	98.9	98.2	98.9	99.1
30	93.2	82.8	85.9	90.1	95.0	99.3	99.6	99.2	99.2	98.5	99.2	99.5
25	98.5	86.4	88.5	91.7	96.3	99.6	99.7	99.5	99.5	99.0	99.5	99.6
20	99.8	88.2	91.5	94.3	97.7	99.7	99.7	99.6	99.6	99.3	99.7	99.7
15	99.8	90.6	94.2	95.8	99.2	99.8	99.8	99.7	99.7	99.5	99.7	99.9
10	99.9	92.1	96.9	98.5	99.7	99.9	99.9	99.8	99.8	99.7	99.8	99.9
5	99.9	97.0	98.1	99.4	99.8	99.9	99.9	99.8	99.8	99.8	99.9	100.0
1	100.0	99.8	99.0	100.0	99.9	100.0	100.0	99.9	99.9	100.0	100.0	100.0

REDEYE BASS ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	56.7	55.6	55.4	55.0	57.9	59.5	62.8	60.8	60.8	70.0	55.3	68.3
95	62.0	63.5	62.4	57.3	71.3	77.3	77.1	77.1	77.1	70.9	75.4	80.6
90	69.6	70.0	70.7	63.4	78.1	81.5	80.9	82.2	82.2	76.1	84.1	88.0
85	73.5	72.6	72.5	67.0	81.8	83.9	84.2	84.9	84.9	76.8	84.8	89.9
80	77.8	74.9	77.1	69.8	82.6	86.0	87.2	87.4	87.4	83.0	85.0	92.4
75	80.5	77.5	80.1	72.2	85.2	89.7	88.9	89.4	89.4	84.9	86.0	94.1
70	82.6	79.4	82.9	73.8	87.6	91.2	90.1	90.5	90.5	87.2	86.5	95.2
65	85.4	81.9	84.8	76.7	88.6	92.8	91.8	90.8	90.8	87.6	90.0	96.7
60	88.1	83.0	86.4	80.3	90.4	94.5	93.8	91.4	91.4	88.4	91.4	97.2
55	90.0	84.2	87.4	81.9	91.6	95.2	94.6	91.6	91.6	89.7	93.5	97.6
50	91.9	84.8	88.5	82.7	92.4	95.7	95.3	92.7	92.7	91.2	94.0	98.0
45	93.7	86.6	89.3	87.3	93.6	96.3	95.8	93.6	93.6	91.9	94.9	98.1
40	94.9	88.2	90.3	91.0	94.3	97.1	96.8	94.1	94.1	93.0	95.3	98.2
35	95.5	88.9	90.8	93.8	95.0	97.7	97.1	94.6	94.6	94.6	96.4	98.4
30	95.9	90.4	92.3	94.7	95.5	98.1	97.8	95.1	95.1	95.4	97.0	98.4
25	96.1	92.6	93.8	95.5	96.4	98.4	98.2	95.7	95.7	96.6	97.6	98.6
20	96.4	93.7	95.5	97.1	97.2	98.6	98.5	96.2	96.2	97.8	98.1	98.9
15	96.9	94.9	97.1	98.0	97.6	99.0	98.8	97.5	97.5	98.4	98.4	99.3
10	97.2	95.8	99.0	98.7	98.6	99.2	99.2	98.6	98.6	98.7	99.0	99.7
5	98.6	96.6	99.6	99.4	99.1	99.6	99.5	99.4	99.4	99.4	99.7	99.9
1	99.8	99.5	100.0	99.9	100.0	99.9	99.8	99.9	99.9	99.9	99.9	100.0

SHOAL BASS YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	12.1	12.3	12.9	12.6	13.2	14.4
95	14.4	17.7	26.9	18.4	18.9	28.6
90	16.5	20.0	36.5	22.4	35.4	35.2
85	18.0	22.5	40.2	34.1	44.0	42.7
80	18.3	25.0	43.8	38.7	51.1	46.3
75	20.0	28.6	46.4	44.7	56.9	48.7
70	21.7	30.9	49.2	49.4	61.6	52.5
65	22.4	36.0	51.0	58.2	66.1	60.1
60	23.6	39.8	53.8	59.6	69.2	63.2
55	24.7	41.4	55.0	62.0	70.0	67.5
50	25.1	44.6	58.1	64.0	71.6	70.1
45	26.7	47.8	60.3	65.9	72.9	71.5
40	28.4	49.7	62.7	67.8	74.6	76.9
35	31.0	51.4	66.3	70.1	76.3	78.4
30	35.1	54.0	71.0	71.0	78.1	79.0
25	38.0	56.8	74.5	72.1	79.4	82.5
20	41.0	59.9	76.9	73.3	81.4	83.2
15	48.9	64.8	81.4	75.3	84.2	89.1
10	56.6	74.5	84.6	82.5	89.3	90.2
5	61.3	85.7	87.6	85.3	92.7	95.6
1	71.8	89.1	91.9	89.3	94.6	96.1

SHOAL BASS ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	42.8	41.9	41.7	41.3	44.0	45.5	48.6	46.7	46.7	56.7	41.5	53.8
95	47.9	49.3	48.2	43.5	56.6	70.7	79.4	73.6	73.6	70.2	61.7	70.1
90	55.0	55.4	56.1	49.2	66.0	76.6	83.8	80.5	80.5	77.5	82.9	81.3
85	58.7	57.8	57.7	52.6	72.0	80.6	87.7	85.6	85.6	80.0	87.7	85.9
80	65.5	60.8	64.4	55.2	73.3	83.3	89.3	87.6	87.6	82.0	89.0	89.1
75	70.0	65.1	69.3	57.5	76.6	85.2	91.8	91.5	91.5	88.9	89.9	91.3
70	73.3	68.2	73.7	58.9	79.2	87.7	92.9	93.1	93.1	89.3	90.2	92.5
65	76.7	72.1	76.1	63.7	80.3	88.8	93.8	93.9	93.9	91.4	91.0	93.8
60	79.8	73.9	77.9	69.6	82.4	91.4	94.8	94.5	94.5	92.0	91.4	94.1
55	81.9	75.4	79.0	72.2	84.0	93.1	95.6	94.7	94.7	92.3	92.8	95.5
50	84.1	76.1	80.2	73.5	84.7	94.9	96.5	95.2	95.2	92.8	93.8	96.1
45	86.2	78.2	81.1	78.9	86.4	96.0	97.4	95.5	95.5	93.9	95.0	97.0
40	87.9	79.9	82.2	83.1	87.8	96.6	97.7	96.4	96.4	95.1	96.7	97.2
35	88.8	80.7	82.9	86.3	89.8	97.7	98.1	97.1	97.1	95.6	97.3	98.0
30	90.0	82.3	84.5	87.7	92.4	98.4	98.4	97.5	97.5	96.6	97.5	98.5
25	97.3	84.9	86.4	88.8	94.2	98.6	98.6	97.7	97.7	97.2	98.1	99.2
20	98.7	86.2	88.7	91.4	95.8	98.9	99.0	98.0	98.0	98.0	98.3	99.4
15	99.0	88.0	91.4	93.5	97.9	99.2	99.3	98.5	98.5	98.4	98.6	99.6
10	99.2	89.2	95.0	97.1	98.5	99.4	99.5	98.7	98.7	98.9	99.1	99.7
5	99.4	95.2	96.6	98.8	99.0	99.8	99.7	99.1	99.1	99.4	99.6	99.9
1	99.8	99.0	98.2	99.8	99.7	100.0	99.9	99.7	99.7	99.9	100.0	100.0

TABLE H-4 (Cont.)

SILVER REDHORSE ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	52.4	51.1	50.8	50.3	53.9	56.1	60.3	57.7	57.7	66.5	50.6	67.3
95	59.3	61.1	59.7	53.3	71.1	76.9	76.5	76.5	76.5	67.3	76.9	84.8
90	68.9	69.4	70.4	61.1	81.1	82.3	79.2	81.4	81.4	74.5	81.8	86.9
85	74.0	72.7	72.6	65.6	86.9	85.9	82.9	84.4	84.4	75.9	82.4	91.2
80	80.6	76.1	79.6	69.2	87.9	88.1	85.2	86.3	86.3	81.9	83.2	94.5
75	84.9	80.2	84.2	72.3	90.3	91.2	86.0	87.4	87.4	82.5	83.4	97.7
70	88.2	83.2	88.6	74.3	91.8	93.1	87.5	87.9	87.9	84.5	86.7	98.2
65	91.2	87.0	90.6	78.9	93.4	94.5	90.1	88.3	88.3	84.7	88.3	99.0
60	93.9	88.7	92.2	84.6	94.0	95.6	91.5	88.7	88.7	85.5	90.1	99.1
55	95.0	90.1	93.2	87.1	95.1	96.9	92.9	89.6	89.6	87.0	90.9	99.1
50	95.2	90.7	94.2	88.4	96.1	98.0	94.2	90.5	90.5	88.5	92.9	99.2
45	96.0	92.4	95.0	93.1	97.1	99.1	96.8	91.6	91.6	89.1	94.2	99.2
40	96.9	93.9	95.9	96.7	97.7	99.1	97.4	92.4	92.4	90.4	96.3	99.2
35	97.5	94.6	96.5	98.8	98.9	99.1	98.4	93.6	93.6	93.1	98.6	99.2
30	98.1	96.1	97.9	99.1	99.1	99.2	99.1	94.5	94.5	96.1	99.1	99.2
25	99.0	97.7	99.1	99.2	99.2	99.2	99.1	95.4	95.4	99.1	99.1	99.3
20	99.2	98.8	99.1	99.2	99.3	99.2	99.2	99.1	99.1	99.1	99.2	99.4
15	99.4	99.2	99.2	99.4	99.4	99.3	99.2	99.1	99.1	99.2	99.2	99.5
10	99.6	99.5	99.4	99.6	99.6	99.5	99.2	99.2	99.2	99.2	99.5	99.6
5	99.8	99.7	99.7	99.8	99.8	99.7	99.4	99.4	99.4	99.6	99.7	99.8
1	100.0	100.0	99.9	100.0	100.0	100.0	99.8	99.7	99.7	99.9	100.0	99.9

STRIPED JUMPROCK YOY

Percent of Time Reached or Exceeded	MAY	JUN	JUL	AUG	SEP	OCT
100	8.8	9.1	9.6	9.3	9.8	10.8
95	10.8	13.2	17.7	13.8	14.1	18.7
90	12.4	14.5	23.6	15.6	22.9	22.8
85	13.5	15.6	26.0	22.1	29.3	27.8
80	13.7	16.7	29.1	25.0	37.7	32.0
75	14.5	18.7	32.2	30.2	44.4	34.8
70	15.2	20.0	35.4	35.7	49.9	39.3
65	15.5	23.3	37.5	45.8	55.1	48.1
60	16.1	25.7	40.7	47.5	59.0	51.7
55	16.5	26.7	42.2	50.3	60.0	56.9
50	16.7	30.1	45.8	52.6	61.9	60.1
45	17.6	33.8	48.3	54.9	63.6	61.8
40	18.6	36.0	51.2	57.3	65.7	68.5
35	20.1	37.9	55.3	60.1	67.8	70.6
30	22.7	41.0	61.1	61.1	70.1	71.3
25	24.6	44.2	65.5	62.6	71.9	76.3
20	26.5	47.9	68.5	64.0	74.7	77.4
15	35.0	53.6	74.7	66.5	78.9	85.5
10	44.1	65.5	79.5	76.3	85.7	87.1
5	49.5	81.1	83.4	80.5	90.9	95.4
1	62.2	85.5	89.5	85.8	93.8	96.0

STRIPED JUMPROCK ADULT

Percent of Time Reached or Exceeded	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100	41.4	40.1	39.9	39.3	42.8	44.9	48.8	46.3	46.3	59.2	39.7	55.5
95	47.9	49.6	48.3	42.2	59.0	71.1	84.7	73.3	73.3	79.2	64.2	70.6
90	57.0	57.5	58.4	49.6	67.5	76.4	89.0	80.9	80.9	80.6	83.7	81.8
85	61.8	60.6	60.5	53.9	72.1	81.0	91.3	88.8	88.8	87.2	89.9	87.0
80	67.1	63.5	66.3	57.3	73.1	85.4	93.5	92.2	92.2	88.6	92.5	90.3
75	70.5	66.8	70.0	60.2	76.4	88.8	94.9	93.9	93.9	91.1	93.5	92.3
70	73.1	69.2	73.4	62.1	79.5	90.0	95.7	95.5	95.5	93.7	93.8	94.0
65	76.6	72.2	75.9	65.7	80.7	91.2	96.6	97.2	97.2	94.2	94.2	94.6
60	80.1	73.6	77.9	70.3	83.0	93.5	97.1	97.6	97.6	95.7	94.9	95.9
55	82.5	75.1	79.2	72.3	84.9	94.9	97.5	97.8	97.8	96.1	95.1	96.4
50	85.0	75.9	80.6	73.3	85.7	96.1	97.9	97.9	97.9	96.4	96.7	97.0
45	87.3	78.2	81.6	79.1	87.5	96.8	98.4	98.2	98.2	97.0	97.5	97.3
40	89.0	80.2	82.8	83.8	88.9	97.7	98.8	98.3	98.3	97.5	97.7	98.1
35	90.0	81.1	83.6	87.4	91.1	98.5	99.1	98.7	98.7	98.1	98.4	98.6
30	91.3	83.0	85.5	88.8	93.3	98.9	99.3	99.0	99.0	98.2	98.8	99.2
25	97.4	85.8	87.6	90.1	94.8	99.3	99.4	99.2	99.2	98.6	99.1	99.3
20	99.6	87.3	89.9	92.5	96.3	99.5	99.5	99.3	99.3	98.9	99.4	99.4
15	99.6	89.2	92.4	94.1	98.5	99.6	99.7	99.4	99.4	99.1	99.4	99.7
10	99.7	90.4	95.4	97.2	99.5	99.7	99.8	99.6	99.6	99.4	99.6	99.9
5	99.8	95.6	96.7	98.9	99.7	99.9	99.9	99.6	99.6	99.7	99.8	100.0
1	99.9	99.7	98.3	99.9	99.9	100.0	99.9	99.9	99.9	100.0	100.0	100.0

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 1996

Reservoir or River	Number of Tournaments Analyzed	Number of Anglers	BassWeighed-in/Angler Hour	Lbs. Weighed-in per angler hour	Percent Anglers with Limit	Percent Anglers with Zero Bass	Percent Anglers with Only One Bass	Average Largest Bass (lbs)	Average Bass Weight (lbs)	Average Winning Weight (lbs)	Percent Bass as Largemouth
Allatoona	19	175	0.219	0.268	11.62	26.95	22.91	3.60	1.22	7.51	28.68
Bartlett's Ferry	53	751	0.250	0.356	7.42	23.97	20.66	4.10	1.50	8.39	62.94
Clarks Hill	125	1,755	0.254	0.424	12.60	18.24	18.81	4.59	1.67	12.29	99.93
Hartwell	88	1,484	0.228	0.392	11.03	19.59	16.79	4.40	1.73	12.61	91.67
Jackson	55	744	0.142	0.203	2.00	36.83	28.01	3.79	1.56	6.37	95.45
Lanier	104	1,680	0.222	0.317	10.70	29.13	20.91	3.66	1.49	8.21	22.05
Oconee*	60	872	0.134	0.261	1.69	40.06	28.52	4.03	1.98	8.47	99.25
Russell	66	1,099	0.283	0.463	15.58	16.76	15.80	4.04	1.59	11.93	98.03
Seminole	16	289	0.133	0.261	3.87	40.01	19.22	4.53	1.99	10.59	98.78
Sinclair	97	1,496	0.203	0.277	7.61	33.40	22.85	3.54	1.43	8.02	98.67
Walter F. George**	30	436	0.090	0.254	1.69	47.74	23.22	4.96	2.87	11.78	97.48
West Point **	34	505	0.076	0.194	0.51	54.56	27.89	4.81	2.69	7.46	94.88
Martin (Ala)	19	267	0.353	0.445	21.40	11.64	16.39	3.77	1.37	11.25	28.22
Weiss (Ala)	38	697	0.292	0.499	17.81	13.09	16.74	5.43	1.72	13.91	73.12
Altamaha River	41	527	0.311	0.498	20.04	21.70	16.49	4.41	1.67	9.97	100.00
Savannah River	22	285	0.267	0.451	5.82	20.09	18.57	4.52	1.78	10.11	100.00
Misc.	151	-	-	-	-	-	-	-	-	-	-
Total	**1,018**	**15,677**	**0.220**	**0.350**	**9.32**	**27.57**	**20.99**	**4.17**	**1.61**	**9.83**	**-**

*14-Inch size limit
**16-Inch size limit (Includes only tournaments where a 16-inch size limit was used for all black bass species)
Note: Only Georgia B.A.S.S. Chapter Federation (GBCF) tournaments with six or more anglers and five or more hours in length were used.
Compiled and analyzed by: Dr. Carl J. Quertermus and Tracey L. Crocker; State University of West Georgia

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 1997

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Limit	Percent Anglers with Zero Bass	Percent Anglers with Only One Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth
Allatoona	12	1,598	0.239	0.295	12.5	23.9	22.8	3.49	1.27	8.27	27.3
Bartlett's Ferry	57	8,591	0.215	0.305	8.6	21.5	23.2	4.41	1.44	8.96	59.6
Blackshear	18	2,986	0.088	0.192	0.8	53.8	25.6	3.99	2.06	8.07	88.9
Clarks Hill	141	19,991	0.281	0.455	17.2	14.4	19.3	4.41	1.63	11.38	96.5
Hartwell	95	18,783	0.255	0.389	13.3	16.7	15.8	4.28	1.52	12.38	83.0
Jackson	55	7,456	0.208	0.304	6.7	25.8	23.2	3.99	1.47	8.37	95.2
Lanier	109	17,213	0.256	0.355	13.4	19.7	19.5	3.81	1.39	9.34	21.1
Oconee*	61	8,946	0.144	0.253	1.9	34.7	26.3	4.01	1.80	8.49	97.3
R. B. Russell	70	12,542	0.213	0.337	8.6	24.1	20.3	4.24	1.53	11.20	93.2
Seminole	15	2,370	0.201	0.390	9.6	25.3	24.5	5.68	1.91	12.58	100.0
Sinclair	88	11,958	0.198	0.261	7.3	31.6	24.6	3.36	1.34	7.37	96.2
W. F. George**	24	4,895	0.076	0.205	1.1	49.2	28.6	4.94	2.71	10.38	97.5
West Point**	22	2,966	0.068	0.190	2.0	56.6	26.0	5.35	2.46	8.24	86.1
Altamaha River	42	5,119	0.232	0.370	14.0	26.8	18.0	3.95	1.66	8.78	92.1
Savannah River	28	4,046	0.235	0.347	8.7	21.0	25.2	4.40	15.1	9.98	100.0
Miscellaneous	208	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Total	**1045**	**163,239**	**0.225**	**0.342**	**11.1**	**23.9**	**21.3**	**4.13**	**1.57**	**9.81**	**75.9**

* 14-inch size limit ** 16-inch size limit (Includes only tournaments where a 16-inch size limit was used for all black bass species)
Note: Only Georgia B.A.S.S. Chapter Federation (GBCF) tournaments with six or more anglers and five or more hours in length were analyzed.
Compiled and analyzed by Dr. Carl Quertermus and Ms. Tracey L. Crocker, State University of West Georgia.

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 1998

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Limit	Percent Anglers with Zero Bass	Percent Anglers with Only One Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth
Allatoona	17	2,314	0.272	0.347	15.5	14.8	21.3	3.65	1.28	8.26	18.0
Bartlett's Ferry	55	8,838	0.168	0.231	4.6	28.8	25.2	4.04	1.47	7.35	62.5
Blackshear	18	2,559	0.108	0.217	3.7	49.2	20.6	3.71	1.98	7.99	93.7
Clarks Hill	156	24,367	0.253	0.401	13.7	20.9	18.6	4.35	1.65	11.56	96.3
Hartwell	82	13,902	0.258	0.402	12.6	17.8	18.9	4.16	1.55	12.03	80.7
Jackson	53	6,708	0.178	0.244	5.3	30.8	24.4	3.60	1.43	7.17	89.9
Lanier	92	12,470	0.212	0.305	9.2	26.0	25.1	3.81	1.47	8.43	21.8
Oconee [a]	64	8,602	0.112	0.207	2.2	43.4	29.5	3.51	1.95	7.40	96.4
R. B. Russell	60	10,507	0.248	0.386	12.2	15.1	18.0	4.25	1.55	11.07	91.9
Seminole	20	2,963	0.116	0.238	2.6	38.4	24.7	4.27	2.08	9.81	90.0
Sinclair	80	11,945	0.175	0.237	8.3	34.8	26.2	3.38	1.39	7.40	93.2
W. F. George [b]	33	6,124	0.037	0.103	0.0	70.7	21.1	4.21	2.83	6.30	93.5
West Point [b]	21	2,480	0.076	0.201	0.8	56.1	24.6	4.64	2.72	7.77	89.2
West Point [c]	46	6,902	0.125	0.192	1.7	38.5	25.8	4.11	1.65	7.12	34.8
Altamaha River	38	3,634	0.282	0.461	23.5	29.9	15.3	3.38	1.68	8.51	97.4
Savannah River	22	3,202	0.264	0.368	17.0	15.1	21.4	3.64	1.40	9.18	100.0
Total	**857**	**127,517**	**0.197**	**0.305**	**9.1**	**29.7**	**22.4**	**3.95**	**1.66**	**9.09**	**78.5**

[a] 14-inch size limit. [b] 16-inch size limit (Includes only tournaments where a 16-inch size limit was used for all black bass species).
[c] 12-inch size limit on spotted bass and 16-inch size limit on largemouth bass.
Note: Only Georgia B.A.S.S. Chapter Federation (GBCF) tournaments with six or more anglers and five or more hours in length were analyzed. For Lanier, the October-December tournaments were not analyzed.
Compiled and analyzed by Dr. Carl Quertermus and Wynter Kelly, State University of West Georgia.

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 1999

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Limit	Percent Anglers with Zero Bass	Percent Anglers with Only One Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth
Allatoona	26	3,864	0.283	0.365	16.7	15.7	22.6	3.39	1.32	8.04	18.2
Bartlett's Ferry	49	7,959	0.241	0.326	11.0	20.3	25.6	4.04	1.34	8.00	56.7
Blackshear [a]	23	3,336	0.073	0.140	0.3	61.4	22.8	3.23	1.96	6.01	100.0
Clarks Hill	168	24,845	0.291	0.481	19.8	17.3	16.7	4.76	1.64	12.27	99.7
Hartwell	82	15,825	0.284	0.472	23.0	16.1	17.8	4.37	1.63	13.85	86.8
Jackson	43	5,778	0.215	0.307	8.4	26.6	27.7	3.68	1.42	8.26	81.6
Lanier [a]	91	12,161	0.156	0.272	4.1	33.6	29.0	3.36	1.71	7.75	24.3
Oconee [a]	69	10,202	0.122	0.221	2.6	43.2	28.4	3.76	1.87	7.66	96.2
R. B. Russell	56	8,867	0.237	0.375	13.0	21.4	21.5	3.69	1.52	9.28	95.4
Seminole	33	6,432	0.124	0.254	2.3	36.4	25.4	4.23	1.97	9.95	97.6
Sinclair	87	11,727	0.217	0.289	10.9	26.4	24.6	3.60	1.35	8.01	98.1
W. F. George [b]	18	2,675	0.056	0.143	0.0	54.6	30.6	3.91	2.57	6.74	96.9
W. F. George [c]	10	2,617	0.091	0.194	2.7	40.4	34.6	3.98	2.06	12.21	62.7
West Point [b]	16	1,889	0.074	0.181	0.4	57.0	26.9	4.24	2.50	6.82	90.6
West Point [c]	43	6,357	0.147	0.228	3.6	36.8	28.9	4.12	1.60	7.96	34.1
Altamaha River	38	2,196	0.249	0.396	19.1	24.2	23.1	4.17	1.62	8.90	100.0
Savannah River	27	3,636	0.227	0.375	9.3	27.3	17.4	4.38	1.59	9.87	100.0
Total	**879**	**130,366**	**0.212**	**0.339**	**11.4**	**27.8**	**23.4**	**4.02**	**1.65**	**9.52**	**80.3**

[a] 14-inch size limit. [b] 16-inch size limit (Includes only tournaments where a 16-inch size limit was used for all black bass species).
[c] 12-inch size limit on spotted bass and 16-inch size limit on largemouth bass.
Note: Only Georgia B.A.S.S. Chapter Federation (GBCF) tournaments with six or more anglers and five or more hours in length were analyzed.
Compiled and analyzed by Dr. Carl Quertermus, State University of West Georgia.

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2000

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Percent Anglers with Only One Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth
Allatoona	29	3,731	0.221	0.300	16.1	26.3	18.9	3.01	1.36	8.34	22.2
Bartlett's Ferry	55	8,293	0.216	0.299	12.7	24.1	26.5	3.22	1.36	6.91	56.1
Blackshear [a]	18	2,077	0.099	0.200	2.5	52.6	25.4	3.64	2.05	6.49	95.9
Carters	14	1,568	0.150	0.237	9.9	36.1	26.9	3.19	1.59	7.46	4.9
Clarks Hill	201	30,794	0.272	0.461	23.3	17.0	17.3	4.75	1.70	12.63	99.5
Hartwell	83	13,605	0.263	0.409	22.0	18.0	18.2	4.14	1.54	11.86	88.7
Jackson	53	6,393	0.191	0.268	7.1	33.0	25.5	3.54	1.45	7.16	75.0
Lanier [a]	84	10,800	0.139	0.238	4.3	40.7	26.2	3.39	1.76	7.06	22.1
Oconee [a]	64	8,742	0.169	0.295	6.3	32.4	27.6	3.60	1.76	8.29	98.0
R. B. Russell	58	9,232	0.226	0.337	13.5	22.1	19.7	3.58	1.47	9.22	91.7
Seminole	25	4,354	0.193	0.350	10.1	29.6	21.3	4.57	1.75	11.03	98.5
Sinclair	83	12,106	0.208	0.290	11.2	27.5	24.0	3.60	1.40	8.06	98.8
W. F. George [b]	22	3,330	0.092	0.242	2.5	51.4	24.7	4.55	2.93	9.90	96.8
W. F. George [c]	8	1,402	0.070	0.143	0.0	55.2	29.5	3.79	1.90	6.27	43.7
West Point [b]	10	1,307	0.053	0.116	0.4	67.1	25.5	3.67	2.31	4.94	84.5
West Point [c]	44	5,991	0.160	0.248	4.5	35.1	25.1	3.63	1.61	7.41	31.4
Altamaha River	24	3,412	0.215	0.315	14.3	35.5	20.8	3.72	1.47	8.83	100.0
Savannah River	38	4,627	0.219	0.304	11.6	30.3	21.3	3.64	1.40	7.87	100.0
Total	**913**	**131,764**	**0.208**	**0.331**	**13.1**	**28.2**	**22.2**	**3.89**	**1.63**	**9.31**	**79.4**

[a] 14-inch size limit. [b] 16-inch size limit (Includes only tournaments where a 16-inch size limit was used for all black bass species).
[c] 12-inch size limit on spotted bass and 16-inch size limit on largemouth bass.
Note: Only Georgia B.A.S.S. Chapter Federation (GBCF) tournaments with six or more anglers and five or more hours in length were analyzed. November and December tournaments for W. F. George, with the 14-inch size limit, were not analyzed.
Compiled and analyzed by Dr. Carl Quertermus, State University of West Georgia.

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2001

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Percent Anglers with Only One Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth
Allatoona	24	3,375	0.249	0.321	19.2	19.4	18.3	3.06	1.28	7.41	14.4
Bartlett's Ferry	34	4,876	0.219	0.287	10.3	23.6	20.6	3.30	1.27	7.09	62.3
Blackshear [a]	16	2,409	0.099	0.203	2.4	52.2	21.5	4.46	2.07	7.57	100.0
Carters	11	1,024	0.144	0.251	3.2	41.5	26.4	3.58	1.67	7.07	23.6
Clarks Hill	150	20,654	0.259	0.426	20.6	19.7	19.6	4.21	1.68	10.69	98.9
Hartwell	60	10,702	0.242	0.373	17.7	18.8	19.9	3.55	1.51	10.71	91.0
Jackson	50	6,428	0.164	0.226	8.9	40.8	22.1	3.51	1.37	6.67	74.9
Lanier [a]	57	7,253	0.156	0.279	7.3	41.7	24.4	3.31	1.80	8.05	17.5
Oconee [a]	73	11,106	0.188	0.362	11.0	32.0	19.6	3.68	1.93	9.83	100.0
R. B. Russell	43	6,634	0.245	0.387	18.6	21.6	22.5	3.32	1.53	10.76	89.5
Seminole	38	4,668	0.211	0.359	9.6	23.8	31.9	4.57	1.74	9.99	100.0
Sinclair	81	10,967	0.291	0.435	22.2	17.8	20.6	4.20	1.48	9.83	96.6
W. F. George [a]	44	8,386	0.143	0.303	6.3	33.2	24.2	4.56	2.18	10.86	95.6
W. F. George [c]	5	1,111	0.146	0.272	7.9	22.0	32.3	3.96	1.78	9.66	73.2
West Point [b]	6	856	0.100	0.218	0.0	44.4	30.7	4.12	2.28	7.59	100.0
West Point [d]	56	8,005	0.232	0.346	14.6	24.2	21.2	3.89	1.50	8.85	26.1
Altamaha River	29	3,825	0.236	0.319	17.3	33.3	23.7	3.28	1.36	7.63	100.0
Savannah River	32	3,874	0.210	0.291	13.3	31.1	23.3	3.60	1.36	7.05	100.0
Total	**809**	**116,153**	**0.219**	**0.350**	**14.5**	**27.0**	**21.6**	**3.85**	**1.63**	**9.30**	**83.8**

[a] 14-inch size limit. [b] 16-inch size limit (Includes only tournaments where a 16-inch size limit was used for all black bass species).
[c] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass. [d] 12-inch size limit on spotted bass and 16-inch size limit on largemouth bass.
Note: Only Georgia B.A.S.S. Chapter Federation (GBCF) tournaments with six or more anglers and five or more hours in length were analyzed.
Compiled and analyzed by Dr. Carl Quertermus, State University of West Georgia.

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2002

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Percent Anglers with Only One Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth
Allatoona	27	3,873	0.258	0.327	16.8	18.4	16.1	3.25	1.30	7.12	18.3
Bartlett's Ferry	30	4,568	0.164	0.221	6.7	33.8	27.0	3.31	1.43	7.03	45.9
Blackshear [a]	20	2,310	0.087	0.164	0.7	50.5	31.3	3.53	1.99	5.34	100.0
Carters	12	1,553	0.136	0.204	5.3	36.6	25.6	3.76	1.52	6.73	8.6
Clarks Hill	147	18,585	0.235	0.384	16.7	23.2	18.5	4.09	1.63	9.73	99.3
Hartwell	40	5,802	0.228	0.357	17.5	22.9	21.8	3.75	1.56	9.82	86.8
Jackson	48	5,556	0.209	0.296	8.7	26.2	29.5	3.71	1.50	7.50	62.8
Lanier [a]	77	9,591	0.161	0.313	5.5	36.4	25.4	3.35	1.93	8.32	14.3
Oconee [a]	96	12,443	0.184	0.393	6.5	27.6	27.9	3.72	2.08	9.27	96.4
R. B. Russell	44	5,784	0.209	0.333	12.5	25.7	24.3	3.35	1.50	8.88	76.6
Seminole	33	5,806	0.174	0.344	14.9	33.4	22.5	4.80	1.96	14.12	99.2
Sinclair	94	12,941	0.228	0.332	12.7	22.8	21.8	3.76	1.45	8.31	92.5
W. F. George [a]	46	9,142	0.185	0.380	12.0	24.9	22.8	4.53	1.98	14.42	93.9
W. F. George [c]	7	1,399	0.189	0.386	12.4	23.0	25.2	4.60	2.07	13.96	89.2
West Point [b]	8	1,012	0.171	0.338	7.9	36.6	18.4	4.30	2.20	10.57	57.1
West Point [d]	37	6,362	0.220	0.333	11.8	20.6	22.4	4.38	1.59	9.05	31.8
West Point [e]	20	2,437	0.159	0.234	6.2	32.6	24.3	2.90	1.45	6.51	33.3
Altamaha River	25	2,750	0.215	0.311	13.7	26.3	23.4	3.37	1.46	7.24	100.0
Savannah River	30	3,412	0.190	0.250	7.8	28.5	26.3	3.04	1.31	6.78	99.8
Total	**842**	**115,326**	**0.201**	**0.333**	**11.2**	**27.2**	**23.5**	**3.79**	**1.68**	**9.08**	**75.5**

[a] 14-inch size limit. [b] 16-inch size limit (Includes only tournaments where a 16-inch size limit was used for all black bass species). [c] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass. [d] 12-inch size limit on spotted bass and 16-inch size limit on largemouth bass. [e] October-December, 14-inch limit

Note: Only Georgia B.A.S.S. Chapter Federation (GBCF) tournaments with six or more anglers and five of more hours in length were analyzed.

Compiled and analyzed by Dr. Carl Quertermus, University of West Georgia.

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2003

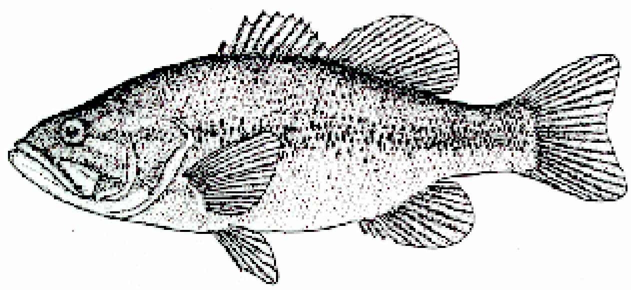
Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Percent Anglers with Only One Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth
Allatoona	20	2,556	0.277	0.387	23.0	20.7	19.6	3.46	1.36	8.74	13.8
Bartlett's Ferry	17	2,544	0.246	0.378	14.5	18.6	18.8	3.51	1.54	8.74	58.9
Blackshear [a]	19	2,044	0.143	0.287	1.3	39.4	22.1	3.92	2.02	8.13	94.7
Carters	7	786	0.210	0.276	14.3	27.4	23.0	3.57	1.43	6.61	5.8
Clarks Hill	132	15,085	0.219	0.348	14.0	27.8	20.6	3.83	1.68	8.90	97.1
Hartwell	43	7,013	0.262	0.409	18.2	17.0	18.1	4.42	1.59	11.65	74.7
Jackson	32	3,339	0.233	0.353	10.6	29.0	24.5	3.76	1.62	8.77	56.3
Lanier [a]	75	10,282	0.155	0.298	6.0	37.5	24.7	3.62	1.93	8.15	12.4
Oconee [a]	90	11,656	0.203	0.386	12.3	28.4	23.2	4.08	1.94	10.09	98.6
R. B. Russell	33	4,514	0.278	0.422	22.4	14.6	20.0	3.57	1.52	10.84	67.2
Seminole	33	4,203	0.204	0.418	13.3	29.4	21.1	4.52	2.18	10.36	99.5
Sinclair	97	12,505	0.236	0.360	14.9	22.1	19.4	3.89	1.54	9.20	97.7
W. F. George [b]	60	10,650	0.172	0.395	13.7	24.3	23.4	4.83	2.30	14.22	89.1
West Point [b]	62	9,167	0.217	0.360	14.2	23.6	21.1	4.37	1.67	10.05	42.4
Altamaha River	27	2,722	0.245	0.374	23.8	36.0	12.5	3.09	1.57	7.01	100.0
Savannah River	28	2,624	0.195	0.292	12.0	35.5	23.8	2.88	1.48	6.63	100.0
Total	**775**	**101,690**	**0.214**	**0.362**	**13.8**	**26.9**	**21.2**	**3.94**	**1.75**	**9.60**	**76.8**

[a] 14-inch size limit. [b] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass.
Note: Only Georgia B.A.S.S. Chapter Federation (GBCF) tournaments with six or more anglers and five of more hours in length were analyzed.
Compiled and analyzed by Dr. Carl Quertermus and Amber Williams, University of West Georgia.

Georgia B.A.S.S. Chapter Federation

2004

Tournament Creel Report



Submitted by

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University of West Georgia

GBCF Tournament Report - 2004

In 2004, 102 bass clubs, affiliated with the Georgia B.A.S.S. Chapter Federation (GBCF), submitted results from 1,114 tournaments. Several of these tournaments were not analyzed because they involved less than six anglers or lasted less than five hours. The data from tournaments held outside of Georgia were not analyzed. Data from tournaments held at Alabama reservoirs were sent to the Alabama Department of Conservation and Natural Resources and became part of their annual tournament data analysis. Data from 824 tournaments on 14 Georgia reservoirs and two rivers were analyzed for this report.

Fishing success at Georgia reservoirs and rivers are compared on the attached table and figures. Bass anglers spent 108,241 hours of effort during the 824 tournaments. The weighed-in average catch rate was 0.218 bass / angler hour. This is about the same as in 2003 (0.214). Surprisingly, the state-wide catch rate has not statistically changed during the past 27 years. **Allatoona** and **R.B. Russell** tied for the highest catch rate (0.290 bass / angler hour). The greatest pounds weighed-in / angler hour was at **R. B. Russell** (0.446 lbs). The lowest percent of unsuccessful anglers (15.1%) was at **Allatoona**, but the highest percent of anglers with five or more bass (23.4%) was at **R.B. Russell**. The greatest average bass weight (2.31 lbs) and the greatest average largest bass (5.21 lbs) was at **Seminole**. The lowest weighed-in catch rate for 2004 was 0.125; this occurred at **Blackshear.** Forty-five percent of the anglers were unsuccessful at **Blackshear** tournaments.

This was the first year that clubs were asked to indicate how many bass 5.0 lbs or larger were caught during each tournament. This information was given for 497 of the 824 tournaments used for this report. Only 161 bass 5.0 lbs or larger were caught during these 497 tournaments. On average, it required 407 angler hours to catch a bass of this size. There was a big difference in this value for the 14 reservoirs and two rivers. Whereas it took 985 hours at **Sinclair**, 941 hours at **Clarks Hill**, and 907 hours at **Allatoona** to catch a bass ≥ 5 lbs, it took only 134 hours at **Seminole**. Although this information was provided for 56 or the 74 tournaments at **Lanier**, there was not even one bass ≥ 5 lbs caught during these tournaments.

The reservoir abbreviations on the attached figures are **AL** (Allatoona), **BF** (Bartlett's Ferry), **BS** (Blackshear), **CA** (Carters), **CH** (Clarks Hill), **HW** (Hartwell), **JA** (Jackson), **LA** (Lanier), **OC** (Oconee), **RU** (R. B. Russell), **SE** (Seminole), **SI** (Sinclair), **WG** (W. F. George), **WP** (West Point).

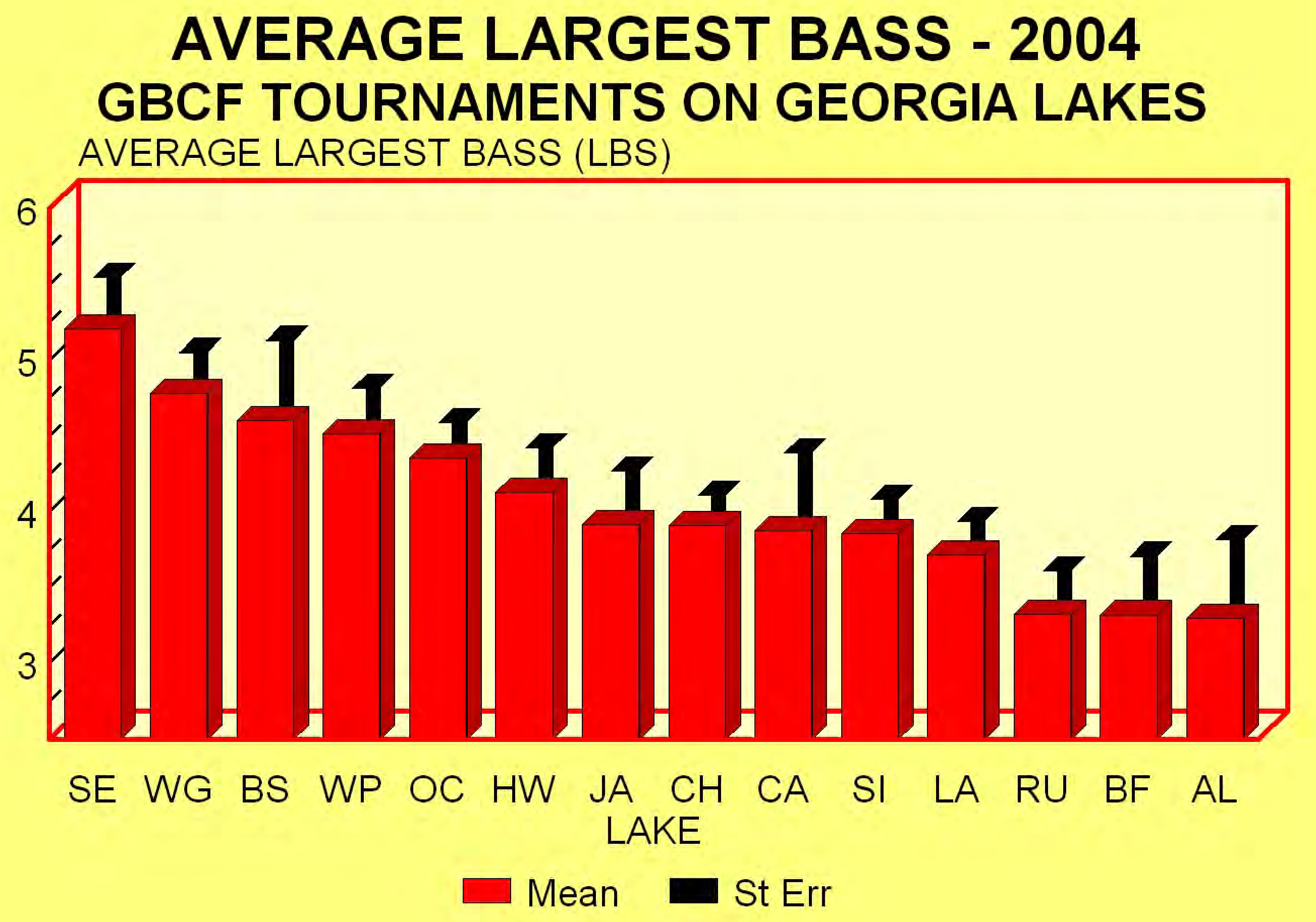
GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2004

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Percent Anglers with Only One Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth	Hours Per ≥ 5 lb Bass
Allatoona	17	2203	0.290	0.361	19.7	15.1	18.0	3.30	1.32	8.00	23.3	907
Bartlett's Ferry	19	2516	0.224	0.293	13.5	26.8	22.3	3.32	1.36	8.06	54.7	794
Blackshear [a]	20	2220	0.125	0.277	3.1	45.2	27.3	4.60	2.20	8.46	97.9	389
Carters	5	581	0.155	0.226	3.1	38.1	25.9	3.88	1.49	5.82	5.9	------
Clarks Hill	146	17578	0.259	0.395	19.2	19.5	19.8	3.91	1.54	9.98	95.7	941
Hartwell	35	5166	0.242	0.392	17.7	19.4	20.8	4.13	1.62	11.17	78.4	885
Jackson	41	4695	0.210	0.331	11.5	29.3	23.8	3.91	1.69	8.73	55.4	344
Lanier [a]	74	9687	0.160	0.307	6.0	34.8	26.8	3.72	1.95	8.90	8.1	------
Oconee [a]	95	12930	0.200	0.394	9.7	25.1	24.6	4.36	2.01	10.09	97.9	318
R. B. Russell	36	4460	0.290	0.446	23.4	19.1	19.7	3.33	2.20	10.22	63.8	273
Seminole	34	4345	0.189	0.424	13.2	31.0	27.5	5.21	2.31	12.24	98.8	134
Sinclair	99	12880	0.233	0.366	16.2	25.4	19.7	3.86	1.61	9.11	98.2	985
W. F. George [b]	66	11425	0.146	0.319	8.1	34.1	25.2	4.78	2.20	12.60	88.7	216
West Point [b]	66	9365	0.207	0.327	13.7	27.1	22.2	4.52	1.67	9.81	39.1	206
Altamaha River	29	3129	0.255	0.408	21.2	26.1	15.6	3.65	1.60	9.23	100.0	370
Savannah River	42	5061	0.263	0.417	18.1	21.1	17.7	4.06	1.58	9.65	99.1	516
Total	**824**	**108241**	**0.218**	**0.367**	**14.2**	**26.1**	**22.2**	**4.09**	**1.76**	**9.90**	**76.7**	**407**

[a] 14-inch size limit. [b] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass.

Note: Only tournaments with six or more anglers and five of more hours in length were analyzed.

Compiled and analyzed by Dr. Carl Quertermus and Amber Williams, University of West Georgia.


AVERAGE LARGEST BASS - 2004
GBCF TOURNAMENTS ON GEORGIA LAKES
AVERAGE LARGEST BASS (LBS)
6
5
4
3
SE
WG
BS
WP
OC
HW
JA
CH
CA
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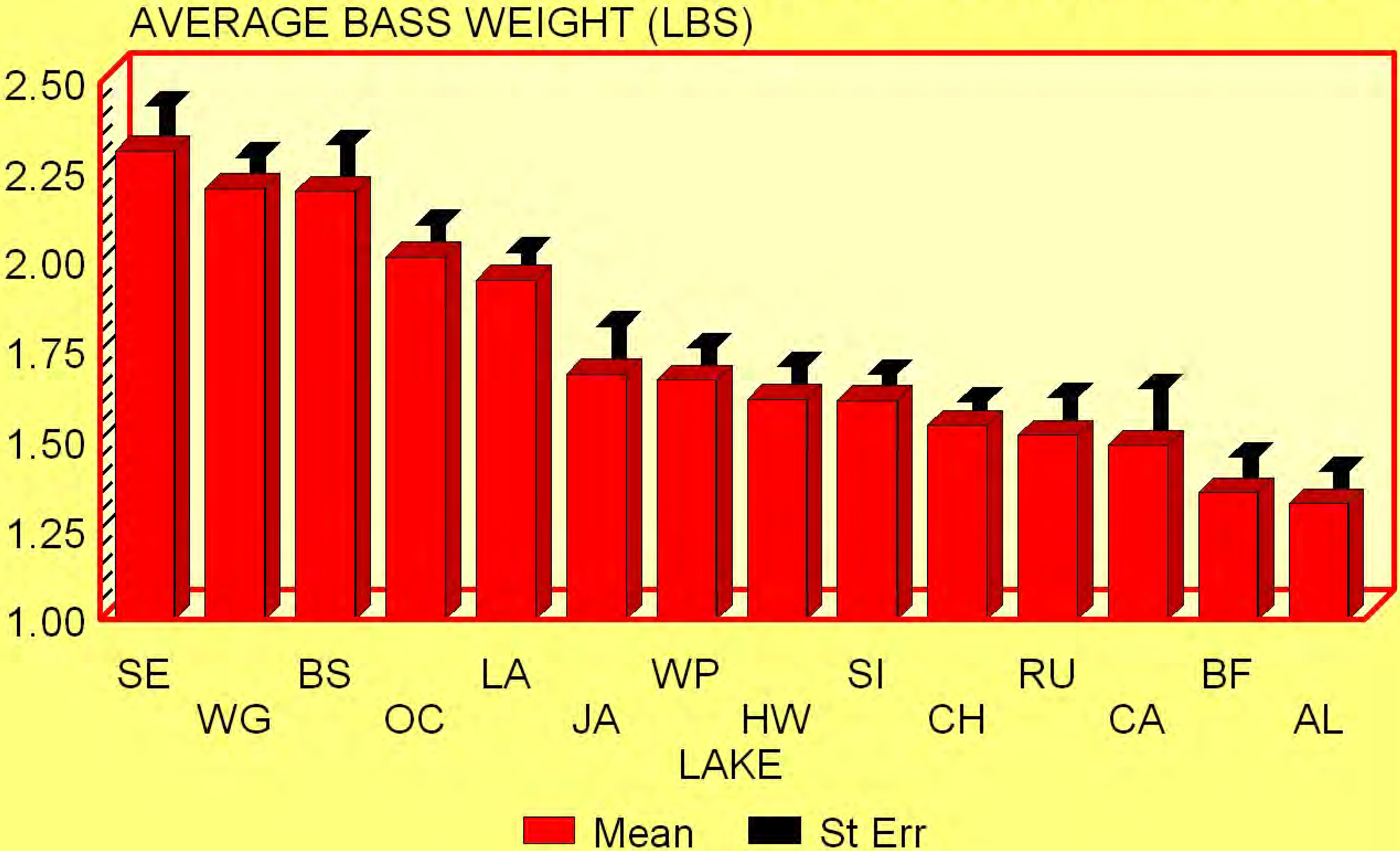
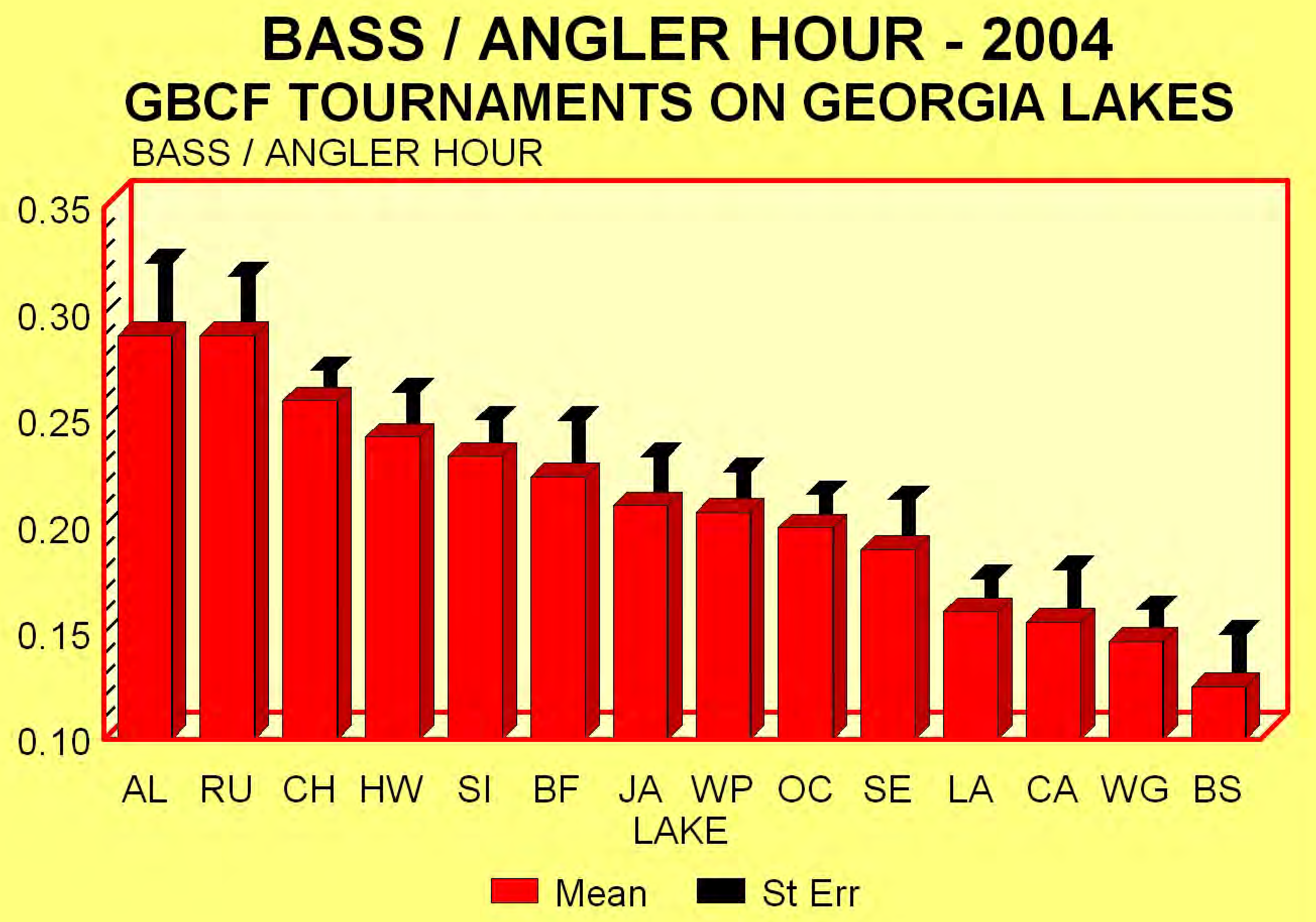
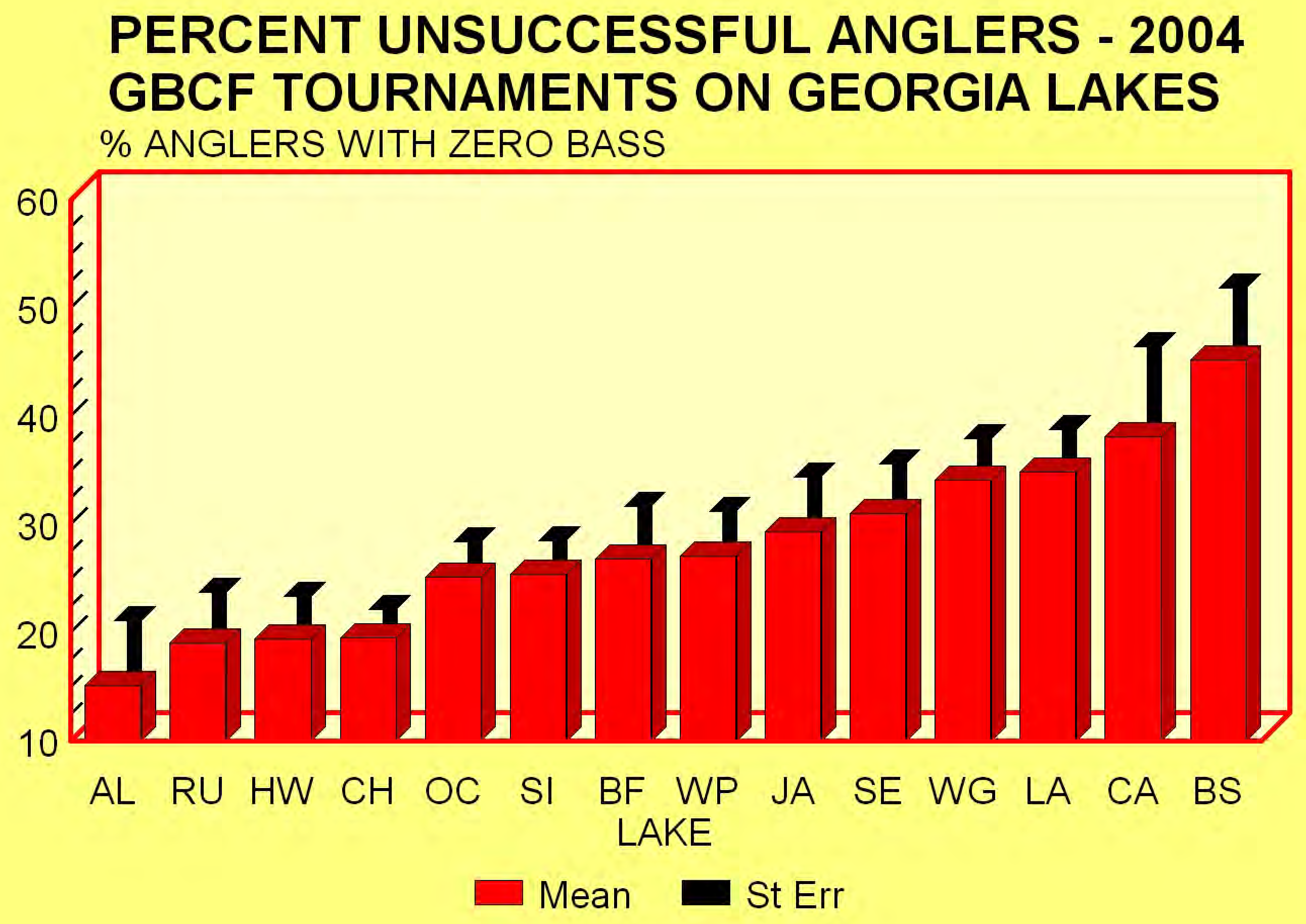
LA
RU
BF
AL
LAKE
Mean
St Err

AVERAGE BASS WEIGHT - 2004
GBCF TOURNAMENTS ON GEORGIA LAKES



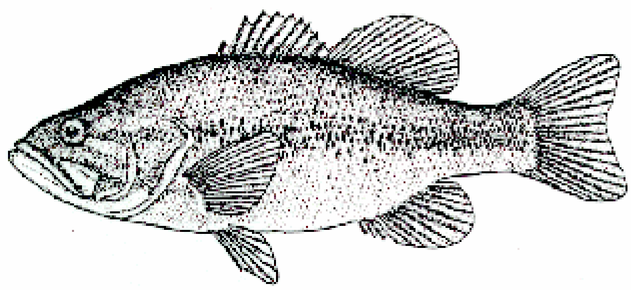

BASS / ANGLER HOUR - 2004
GBCF TOURNAMENTS ON GEORGIA LAKES
BASS / ANGLER HOUR
0.35
0.30
0.25
0.20
0.15
0.10
AL RU CH HW SI BF JA WP OC SE LA CA WG BS
LAKE
Mean
St Err


PERCENT UNSUCCESSFUL ANGLERS - 2004
GBCF TOURNAMENTS ON GEORGIA LAKES
% ANGLERS WITH ZERO BASS
60
50
40
30
20
10
AL
RU
HW
CH
OC
SI
BF
WP
JA
SE
WG
LA
CA
BS
LAKE
Mean
St Err

Georgia Bass Chapter Federation

2005

Tournament Creel Report



Submitted by

Carl Quertermus, Ph.D.
University of West Georgia

GBCF Tournament Report - 2005

In 2005, 102 bass clubs, affiliated with the Georgia Bass Chapter Federation (GBCF), submitted results from 1,101 tournaments. Several of these tournaments were not analyzed because they involved less than six anglers or lasted less than five hours. The data from tournaments held outside of Georgia were not analyzed. Data from tournaments held at Alabama reservoirs were sent to the Alabama Department of Conservation and Natural Resources and became part of their annual tournament data analysis. Data from 796 tournaments on 14 Georgia reservoirs and two rivers were analyzed for this report.

Fishing success at Georgia reservoirs and rivers are compared on the attached table and figures. Bass anglers spent 99,240 hours of effort during the 796 tournaments. The weighed-in average catch rate was 0.244 bass / angler hour. This is slightly better than in 2004 (0.218). The state-wide catch rate has remained fairly constant during the past 28 years, with an average of 0.22 (range 0.19-0.24) bass / angler hour. **Allatoona** had the highest catch rate (0.316 bass / angler hour) and the greatest pounds weighed-in / angler hour (0.468 lbs / angler hour). The lowest percent of unsuccessful anglers (14.8%) was at **West Point**, but the highest percent of anglers with five or more bass was at **Clarks Hill** (25.6%). The greatest average bass weight (2.17 lbs) was at **Walter F. Georgia** and the greatest average largest bass (5.18 lbs) was at **Seminole**. The lowest weighed-in catch rate for 2005 was 0.164; this occurred at **Blackshear.** Thirty-six percent of the anglers were unsuccessful at **Blackshear** tournaments. However, the relatively few bass caught in **Blackshear** tournaments averaged 2.16 lbs, and the average largest bass was 5.04 lbs.

This was the second year that clubs were asked to indicate how many bass 5.0 lbs or larger were caught during each tournament. This information was given for 664 of the 796 tournaments used for this report. Only 258 bass 5.0 lbs or larger were caught during these 664 tournaments. On average, it required 321 angler hours to catch a bass of this size. This is down from 407 hours in 2004. There was a big difference in this value for the 14 reservoirs and two rivers. Whereas it took 1,483 hours at **Richard B. Russell** and 1,207 hours at **Hartwell** to catch a bass $\geq$ 5 lbs, it took only 136 hours at **Seminole** and 151 hours at **Blackshear**. Only at **Seminole** was there an average of one 5 lbs bass caught in each tournament.

The reservoir abbreviations on the attached figures are **AL** (Allatoona), **BF** (Bartlett's Ferry), **BS** (Blackshear), **CA** (Carters), **CH** (Clarks Hill), **HW** (Hartwell), **JA** (Jackson), **LA** (Lanier), **OC** (Oconee), **RU** (R. B. Russell), **SE** (Seminole), **SI** (Sinclair), **WG** (W. F. George), **WP** (West Point).

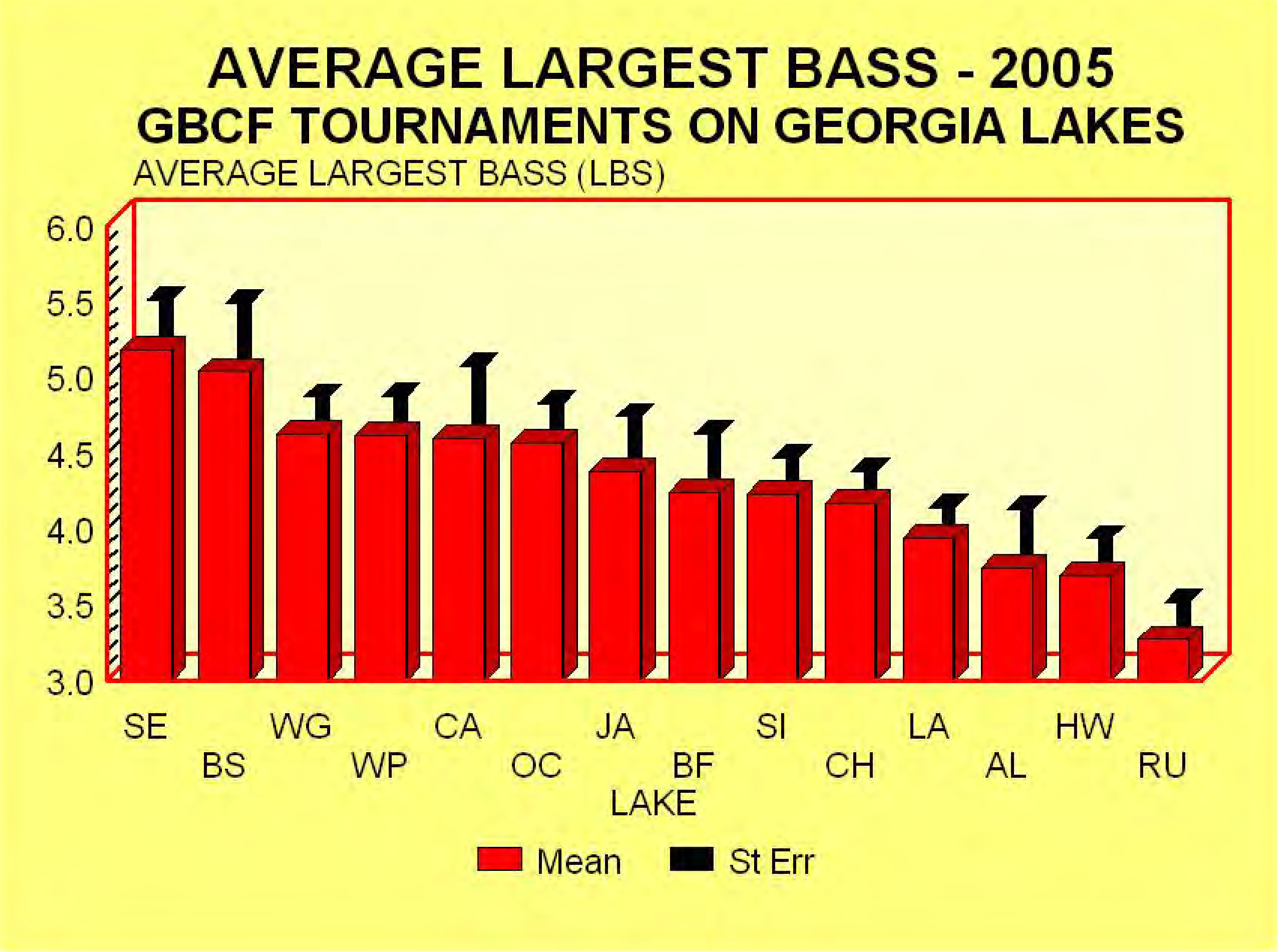
GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2005

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth	Hours Per ≥ 5 lb Bass
Allatoona	24	2691	0.316	0.468	25.4	15.4	3.74	1.47	9.13	12.3	449
Bartlett's Ferry	16	2202	0.264	0.374	17.5	20.6	4.24	1.43	8.35	48.2	386
Blackshear [a]	25	2832	0.164	0.358	9.2	36.3	5.04	2.16	9.92	97.9	151
Carters	4	706	0.218	0.327	10.0	15.7	4.60	1.47	8.58	15.0	706
Clarks Hill	145	17457	0.285	0.445	25.6	18.1	4.17	1.57	10.53	98.5	352
Hartwell	40	5361	0.244	0.381	19.3	18.3	3.70	1.55	10.49	74.0	1207
Jackson	38	4201	0.223	0.371	9.3	25.7	4.38	1.69	9.07	57.3	184
Lanier [a]	82	9894	0.199	0.397	8.6	28.2	3.94	1.99	9.77	13.2	935
Oconee [a]	85	10978	0.216	0.426	16.9	23.9	4.57	2.02	11.09	98.3	286
R. B. Russell	43	5484	0.246	0.366	17.4	18.4	3.27	1.47	9.70	51.9	1483
Seminole	38	5327	0.232	0.449	16.9	22.4	5.18	2.02	12.10	99.7	136
Sinclair	88	10005	0.271	0.444	20.1	19.5	4.23	1.64	10.03	98.8	368
W. F. George [b]	34	5511	0.195	0.421	14.3	24.1	4.63	2.17	13.29	89.7	344
West Point [b]	55	8395	0.254	0.437	19.5	14.8	4.62	1.75	12.36	38.4	254
Altamaha River	35	3616	0.240	0.400	22.8	29.5	3.98	1.68	9.88	100.0	320
Savannah River	44	4580	0.244	0.395	24.5	22.3	3.95	1.61	8.94	99.1	245
Total	**796**	**99240**	**0.244**	**0.417**	**18.0**	**21.8**	**4.23**	**1.75**	**10.43**	**75.7**	**321**

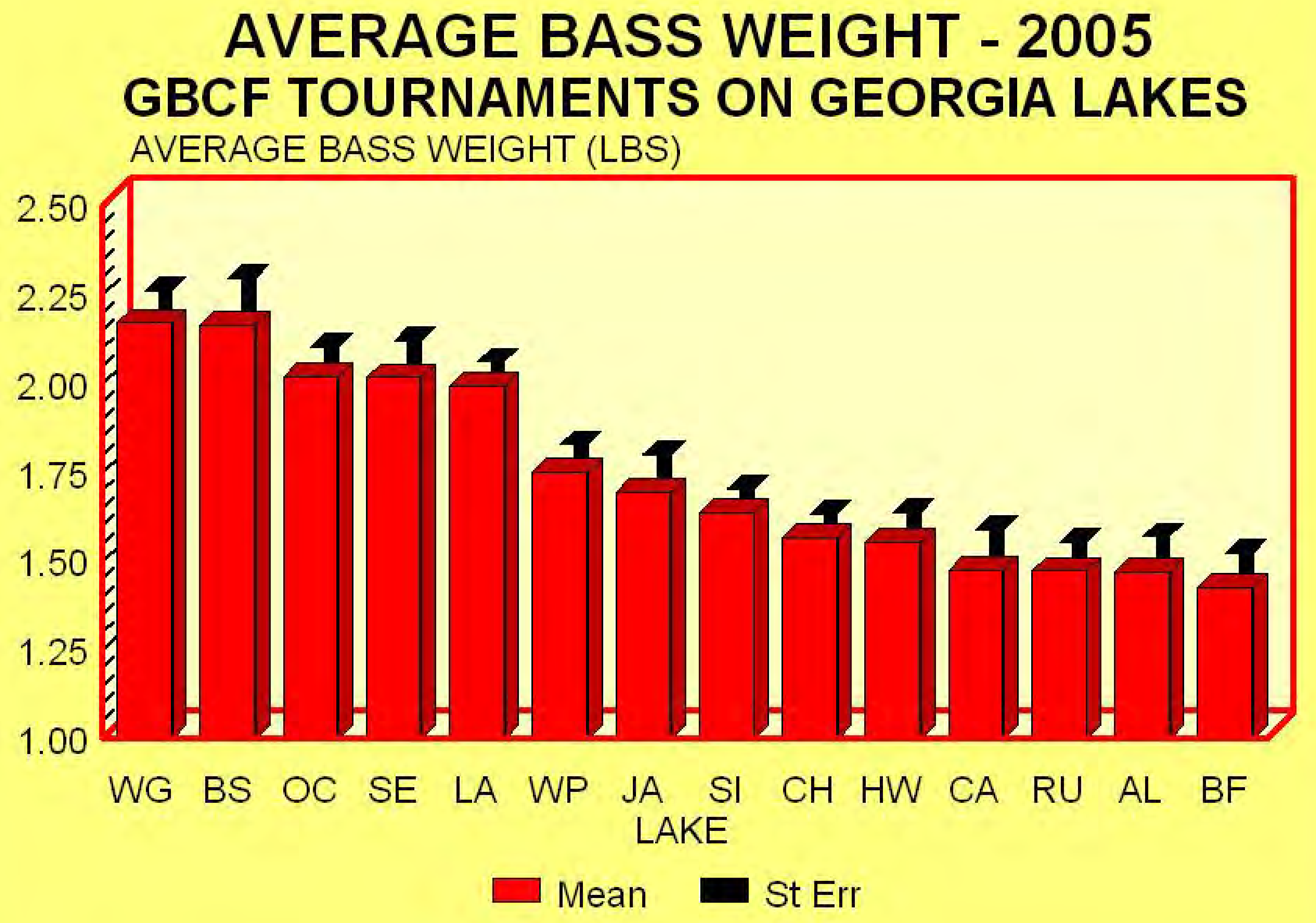
[a] 14-inch size limit. [b] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass.

Note: Only tournaments with six or more anglers and five of more hours in length were analyzed.

Compiled and analyzed by Dr. Carl Quertermus and Margaret Kukucka, University of West Georgia.



AVERAGE LARGEST BASS - 2005
GBCF TOURNAMENTS ON GEORGIA LAKES
AVERAGE LARGEST BASS (LBS)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
SE
BS
WG
WP
CA
OC
JA
BF
SI
CH
LA
AL
HW
RU
LAKE
Mean
St Err


AVERAGE BASS WEIGHT - 2005
GBCF TOURNAMENTS ON GEORGIA LAKES
AVERAGE BASS WEIGHT (LBS)
2.50
2.25
2.00
1.75
1.50
1.25
1.00
WG
BS
OC
SE
LA
WP
JA
SI
CH
HW
CA
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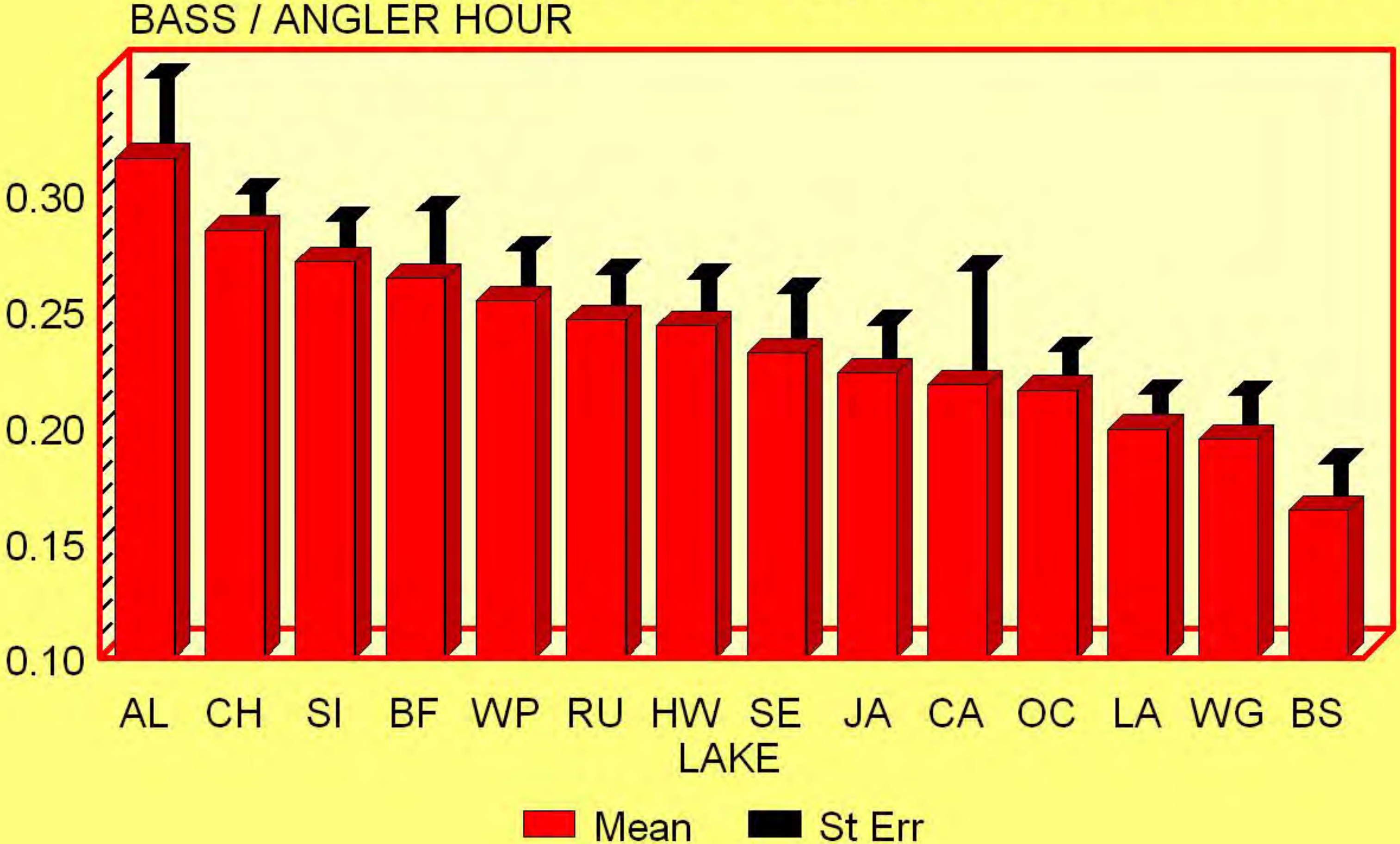
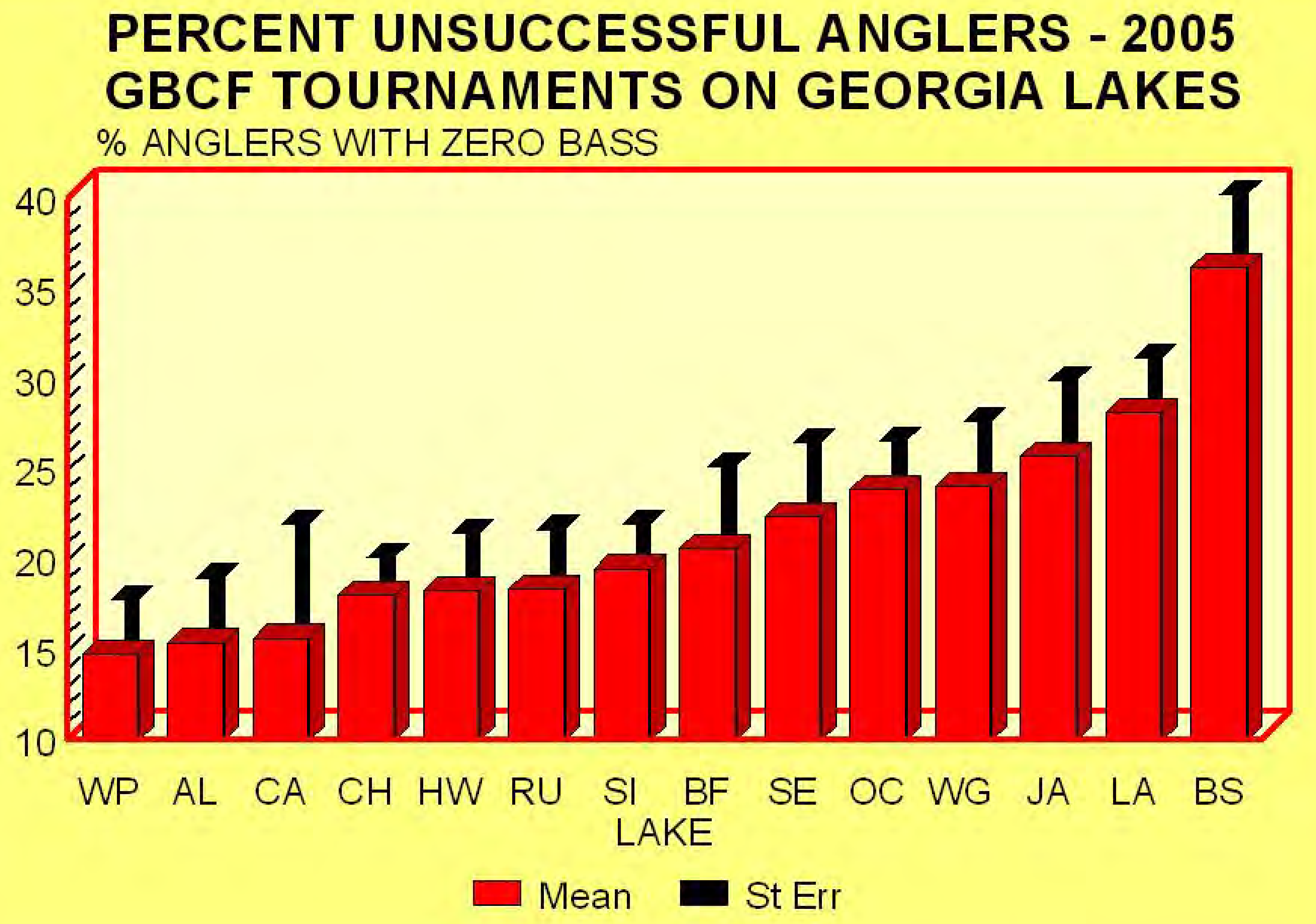
AL
BF
LAKE
Mean
St Err

BASS / ANGLER HOUR - 2005
GBCF TOURNAMENTS ON GEORGIA LAKES




PERCENT UNSUCCESSFUL ANGLERS - 2005
GBCF TOURNAMENTS ON GEORGIA LAKES
% ANGLERS WITH ZERO BASS
40
35
30
25
20
15
10
WP
AL
CA
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WG
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LAKE
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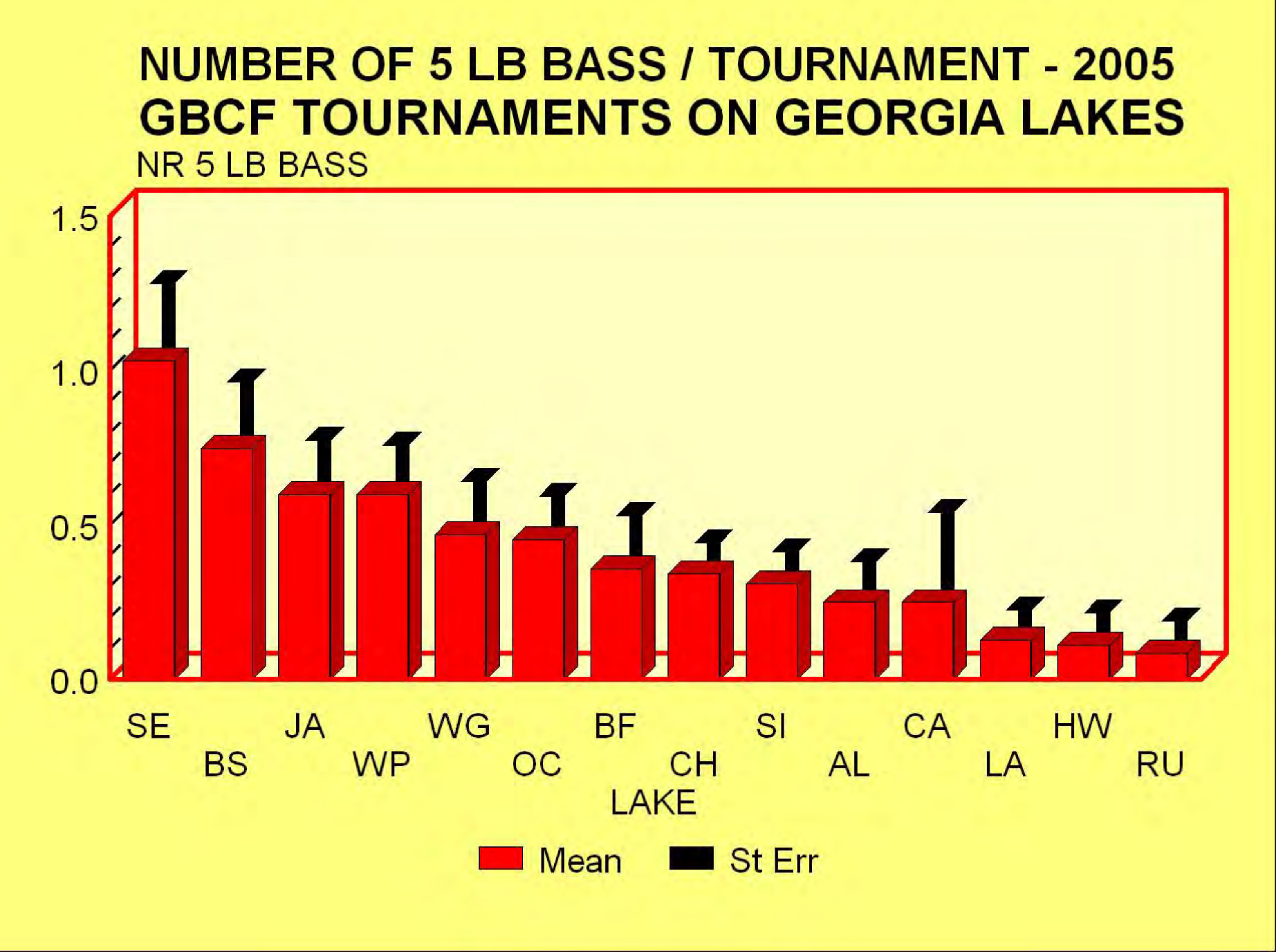
St Err


NUMBER OF 5 LB BASS / TOURNAMENT - 2005
GBCF TOURNAMENTS ON GEORGIA LAKES
NR 5 LB BASS
1.5
1.0
0.5
0.0
SE
BS
JA
WP
WG
OC
BF
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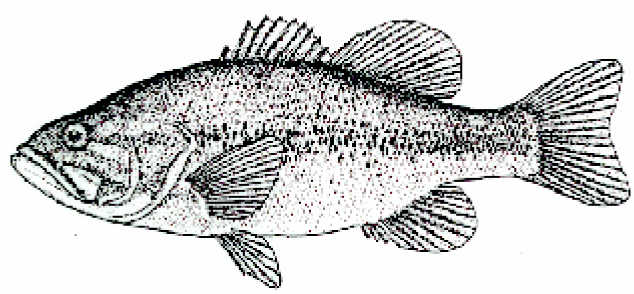
LAKE
Mean
St Err

Georgia Bass Chapter Federation

2006

Tournament Creel Report



Submitted by

Carl Quertermus, Ph.D.

GBCF Tournament Report - 2006

In 2006, 90 bass clubs, affiliated with the Georgia Bass Chapter Federation (GBCF), submitted results from 884 tournaments. Several of these tournaments were not analyzed because they involved less than six anglers or lasted less than five hours. The data from tournaments held outside of Georgia were not analyzed. Data from 210 tournaments held at Alabama reservoirs were sent to the Alabama Department of Conservation and Natural Resources and became part of their annual tournament data analysis (B.A.I.T). Data from 648 tournaments on 14 Georgia reservoirs and two rivers were analyzed for this report.

Fishing success at Georgia reservoirs and rivers are compared on the attached table and figures. Bass anglers spent 83,468 hours of effort during the 648 tournaments. The weighed-in, tournament-average catch rate was 0.260 bass / angler hour. This is the highest catch rate in the 29 years of this project. The state-wide catch rate average over the 29 years is 0.220 bass / angler hour. The record high catch rate in 2006 was mainly caused by the 128 tournaments at Clarks Hill where the average catch rate was 0.312. **Richard B. Russell** had the highest catch rate (0.357 bass / angler hour) and the greatest pounds weighed-in / angler hour (0.584 lbs / angler hour). The lowest percent of unsuccessful anglers (12.5%) and the highest percent of anglers with five or more bass (36.5%) were also at **Richard B. Russell**. The greatest average bass weight (2.26 lbs) and the greatest average largest bass (5.10 lbs) were at **Blackshear**. However, the lowest weighed-in catch rate (0.139 bass / angler hour) and the highest percent of unsuccessful anglers (41.3%) were also at **Blackshear.**

This was the third year that clubs were asked to indicate how many bass 5.0 lbs or larger were caught during each tournament. This information was given for 614 of the 648 tournaments used for this report. Only 259 bass 5.0 lbs or larger were caught during these 614 tournaments. On average, it required 305 angler hours to catch a bass of this size. This is down from 407 hours in 2004 and 321 in 2005. There was a big difference in this value for the 14 reservoirs and two rivers. Whereas it took 1,648 hours at **Richard B. Russell** and 1,198 hours at **Lanier** to catch a bass ≥ 5 lbs, it took only 123 hours at **Seminole** and 174 hours at the **Savannah River**. Only at **Seminole** was there an average of one 5 lbs bass caught in each tournament.

The reservoir abbreviations on the attached figures are **AL** (Allatoona), **BF** (Bartlett's Ferry), **BS** (Blackshear), **CA** (Carters), **CH** (Clarks Hill), **HW** (Hartwell), **JA** (Jackson), **LA** (Lanier), **OC** (Oconee), **RU** (R. B. Russell), **SE** (Seminole), **SI** (Sinclair), **WG** (W. F. George), **WP** (West Point).

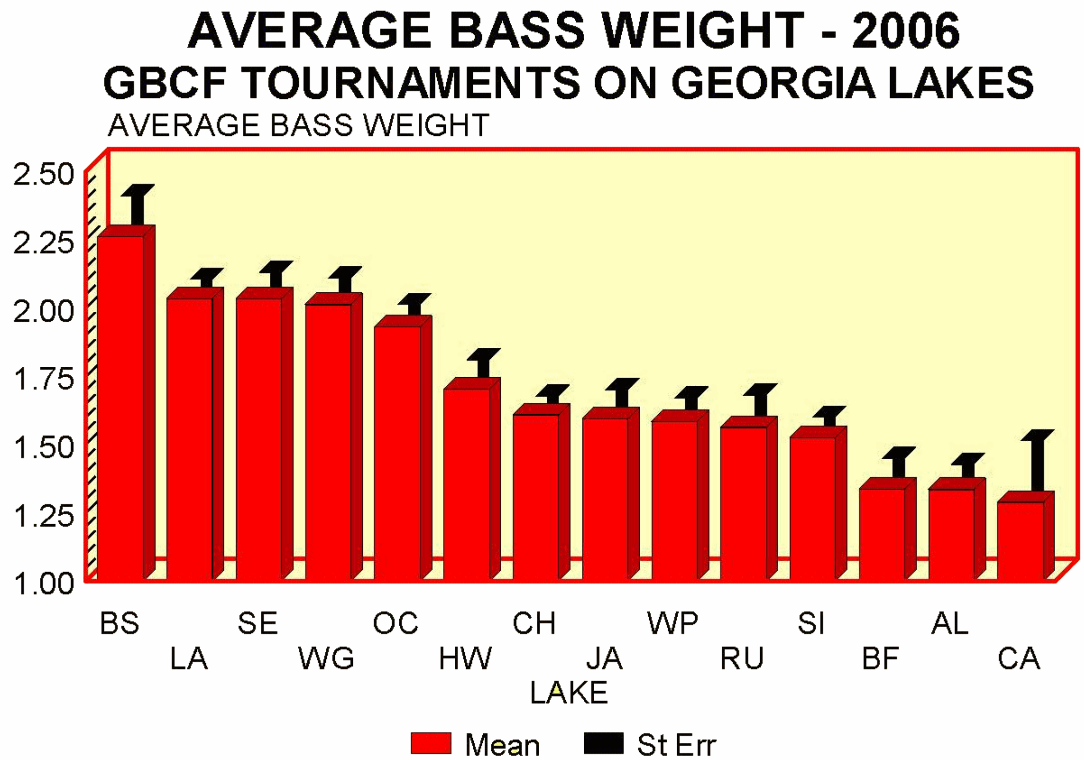
GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2006

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth	Angler-Hrs Per ≥ 5 lb Bass
Allatoona	17	2009	0.293	0.392	23.8	24.2	3.10	1.34	8.18	22.6	1004
Bartlett's Ferry	12	1852	0.201	0.274	9.1	28.5	3.51	1.34	7.95	52.5	617
Blackshear [a]	17	2346	0.139	0.340	7.5	41.3	5.10	2.26	10.78	100.0	245
Carters	4	386	0.217	0.303	3.9	27.5	2.72	1.29	6.30	2.4	-------
Clarks Hill	128	15266	0.312	0.502	29.3	18.1	4.30	1.61	11.47	98.1	290
Hartwell	30	3305	0.309	0.523	30.1	19.7	3.76	1.70	12.15	70.8	425
Jackson	26	3019	0.229	0.364	13.9	25.9	4.20	1.60	9.15	52.4	415
Lanier [a]	65	7536	0.242	0.493	15.5	21.4	3.79	2.04	11.56	16.4	1198
Oconee [a]	82	10283	0.203	0.391	8.5	27.5	4.01	1.93	10.33	97.7	515
R. B. Russell	24	3438	0.357	0.584	36.5	12.5	3.73	1.56	12.78	49.4	1648
Seminole	40	5337	0.217	0.447	14.1	26.4	5.06	2.03	12.00	99.1	123
Sinclair	73	10020	0.271	0.414	18.3	21.4	4.28	1.53	10.15	95.6	266
W. F. George [b]	40	6068	0.193	0.383	13.0	25.9	4.29	2.01	11.75	84.9	276
West Point [b]	35	6031	0.284	0.446	26.9	14.6	4.41	1.59	12.13	33.6	211
Altamaha River	9	1118	0.183	0.312	9.9	34.7	3.88	1.58	8.70	100.0	559
Savannah River	46	5454	0.297	0.490	22.3	17.3	4.79	1.66	10.50	99.2	174
Total	**648**	**83468**	**0.260**	**0.447**	**19.7**	**22.1**	**4.21**	**1.74**	**10.95**	**78.0**	**305**

[a] 14-inch size limit. [b] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass.

Note: Only tournaments with six or more anglers and five of more hours in length were analyzed.

Compiled and analyzed by Dr. Carl Quertermus and Margaret Kukucka, University of West Georgia.


AVERAGE BASS WEIGHT - 2006
GBCF TOURNAMENTS ON GEORGIA LAKES
AVERAGE BASS WEIGHT
2.50
2.25
2.00
1.75
1.50
1.25
1.00
BS
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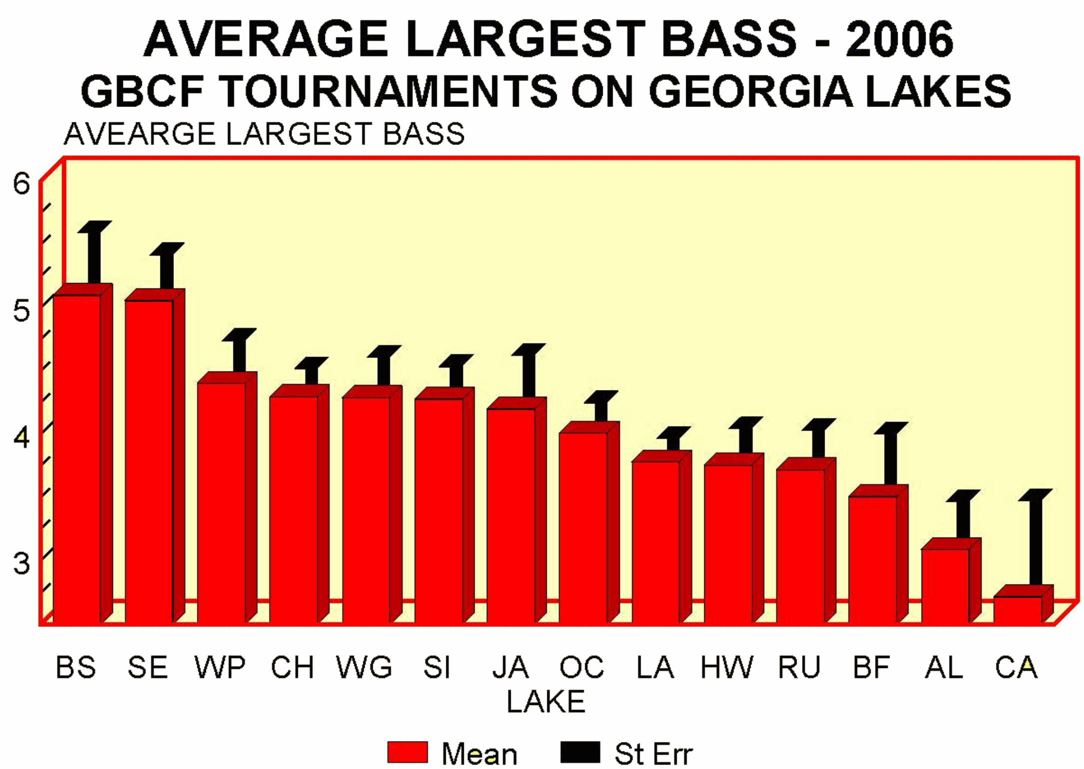
LAKE
Mean
St Err


AVERAGE LARGEST BASS - 2006
GBCF TOURNAMENTS ON GEORGIA LAKES
AVEARGE LARGEST BASS
6
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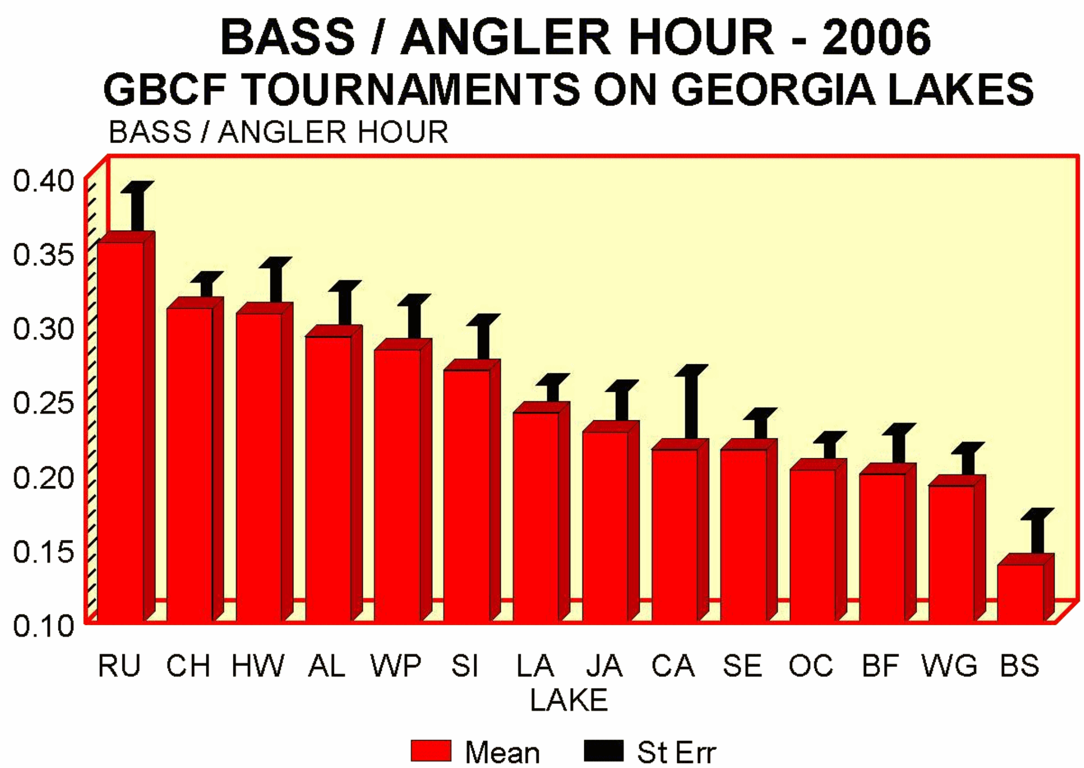
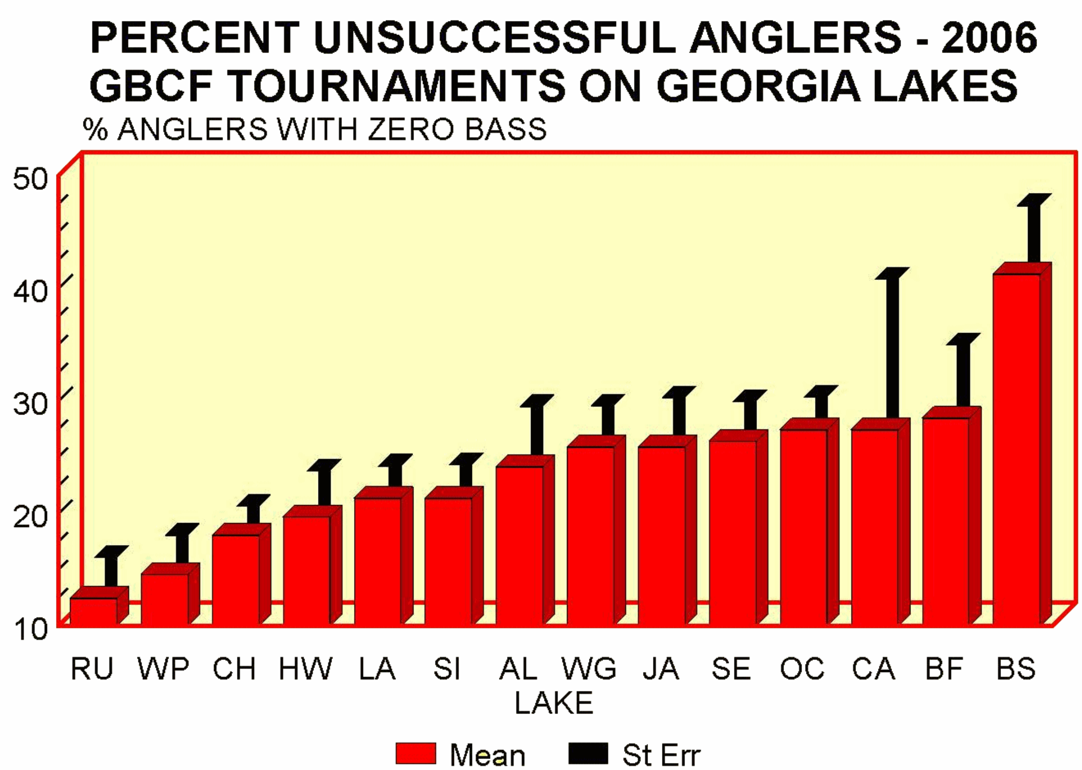
LAKE
Mean
St Err


BASS / ANGLER HOUR - 2006
GBCF TOURNAMENTS ON GEORGIA LAKES
BASS / ANGLER HOUR
0.40
0.35
0.30
0.25
0.20
0.15
0.10
RU CH HW AL WP SI LA JA CA SE OC BF WG BS
LAKE
Mean
St Err


PERCENT UNSUCCESSFUL ANGLERS - 2006
GBCF TOURNAMENTS ON GEORGIA LAKES
% ANGLERS WITH ZERO BASS
50
40
30
20
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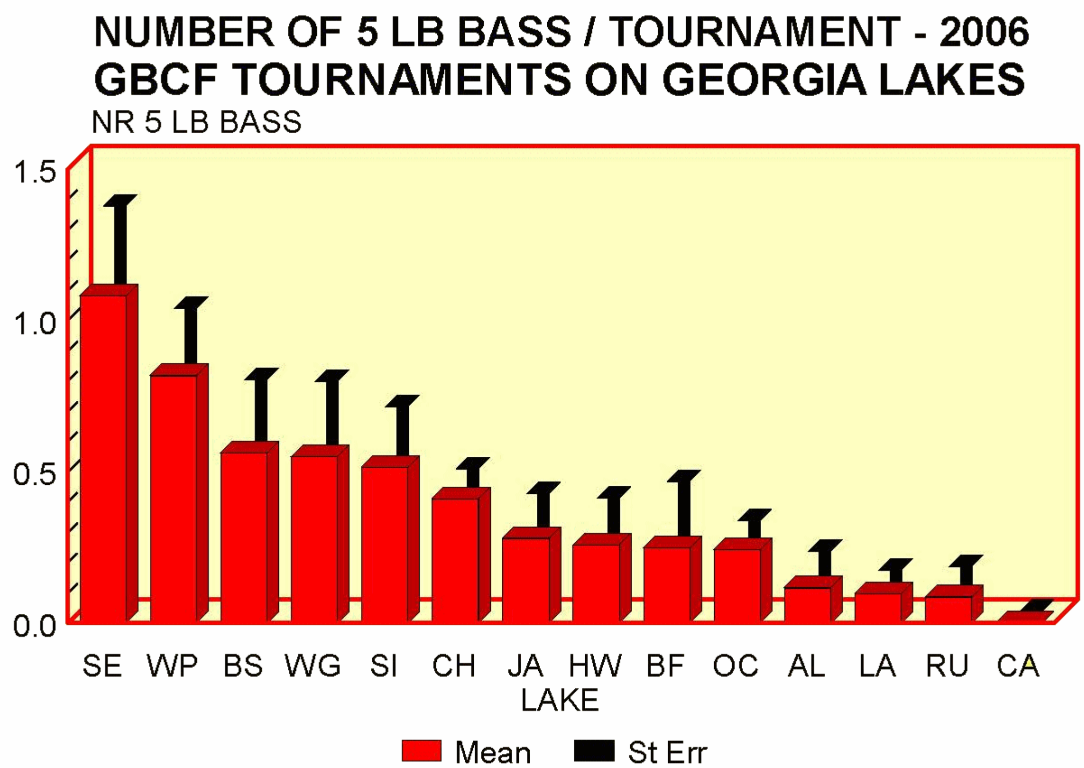
RU WP CH HW LA SI AL WG JA SE OC CA BF BS
LAKE
Mean
St Err



NUMBER OF 5 LB BASS / TOURNAMENT - 2006
GBCF TOURNAMENTS ON GEORGIA LAKES
NR 5 LB BASS
1.5
1.0
0.5
0.0
SE
WP
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LAKE
Mean
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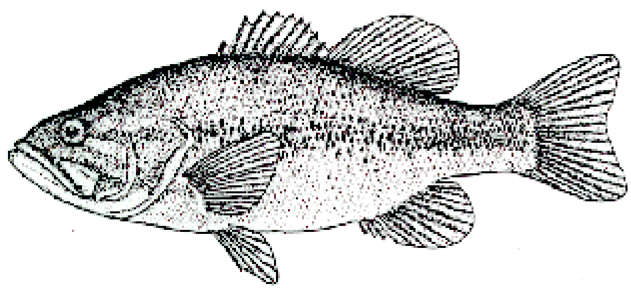
Georgia Bass Chapter Federation

2007

Tournament Creel Report



Submitted by

Carl Quertermus, Ph.D.

GBCF Tournament Report - 2007

This is the 30th year of the Georgia Bass Chapter Federation (GBCF) Tournament Creel Report. In 2007, 88 bass clubs submitted results from 920 tournaments. Several of these tournaments were not analyzed because they involved less than six anglers or lasted less than five hours. Also, Georgia reservoirs and rivers with less than six submitted tournaments were not analyzed. The data from tournaments held outside of Georgia were not analyzed. Data from 203 tournaments held at Alabama reservoirs were sent to the Alabama Department of Conservation and Natural Resources and became part of their annual tournament data analysis (B.A.I.T). Data from 684 tournaments on 14 Georgia reservoirs and one river were analyzed for this report.

Fishing success at Georgia reservoirs and rivers are compared on the attached table and figures. Bass anglers spent 83,383 hours of effort during the 684 tournaments. The weighed-in, tournament-average catch rate was 0.259 bass / angler hour. This is the second highest catch rate in the 30 years of this project. In 2006, the catch rate was 0.260 bass / angler hour. The state-wide catch rate average over the 30 years is 0.221 bass / angler hour. The record high catch rates in 2006 and 2007 were mainly caused by the large number of tournaments at Clarks Hill where the catch rate was well above the average. **Allatoona** had the highest catch rate (0.352 bass / angler hour), the greatest pounds weighed-in / angler hour (0.567 lbs), and the greatest percent of anglers with a limit of five bass (35.9%). The lowest percent of unsuccessful anglers was at **Carters** (3.0%), but only six tournaments were reported. The second lowest percent of unsuccessful anglers was at **Hartwell** (12.4%). **Seminole** came in with the greatest average largest bass (5.17 lbs) and the greatest tournament winning weight (12.93). The greatest average bass weight (2.26 lbs) was at **Blackshear**. However, the lowest weighed-in number of bass / angler hour (0.124), the lowest weighed-in weight / angler hour (0.267 lbs), the lowest percent of anglers with five bass (4.6%), and the highest percent of unsuccessful anglers (43.9%) were also at **Blackshear.**

This was the 4th year that clubs were asked to indicate how many bass 5.0 lbs or larger were caught during each tournament. This information was given for 656 of the 684 tournaments used for this report. Only 251 bass 5.0 lbs or larger were caught during these 656 tournaments. On average, it required 319 angler hours to catch a bass of this size. This is greater than the 305 hours in 2006, but less than the 407 hours in 2004 and 321 hours in 2005. There was a big difference in this value for the 14 reservoirs. Whereas it took 1,026 hours at **Lanier** to catch a bass ≥ 5 lbs, it took only 131 hours at **Seminole.** Only at **Seminole** was there an average of one 5 lb or larger bass caught in each tournament.

The reservoir abbreviations on the attached graphs are **AL** (Allatoona), **BF** (Bartlett's Ferry), **BS** (Blackshear), **CA** (Carters), **CH** (Clarks Hill), **HW** (Hartwell), **JA** (Jackson), **LA** (Lanier), **OC** (Oconee), **RU** (R. B. Russell), **SE** (Seminole), **SI** (Sinclair), **WG** (W. F. George), **WP** (West Point).

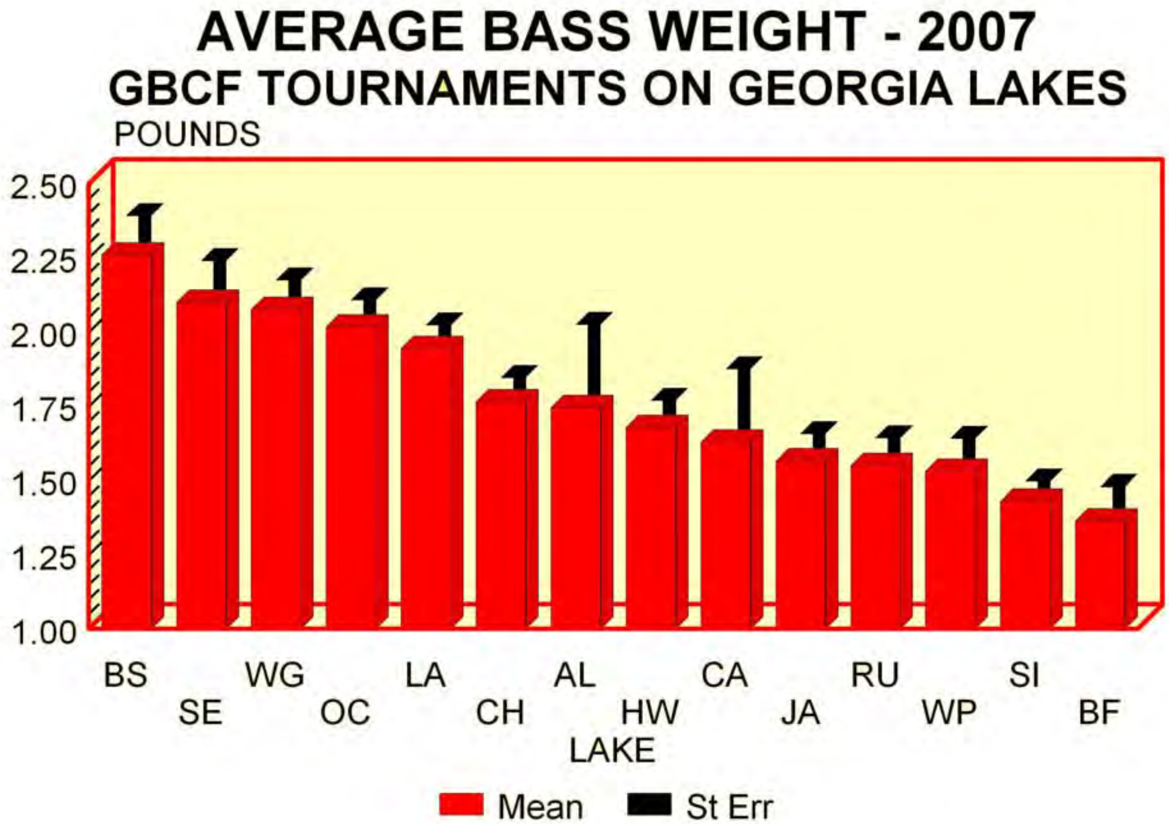
GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2007

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth	Angler-Hrs Per ≥ 5 lb Bass
Allatoona	14	1684	0.352	0.567	35.9	14.1	3.53	1.75	9.43	10.0	None Caught
Bartlett's Ferry	12	1358	0.287	0.384	20.1	14.6	3.16	1.37	7.36	42.7	None Caught
Blackshear [a]	21	2434	0.124	0.267	4.6	43.9	4.24	2.26	8.14	100.0	261
Carters	6	509	0.316	0.481	26.8	3.0	3.80	1.63	10.20	4.5	507
Clarks Hill	125	13929	0.306	0.532	30.1	20.8	4.49	1.77	11.34	99.3	225
Hartwell	30	3608	0.296	0.507	30.5	12.4	3.58	1.68	12.03	66.6	562
Jackson	44	4696	0.270	0.418	21.1	18.6	3.49	1.57	8.57	43.2	407
Lanier [a]	83	9707	0.256	0.503	19.4	23.0	3.86	1.95	11.09	15.8	1026
Oconee [a]	69	9161	0.213	0.416	13.8	25.9	4.41	2.02	11.93	93.3	329
R. B. Russell	41	4778	0.290	0.455	24.8	19.5	3.54	1.55	10.22	43.6	651
Seminole	46	6558	0.221	0.474	18.8	26.9	5.17	2.10	12.93	98.6	131
Sinclair	76	9006	0.247	0.353	19.0	22.1	4.03	1.43	8.72	97.0	288
W. F. George [b]	32	5201	0.172	0.354	9.4	27.1	4.60	2.08	10.90	82.1	289
West Point [b]	39	5619	0.303	0.474	27.5	21.0	3.90	1.53	10.40	23.6	743
Savannah River	46	5135	0.256	0.391	18.6	22.4	4.17	1.58	8.61	99.7	271
Total	**684**	**83383**	**0.259**	**0.447**	**21.4**	**22.4**	**4.12**	**1.76**	**10.46**	**72.2**	**319**

[a] 14-inch size limit. [b] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass.

Note: Only tournaments with six or more anglers and five of more hours in length were analyzed.
Reservoirs or rivers with less than six tournaments were not analyzed.

Compiled and analyzed by Dr. Carl Quertermus and Margaret Kukucka, University of West Georgia.


AVERAGE BASS WEIGHT - 2007
GBCF TOURNAMENTS ON GEORGIA LAKES
POUNDS
2.50
2.25
2.00
1.75
1.50
1.25
1.00
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LAKE
Mean
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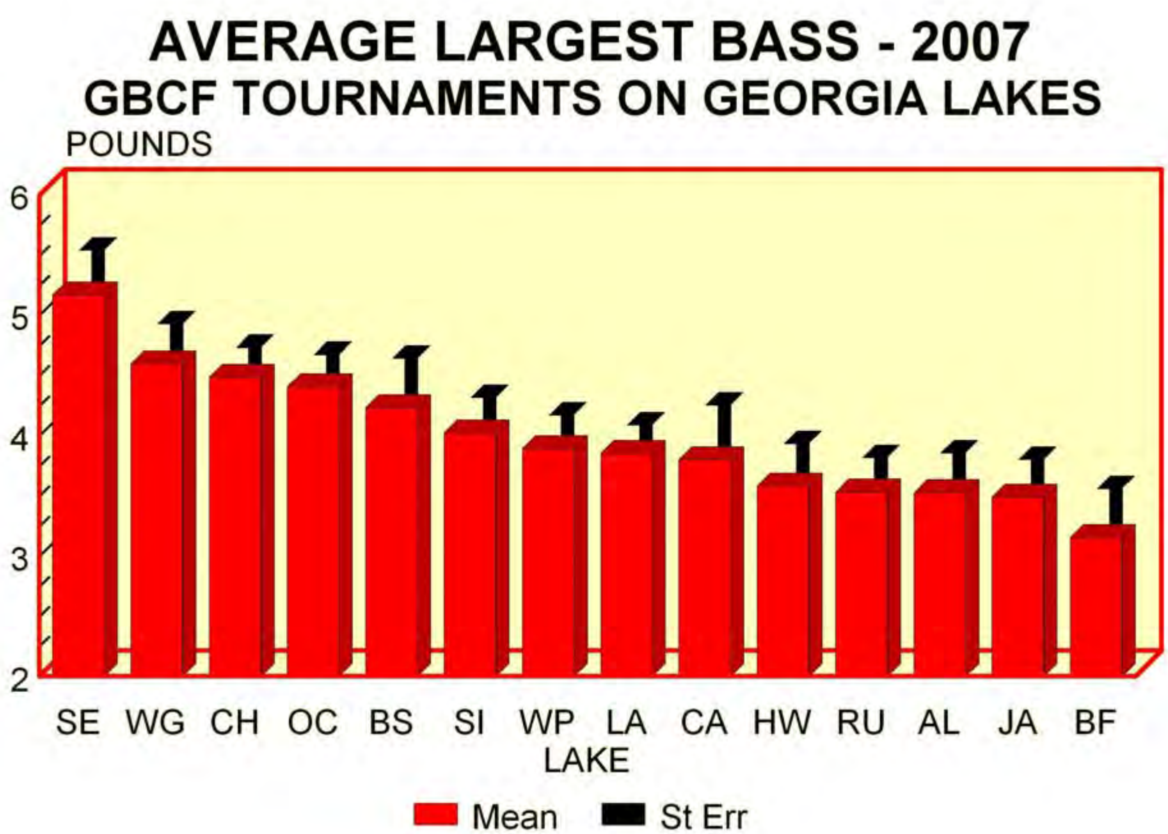
AVERAGE LARGEST BASS - 2007
GBCF TOURNAMENTS ON GEORGIA LAKES
POUNDS
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Mean
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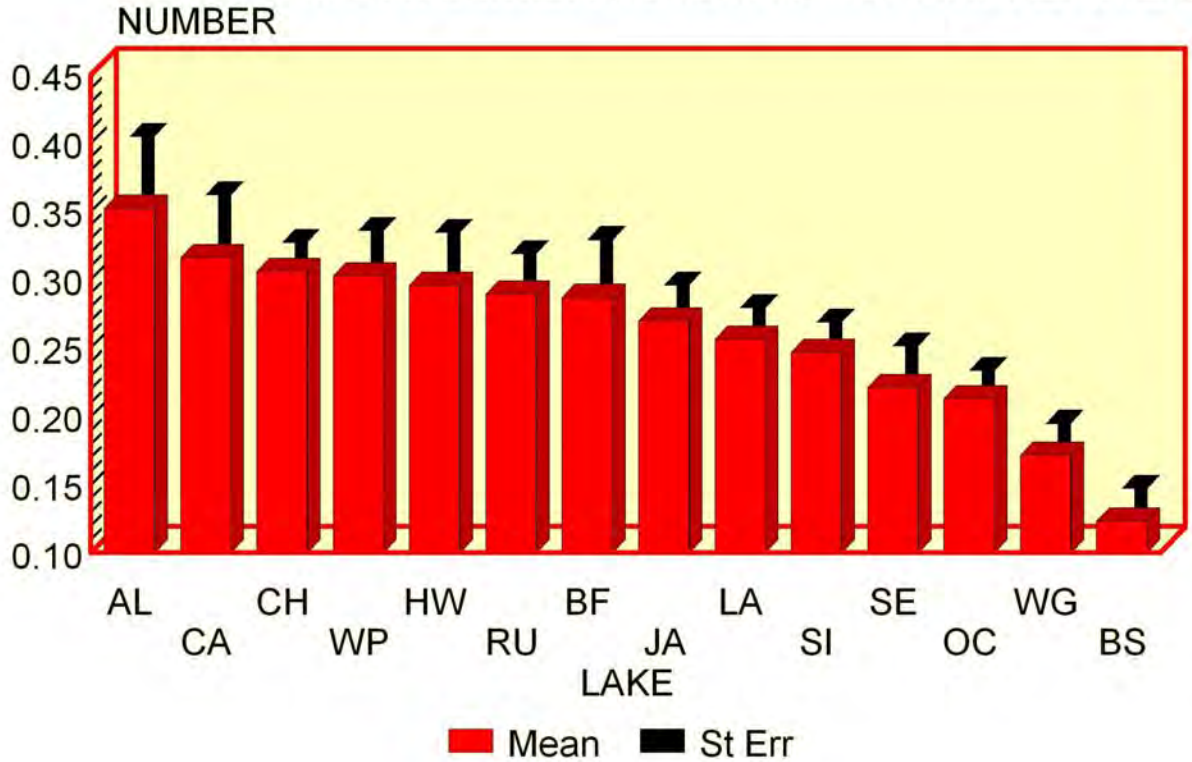
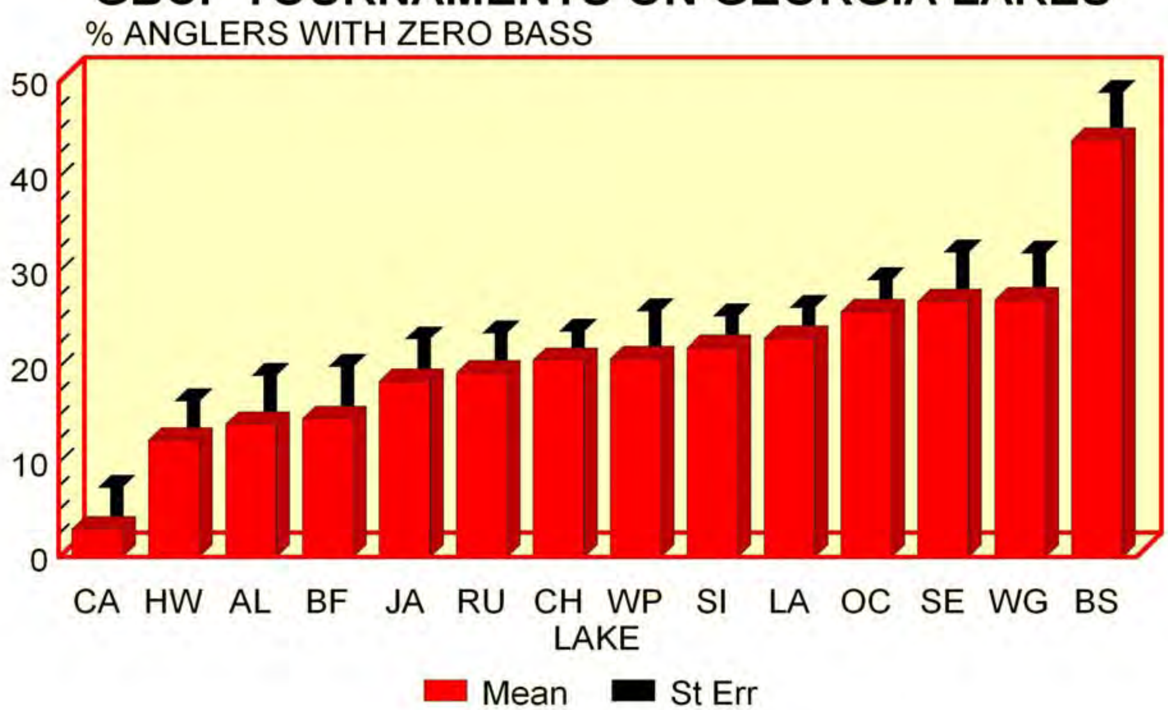
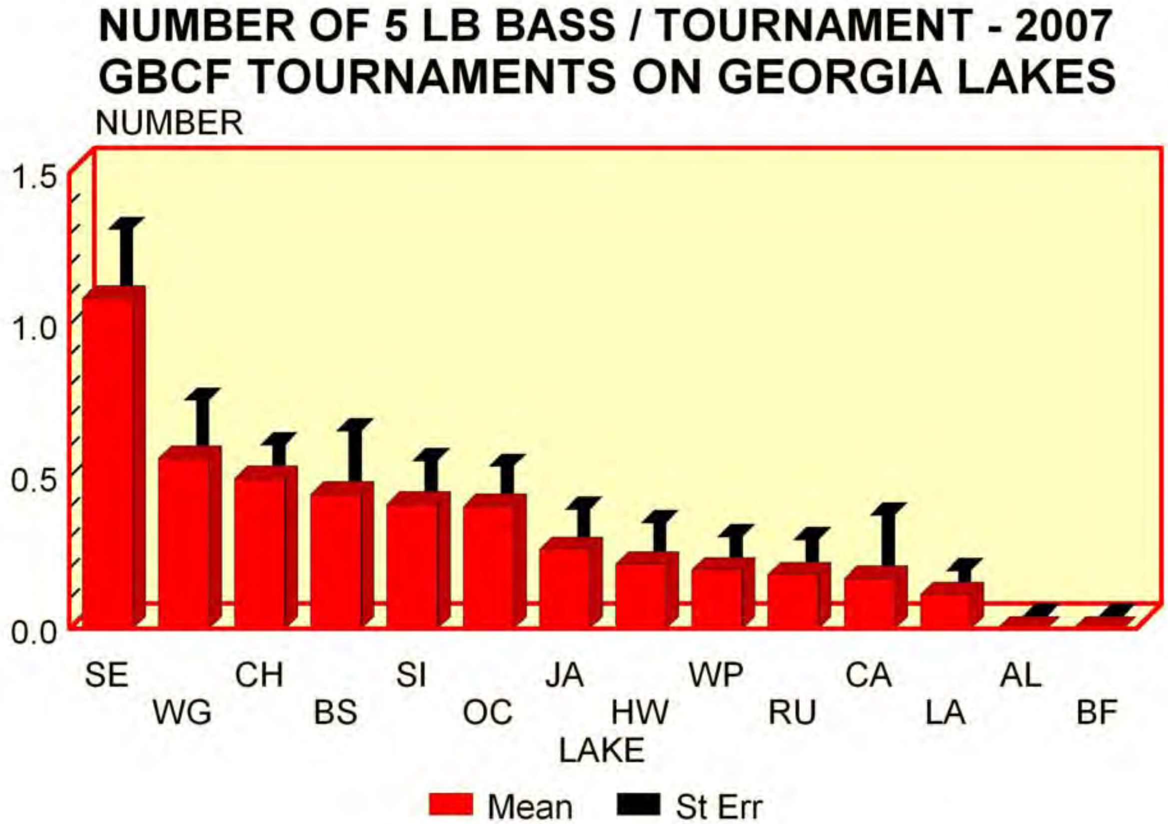
BASS / ANGLER HOUR - 2007
GBCF TOURNAMENTS ON GEORGIA LAKES



PERCENT UNSUCCESSFUL ANGLERS - 2007
GBCF TOURNAMENTS ON GEORGIA LAKES

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GBCF TOURNAMENTS ON GEORGIA LAKES
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1.0
0.5
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LAKE
Mean
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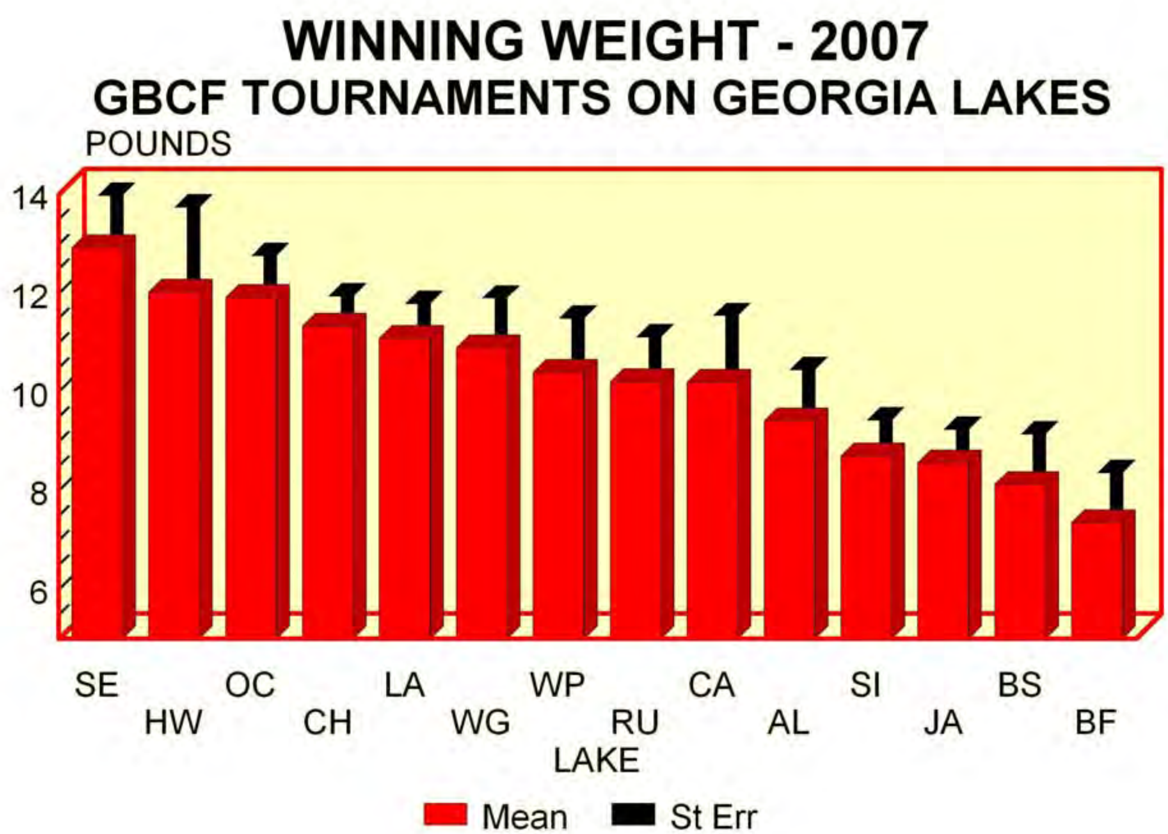
WINNING WEIGHT - 2007
GBCF TOURNAMENTS ON GEORGIA LAKES
POUNDS
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10
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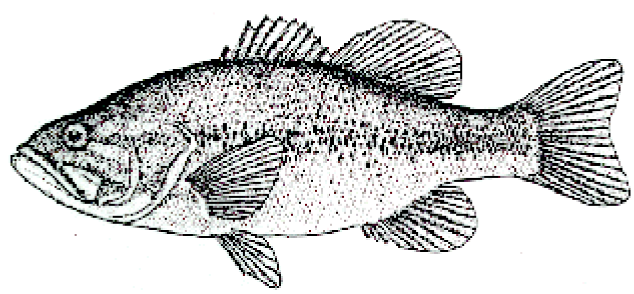
BS
BF
LAKE
Mean
St Err

Georgia Bass Chapter Federation

2008

Tournament Creel Report



Submitted by

Carl Quertermus, Ph.D.

GBCF Tournament Report - 2008

This is the 31st year of the Georgia Bass Chapter Federation (GBCF) Tournament Creel Report. In 2008, 85 bass clubs submitted results from 833 tournaments. Several of these tournaments were not analyzed because they involved less than six anglers or lasted less than five hours. Also, Georgia reservoirs and rivers with less than six submitted tournaments were not analyzed. The data from tournaments held outside of Georgia were not analyzed. Data from 200 tournaments held at Alabama reservoirs were sent to the Alabama Department of Conservation and Natural Resources and became part of their annual tournament data analysis (B.A.I.T.). Data from 614 tournaments on 14 Georgia reservoirs and two rivers were analyzed for this report.

Fishing success at Georgia reservoirs and rivers are compared on the attached table and figures. Bass anglers spent 71,785 hours of effort during the 614 tournaments. The weighed-in, tournament-average catch rate was 0.268 bass / angler hour. This is the highest catch rate in the 31 years of this project. The state-wide catch rate average over the 31 years is 0.223 bass / angler hour. The record high catch rates in 2006-2008 were mainly caused by the large number of tournaments at Clarks Hill where the catch rate was above the average. **Hartwell** had the highest catch rate (0.331 bass / angler hour), the greatest percent of anglers with five bass (46.1%), the lowest percent of unsuccessful anglers (9.6%), and the highest average winning weight (15.96 lbs). This was also a good year at **Seminole**. It came in with the highest weighed-in average weight (0.630 lbs / angler hour), the greatest average largest bass (5.22 lbs), and the least number of hours to catch a 5.0 pound or larger bass (113 hours). The greatest average bass weight (2.13 lbs) was at **W. F. George**.

This was the 5th year that clubs were asked to indicate how many bass 5.0 lbs or larger were caught during each tournament. This information was given for 601 of the 614 tournaments used for this report. Only 247 bass 5.0 lbs or larger were caught during these 601 tournaments. On average, it required 285 angler hours to catch a bass of this size. This is the least number of hours to catch a 5.0 lb bass during the five years of this analysis. There was a big difference in this value for the 14 reservoirs. Whereas it took 1,984 hours at **Bartlett's Ferry** to catch a bass ≥ 5 lbs, it took only 113 hours at **Seminole.** Only at **Seminole** was there an average of one 5 lb or larger bass caught in each tournament. A bass of this size was caught in only 27.6% of the 601 tournaments, and no 5 lb bass were caught in the 22 tournaments at **Allatoona** or the eight tournaments at **Carters**. The largest bass reported in 2008 was 10.63 lbs caught in the **Savannah River** in January.

The reservoir abbreviations on the attached graphs are **AL** (Allatoona), **BF** (Bartlett's Ferry), **BS** (Blackshear), **CA** (Carters), **CH** (Clarks Hill), **HW** (Hartwell), **JA** (Jackson), **LA** (Lanier), **OC** (Oconee), **RU** (R. B. Russell), **SE** (Seminole), **SI** (Sinclair), **WG** (W. F. George), **WP** (West Point).

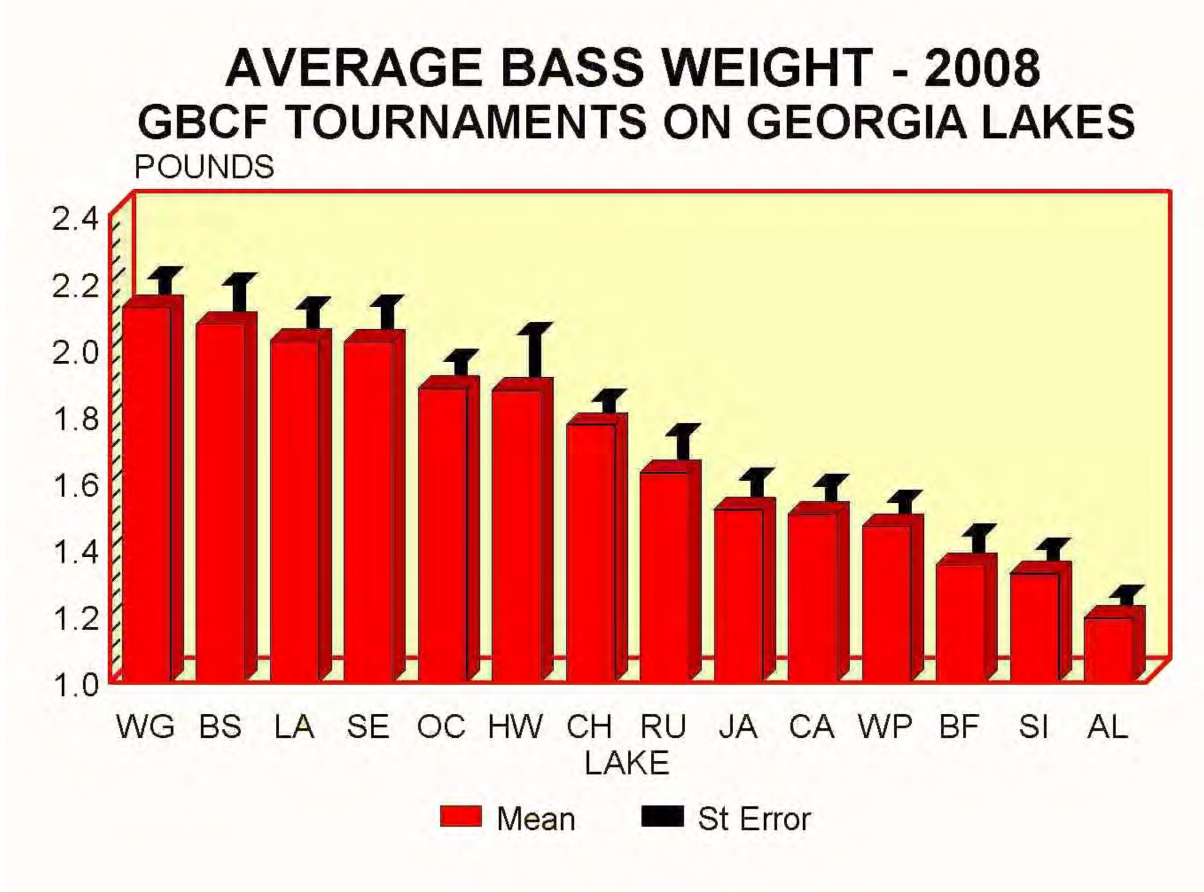
GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2008

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth	Angler-Hrs Per ≥ 5 lb Bass
Allatoona	22	2462	0.281	0.333	21.0	18.3	2.88	1.19	7.71	7.3	None Caught
Bartlett's Ferry	15	1994	0.310	0.414	23.0	12.9	3.24	1.35	7.67	43.1	1984
Blackshear [a]	20	2180	0.133	0.280	4.9	39.3	4.26	2.08	8.37	99.1	363
Carters	8	714	0.292	0.452	31.7	17.0	3.92	1.51	10.03	5.9	None Caught
Clarks Hill	118	12890	0.280	0.496	25.3	21.9	4.26	1.77	10.91	97.1	213
Hartwell	18	2198	0.331	0.599	46.1	9.6	4.13	1.88	15.96	67.9	244
Jackson	36	3851	0.263	0.391	18.2	22.2	4.16	1.52	7.93	37.9	467
Lanier [a]	43	5246	0.279	0.558	24.6	18.7	4.06	2.03	12.36	13.8	584
Oconee [a]	68	7774	0.241	0.443	18.0	18.6	4.20	1.88	11.21	97.3	286
R. B. Russell	33	3969	0.285	0.477	29.3	13.5	3.80	1.63	11.67	49.2	640
Seminole	40	4952	0.307	0.630	26.6	17.1	5.22	2.02	14.17	99.7	113
Sinclair	58	7213	0.290	0.391	28.0	18.7	3.66	1.32	8.56	96.4	278
W. F. George [b]	30	4221	0.220	0.467	14.9	17.1	4.80	2.13	13.05	91.3	192
West Point [b]	48	6325	0.303	0.451	31.7	14.0	3.99	1.47	10.36	24.7	351
Altamaha River	7	608	0.120	0.182	2.2	40.9	3.26	2.07	5.35	100.0	261
Savannah River	50	5188	0.224	0.308	14.6	27.0	3.64	1.37	8.25	99.4	424
Total	**614**	**71785**	**0.268**	**0.450**	**23.3**	**19.8**	**4.08**	**1.70**	**10.54**	**73.4**	**285**

[a] 14-inch size limit. [b] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass.

Note: Only tournaments with six or more anglers and five of more hours in length were analyzed.
Reservoirs or rivers with less than six tournaments were not analyzed.

Compiled and analyzed by Dr. Carl Quertermus and Margaret Kukucka, University of West Georgia.


AVERAGE BASS WEIGHT - 2008
GBCF TOURNAMENTS ON GEORGIA LAKES
POUNDS
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2.2
2.0
1.8
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WG BS LA SE OC HW CH RU JA CA WP BF SI AL
LAKE
Mean
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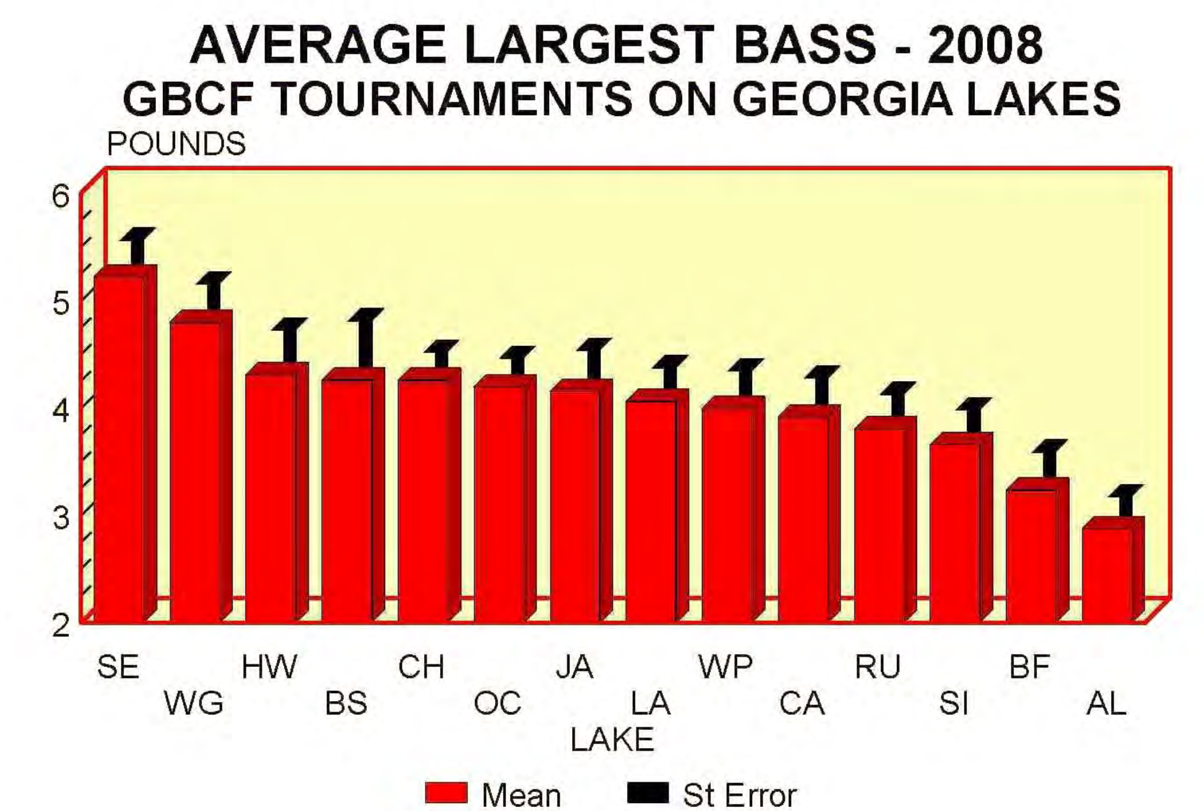
AVERAGE LARGEST BASS - 2008
GBCF TOURNAMENTS ON GEORGIA LAKES
POUNDS
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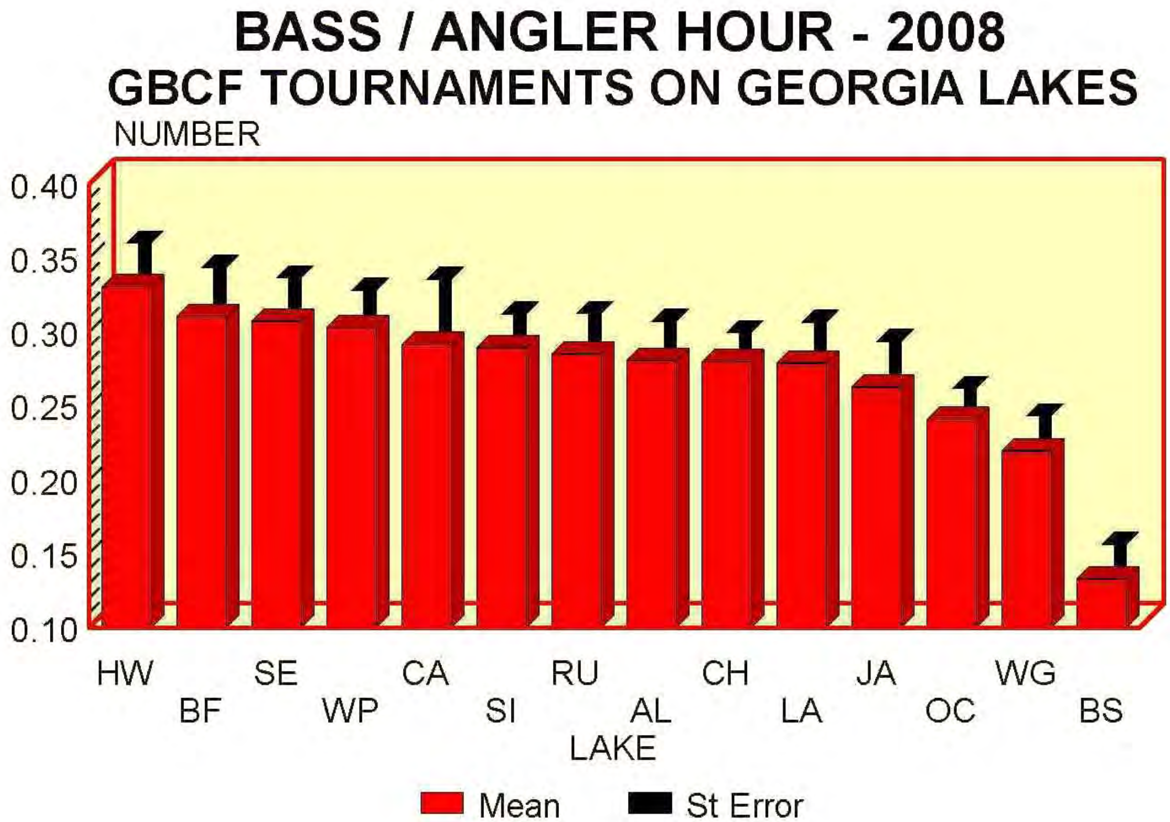
SE WG HW BS CH OC JA LA WP CA RU SI BF AL
LAKE
Mean
St Error


BASS / ANGLER HOUR - 2008
GBCF TOURNAMENTS ON GEORGIA LAKES
NUMBER
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0.35
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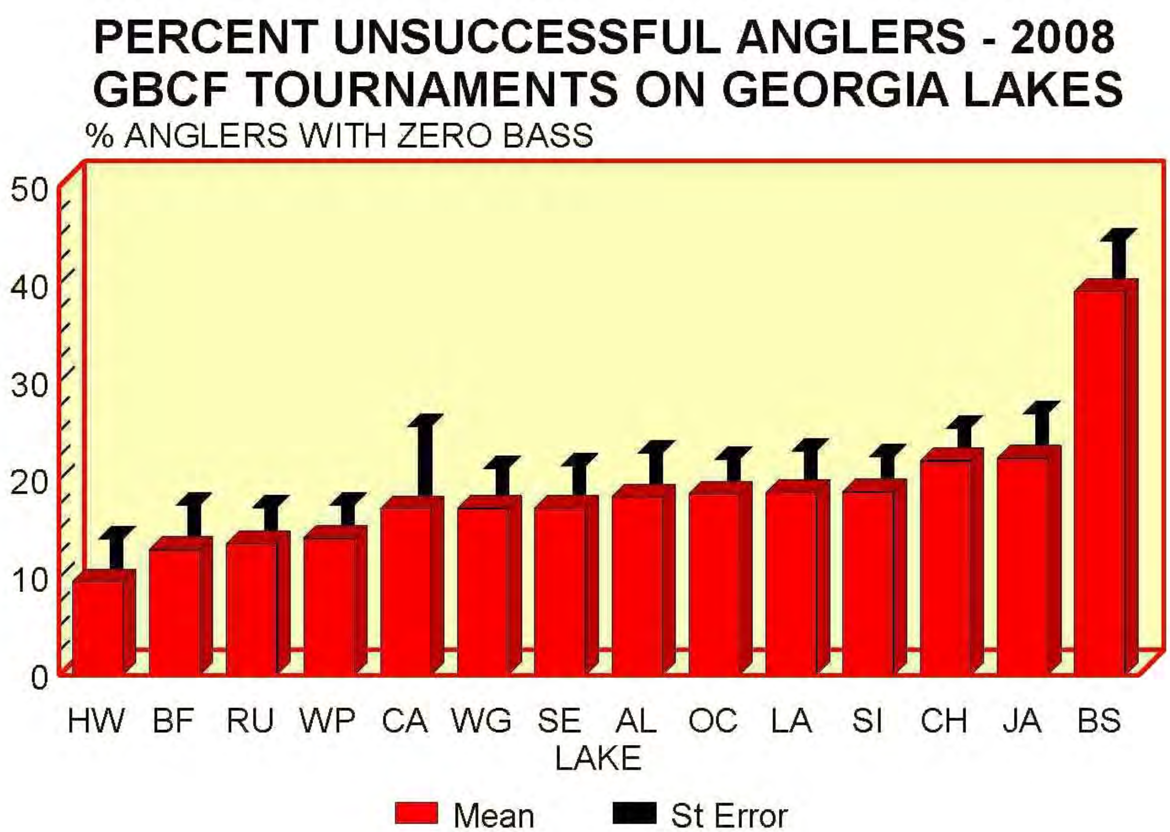
PERCENT UNSUCCESSFUL ANGLERS - 2008
GBCF TOURNAMENTS ON GEORGIA LAKES
% ANGLERS WITH ZERO BASS
50
40
30
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WP
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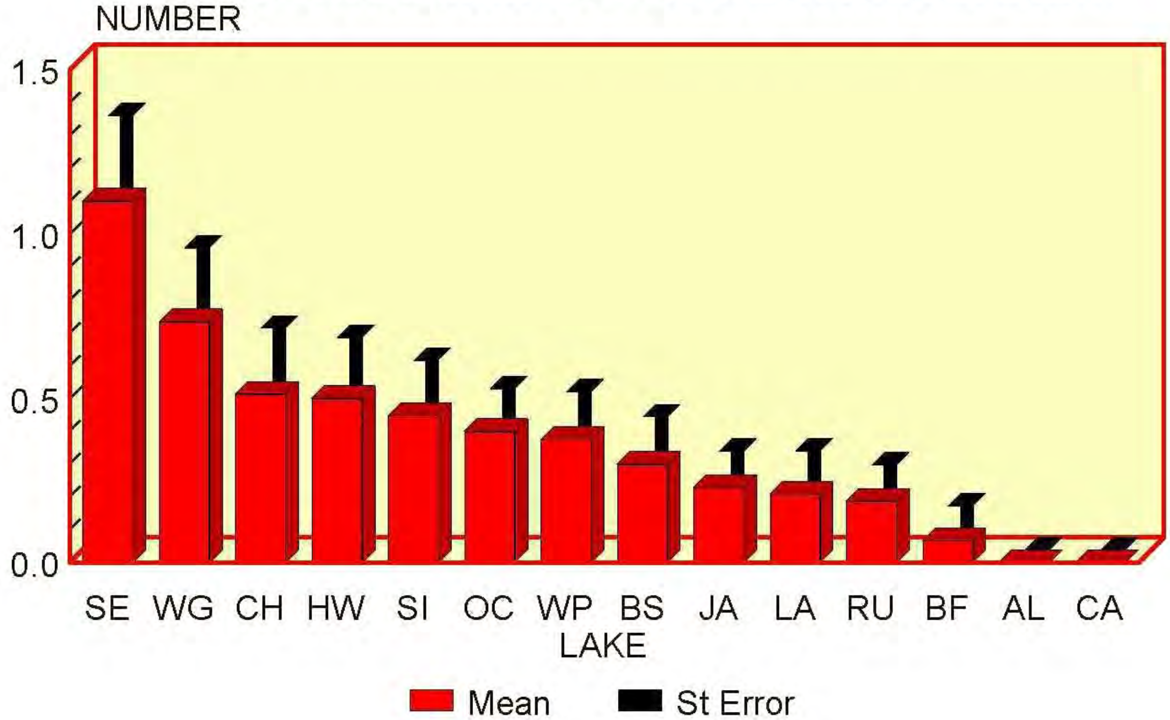
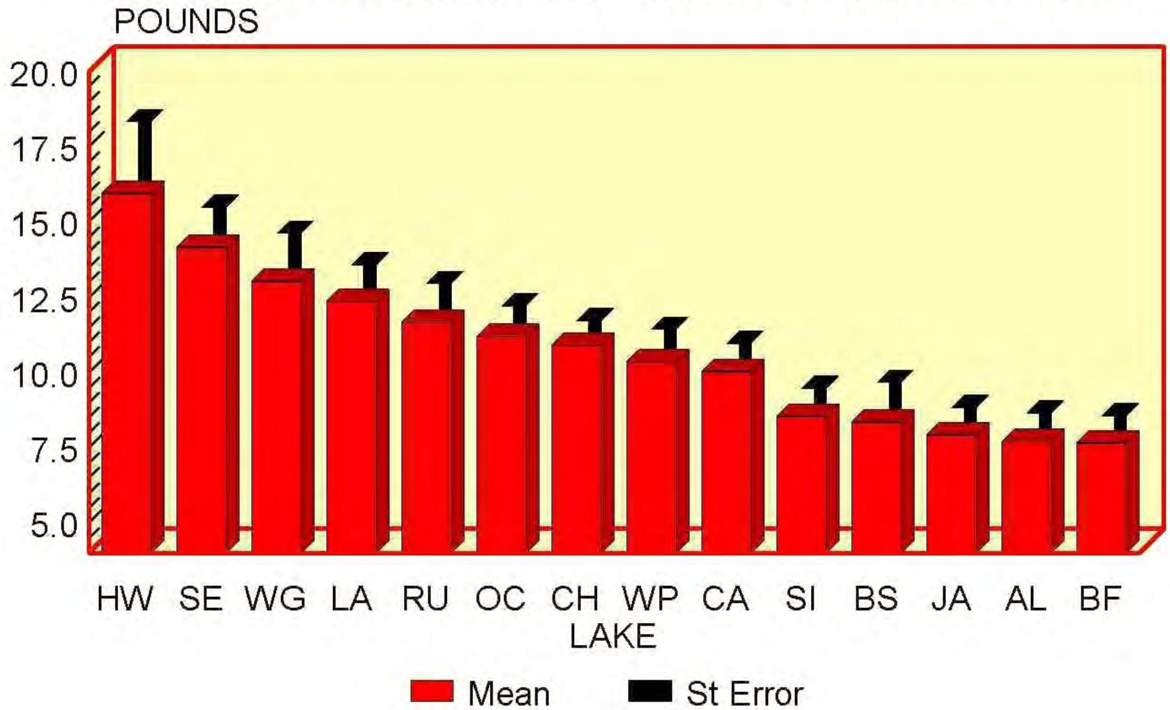
Mean
St Error

NUMBER OF 5 LB BASS / TOURNAMENT - 2008
GBCF TOURNAMENTS ON GEORGIA LAKES



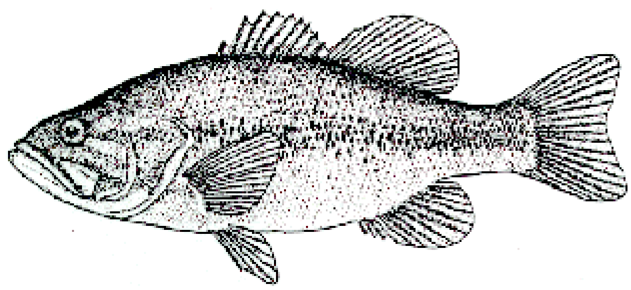
WINNING WEIGHT - 2008
GBCF TOURNAMENTS ON GEORGIA LAKES



Georgia Bass Chapter Federation

2009

Tournament Creel Report



Submitted by

Carl Quertermus, Ph.D.

GBCF Tournament Report - 2009

This is the 32nd year of the Georgia Bass Chapter Federation (GBCF) Tournament Creel Report. In 2009, 69 bass clubs submitted results from 677 tournaments. Several of these tournaments were not analyzed because they involved less than six anglers or lasted less than five hours. Also, Georgia reservoirs and rivers with less than six submitted tournaments were not analyzed. The data from tournaments held outside of Georgia were not analyzed. Data from 168 tournaments held at Alabama reservoirs were sent to the Alabama Department of Conservation and Natural Resources and became part of their annual tournament data analysis (B.A.I.T.). Data from 500 tournaments on 13 Georgia reservoirs and two rivers were analyzed for this report.

Fishing success at Georgia reservoirs and rivers are compared on the attached table and figures. Bass anglers spent 57,111 hours of effort during the 500 tournaments. The weighed-in, tournament-average catch rate was 0.265 bass / angler hour. This is the second highest catch rate in the 32 years of this project. The state-wide catch rate average over the 32 years is 0.224 bass / angler hour. The highest catch rate was 0.268 in 2008.

R. B. Russell had the highest catch rate (0.348 bass / angler hour) and the lowest percent of unsuccessful anglers (9.6%). Catch rates were also excellent at **Bartlett's Ferry** (0.343) and **West Point** (0.336). **West Point** had the greatest percent (39.3%) of anglers that weighed in five bass (a tournament limit). Tournament fishing was also very good year at **W. F. George.** Tournaments there had the highest winning weight (18.67 lbs), the greatest average bass weight (2.59 lbs), and greatest average largest bass weight (5.68 lbs).

This was the 6th year that clubs were asked to indicate how many bass 5.0 lbs or larger were caught during each tournament. This information was given for 476 of the 500 tournaments used for this report. Only 205 bass 5.0 lbs or larger were caught during these 476 tournaments. On average, it required 265 angler hours to catch a bass of this size. This is the least number of hours to catch a 5.0 lb bass during the six years of this analysis. There was a big difference in this value for the 13 reservoirs. Whereas it took 1,382 hours at **Bartlett's Ferry** to catch a bass ≥ 5 lbs, it took only 85 hours at **Seminole.** Only at **Seminole** and **W. F. George** was there an average of one 5 lb or larger bass caught in each tournament. A bass of this size was caught in only 29% of the 476 tournaments. The largest bass reported in 2009 was 11.1 lbs caught at **Seminole** during February. No other bass 10 pounds or larger were reported for the 500 tournaments in 2009.

The reservoir abbreviations on the attached graphs are **AL** (Allatoona), **BF** (Bartlett's Ferry), **BS** (Blackshear), **CA** (Carters), **CH** (Clarks Hill), **HW** (Hartwell), **JA** (Jackson), **LA** (Lanier), **OC** (Oconee), **RU** (R. B. Russell), **SE** (Seminole), **SI** (Sinclair), **WG** (W. F. George), **WP** (West Point).

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2009

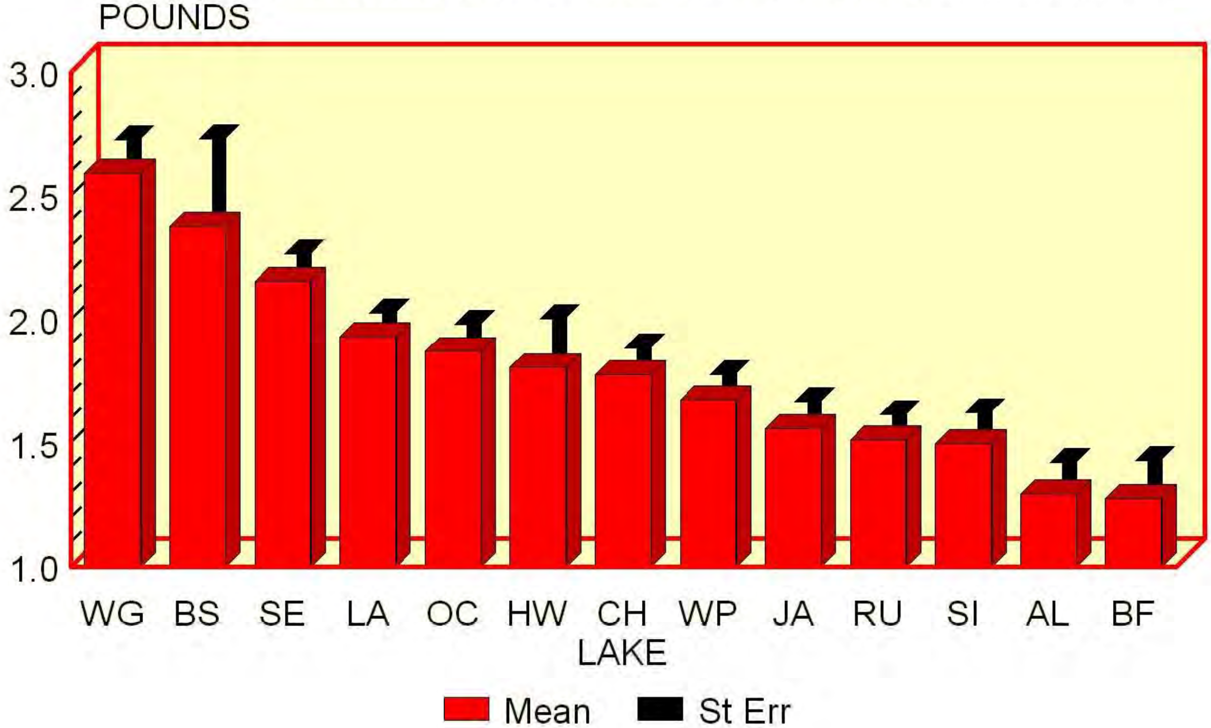
Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth	Angler-Hrs Per ≥ 5 lb Bass
Allatoona	12	1343	0.279	0.360	24.2	11.3	3.02	1.29	8.21	18.5	1229
Bartlett's Ferry	9	1381	0.343	0.429	30.2	11.1	3.98	1.27	10.74	40.8	1382
Blackshear [a]	10	939	0.181	0.387	4.5	35.9	4.04	2.38	8.71	99.2	None Caught
Clarks Hill	85	8267	0.235	0.408	15.5	26.7	3.84	1.78	9.63	99.0	296
Hartwell	23	2515	0.278	0.514	23.2	18.3	3.79	1.81	10.16	51.2	1201
Jackson	28	2854	0.251	0.384	18.2	24.1	3.68	1.56	8.47	41.9	441
Lanier [a]	46	4448	0.245	0.476	16.1	26.7	3.66	1.93	11.34	10.7	1362
Oconee [a]	62	6979	0.231	0.432	12.4	23.5	4.13	1.87	10.76	94.5	323
R. B. Russell	26	3352	0.348	0.526	35.9	9.6	3.71	1.51	12.05	41.0	992
Seminole	40	4903	0.317	0.704	32.2	14.8	5.65	2.16	15.44	99.3	85
Sinclair	47	5153	0.310	0.473	29.3	16.7	4.05	1.50	9.64	98.0	322
W. F. George [b]	31	4982	0.242	0.618	22.1	16.2	5.68	2.59	18.67	89.4	156
West Point [b]	33	5096	0.336	0.555	39.3	12.8	4.90	1.67	12.81	33.4	190
Altamaha River	6	445	0.138	0.218	1.5	40.4	2.87	1.57	5.07	100.0	444
Savannah River	42	4454	0.233	0.318	11.9	25.7	3.50	1.35	7.26	100.0	322
Total	**500**	**57111**	**0.265**	**0.467**	**21.1**	**21.0**	**4.14**	**1.78**	**10.95**	**45.7**	**265**

[a] 14-inch size limit. [b] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass.

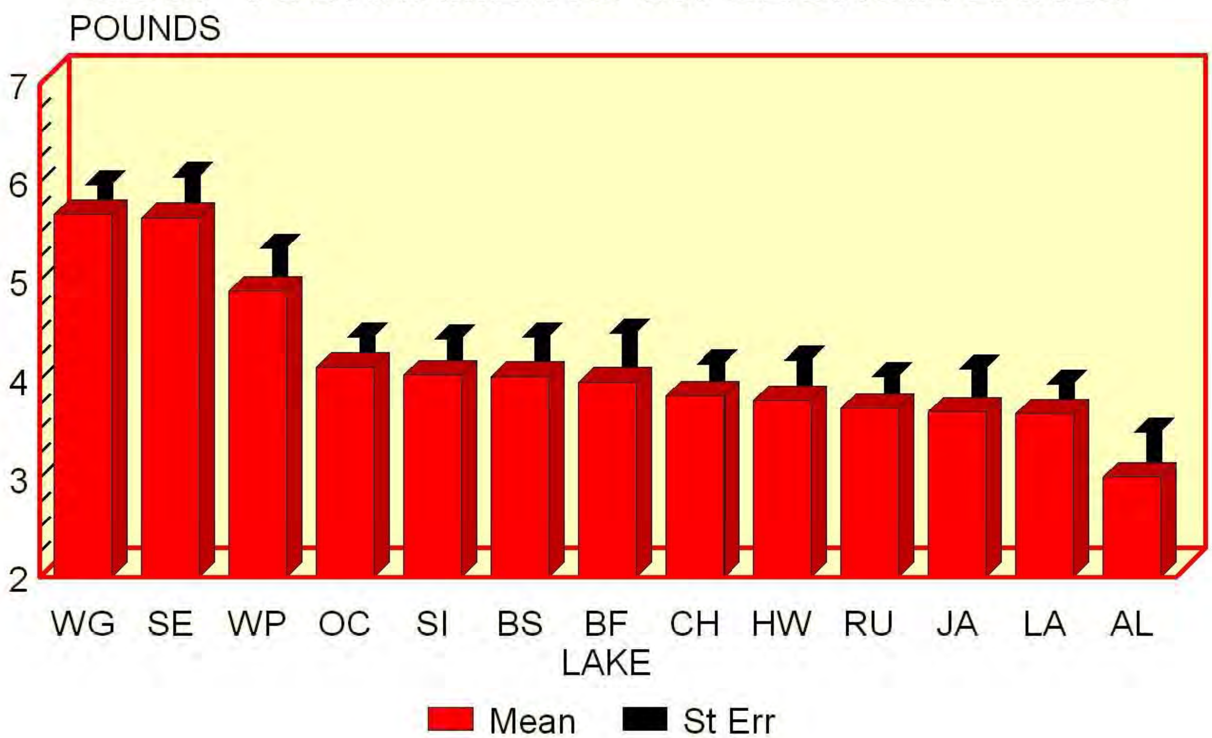
Note: Only tournaments with six or more anglers and five of more hours in length were analyzed.
Reservoirs or rivers with less than six tournaments were not analyzed.

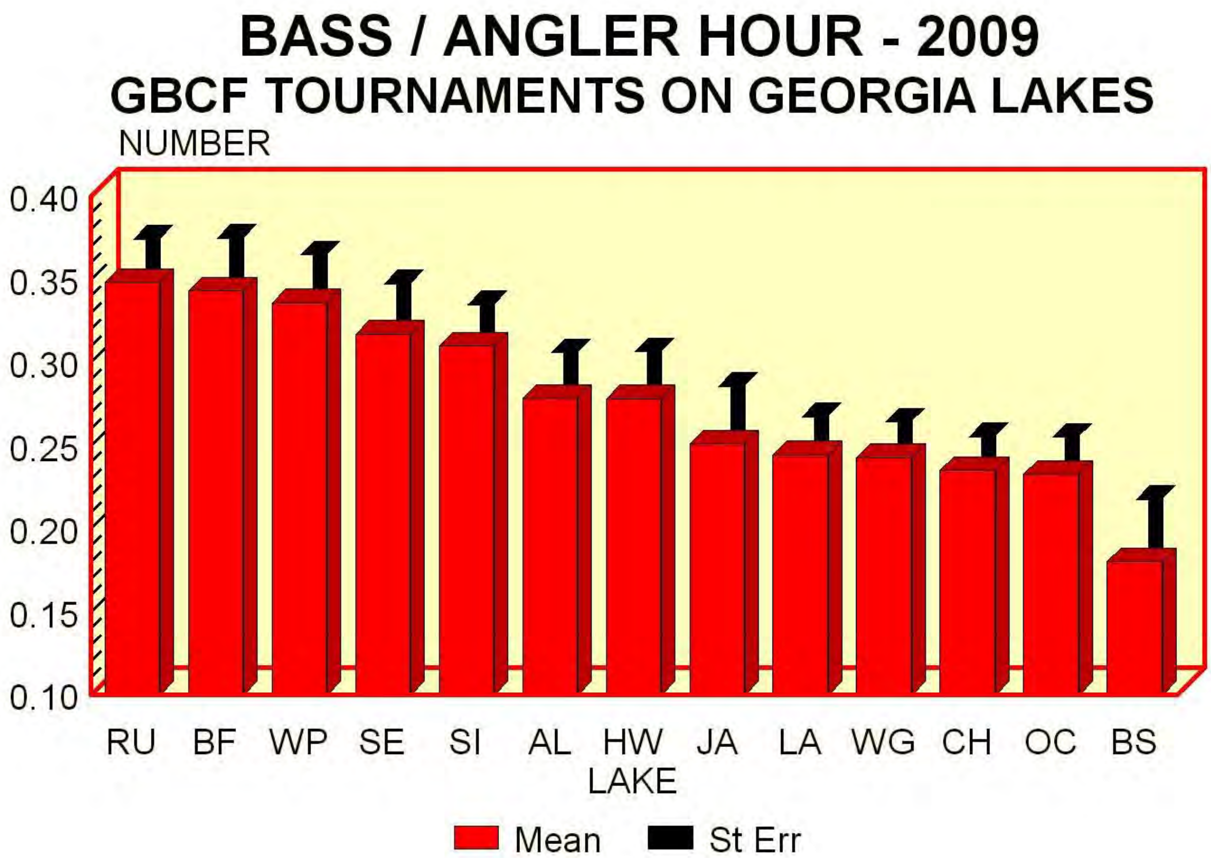
Compiled and analyzed by Dr. Carl Quertermus and Margaret Kukucka, University of West Georgia.

AVERAGE BASS WEIGHT - 2009
GBCF TOURNAMENTS ON GEORGIA LAKES



AVERAGE LARGEST BASS - 2009
GBCF TOURNAMENTS ON GEORGIA LAKES





BASS / ANGLER HOUR - 2009
GBCF TOURNAMENTS ON GEORGIA LAKES
NUMBER
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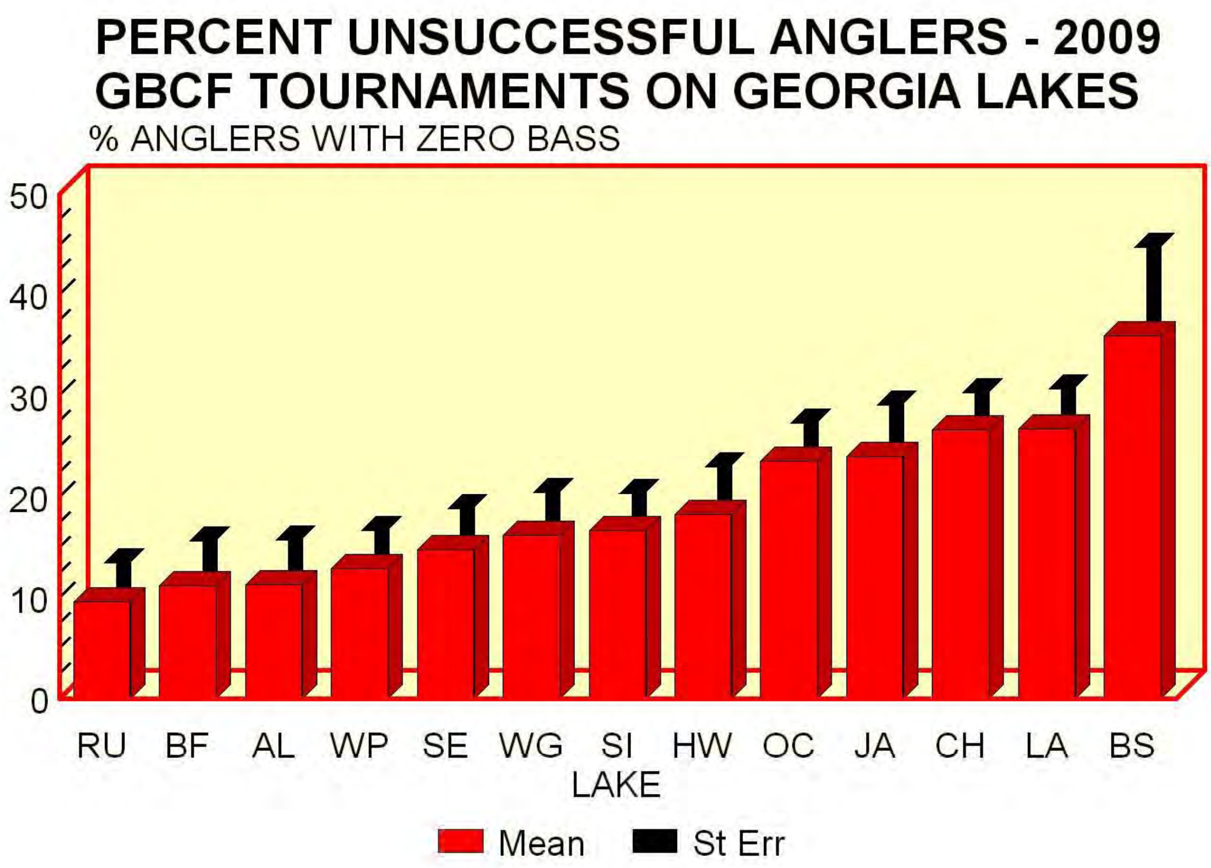

PERCENT UNSUCCESSFUL ANGLERS - 2009
GBCF TOURNAMENTS ON GEORGIA LAKES
% ANGLERS WITH ZERO BASS
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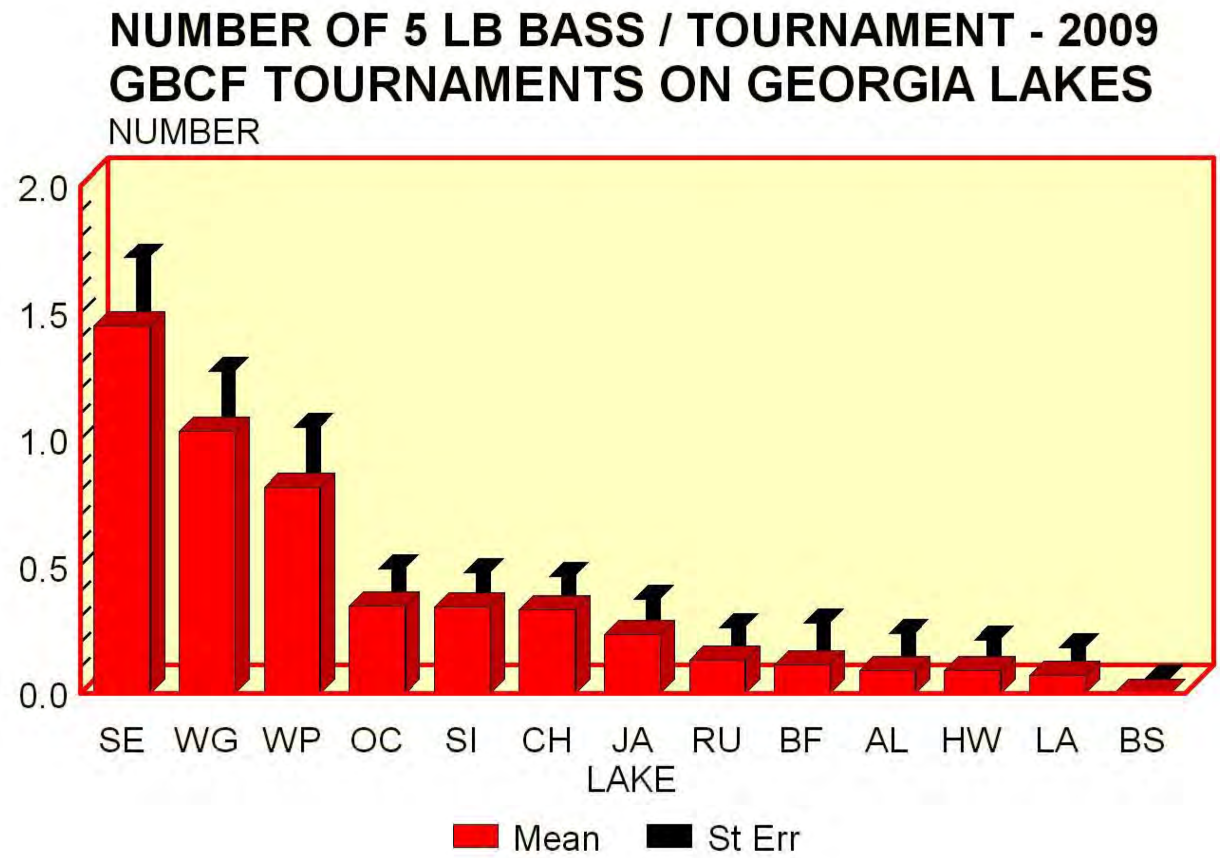
NUMBER OF 5 LB BASS / TOURNAMENT - 2009
GBCF TOURNAMENTS ON GEORGIA LAKES
NUMBER
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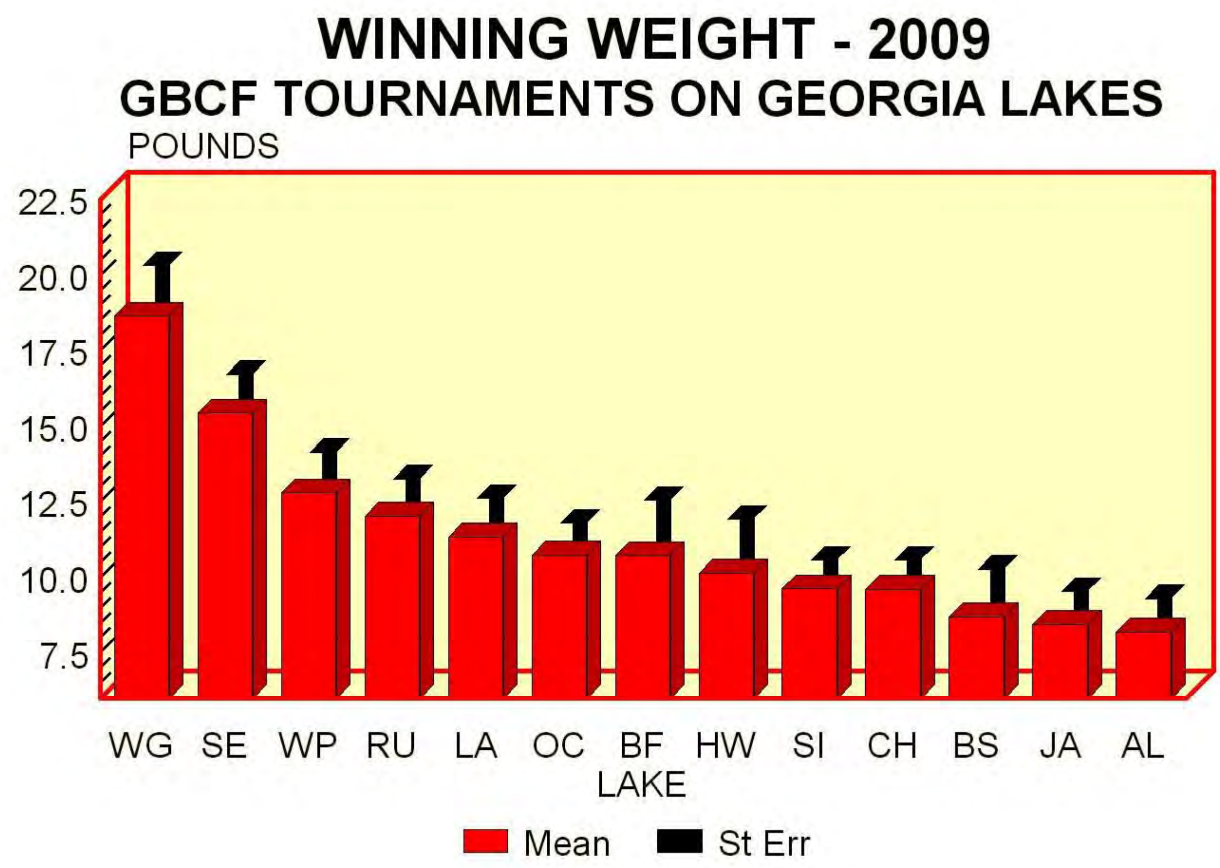
WINNING WEIGHT - 2009
GBCF TOURNAMENTS ON GEORGIA LAKES
POUNDS
22.5
20.0
17.5
15.0
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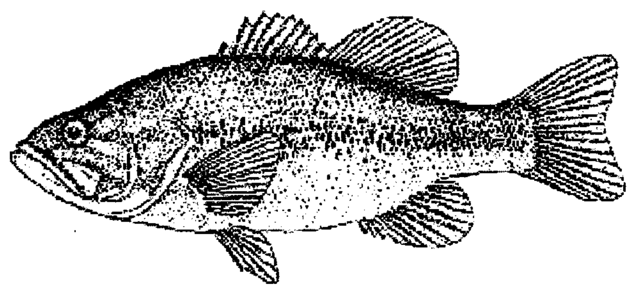
Georgia Bass Chapter Federation

2010

Tournament Creel Report



Submitted by

Carl Quertermus, Ph.D.

GBCF Tournament Report - 2010

This is the 33rd year of the Georgia Bass Chapter Federation (GBCF) Tournament Creel Report. In 2010, 63 bass clubs submitted results from 656 tournaments. Several of these tournaments were not analyzed because they involved less than six anglers or lasted less than five hours. Also, Georgia reservoirs and rivers with less than six submitted tournaments were not analyzed. The data from tournaments held outside of Georgia were not analyzed. Data from 161 tournaments held at Alabama reservoirs were sent to the Alabama Department of Conservation and Natural Resources and became part of their annual tournament data analysis (B.A.I.T.). Data from 455 tournaments on 13 Georgia reservoirs and the Savannah River were analyzed for this report.

Fishing success at Georgia reservoirs and the Savannah River are compared on the attached table and figures. Bass anglers spent 52,280 hours of effort during the 455 tournaments. The weighed-in, tournament-average catch rate was 0.250 bass / angler hour. This is below the average for the past four years but above the 0.224 average of the previous 32 years. The highest catch rate was 0.268 in 2008.

R. B. Russell had the highest catch rate (0.329 bass / angler hour). Catch rates were also good at **W.F. George** (0.309), **West Point** (0.292), and **Seminole** (0.290). The lowest percent of unsuccessful anglers was at **W.F. George** (12.9%) and **Hartwell** (14.5%). The average bass weight was greatest at **Seminole** (2.41 lbs), but it was almost as good at **Blackshear** (2.37 lbs) and **W.F. George** (2.33 lbs). The average largest bass weighed in was at **Seminole** (5.63 lbs). The only other lake where the average largest bass exceeded five pounds was at **W.F. George** (5.06 lbs). The greatest winning weight average was at **W.F. George** (18.84 lbs), and the second highest was 16.93 lbs at **Seminole**. Both these lakes had several two-day tournaments, which contribute to greater winning weights.

This was the 7th year that clubs were asked to indicate how many bass 5.0 lbs or larger were caught during each tournament. Only 217 bass 5.0 lbs or larger were caught during the 455 tournaments. On average, it required 241 angler hours to catch a bass of this size. This is the least number of hours to catch a 5.0 lb bass during the seven years of this analysis. There was a big difference in this value for the 13 reservoirs. Whereas it took 1,337 hours at **Bartlett's Ferry** and 1,321 hours at **Lanier** to catch a bass ≥ 5 lbs, it took only 64 hours at **Seminole.** Only at **Seminole** and **W.F. George** was there an average of one 5 lb or larger bass caught in each tournament. A bass of this size was caught in only 27% of the 455 tournaments. The largest bass reported in 2010 was 9.89 lbs caught in the **Savannah River** during October. Only six bass of 8.0 lbs or larger were caught in the 455 tournaments!

The reservoir abbreviations on the attached graphs are **AL** (Allatoona), **BF** (Bartlett's Ferry), **BS** (Blackshear), **CA** (Carters), **CH** (Clarks Hill), **HW** (Hartwell), **JA** (Jackson), **LA** (Lanier), **OC** (Oconee), **RU** (R. B. Russell), **SE** (Seminole), **SI** (Sinclair), **WG** (W. F. George), **WP** (West Point).

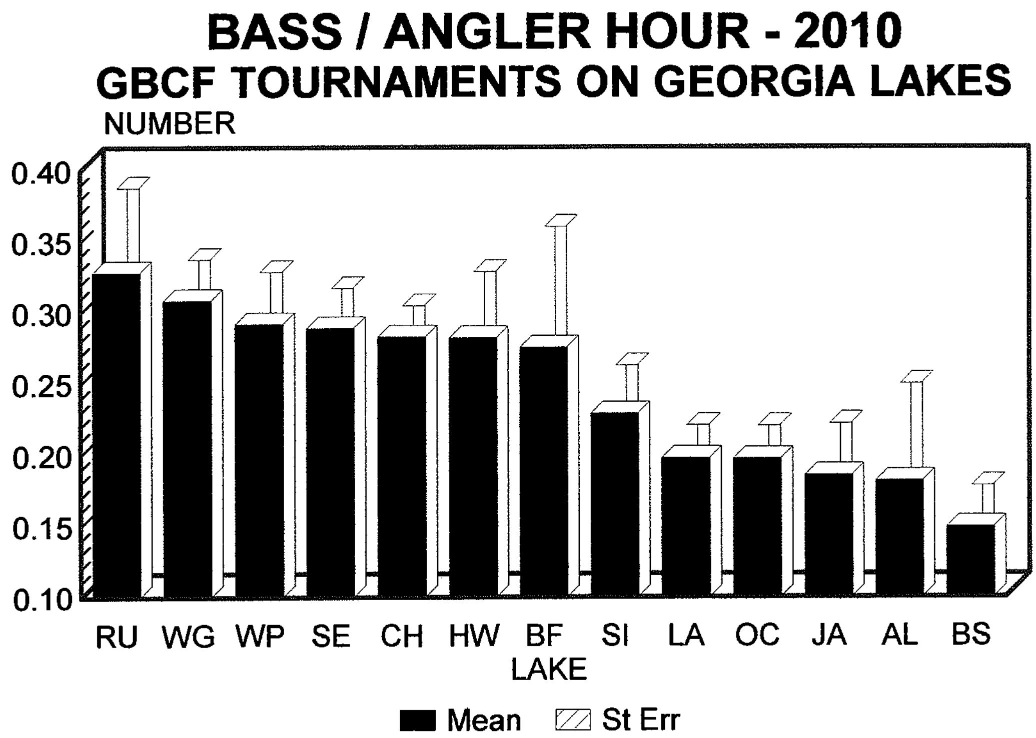
GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2010

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth	Angler Hours Per ≥ 5 lb Bass
Allatoona	7	967	0.182	0.236	23.1	42.2	2.81	1.45	6.44	9.8	None Caught
Bartlett's Ferry	9	1337	0.276	0.391	22.2	27.3	3.97	1.47	10.61	70.7	1337
Blackshear [a]	13	1135	0.149	0.355	5.5	30.6	4.33	2.37	9.37	100.0	162
Clarks Hill	87	8952	0.283	0.449	23.1	21.0	3.80	1.64	9.65	99.7	471
Hartwell	20	2280	0.283	0.472	25.4	14.5	3.85	1.61	10.78	49.5	456
Jackson	21	1827	0.186	0.294	12.7	44.4	3.12	1.65	6.73	52.1	609
Lanier [a]	58	6604	0.198	0.386	13.5	31.6	3.75	1.99	9.53	10.0	1321
Oconee [a]	46	5486	0.198	0.390	11.5	32.5	3.89	1.99	10.12	93.4	499
R. B. Russell	14	1064	0.329	0.495	36.1	20.2	2.87	1.45	8.12	42.5	None Caught
Seminole	43	4934	0.290	0.701	27.9	20.8	5.63	2.41	16.93	98.6	64
Sinclair	38	4370	0.229	0.336	21.0	32.2	3.83	1.48	7.94	100.0	363
W. F. George [b]	39	6056	0.309	0.729	34.1	12.9	5.06	2.33	18.84	87.7	114
West Point [b]	23	2827	0.292	0.470	31.4	22.7	4.27	1.69	11.21	34.3	257
Savannah River	37	4441	0.240	0.330	19.1	31.1	3.60	1.36	8.07	99.7	444
Total	455	52280	0.250	0.453	21.4	26.1	4.06	1.83	10.79	74.9	241

[a] 14-inch size limit. [b] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass.

Note: Only tournaments with six or more anglers and five of more hours in length were analyzed.
Reservoirs or rivers with less than six tournaments were not analyzed.

Compiled and analyzed by Dr. Carl Quertermus, University of West Georgia.


BASS / ANGLER HOUR - 2010
GBCF TOURNAMENTS ON GEORGIA LAKES
NUMBER
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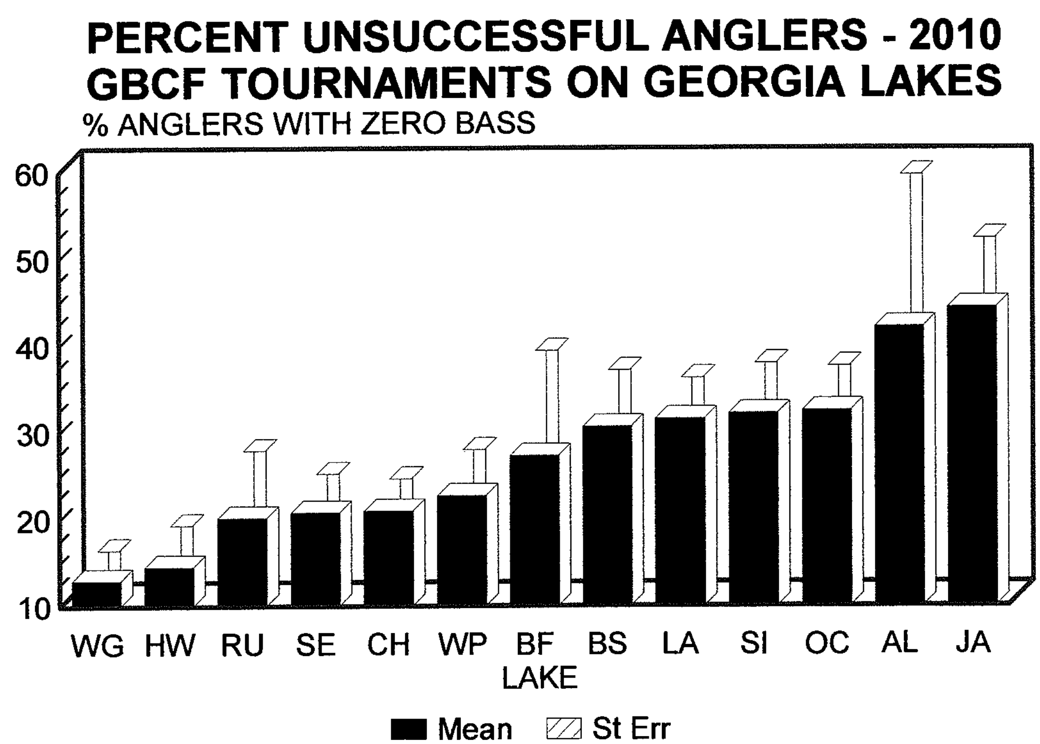
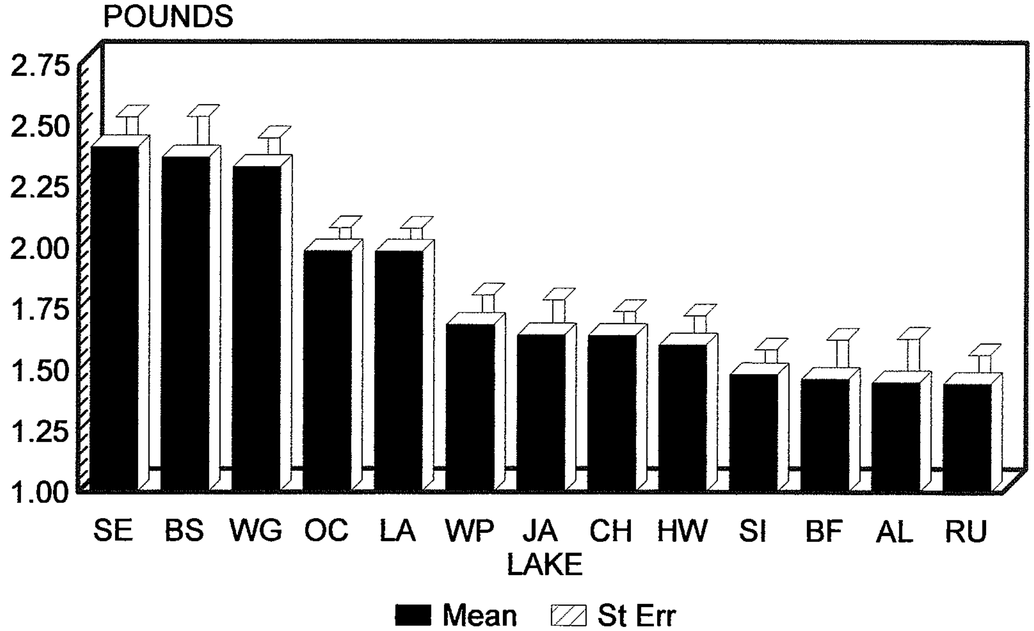
0.35
0.30
0.25
0.20
0.15
0.10
RU WG WP SE CH HW BF SI LA OC JA AL BS
LAKE
Mean St Err


PERCENT UNSUCCESSFUL ANGLERS - 2010
GBCF TOURNAMENTS ON GEORGIA LAKES
% ANGLERS WITH ZERO BASS
60
50
40
30
20
10
WG HW RU SE CH WP BF BS LA SI OC AL JA
LAKE
Mean St Err

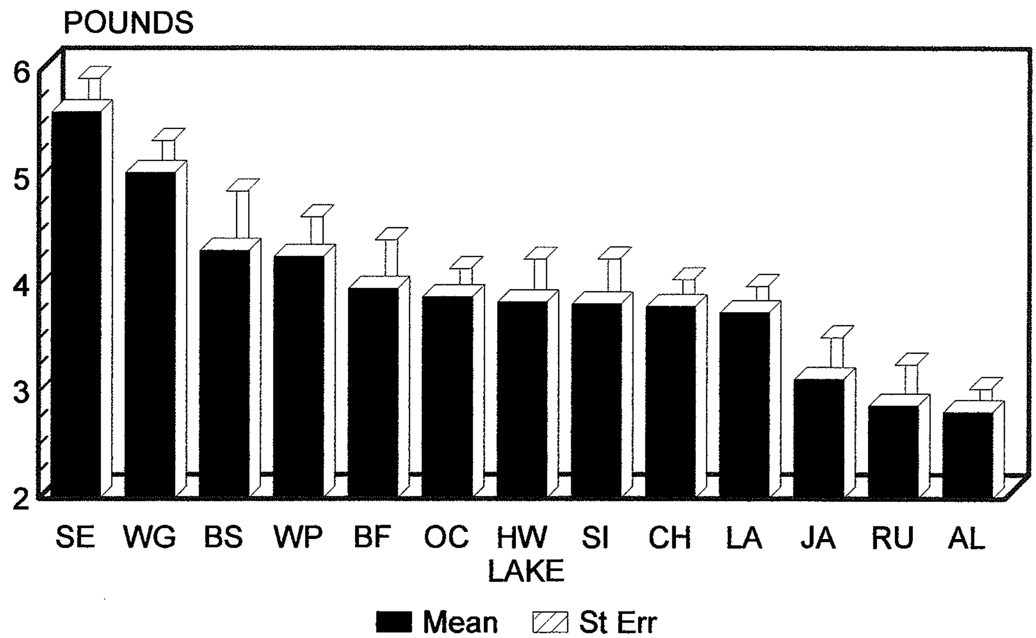
AVERAGE BASS WEIGHT - 2010

GBCF TOURNAMENTS ON GEORGIA LAKES

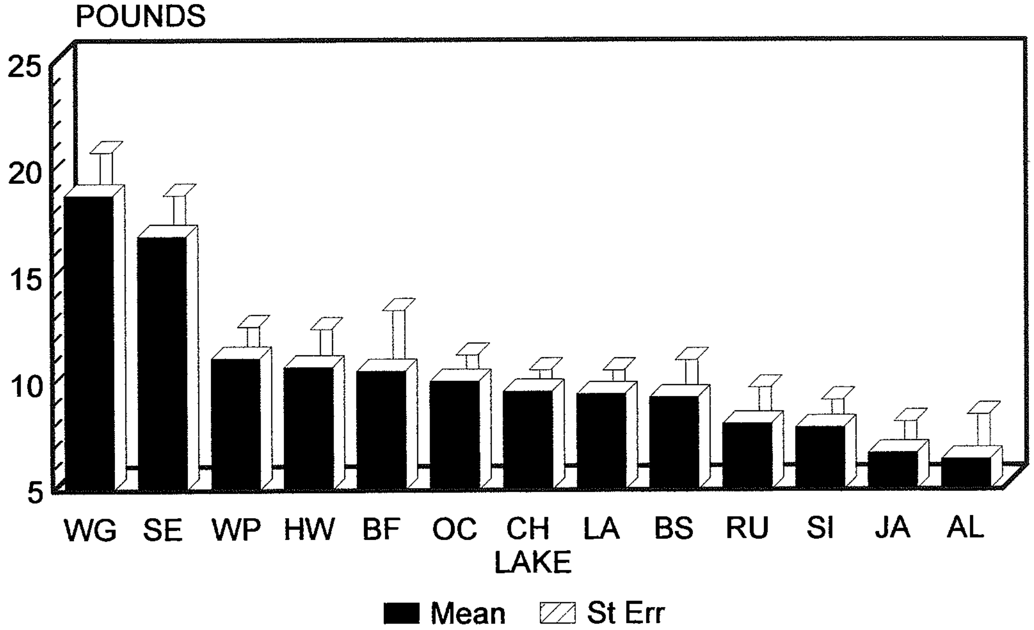


AVERAGE LARGEST BASS - 2010

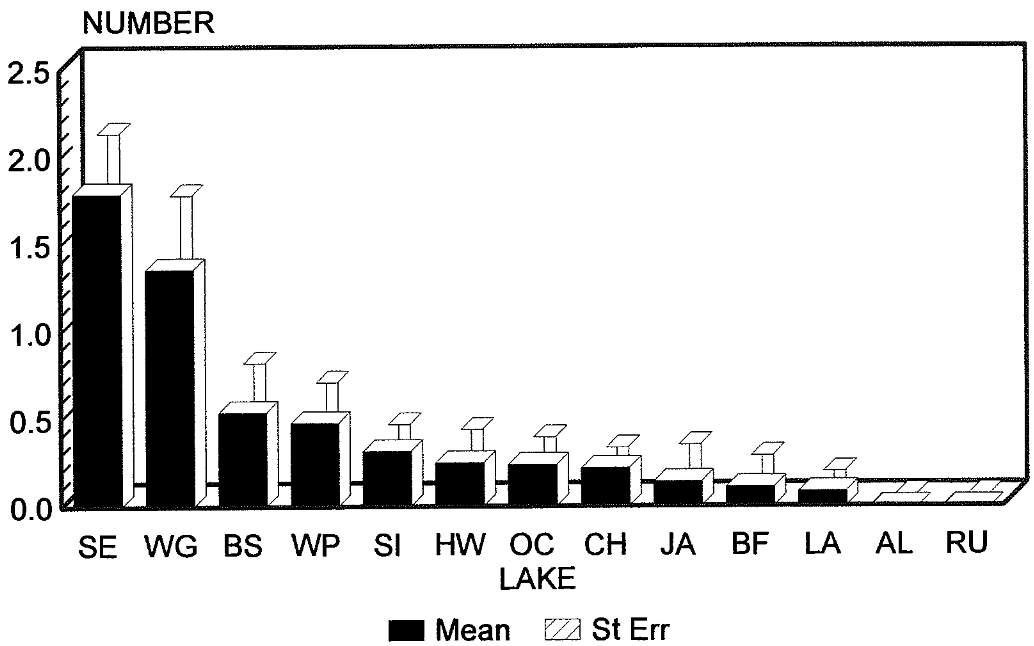
GBCF TOURNAMENTS ON GEORGIA LAKES



WINNING WEIGHT - 2010
GBCF TOURNAMENTS ON GEORGIA LAKES



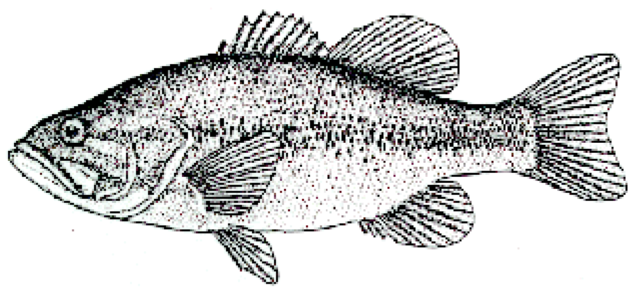
NUMBER OF 5 LB BASS / TOURNAMENT - 2010
GBCF TOURNAMENTS ON GEORGIA LAKES



Georgia Bass Chapter Federation

2011

Tournament Creel Report



Submitted by

Carl Quertermus, Ph.D.
University of West Georgia

GBCF Tournament Report - 2011

This is the 34th year of the Georgia Bass Chapter Federation (GBCF) Tournament Creel Report. In 2011, 52 bass clubs submitted results from 543 tournaments. Several of these tournaments were not analyzed because they involved less than six anglers or lasted less than five hours. Also, Georgia reservoirs and rivers with less than six submitted tournaments were not analyzed. The data from tournaments held outside of Georgia were not analyzed. Data from 86 tournaments held at Alabama interior reservoirs and 59 from border reservoirs were sent to the Alabama Department of Conservation and Natural Resources and became part of their annual tournament data analysis (B.A.I.T.). Data from 389 tournaments on 13 Georgia reservoirs and the Savannah River were analyzed for this report.

Fishing success at Georgia reservoirs and the Savannah River are compared on the attached table and figures. Bass anglers spent 45,631 hours of effort during the 389 tournaments. The weighed-in, tournament average catch rate was 0.272 bass / angler hour (or 2.72 bass in a 10-hour fishing day). This is the highest catch rate of the 34 years of this project and is significantly above the 0.245 catch rate average of the last 10 years. The second highest catch rate was 0.268 in 2008.

R. B. Russell again had the highest catch rate (0.389 bass / angler hour). Catch rates were also good at **Hartwell** (0.360), **West Point** (0.342), and **Clarks Hill** (0.337). The lowest percent of unsuccessful anglers was at **Hartwell** (10.4%), **Russell** (10.9%), and **West Point** (12.1%). The percent of anglers with five weighed-in bass (a "limit") was greatest at **Hartwell** (42%); also, over 30% of tournament anglers had a limit at **West Point, Clarks Hill,** and **Allatoona.** The average bass weight was greatest at **Seminole** (2.31 lbs), but it was almost as good at **Blackshear** (2.06 lbs) and **Lanier** (2.02 lbs). Note that **Blackshear** and **Lanier** have a 14-inch length limit but **Seminole** has a 12-inch limit. The tournament average largest bass was at **Seminole** (4.74 lbs), but this was not significantly greater than at **W.F. George** (4.72 lbs). The greatest winning weight average was 14.69 lbs at **Seminole**, and the second highest was 14.44 lbs at **W.F. George**. Both these lakes had several two-day tournaments, which contribute to greater winning weights.

This was the 8th year that clubs were asked to indicate how many bass 5.0 lbs or larger were caught during each tournament. Only 137 bass 5.0 lbs or larger were caught during the 389 tournaments. On average, it required 333 angler hours to catch a bass of this size. There was a big difference in this value across the fishing locations. Whereas it took 842 angler hours at **Russell** and 685 angler hours at the **Savannah River** to catch a bass $\geq$ 5 lbs, it took only 158 angler hours at **Seminole.** No five pound bass were caught during the eight tournaments an **Allatoona** or the seven tournaments at **Bartlett's Ferry**.

Only at 21.3% of the tournaments were one or more five pound or larger bass caught. The most caught in one tournament was five in a tournament at **Jackson**. The largest bass reported in 2011 was 9.08 lbs caught at **Jackson** during a June tournament. Only five bass of 8.0 lbs or larger were caught in the 389 tournaments!

The reservoir abbreviations on the attached graphs are **AL** (Allatoona), **BF** (Bartlett's Ferry), **BS** (Blackshear), **CH** (Clarks Hill), **HW** (Hartwell), **JA** (Jackson), **LA** (Lanier), **OC** (Oconee), **RU** (R. B. Russell), **SE** (Seminole), **SI** (Sinclair), **SR** (Savannah River), **WG** (W. F. George), **WP** (West Point).

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2011

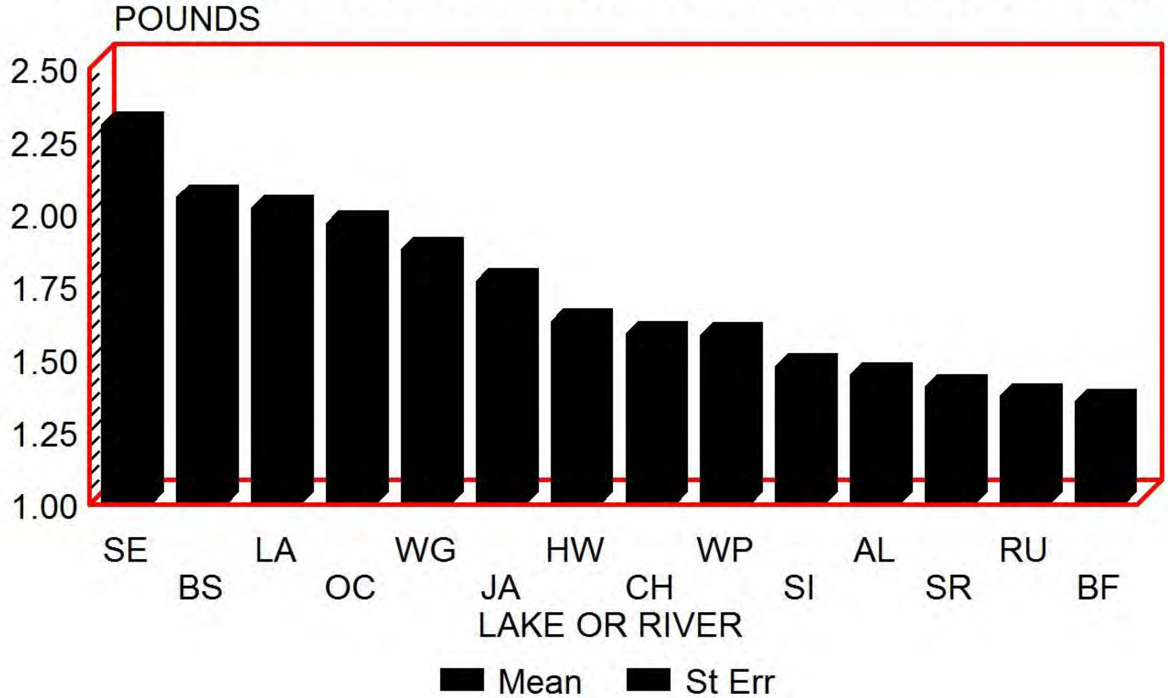
Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth	Angler Hours Per ≥ 5 lb Bass
Allatoona	8	759	0.267	0.350	32.0	34.1	2.86	1.45	6.12	8.7	None Caught
Bartlett's Ferry	7	808	0.231	0.321	18.3	24.6	3.26	1.36	8.10	71.2	None Caught
Blackshear [a]	14	1209	0.166	0.328	5.3	32.9	4.02	2.06	8.18	100.0	605
Clarks Hill	68	7577	0.337	0.539	34.3	17.4	4.14	1.59	11.50	99.1	291
Hartwell	16	2174	0.360	0.599	42.0	10.4	4.06	1.63	12.63	55.9	544
Jackson	23	2283	0.236	0.418	13.9	26.1	4.09	1.77	9.15	50.4	254
Lanier [a]	47	5565	0.241	0.479	16.4	25.5	4.09	2.02	10.67	11.0	397
Oconee [a]	42	4392	0.185	0.358	9.0	33.8	3.81	1.96	8.51	99.3	338
R. B. Russell	11	842	0.389	0.545	29.6	10.9	3.28	1.38	10.12	31.0	842
Seminole	23	2843	0.238	0.547	16.3	29.1	4.74	2.31	14.69	98.5	158
Sinclair	40	4598	0.301	0.442	29.4	15.9	3.55	1.48	9.13	99.8	383
W. F. George [b]	32	5305	0.262	0.498	23.3	17.3	4.72	1.88	14.44	83.4	265
West Point [b]	19	3164	0.342	0.529	36.4	12.1	4.25	1.58	12.92	36.6	264
Savannah River	39	4112	0.253	0.357	17.0	24.5	3.14	1.41	7.80	97.3	685
Total	389	45631	0.272	0.461	22.9	22.1	3.94	1.74	10.53	75.0	333

[a] 14-inch size limit. [b] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass.

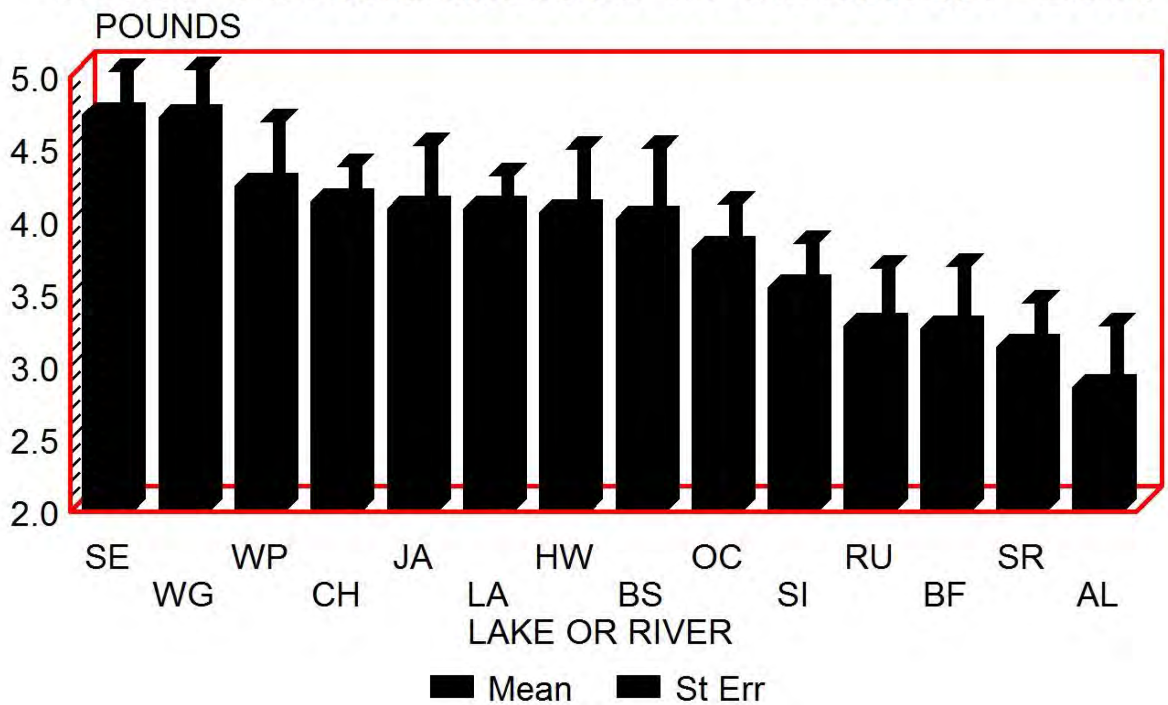
Note: Only tournaments with six or more anglers and five or more hours in length were analyzed.
Reservoirs or rivers with less than six tournaments were not analyzed.

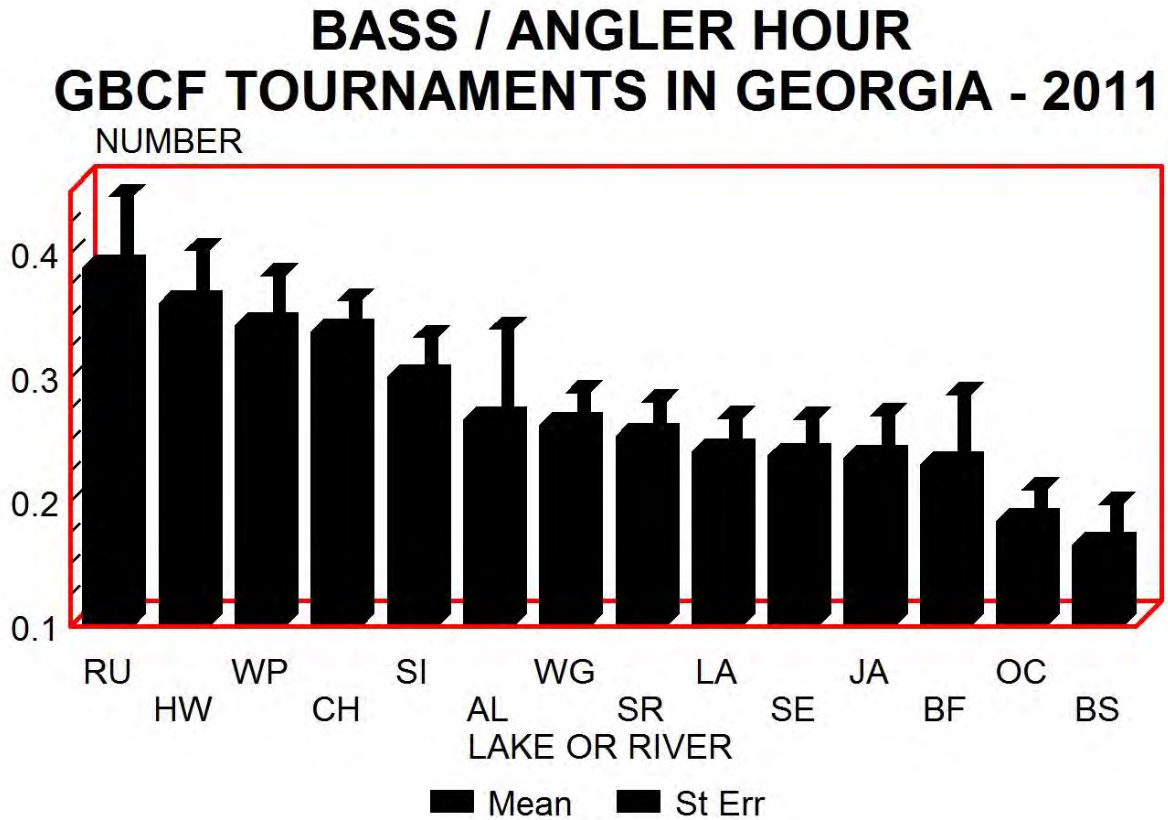
Compiled and analyzed by Dr. Carl Quertermus, Biology Department, University of West Georgia.

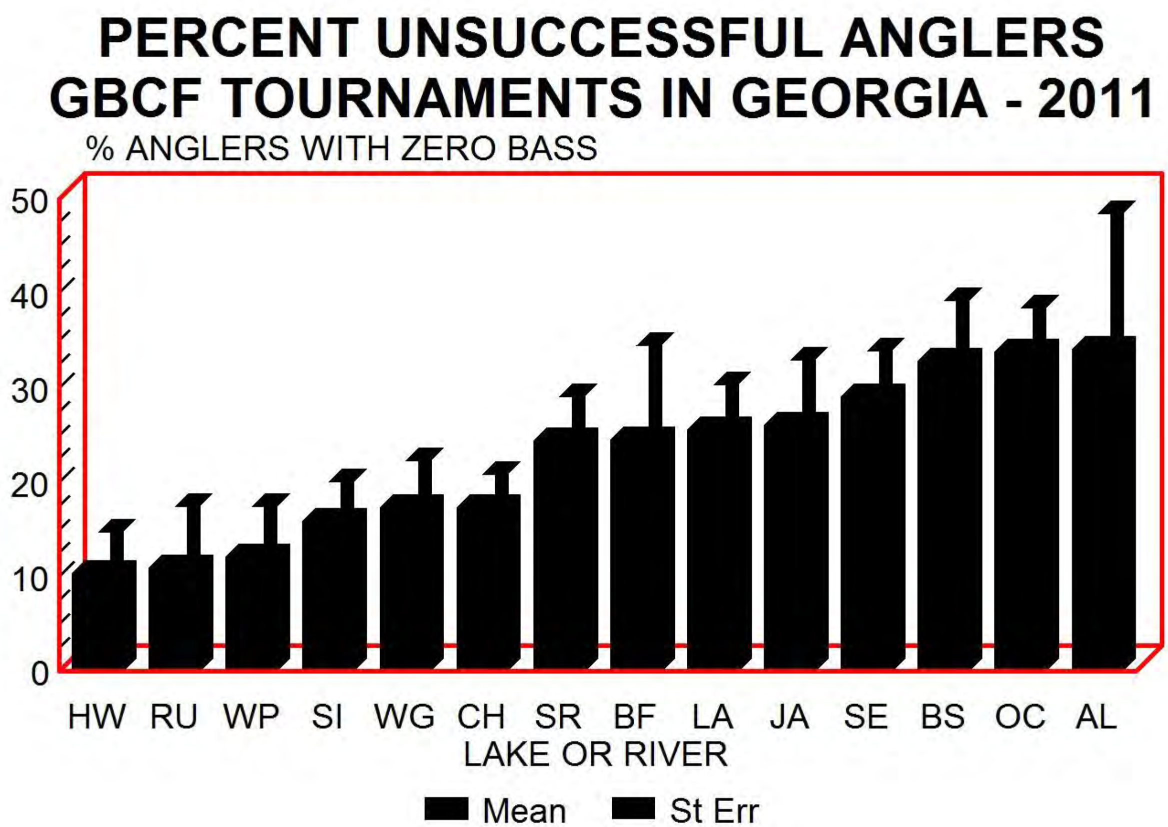
AVERAGE BASS WEIGHT
GBCF TOURNAMENTS IN GEORGIA - 2011

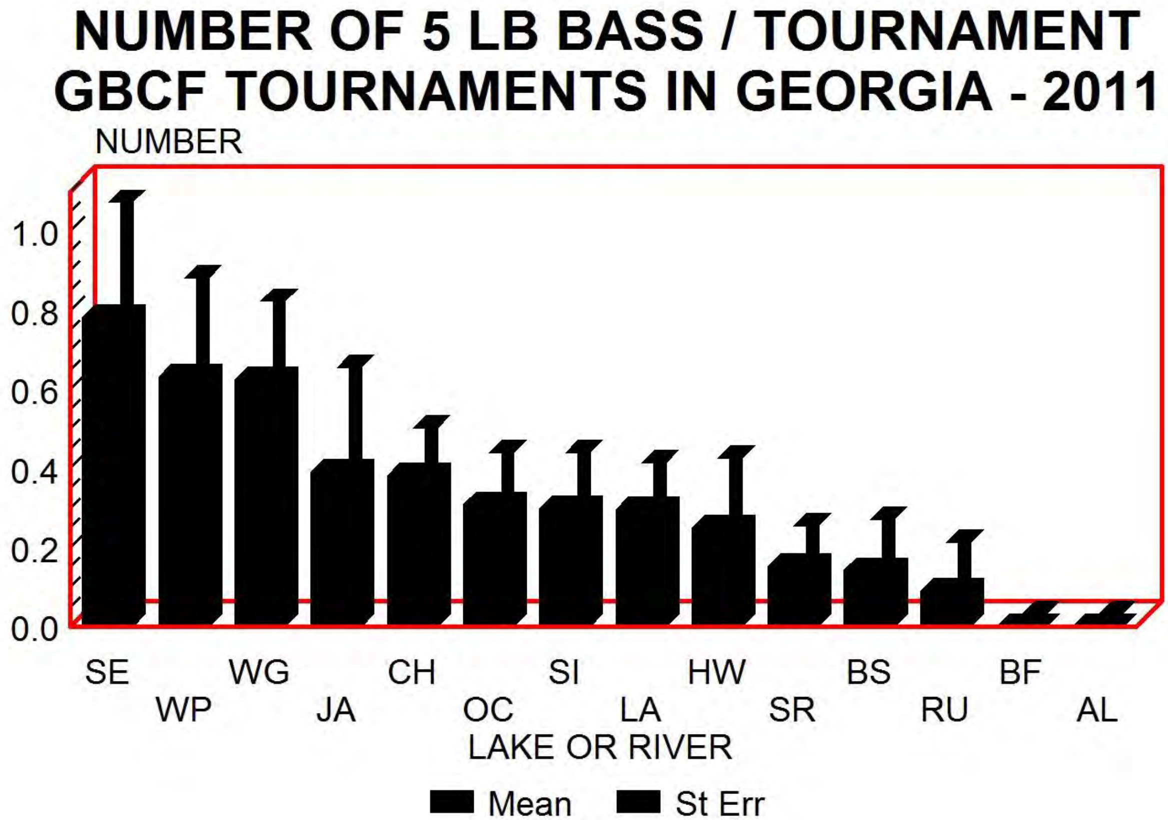


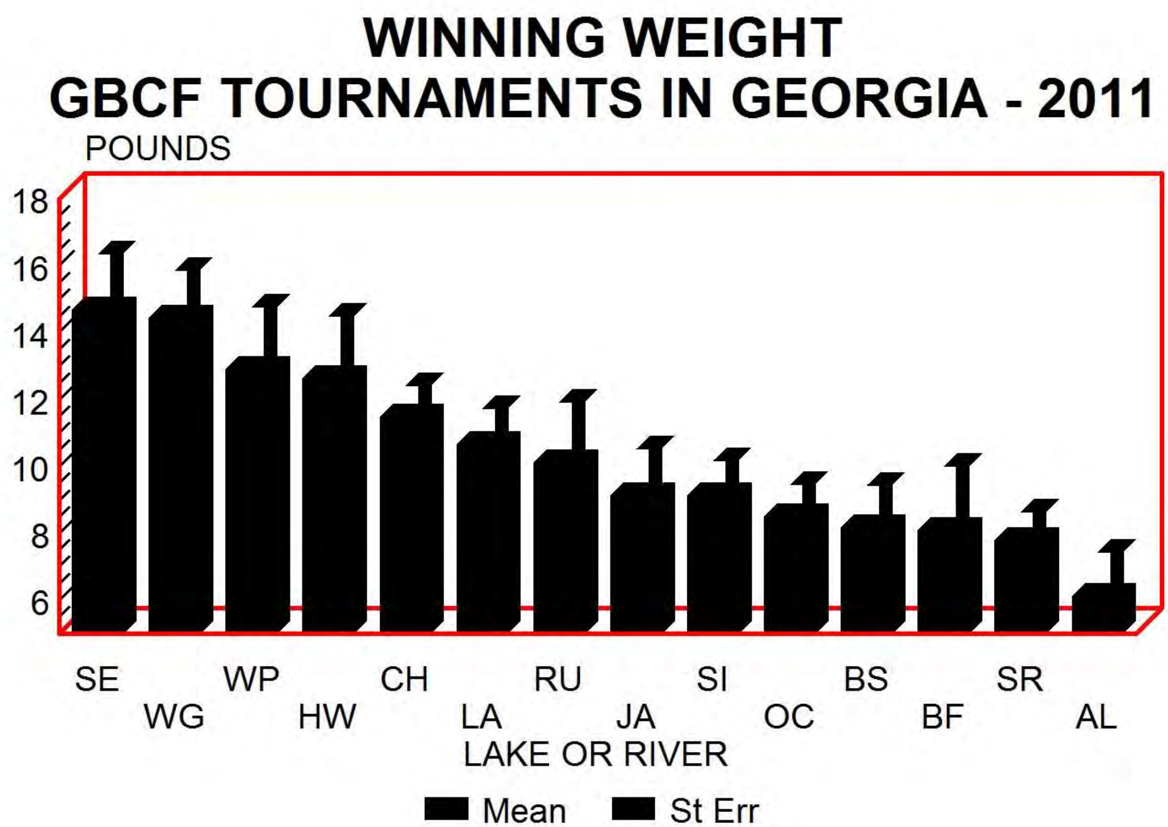
AVERAGE LARGEST BASS
GBCF TOURNAMENTS IN GEORGIA - 2011



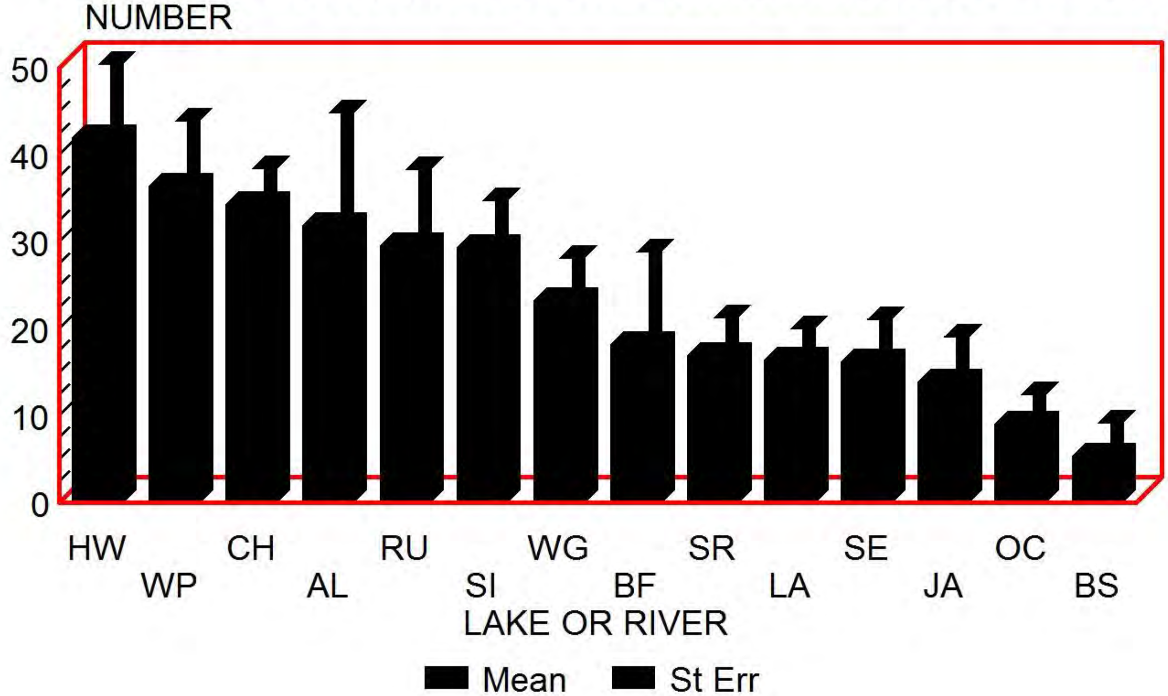

BASS / ANGLER HOUR
GBCF TOURNAMENTS IN GEORGIA - 2011
NUMBER
0.4
0.3
0.2
0.1
RU
HW
WP
CH
SI
AL
WG
SR
LA
SE
JA
BF
OC
BS
LAKE OR RIVER
Mean
St Err


PERCENT UNSUCCESSFUL ANGLERS
GBCF TOURNAMENTS IN GEORGIA - 2011
% ANGLERS WITH ZERO BASS
50
40
30
20
10
0
HW
RU
WP
SI
WG
CH
SR
BF
LA
JA
SE
BS
OC
AL
LAKE OR RIVER
Mean
St Err


NUMBER OF 5 LB BASS / TOURNAMENT
GBCF TOURNAMENTS IN GEORGIA - 2011
NUMBER
1.0
0.8
0.6
0.4
0.2
0.0
SE
WP
WG
JA
CH
OC
SI
LA
HW
SR
BS
RU
BF
AL
LAKE OR RIVER
Mean
St Err


WINNING WEIGHT
GBCF TOURNAMENTS IN GEORGIA - 2011
POUNDS
18
16
14
12
10
8
6
SE
WG
WP
HW
CH
LA
RU
JA
SI
OC
BS
BF
SR
AL
LAKE OR RIVER
Mean
St Err

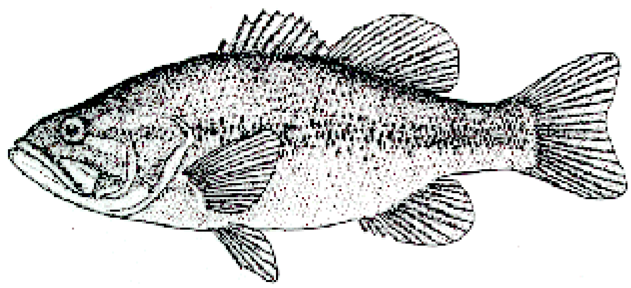
PERCENT ANGLERS WITH FIVE BASS
GBCF TOURNAMENTS IN GEORGIA - 2011



Georgia Bass Chapter Federation

2012

Tournament Creel Report



Submitted by

Carl Quertermus, Ph.D.
University of West Georgia

GBCF Tournament Report - 2012

This is the 35th year of the Georgia Bass Chapter Federation (GBCF) Tournament Creel Report. In 2012, 45 bass clubs submitted results from 436 tournaments. Several of these tournaments were not analyzed because they involved less than six anglers or lasted less than five hours. Also, Georgia reservoirs and rivers with less than six submitted tournaments were not analyzed. Allatoona and Hartwell had less than six tournaments but were retained since they had been part of the analysis for the previous 34 years. The data from tournaments held outside of Georgia were not analyzed. Georgia clubs fished many tournaments in other states including, Alabama, Tennessee, South Carolina and Florida. Data from 63 tournaments held at Alabama interior reservoirs and 42 at border reservoirs were sent to the Alabama Department of Conservation and Natural Resources and became part of their annual tournament data analysis (B.A.I.T.). Data from 305 tournaments on 13 Georgia reservoirs and the Savannah River were analyzed for this report.

Fishing success at Georgia reservoirs and the Savannah River are compared on the attached table and figures. Bass anglers spent 38,321 hours of effort during the 305 tournaments. The weighed-in, tournament average catch rate was 0.295 bass / angler hour (or 2.95 bass in a 10-hour fishing day). This is the highest catch rate of the 35 years of this project and is significantly above the 0.255 catch rate average of the last 10 years. The second highest catch rate was 0.272 in 2011.

R. B. Russell again had the highest catch rate (0.368 bass / angler hour). This was the fourth consecutive year that R. B. Russell had the highest catch rate. Catch rates were also good at **Clarks Hill** (0.361), **West Point** (0.338) and **Allatoona** (0.337). The lowest percent of unsuccessful anglers was at **Bartlett's Ferry** (9.7%), **Russell** (10.5%), **Hartwell** (10.7%) and **West Point** (11.4%). The percent of anglers with five weighed-in bass (a "limit") was greatest at **Clarks Hill** (38.8%); also, over 30% of tournament anglers had a limit at **Russell** and **Hartwell.** The average bass weight was greatest at **Blackshear** (2.21 lbs), but it was also as good at **Lanier** (2.07 lbs). Note that both **Blackshear** and **Lanier** have a 14-inch minimum length limit. The tournament average largest bass was at **Seminole** (5.05 lbs). The greatest winning weight average was 15.72 lbs at **Hartwell;** however, this was for only 5 tournaments. For lakes with a significant number of submitted tournaments, **Seminole** had the highest winning weight (14.34 lbs). Both **Hartwell** and **Seminole** had several two-day tournaments, which contribute to greater winning weights.

This was the 9th year that clubs were asked to indicate how many bass 5.0 lbs or larger were caught during each tournament. Only 130 bass 5.0 lbs or larger were caught during the 305 tournaments. On average, it required 295 angler hours to catch a bass of this size. There was a big difference in this value across the fishing locations. Whereas it took 784 angler hours at **Russell** and 956 angler hours at the **Bartlett's Ferry** to catch a bass ≥ 5 lbs, it took only 134 angler hours at **Seminole** and 177 angler hours at **Oconee.** Only at 31.9% of the tournaments were one or more five pound or larger bass caught. The most caught in one tournament was five in a tournament in March at **W. F. George**. The largest bass reported in 2012 was 9.94 lbs caught at **Clarks Hill** during a November tournament. Only nine bass of 8.0 lbs or larger were caught in the 305 tournaments!

The reservoir and river abbreviations on the attached graphs are **AL** (Allatoona), **BF** (Bartlett's Ferry), **BS** (Blackshear), **CH** (Clarks Hill), **HW** (Hartwell), **JA** (Jackson), **LA** (Lanier), **OC** (Oconee), **RU** (R. B. Russell), **SE** (Seminole), **SI** (Sinclair), **SR** (Savannah River), **WG** (W. F. George), **WP** (West Point).

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2012

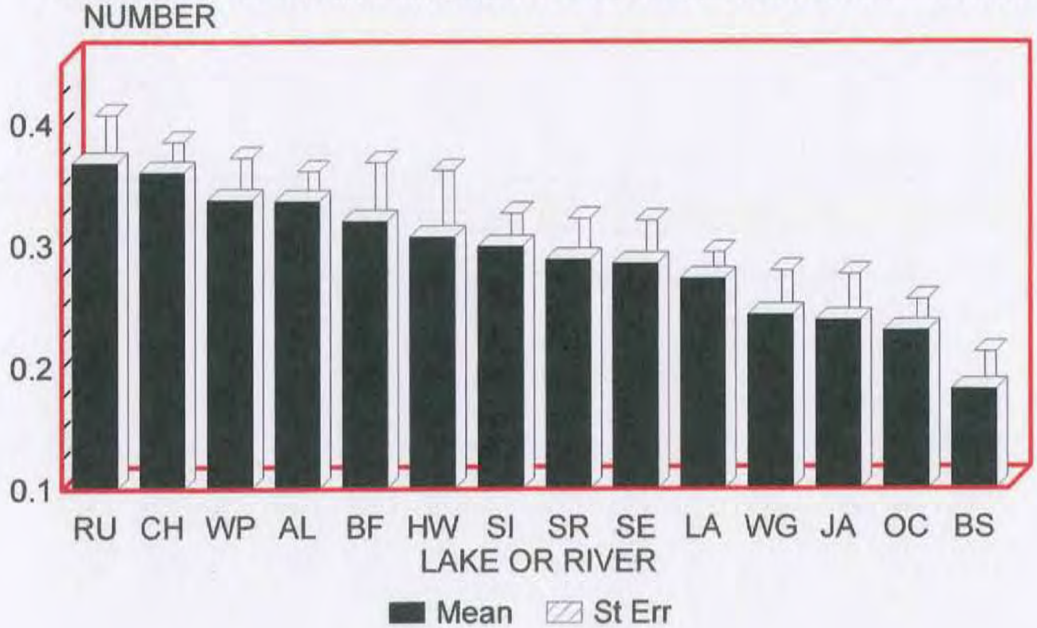
Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth	Angler Hours Per ≥ 5 lb Bass
Allatoona	3	441	0.337	0.458	25.9	13.4	2.64	1.37	8.37	7.1	None Caught
Bartlett's Ferry	6	956	0.320	0.469	23.1	9.7	4.13	1.45	9.80	31.1	956
Blackshear [a]	10	1259	0.182	0.391	6.9	30.9	4.47	2.21	9.85	96.2	420
Clarks Hill	66	8292	0.361	0.601	38.8	17.3	4.61	1.64	12.19	99.4	244
Hartwell	5	1496	0.307	0.480	33.5	10.7	4.17	1.56	15.72	52.5	748
Jackson	13	1571	0.239	0.375	13.5	26.3	4.09	1.65	8.72	37.3	393
Lanier [a]	45	5103	0.273	0.565	15.8	16.5	4.14	2.07	10.69	11.8	638
Oconee [a]	33	3721	0.230	0.459	17.1	24.1	4.56	1.99	11.52	96.0	177
R. B. Russell	7	784	0.368	0.512	36.4	10.5	3.81	1.41	10.33	27.9	784
Seminole	18	2269	0.286	0.534	21.2	18.3	5.05	1.92	14.34	99.3	134
Sinclair	40	4638	0.300	0.461	28.8	17.7	3.87	1.53	10.26	100.0	422
W. F. George [b]	19	2567	0.244	0.447	18.5	21.7	4.50	1.94	12.45	86.2	221
West Point [b]	19	3008	0.338	0.477	29.5	11.4	4.05	1.40	11.33	26.2	334
Savannah River	21	2216	0.289	0.385	17.5	21.8	3.74	1.33	8.05	100.0	277
Total	305	38321	0.295	0.501	24.7	18.6	4.28	1.73	11.16	73.4	295

[a] 14-inch size limit. [b] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass.

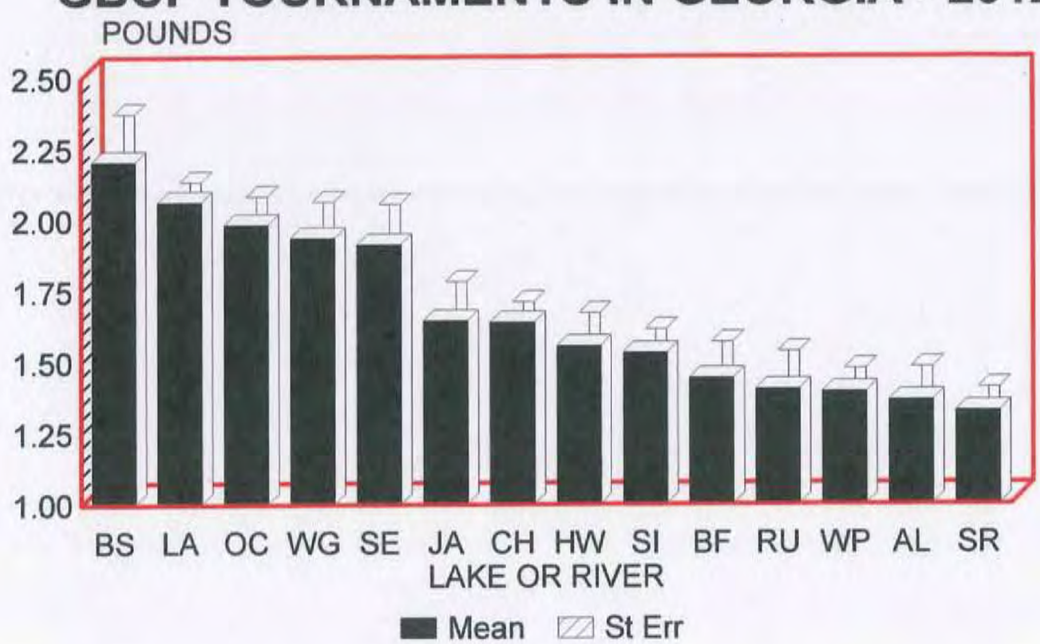
Note: Only tournaments with six or more anglers and five or more hours in length were analyzed.
Reservoirs or rivers with less than six tournaments were not analyzed, except for Allatoona and Hartwell

Compiled and analyzed by Dr. Carl Quertermus, Biology Department, University of West Georgia.

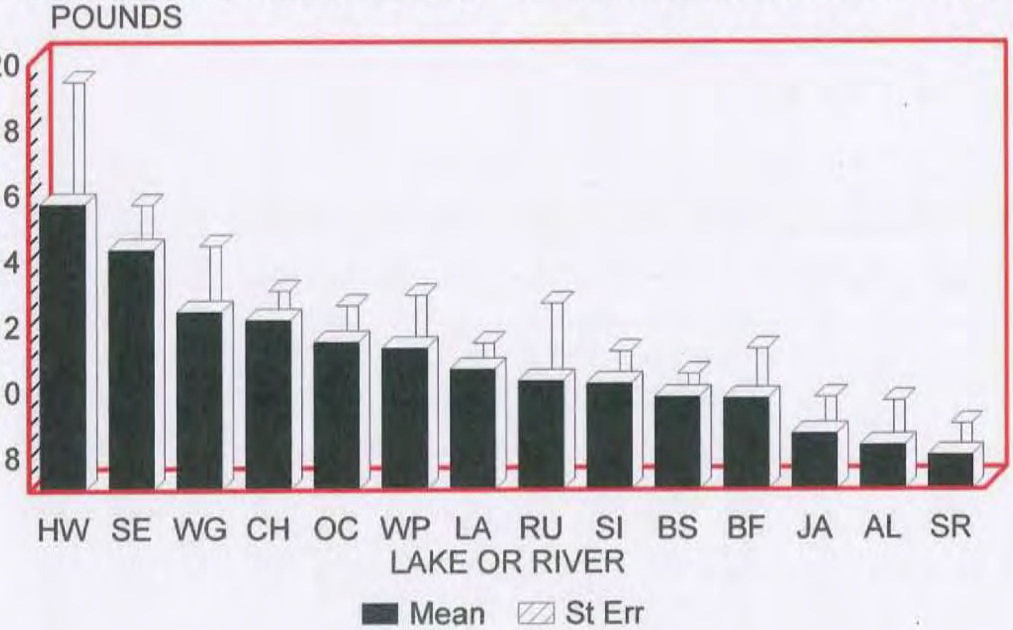
BASS / ANGLER HOUR
GBCF TOURNAMENTS IN GEORGIA - 2012



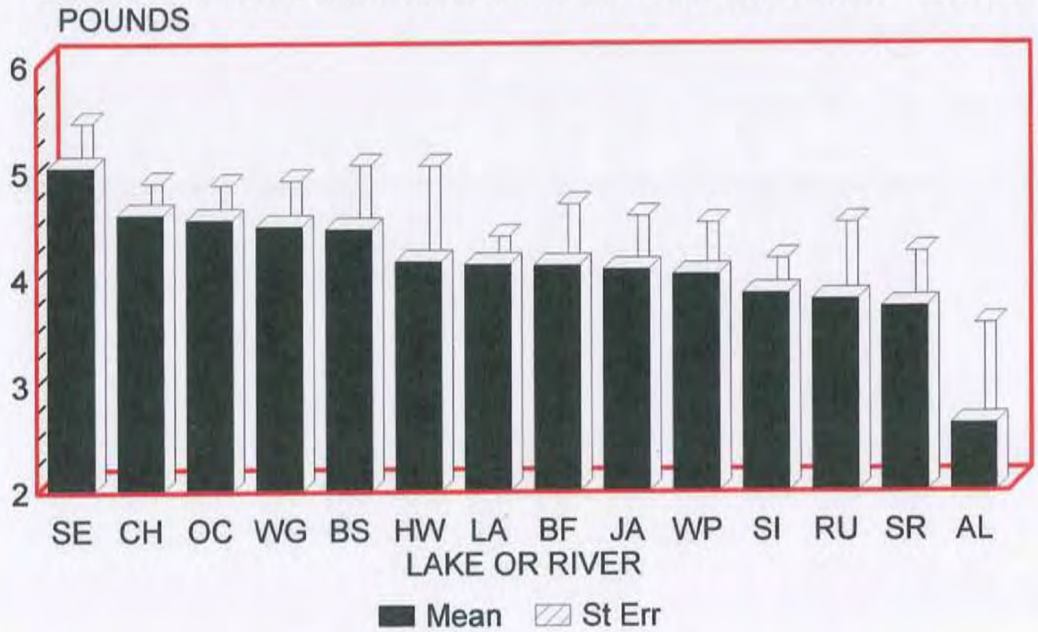
AVERAGE BASS WEIGHT
GBCF TOURNAMENTS IN GEORGIA - 2012

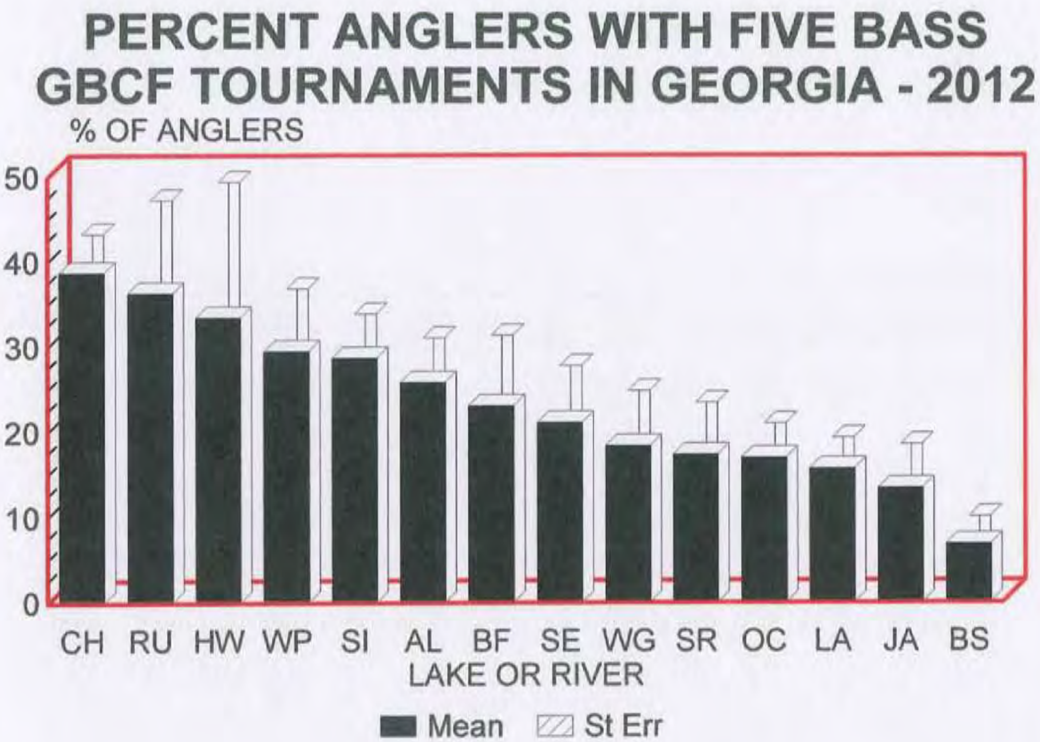


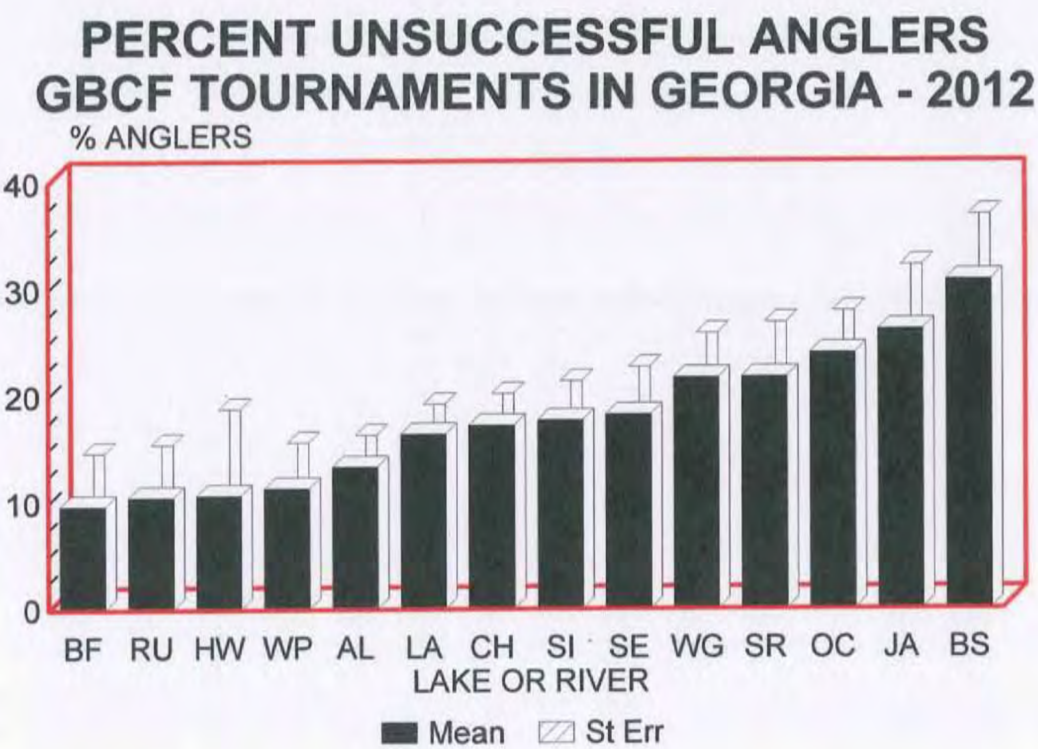
WINNING WEIGHT
GBCF TOURNAMENTS IN GEORGIA - 2012



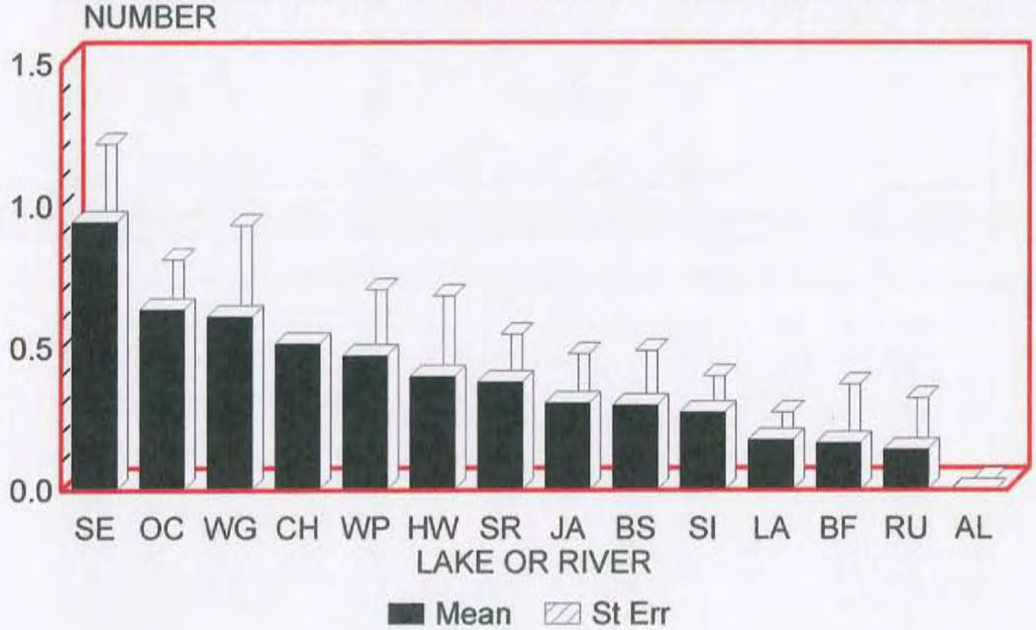
AVERAGE LARGEST BASS
GBCF TOURNAMENTS IN GEORGIA - 2012




PERCENT ANGLERS WITH FIVE BASS
GBCF TOURNAMENTS IN GEORGIA - 2012
% OF ANGLERS
0
10
20
30
40
50
CH RU HW WP SI AL BF SE WG SR OC LA JA BS
LAKE OR RIVER
Mean
St Err


PERCENT UNSUCCESSFUL ANGLERS
GBCF TOURNAMENTS IN GEORGIA - 2012
% ANGLERS
0
10
20
30
40
BF RU HW WP AL LA CH SI SE WG SR OC JA BS
LAKE OR RIVER
Mean
St Err

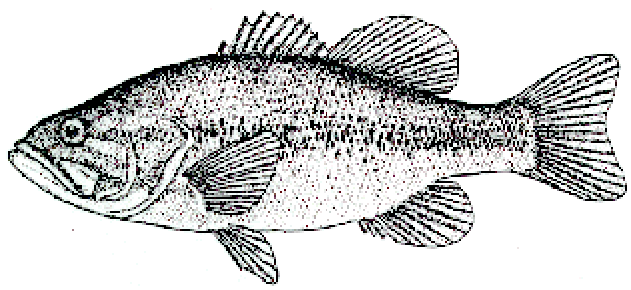
NUMBER OF 5 LB BASS / TOURNAMENT
GBCF TOURNAMENTS IN GEORGIA - 2012



Georgia Bass Chapter Federation

2013

Tournament Creel Report



Submitted by

Carl Quertermus, Ph.D.
Professor Emeritus
University of West Georgia

GBCF Tournament Report - 2013

This is the 36th year of the Georgia Bass Chapter Federation (GBCF) Tournament Creel Report. In 2013, 41 bass clubs submitted results from 430 tournaments. Several of these tournaments were not analyzed because they involved less than five anglers or lasted less than five hours. Also, Georgia reservoirs and rivers with less than five submitted tournaments were not analyzed. The data from tournaments held outside of Georgia were not analyzed. Georgia clubs fished many tournaments in other states including, Alabama, Tennessee, South Carolina and Florida. Data from 61 tournaments held at Alabama interior reservoirs and 37 at border reservoirs were sent to the Alabama Department of Conservation and Natural Resources and became part of their annual tournament data analysis (B.A.I.T.). Data from 314 tournaments on 15 Georgia reservoirs and the Savannah River were analyzed for this report.

Fishing success at Georgia reservoirs and the Savannah River are compared on the attached table and figures. Bass anglers spent 38,099 hours of effort during the 314 tournaments. The weighed-in, tournament average catch rate was 0.308 bass / angler hour (or 3.08 bass in a 10-hour fishing day). This is the highest catch rate of the 36 years of this project and is significantly above the 0.255 catch rate average of the previous 10 years. The second highest catch rate was 0.295 in 2012 and the third highest was 0.272 in 2011.

Tobesofkee had the highest catch rate (0.440 bass / angler hour). **Bartlett's Ferry** (0.396) and **Carters** (0.379) were second and third. However, there were only five to seven tournaments at these three reservoirs. Catch rates were also very good at **Russell** (0.376) and **Hartwell** (0.366). The lowest percent of unsuccessful anglers was at **Tobesofkee** (4.4%), **Bartlett's Ferry** (9.1%) and **Hartwell** (10.2%). The percent of anglers with five weighed-in bass (a "limit") was greatest at **Tobesofkee** (44.4%); also, over 40% of tournament anglers had a limit at **Bartlett's Ferry** and **Hartwell.** The average bass weight was greatest at **W.F.George** (2.32 lbs), but it was also good at **Seminole** (2.28 lbs) and **Blackshear** (2.18). The tournament average largest bass was at **Seminole** (5.69 lbs). The greatest winning weight average was 16.67 lbs at **W.F.George**; however, this reservoir had several two-day tournaments, which would contribute to a greater winning weight.

This was the 10th year that clubs were asked to indicate how many bass 5.0 lbs or larger were caught during each tournament. Only 125 bass 5.0 lbs or larger were caught during the 314 tournaments. On average, it required 305 angler hours to catch a bass of this size. There was a big difference in this value across the fishing locations. Whereas it took 926 angler hours at **Russell** to catch a bass ≥ 5.0 lbs, it took only 78 angler hours at **Seminole.** No bass ≥5.0 lbs where caught during the six tournaments at **Allatoona**, the six tournaments at **Carters**, or the seven tournaments at **Hartwell**. There was an average of only 0.40 bass $\geq$5.0 lbs caught during the 314 tournaments. The largest bass reported in 2013 was 8.58 lbs caught in the **Savannah River** during a November tournament. Only four bass of 8.0 lbs or larger were caught in the 314 tournaments. That works out to 9,525 angler hours to catch a bass $\geq$ 8.0 lbs!

The reservoir and river abbreviations on the attached graphs are **AL** (Allatoona), **BF** (Bartlett's Ferry), **BS** (Blackshear), **CA** (Carters), **CH** (Clarks Hill), **HW** (Hartwell), **JA** (Jackson), **LA** (Lanier), **OC** (Oconee), **RU** (R. B. Russell), **SE** (Seminole), **SI** (Sinclair), **SR** (Savannah River), **TB** (Tobesofkee), **WG** (W. F. George), **WP** (West Point).

GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2013

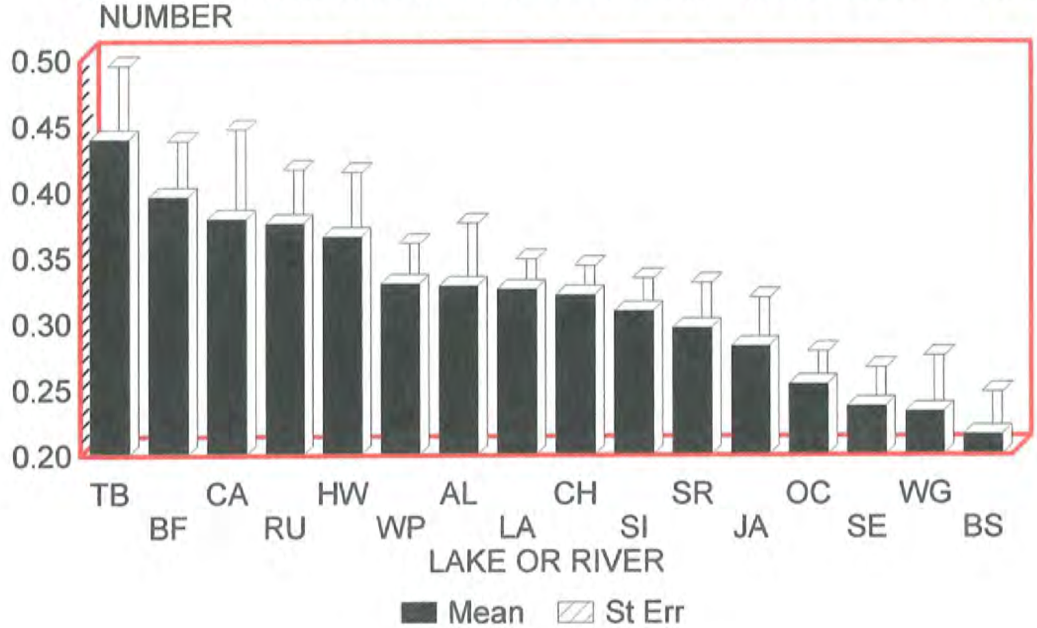
Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth	Angler Hours Per ≥ 5 lb Bass
Allatoona	6	721	0.329	0.414	27.0	15.0	2.64	1.27	7.66	7.7	None Caught
Bartlett's Ferry	7	1065	0.396	0.567	40.8	9.1	5.10	1.42	10.25	42.9	266
Blackshear [a]	9	800	0.216	0.475	7.0	22.9	5.00	2.18	10.56	100.0	200
Carters	6	889	0.379	0.673	37.9	14.5	4.18	1.77	12.50	1.5	None Caught
Clarks Hill	59	7270	0.322	0.558	33.5	17.8	4.23	1.73	11.57	98.3	259
Hartwell	7	1023	0.366	0.597	37.4	10.2	3.89	1.67	13.86	36.9	None Caught
Jackson	14	1986	0.283	0.374	20.0	22.9	3.15	1.35	6.63	41.9	199
Lanier [a]	48	5567	0.326	0.654	27.7	16.1	4.30	2.03	12.76	8.0	558
Oconee [a]	29	2794	0.254	0.511	16.2	21.3	3.93	2.00	10.69	100.0	349
R. B. Russell	13	1853	0.376	0.567	42.2	12.1	3.81	1.50	10.92	21.5	926
Seminole	13	1477	0.237	0.532	13.9	21.8	5.69	2.28	13.79	100.0	78
Sinclair	38	4266	0.310	0.523	29.2	19.0	4.26	1.65	10.87	100.0	251
W. F. George [b]	18	3205	0.233	0.516	25.0	21.7	4.89	2.32	16.67	82.5	214
Tobesofkee	5	534	0.440	0.737	44.4	4.4	4.89	1.64	11.91	100.0	178
West Point [b]	17	2372	0.330	0.501	33.9	12.9	4.66	1.52	10.99	31.9	296
Savannah River	25	2277	0.297	0.458	24.9	25.6	3.53	1.47	8.93	100.0	380
Total	314	38099	0.308	0.543	27.9	18.2	4.23	1.78	11.43	68.8	305

[a] 14-inch size limit. [b] 12-inch size limit on spotted bass and 14-inch size limit on largemouth bass.

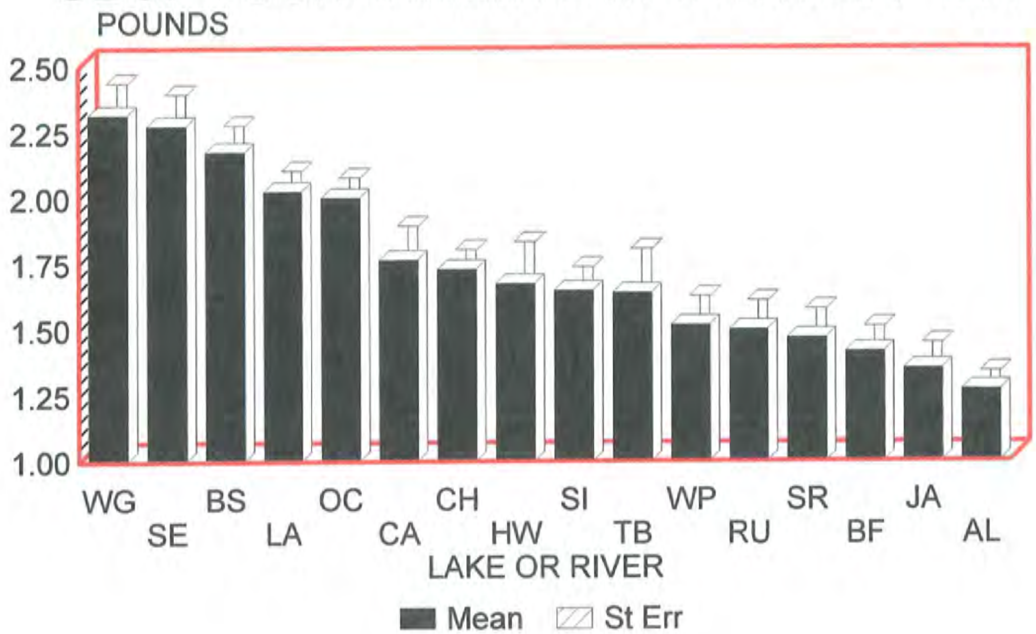
Note: Only tournaments with five or more anglers and five or more hours in length were analyzed.
Reservoirs or rivers with less than five tournaments were not analyzed.

Compiled and analyzed by Dr. Carl Quertermus, Biology Department, University of West Georgia.

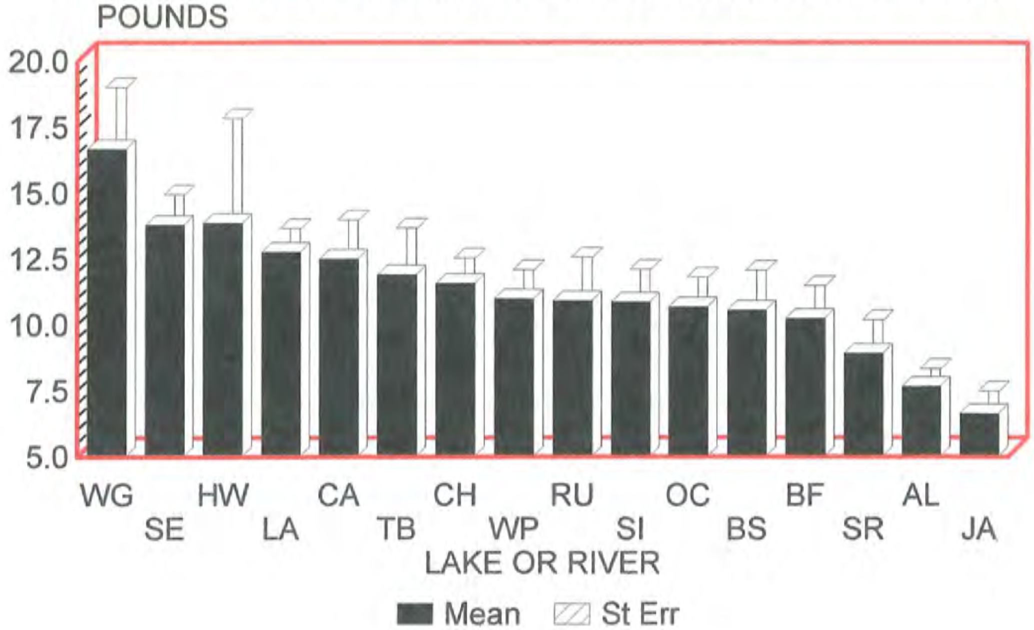
BASS / ANGLER HOUR
GBCF TOURNAMENTS IN GEORGIA - 2013



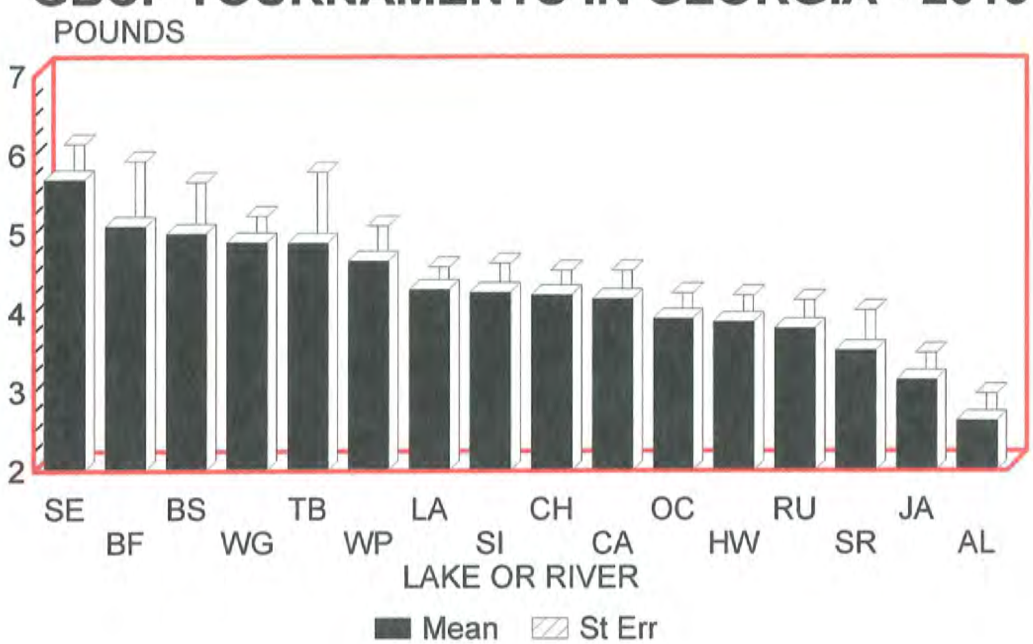
AVERAGE BASS WEIGHT
GBCF TOURNAMENTS IN GEORGIA - 2013

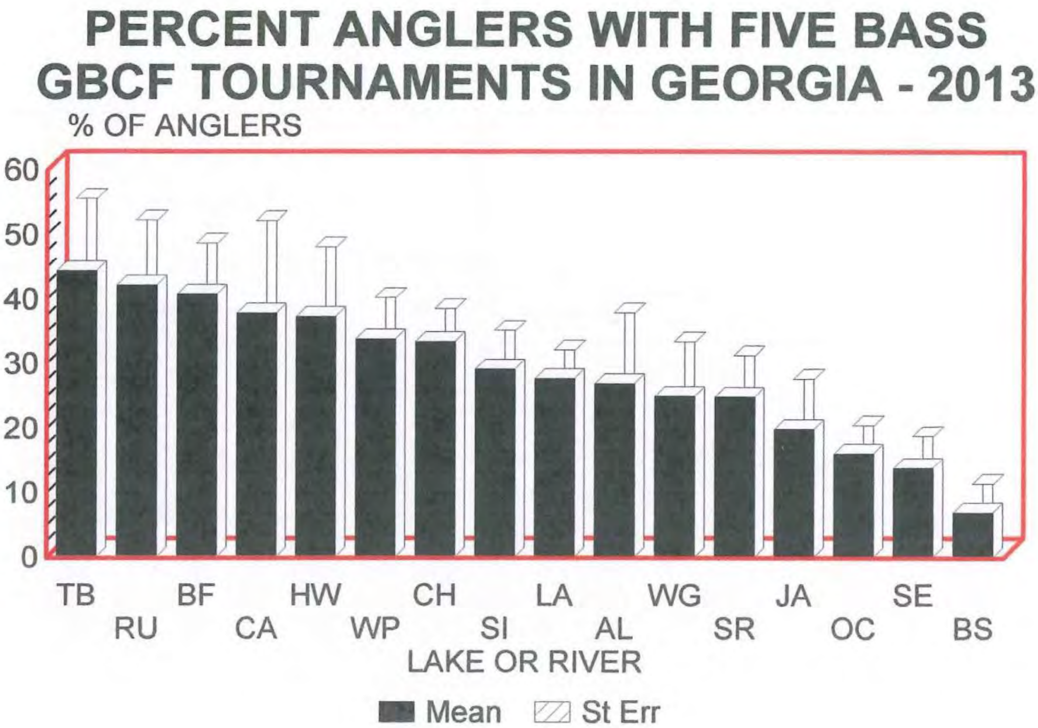


WINNING WEIGHT
GBCF TOURNAMENTS IN GEORGIA - 2013

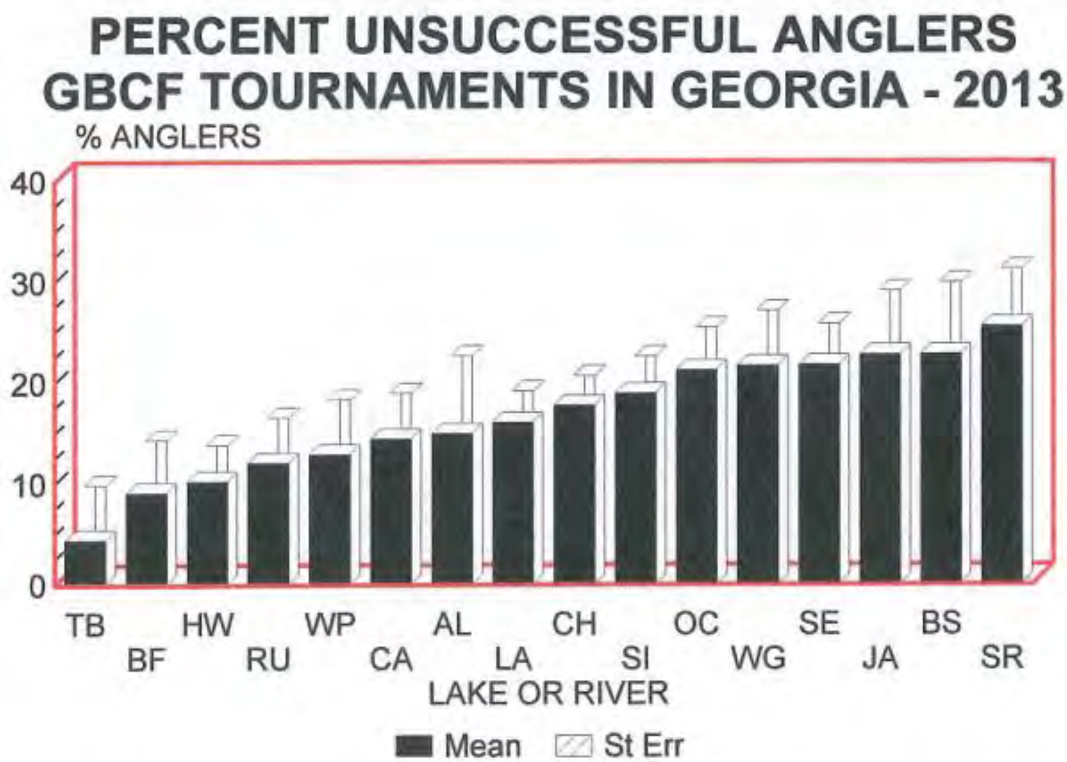


AVERAGE LARGEST BASS
GBCF TOURNAMENTS IN GEORGIA - 2013





PERCENT ANGLERS WITH FIVE BASS
GBCF TOURNAMENTS IN GEORGIA - 2013
% OF ANGLERS
60
50
40
30
20
10
0
TB
RU
BF
CA
HW
WP
CH
SI
LA
AL
WG
SR
JA
OC
SE
BS
LAKE OR RIVER
Mean
St Err



PERCENT UNSUCCESSFUL ANGLERS
GBCF TOURNAMENTS IN GEORGIA - 2013
% ANGLERS
40
30
20
10
0
TB
BF
HW
RU
WP
CA
AL
LA
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SI
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SR
LAKE OR RIVER
Mean
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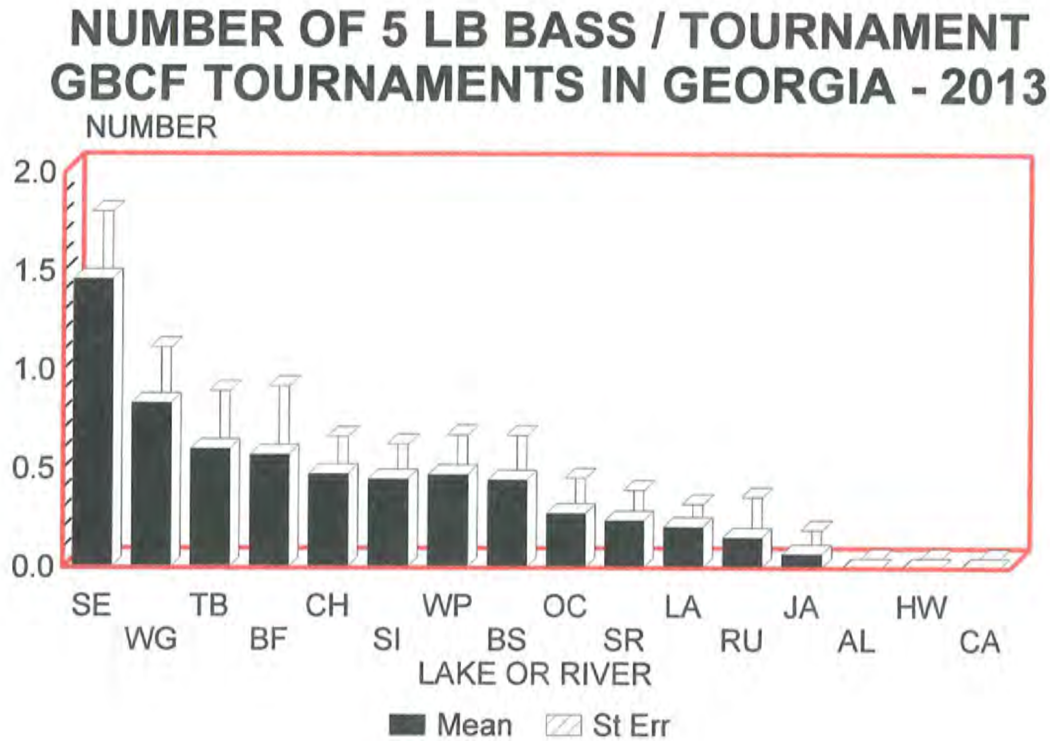
NUMBER OF 5 LB BASS / TOURNAMENT
GBCF TOURNAMENTS IN GEORGIA - 2013
NUMBER
2.0
1.5
1.0
0.5
0.0
SE
WG
TB
BF
CH
SI
WP
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LAKE OR RIVER
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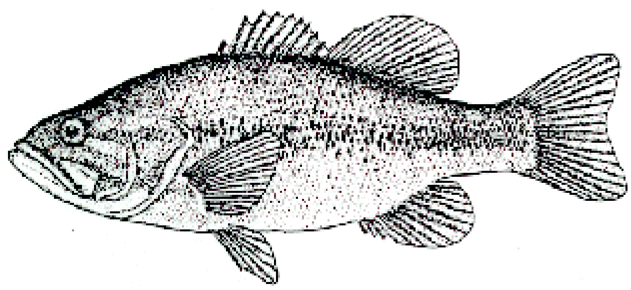
Georgia Bass Chapter Federation

2014

Tournament Creel Report



Submitted by

Carl Quertermus, Ph.D.
Professor Emeritus of Biology
University of West Georgia

GBCF Tournament Report - 2014

This was the 37th year of the Georgia Bass Chapter Federation (GBCF) Tournament Creel Report. In 2014, 39 bass clubs submitted results from 407 tournaments. Several of these tournaments were not analyzed because they involved less than five anglers or lasted less than five hours. Also, Georgia reservoirs and rivers with less than five submitted tournaments were not analyzed. Although Allatoona had only four submitted tournaments, it was included since it has been in the reports since 1978. The data from tournaments held outside of Georgia were not analyzed. Georgia clubs fished many tournaments in other states including, Alabama, Tennessee, South Carolina and Florida. Data from 55 tournaments held at Alabama interior reservoirs and 38 at border reservoirs were sent to the Alabama Department of Conservation and Natural Resources and became part of their annual tournament data analysis (B.A.I.T.). Data from 301 tournaments on 13 Georgia reservoirs and the Savannah River were analyzed for this report.

Fishing success at Georgia reservoirs and the Savannah River are compared on the attached table and figures. Bass anglers spent 38,857 hours of effort during the 301 tournaments. The weighed-in, tournament average catch rate was 0.312 bass / angler hour (or 3.12 bass in a 10-hour fishing day). This is the highest catch rate of the 37 years of this project and is significantly above the 0.264 catch rate average of the previous 10 years. The second highest catch rate was 0.308 in 2013 and the third highest was 0.295 in 2012.

Hartwell had the highest catch rate (0.414 bass / angler hour), and **Russell** was second with a catch rate of 0.401bass / angler hour. The lowest percent of unsuccessful anglers was at **Hartwell** (4.9%); and **Russell** was second lowest (11.8%). The percent of anglers with five weighed-in bass (a "limit") was greatest at **Hartwell** (46.4%). **Russell** was also second in this category with 44.9% of tournament anglers with five bass. The average bass weight was greatest at **Seminole** (2.53 lbs); but it was also good at **W.F. George** (2.29 lbs). The tournament-average largest bass was at **Seminole** (5.48 lbs). **W.F. George** and **Clarks Hill** also had a tournament-average largest bass over 5.0 lbs. The greatest winning weight average was 18.42 lbs at **W.F. George**; however, this reservoir had several two-day tournaments, which would contribute to a greater winning weight.

This was the 11th year that clubs were asked to indicate how many bass 5.0 lbs or larger were caught during each tournament. Only 149 bass 5.0 lbs or larger were caught during the 301 tournaments. On average, it required 261 angler hours to catch a bass of this size. There was a big difference in this value across the fishing locations. Whereas it took 1,408 angler hours at the **Savannah River** to catch a bass ≥ 5.0 lbs, it took only 50 angler hours at **Seminole**. There was an average of only 0.495 bass ≥5.0 lbs caught during the 301 tournaments. The largest bass reported in 2014 was 9.5 lbs caught in the **Savannah River** during a November tournament. Only six bass of 8.0 lbs or larger were caught in the 301 tournaments. That works out to 6,476 angler hours to catch a bass ≥ 8.0 lbs! This was much better than last year when it took 9,525 hours!

The reservoir and river abbreviations on the attached graphs are **AL** (Allatoona), **BF** (Bartlett's Ferry), **BS** (Blackshear), **CH** (Clarks Hill), **HW** (Hartwell), **JA** (Jackson), **LA** (Lanier), **OC** (Oconee), **RU** (R. B. Russell), **SE** (Seminole), **SI** (Sinclair), **SR** (Savannah River), **WG** (W. F. George), and **WP** (West Point).

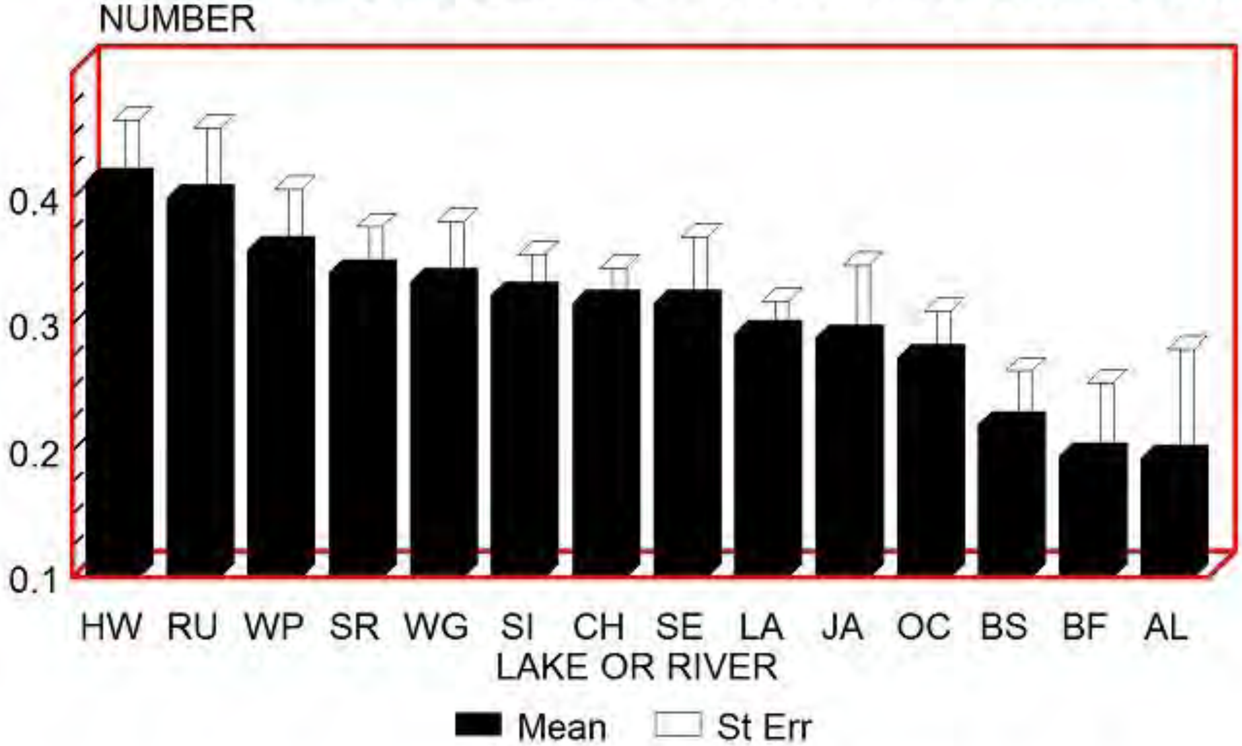
GBCF TOURNAMENT RESULTS FOR GEORGIA RESERVOIRS AND RIVERS - 2014

Reservoir or River	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in /Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth	Angler Hours Per ≥ 5 lb Bass
Allatoona	4	599	0.195	0.266	6.9	36.0	2.74	1.59	6.40	18.8	None Caught
Bartlett's Ferry	7	1320	0.196	0.286	15.9	34.8	3.80	1.59	7.14	50.7	439
Blackshear [b]	8	870	0.221	0.480	11.6	32.3	4.52	2.14	9.96	100.0	218
Clarks Hill	54	7136	0.318	0.609	35.0	18.6	5.05	1.90	13.43	96.1	198
Hartwell	9	2065	0.414	0.694	46.4	4.9	4.59	1.64	13.52	35.0	1034
Jackson	12	1338	0.290	0.432	30.9	24.4	3.96	1.52	10.75	42.3	446
Lanier [a]	64	8173	0.293	0.590	25.4	18.1	4.12	2.04	12.01	10.3	742
Oconee [b]	28	2724	0.274	0.563	22.7	24.0	4.64	2.08	11.09	98.8	182
R. B. Russell	10	1588	0.401	0.568	44.9	11.8	3.88	1.51	11.50	18.9	794
Seminole	11	1152	0.317	0.778	20.7	15.9	5.48	2.53	15.62	100.0	50
Sinclair	32	4346	0.324	0.577	37.4	17.3	4.74	1.73	11.97	96.8	229
W. F. George [b]	16	2419	0.334	0.776	32.6	13.9	5.42	2.29	18.42	78.5	97
West Point [b]	16	2297	0.360	0.562	37.0	12.9	4.15	1.63	10.55	24.2	574
Savannah River	30	2830	0.342	0.535	33.2	19.9	3.27	1.58	9.46	100.0	1408
Total	301	38857	0.312	0.581	30.4	18.9	4.42	1.88	12.05	65.4	261

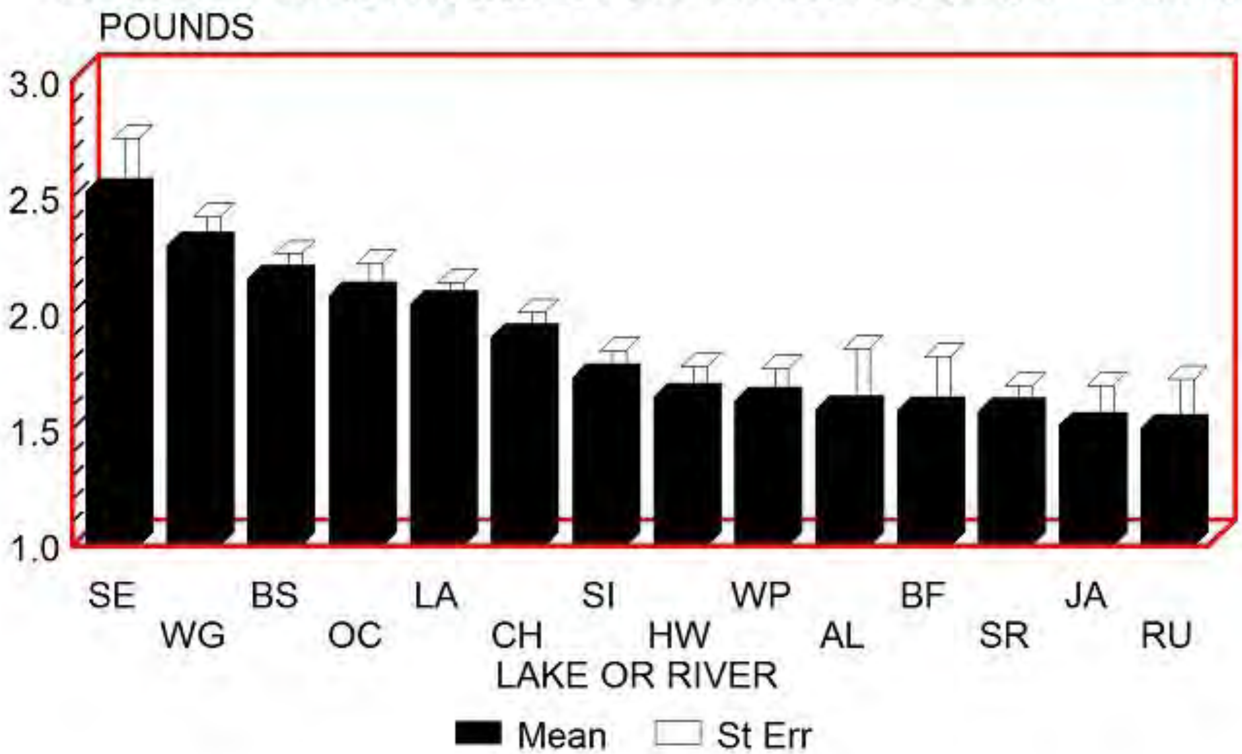
[a] 14-inch size limit on all black bass [b] 14-inch size limit on largemouth bass and 12-inch size limit on other black bass.
Note: Only tournaments with five or more anglers and five or more hours in length were analyzed.
Reservoirs (except Allatoona) and rivers with less than five tournaments were not analyzed.

Compiled and analyzed by Dr. Carl Quertermus, Biology Department, University of West Georgia.

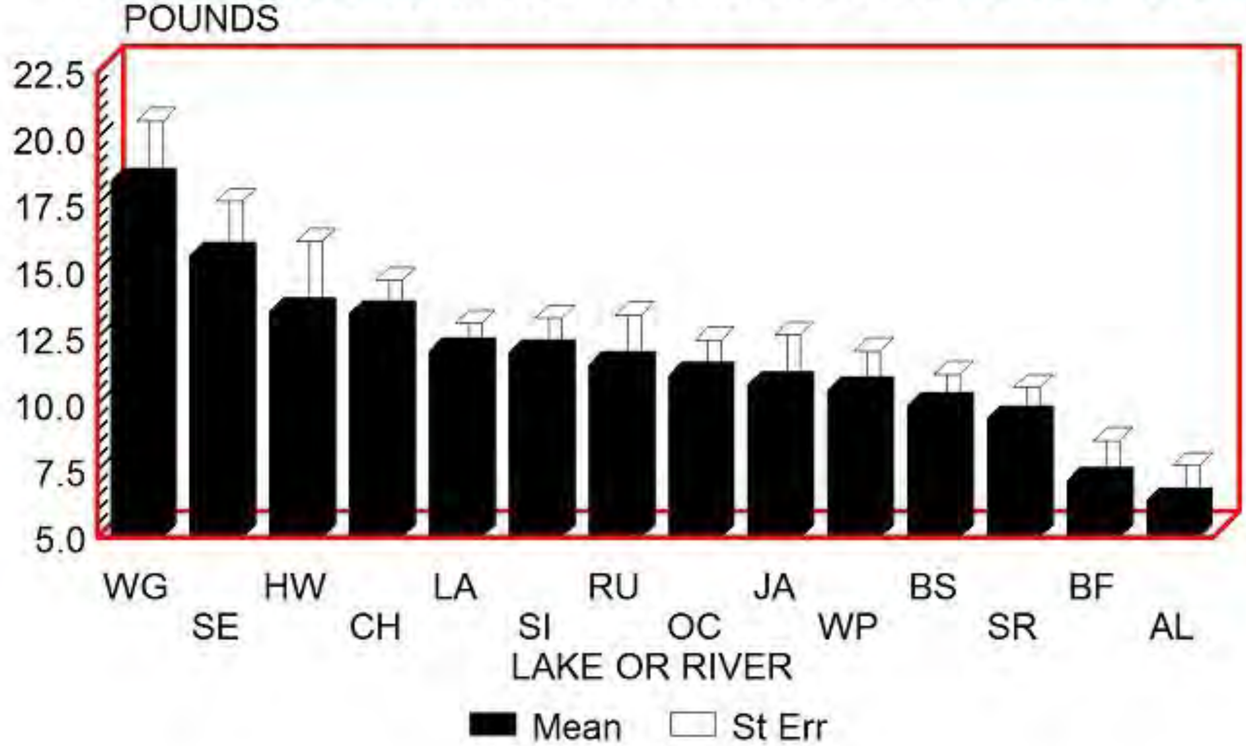
BASS / ANGLER HOUR
GBCF TOURNAMENTS IN GEORGIA - 2014



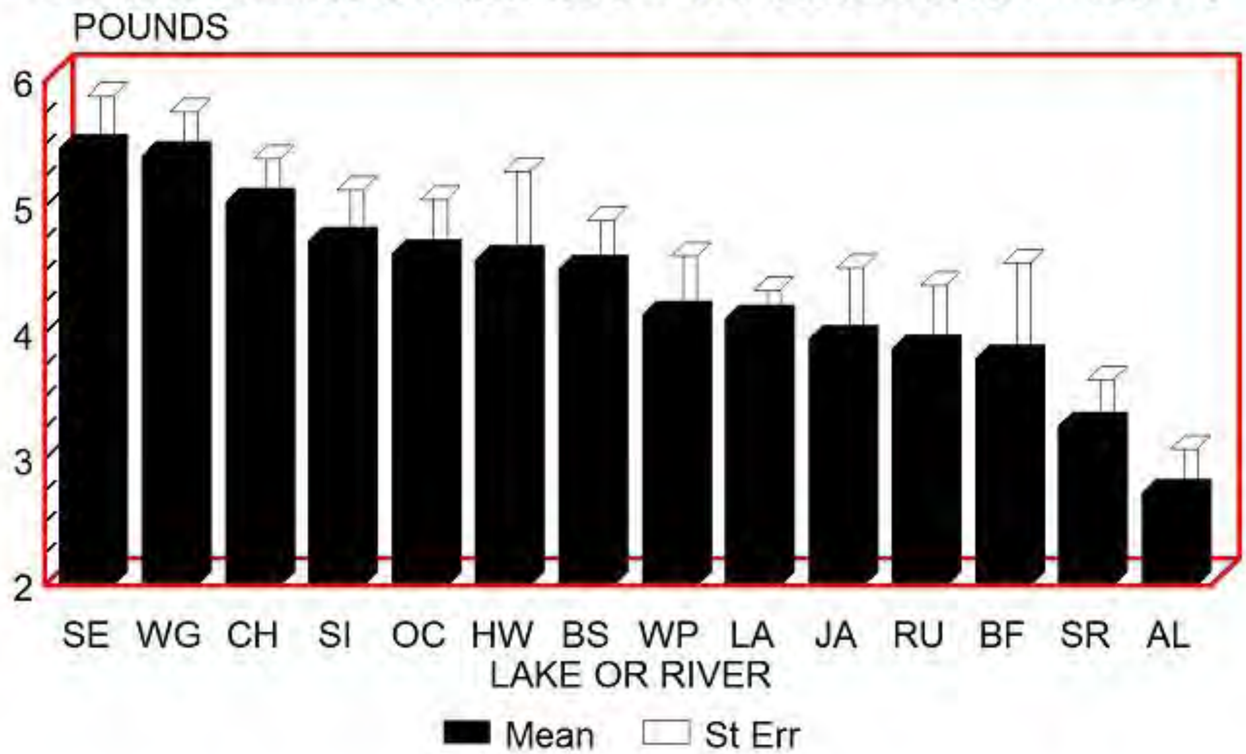
AVERAGE BASS WEIGHT
GBCF TOURNAMENTS IN GEORGIA - 2014



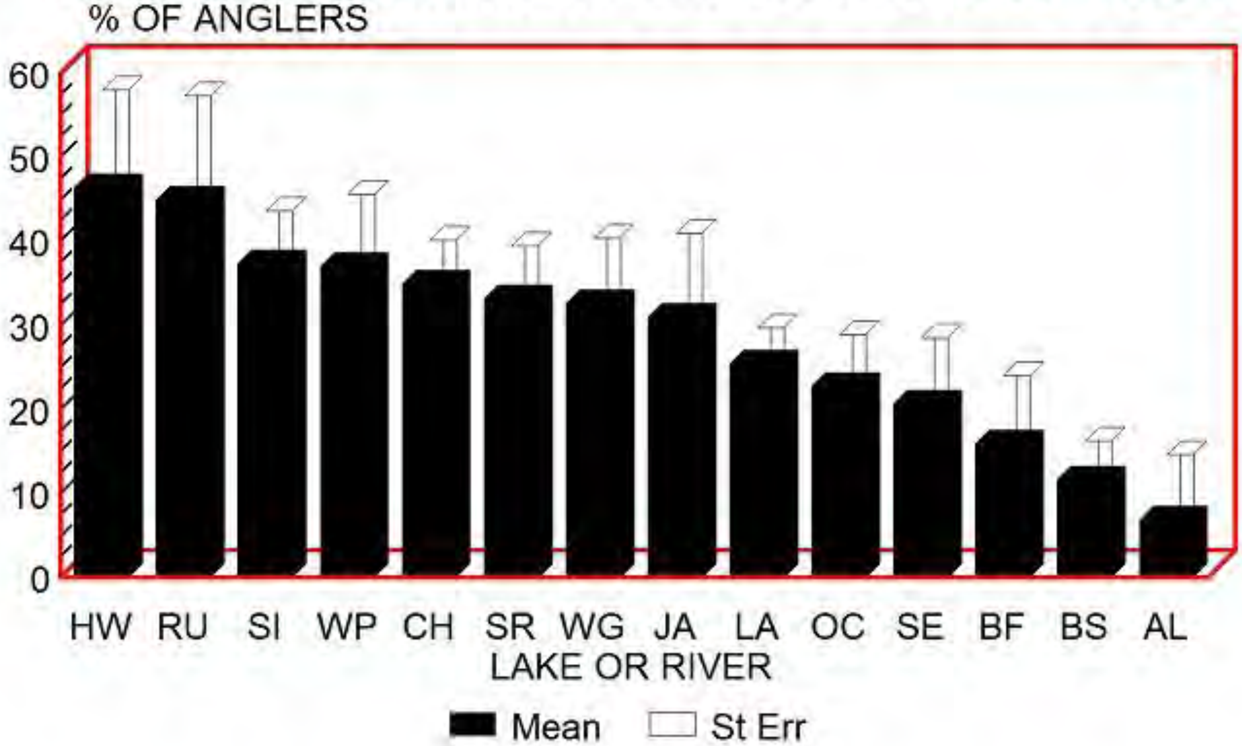
WINNING WEIGHT
GBCF TOURNAMENTS IN GEORGIA - 2014



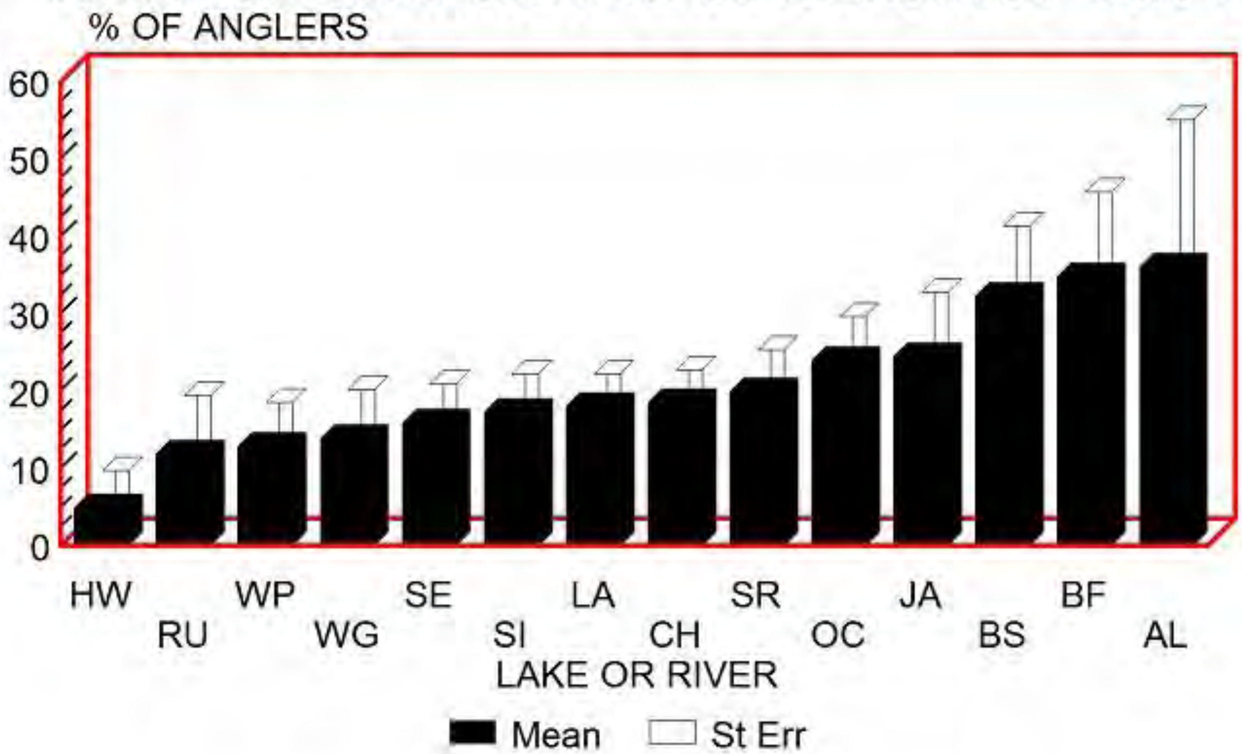
AVERAGE LARGEST BASS
GBCF TOURNAMENTS IN GEORGIA - 2014

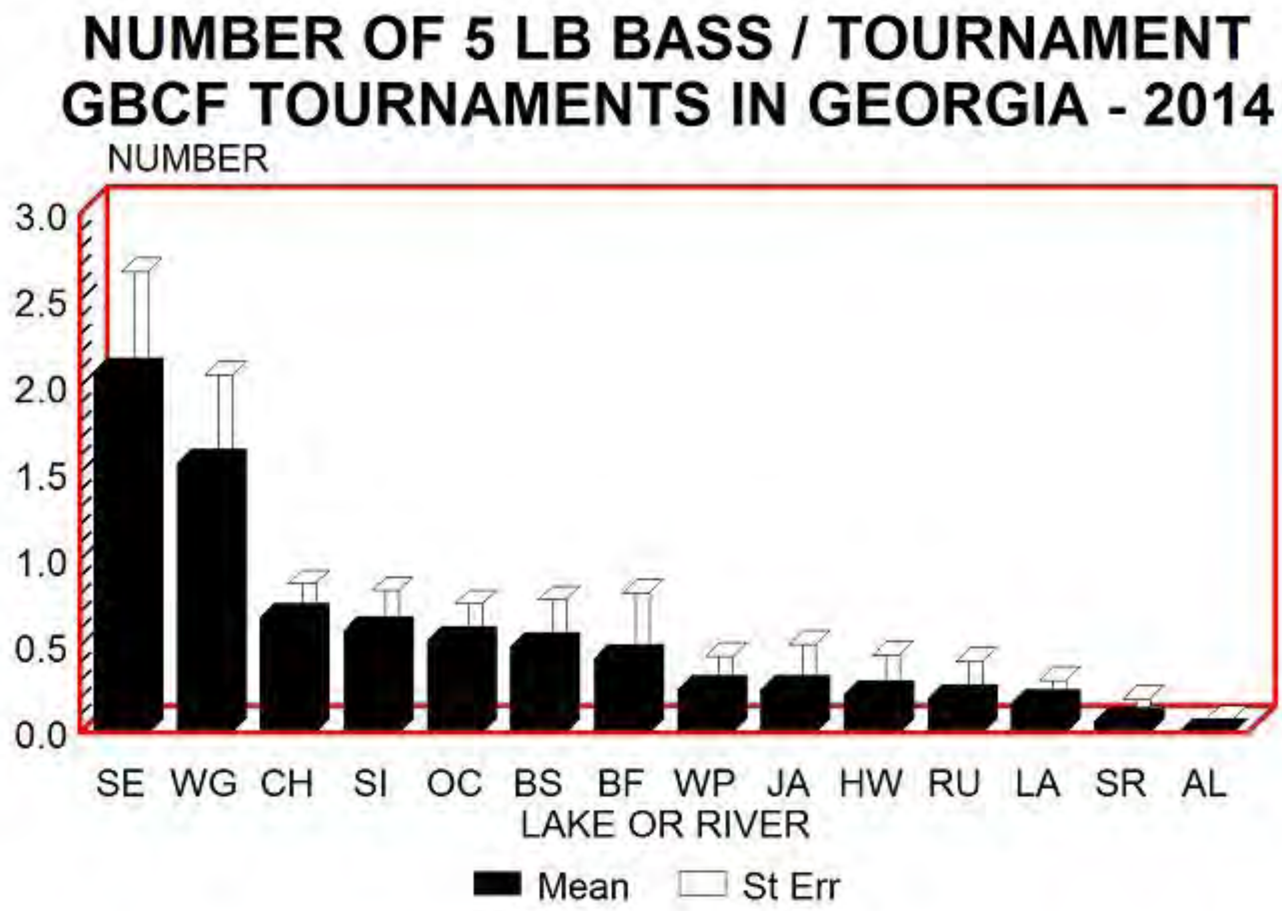


PERCENT ANGLERS WITH FIVE BASS GBCF TOURNAMENTS IN GEORGIA - 2014



PERCENT UNSUCCESSFUL ANGLERS GBCF TOURNAMENTS IN GEORGIA - 2014




NUMBER OF 5 LB BASS / TOURNAMENT
GBCF TOURNAMENTS IN GEORGIA - 2014
NUMBER
3.0
2.5
2.0
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SE
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Georgia Bass Clubs

2015

Tournament Creel Report

Submitted By:

Clint Peacock
Fisheries Biologist
Georgia Department of Natural Resources
Wildlife Resources Division

Introduction

This is the 38th year Georgia bass club tournament creel data has been summarized in an annual report. During 2015, 45 bass clubs submitted results from 425 tournaments. In the past, only clubs that were associated with the Georgia Bass Chapter Federation had contributed to this report. Clubs associated with Georgia BASS Nation also reported their tournament results in 2015.

Methods

Of the 425 bass tournaments reported, only 325 were analyzed for this report. Seven clubs are in both organizations and their tournaments were only analyzed once. Tournaments that included fewer than five anglers and waterbodies with fewer than five tournaments were excluded from analysis. Although Allatoona had only four submitted tournaments, it was included in this report since it has been in every report since 1978. Creel reports from tournaments held outside of Georgia were also removed from analysis. Georgia based clubs fished tournaments in Alabama, Florida, South Carolina, and Tennessee. All data from tournaments held in Alabama as well as on the border waterbodies was shared with the Alabama Department of Conservation. They issue an annual report (B.A.I.T) on black bass tournaments as well.

In total, tournaments from 16 bodies of water were analyzed in the following tables and figures. Waterbody abbreviations are as follows: Allatoona (**AL**), Bartlett's Ferry (**BF**), Blackshear (**BS**), Burton (**BU**), Carter's (**CA**), Clarks Hill (**CH**), Hartwell (**HW**), Jackson (**JA**), Lanier (**LA**), Oconee (**OC**), R. B. Russell (**RU**), Savannah River (**SR**), Seminole (**SE**), Sinclair (**SI**), Walter F. George (**WG**), and West Point (**WP**).

Results

Angler success in Georgia waterbodies with at least 5 submitted tournaments is analyzed in the attached tables and figures. Anglers spent 40,990 hours of effort during the 325 tournaments analyzed in 2015 (Table 1). The weighed-in, tournament average catch rate was 0.277 bass/angler hour (or 2.22 bass in an 8-hour fishing day). While down from 2014 (0.312 bass/angler hour), this is above the 10 average of 0.271 bass/angler hour.

Russell had the highest catch rate (0.361 bass/angler hour), with Allatoona coming in second (0.357 bass/angler hour; Figure 1). Russell was also the waterbody with the lowest percentage of anglers with zero bass weighed-in (10.9%; Figure 2) and the highest percentage of anglers weighing-in five bass (42.7%; Figure 3).

While a lot of black bass were caught by anglers on Russell, it was not the waterbody with the largest bass and highest tournaments winning weights. Seminole produced the largest average bass (2.51 lbs.; Figure 4), highest tournament winning weight (15.62 lbs.; Figure 5), largest average big bass (5.55 lbs.; Figure 6) and the most bass over 5 lbs/tournament (1.47; Figure 7).

This was the 12th year clubs were asked to indicate how many bass ≥5.0 lbs or larger were caught during each tournament. During the 325 tournaments, 176 bass ≥5.0 lbs or larger were caught. Statewide it took 232 angler hours to catch a bass of this size and there were 0.542 bass over 5.0 lbs./tournament. Both of these values are better than the 10 year average. The number of angler hours needed to catch a bass 5.0 lbs. or larger varies widely across the 16 waterbodies. On Jackson it required 1553 angler hours to catch a bass 5.0 lbs. or larger while on Blackshear one was caught every 74 angler hours (Figure 8). The largest bass reported in 2015 was caught on Seminole and weighed 8.78 lbs.

Overall, bass tournaments in Georgia during 2015 were fairly comparable with the averages from 2012-2014 (Table 2). The biggest difference was a decrease in angler success. Fewer anglers weighed-in five bass and more anglers weighed-in zero bass. However, the average bass was larger in 2015 than in past years, and it took fewer angler hours to catch a bass ≥5.0 lbs.

Table 1. Georgia bass clubs tournament results for Georgia waterbodies in 2015.

Waterbody	Number of Tournaments Analyzed	Number of Angler Hours	Bass Weighed-in/Angler Hour	Lbs. Weighed-in/Angler Hour	Percent Anglers with Five or More Bass	Percent Anglers with Zero Bass	Average Largest Bass (lbs.)	Average Bass Weight (lbs.)	Average Winning Weight (lbs.)	Percent Bass as Largemouth Bass	Angler Hours Per ≥ 5 lb Bass
Allatoona	4	543	0.357	0.479	25.6	19.4	3.23	1.38	9.06	6.3	None Caught
Bartlett's Ferry[b]	5	857.5	0.294	0.407	20.5	11.1	3.70	1.45	9.21	49.1	857.50
Blackshear	7	521	0.250	0.536	10.0	22.5	5.11	2.18	10.66	98.7	74.43
Burton	5	463	0.234	0.475	13.3	23.6	4.13	1.94	9.99	33.4	None Caught
Carters	5	784	0.191	0.349	9.9	30.6	3.90	1.81	10.14	1.0	784.00
Clarks Hill	57	6801	0.318	0.610	30.5	16.8	4.92	1.93	13.84	94.9	151.13
Hartwell	10	1369	0.270	0.467	39.1	17.9	4.36	1.73	14.73	42.9	684.50
Jackson	15	1553	0.275	0.387	12.8	25.3	3.65	1.44	9.12	28.8	1553.00
Lanier[a]	48	6123	0.250	0.494	15.6	22.2	4.03	2.01	11.31	9.6	612.30
Oconee[b]	35	3668.5	0.230	0.483	14.2	27.9	4.32	2.06	10.64	100.0	262.04
R. B. Russell	7	802	0.361	0.531	42.7	10.9	3.41	1.46	9.94	21.4	None Caught
Savannah River	32	3202	0.244	0.367	17.3	29.9	3.25	1.52	8.09	99.6	800.50
Seminole	17	2094	0.258	0.665	14.7	19.4	5.55	2.51	15.62	98.0	83.76
Sinclair	32	4444	0.319	0.669	30.4	16.2	4.23	1.65	11.76	95.3	130.71
Walter F. George[b]	17	3735.5	0.252	0.502	17.5	15.1	4.73	1.96	14.95	86.6	339.59
West Point[b]	29	4029.5	0.316	0.557	32.0	15.8	4.99	1.79	12.47	38.5	191.88
Total[c]	325	40990	0.277	0.525	22.3	20.7	4.35	1.90	11.77	67.7	233

[a] 14-inch size limit on all black bass

[b] 14-inch size limit on largemouth bass and 12-inch size limit on other black bass

[c] Values calculated from raw creel report data, not the values in table

Table 2. Comparing state-wide 2015 Bass Tournament data to the 2012-2014 average.

Metric	2012-2014 Average	2015 Results	Change
Tournaments	307	325	6.0%
Angler Hours	38426	40990	6.7%
Bass Weighed in Per Hour	0.305	0.277	-9.2%
Pounds Weighed in Per Hour	0.542	0.525	-3.1%
Percent Angler with Five Bass	27.7	22.3	-19.4%
Percent Angler with Zero Bass	18.6	20.7	11.5%
Biggest Bass Weight	4.31	4.35	0.9%
Average Bass Weight	1.80	1.90	5.8%
Tournament Winning Weight	11.55	11.77	1.9%
Percentage Largemouth Bass	69.2	67.7	-2.2%
Angler Hours Per ≥5 lbs. Bass	287	233	-18.8%

Figure 1. Bass Weighed-in Per Angler Hour in Georgia Bass Club Tournaments in 2015.

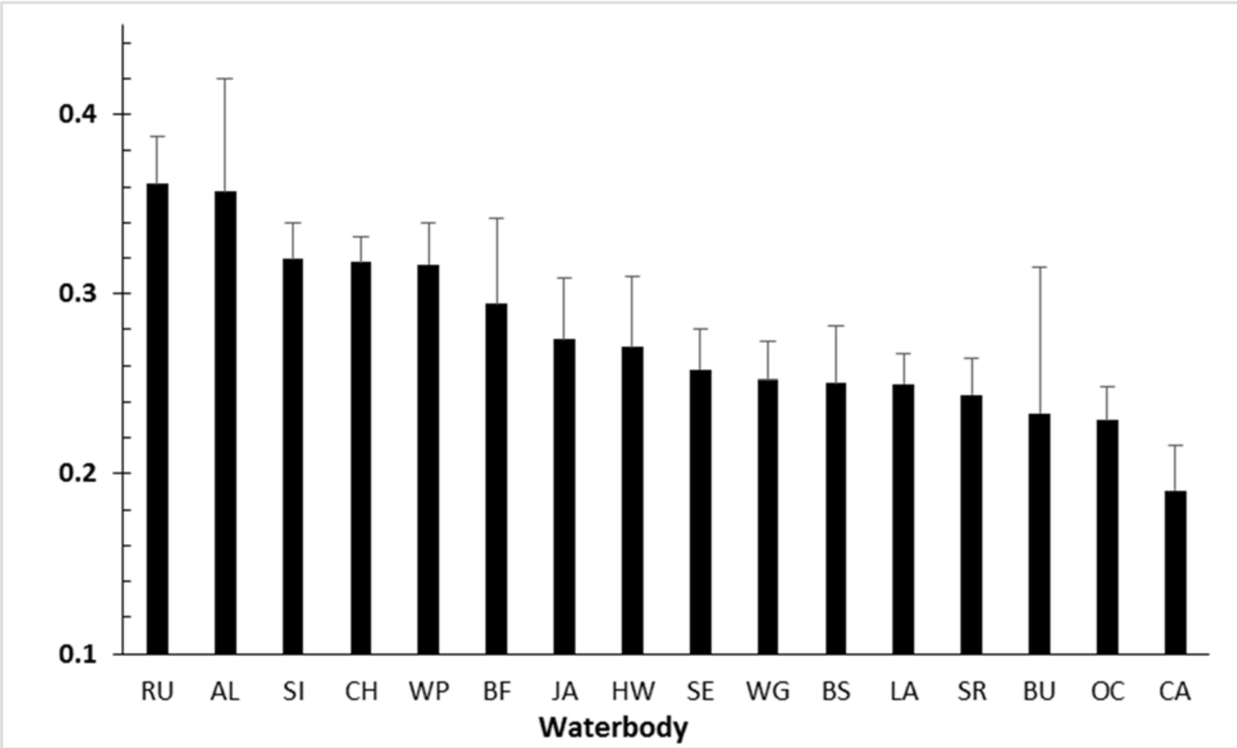


Figure 2. Percentage of Anglers with Zero Bass in Georgia Bass Club Tournaments in 2015.

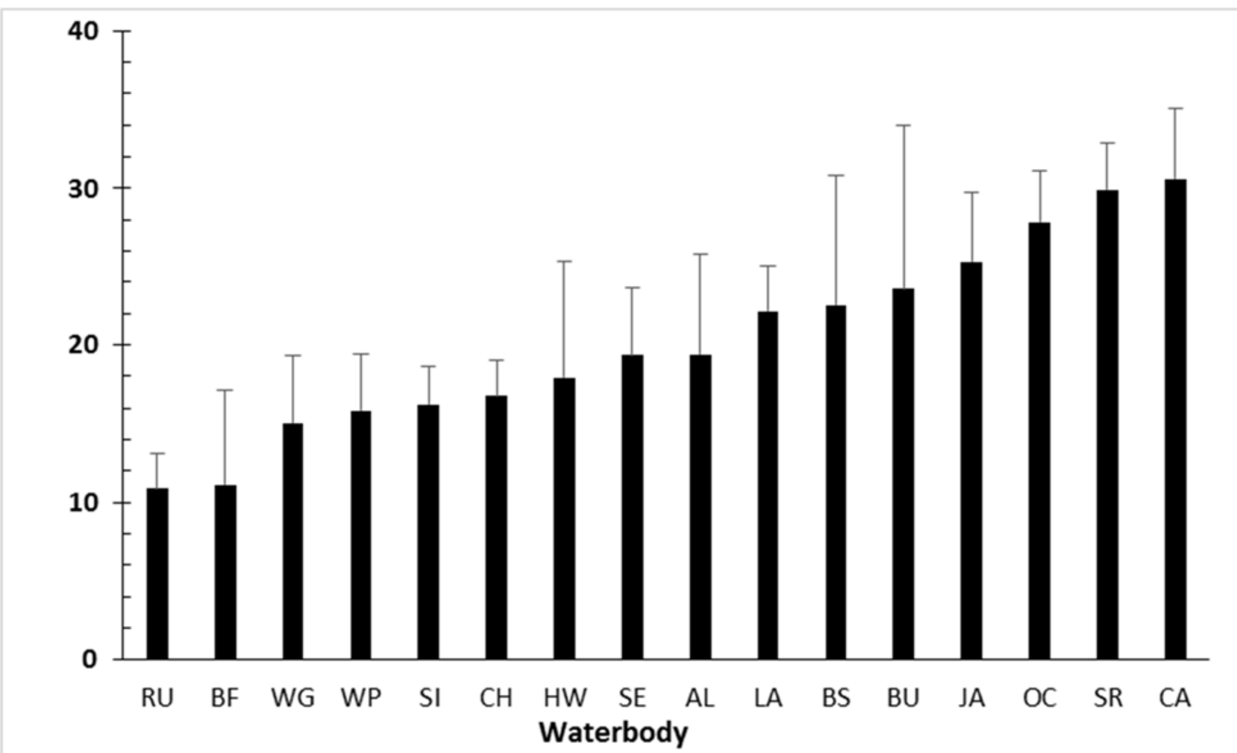


Figure 3. Percentage of Anglers with Five Bass in Georgia Bass Club Tournaments in 2015.

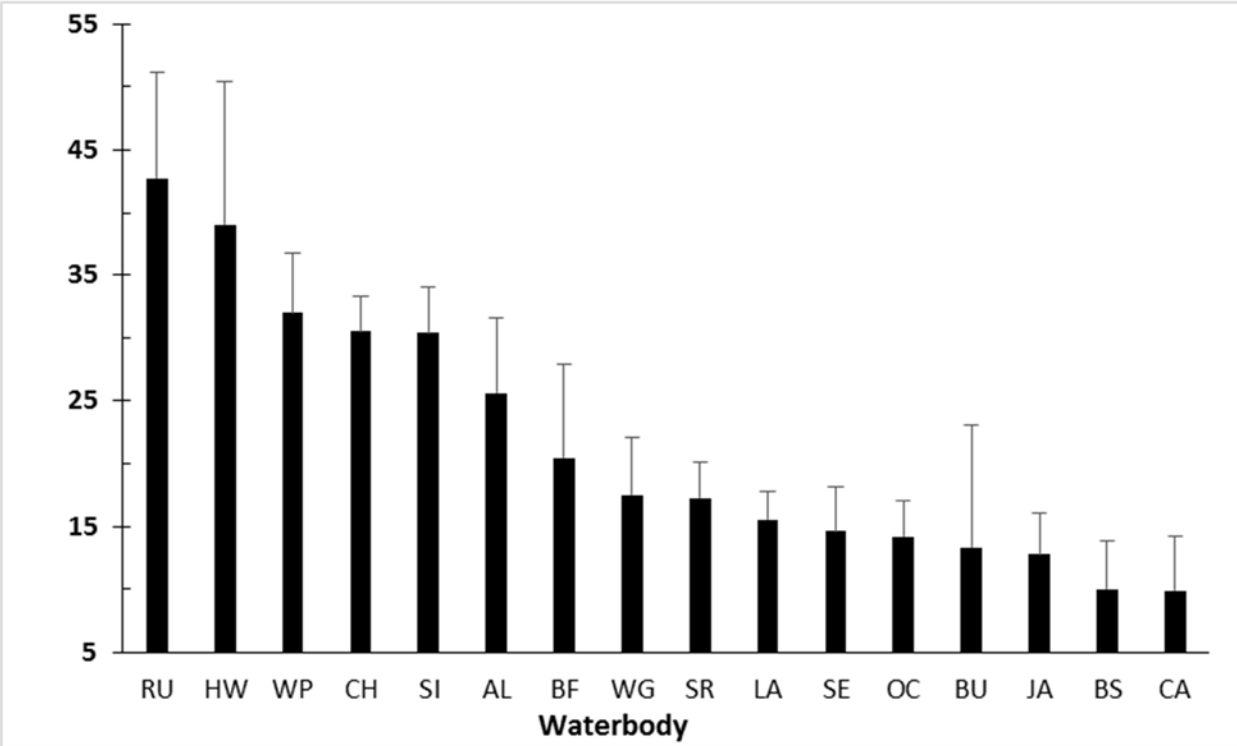


Figure 4. Average Bass Weight in Georgia Bass Club Tournaments in 2015.

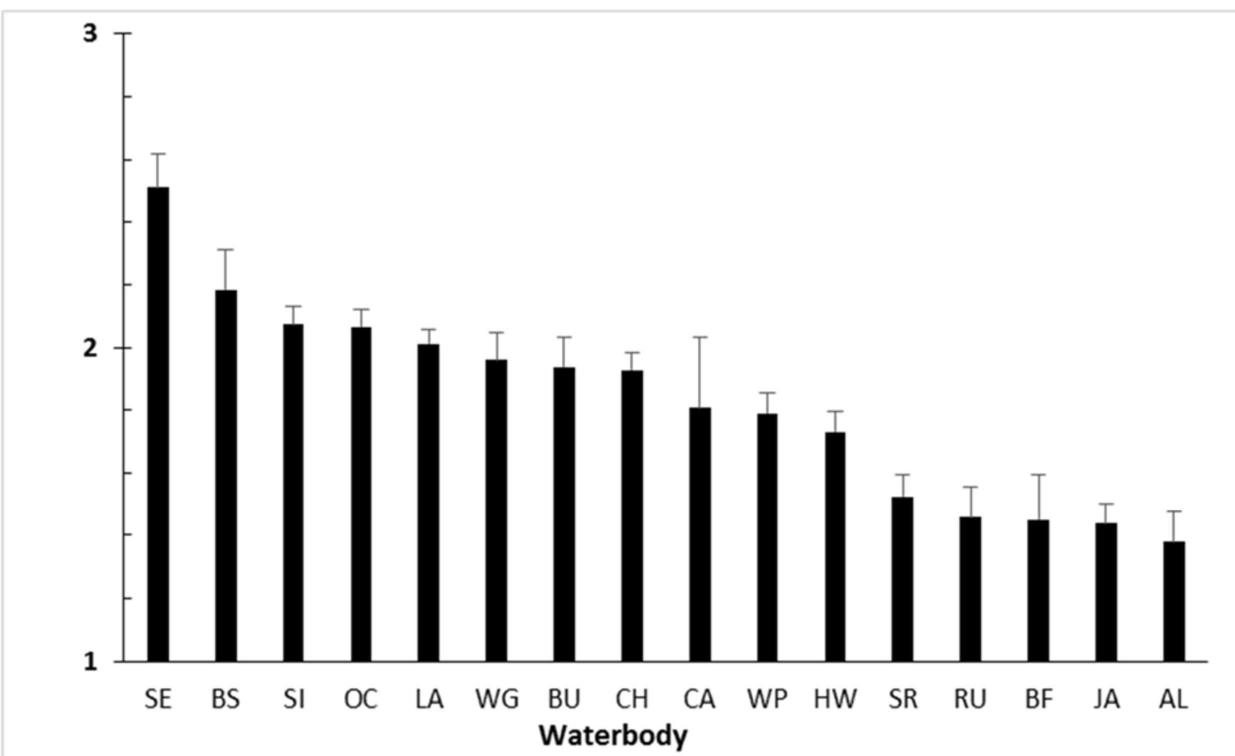


Figure 5. Average Winning Weight in Georgia Bass Club Tournaments in 2015.

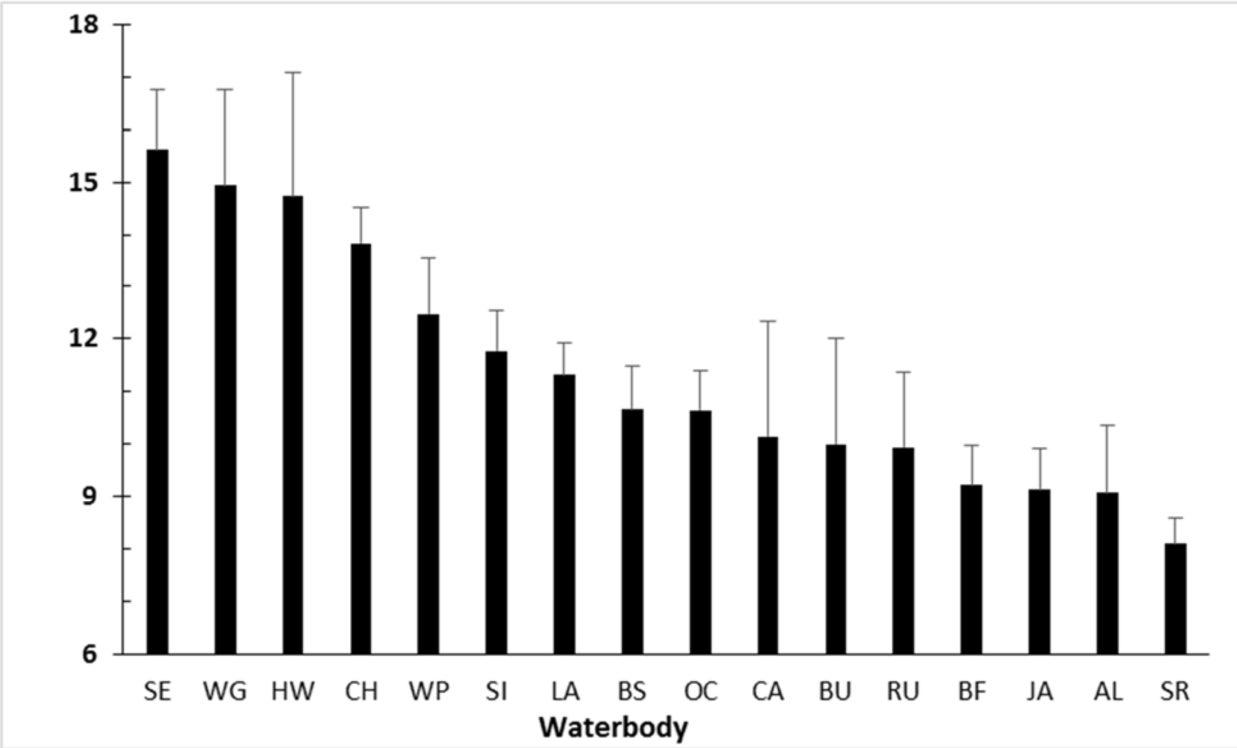


Figure 6. Average Big Bass Weight in Georgia Bass Club Tournaments in 2015.

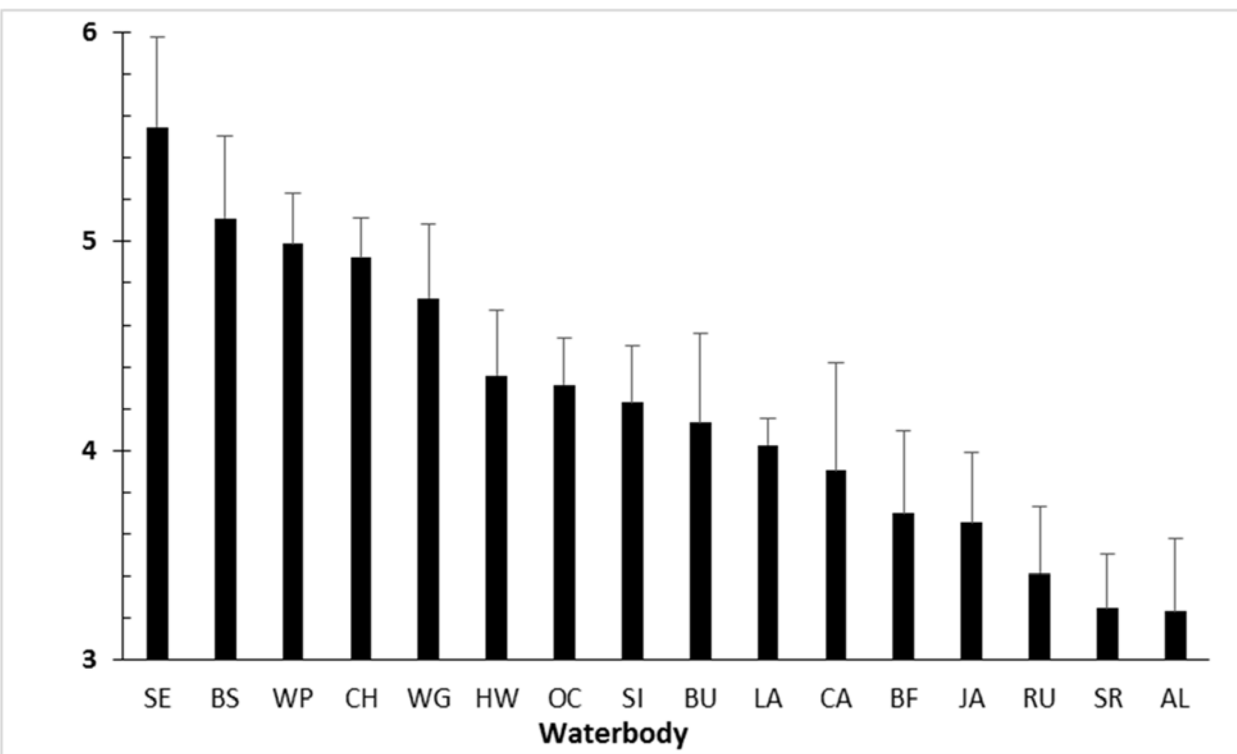


Figure 7. Number of bass ≥5.0 lbs. per Tournament in Georgia Bass Club Tournaments in 2015.

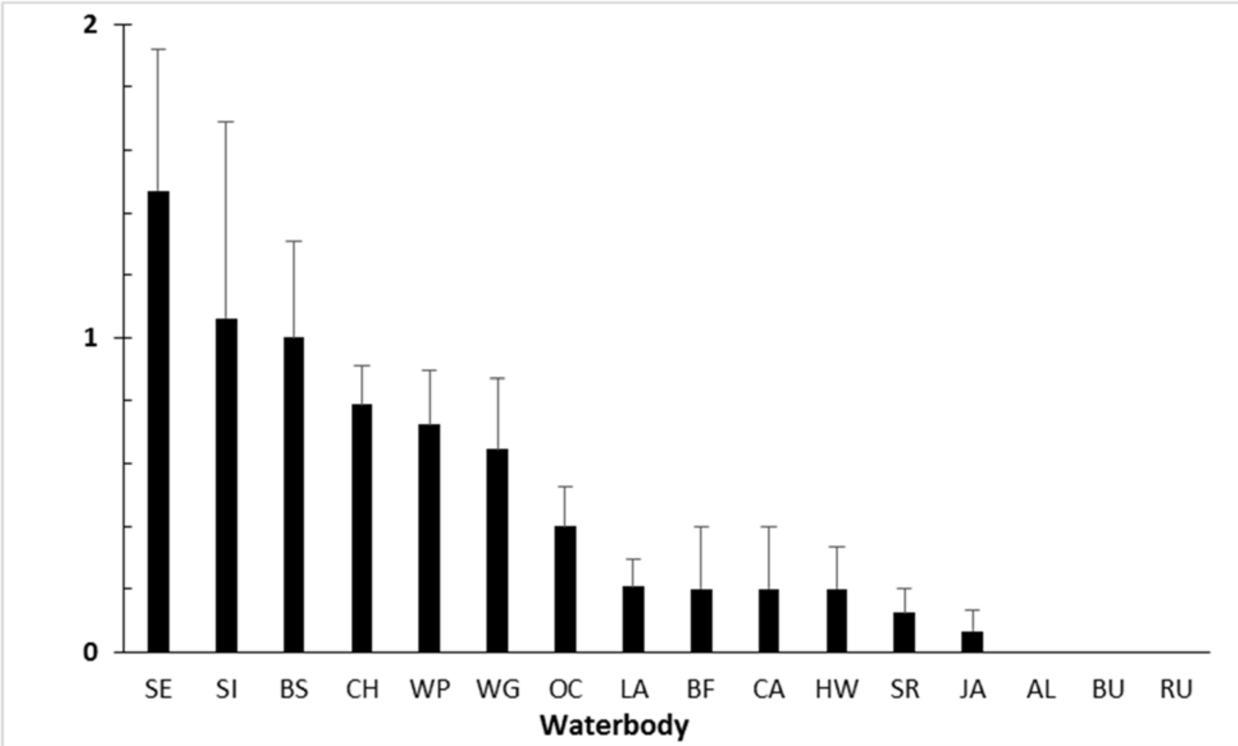
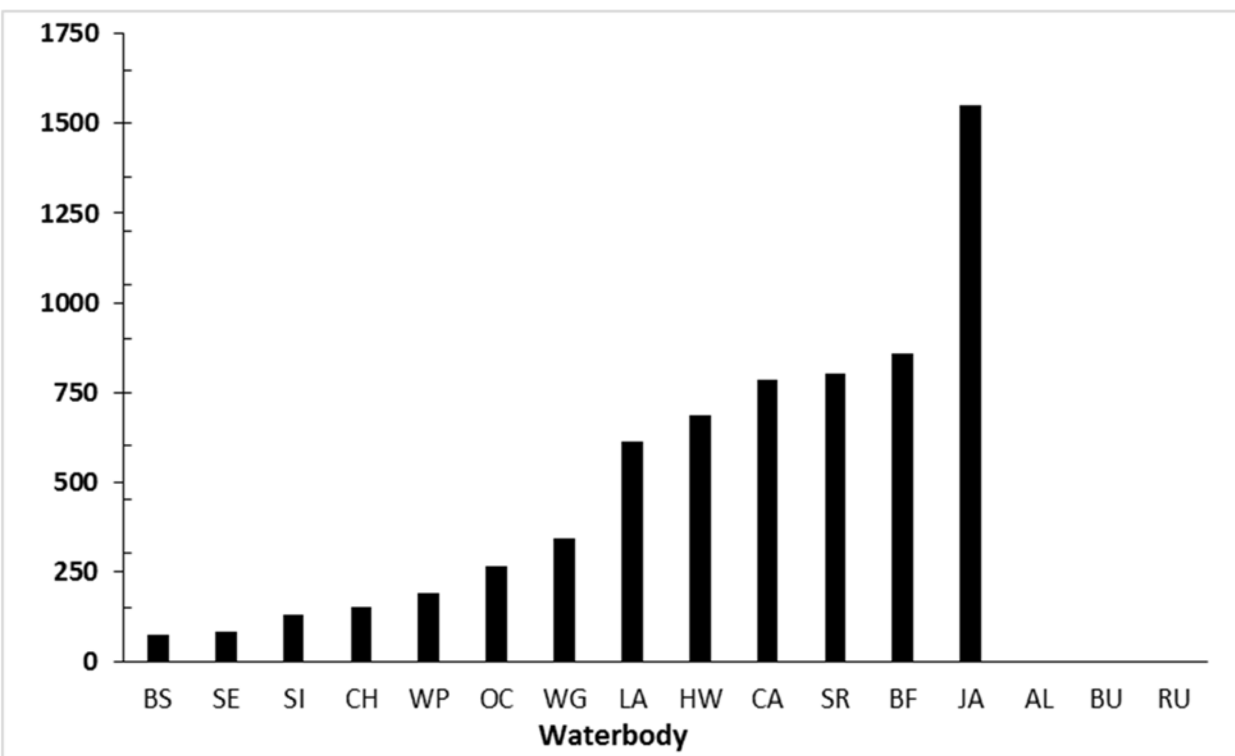
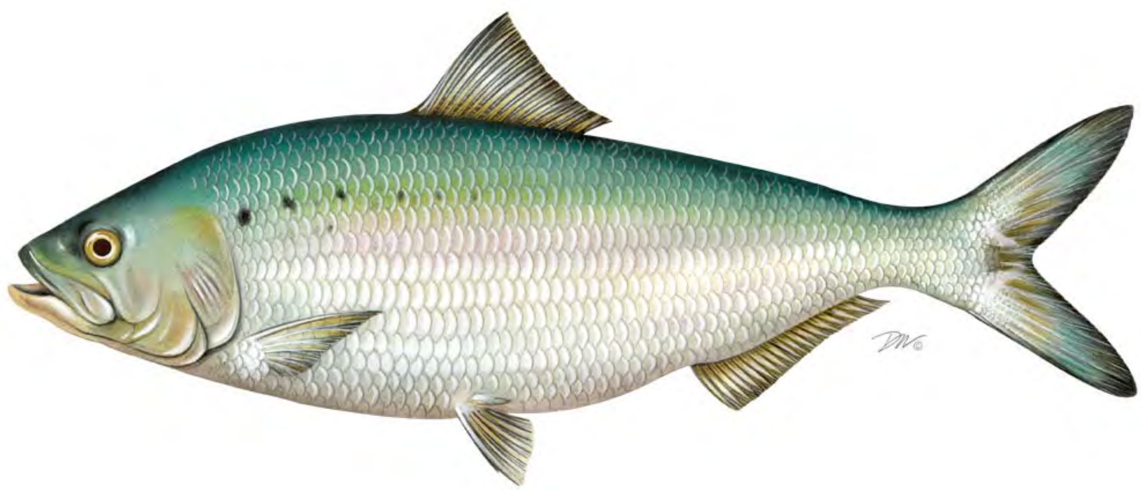


Figure 8. Hours to catch ≥5.0 lbs. bass Tournament in Georgia Bass Club Tournaments in 2015.



Georgia Department of Natural Resources

American Shad Habitat Plan



Submitted to the Atlantic States Marine Fisheries Commission as a requirement of Amendment 3 to the Interstate Management Plan for Shad and River Herring

Approved February 6, 2014

Shad Habitat Plan-Georgia

Altamaha River

Habitat Assessment

The Altamaha River is formed by the confluence of the Ocmulgee and Oconee rivers and flows approximately 220 km before emptying into the Atlantic Ocean near Darien, GA. Including its longest tributary (the Ocmulgee River) the Altamaha River runs for approximately 756 km making it the seventh longest river in the U.S. that is entirely within one state. The Altamaha River drainage basin covers an area of approximately 36,000 km^2 with its headwaters arising near Atlanta, GA for the Ocmulgee River and near Athens, GA for the Oconee River. There are no dams directly on the Altamaha, though there are dams on both the Oconee and the Ocmulgee rivers.

With no barriers directly on the Altamaha all historical estuarine habitat remains available to juvenile and migrating adult shad.

Historical evidence suggests that American shad once occurred in the Altamaha Basin at least as far upstream as the vicinity of Covington, GA in the Ocmulgee River Basin and near the city of Athens, GA in the Oconee River Basin [Bryson 1826; Baird 1884; Bill Frazier, U. S. Fish and Wildlife Service (retired), 2001, personal communication; Elizabeth Reitz, University of Georgia, 2007, personal communication]. However, the construction of dams has limited the migrations. Most of these structures are still in place and continue to serve as barriers to nearly 6,000 acres of potential riverine shad habitat.

American shad currently occur from the mouth of the Altamaha River to the East Juliette Hydroelectric Dam on the Ocmulgee River (approximately river km 570) and Sinclair Dam on the Oconee River (approximately river km 446). Approximately 70% of the historical riverine habitat currently remains available to migrating adult American shad.

Threats Assessment

1. **Migration Barriers**- Full utilization of all potential spawning habitat in the Altamaha River Basin could entail modification of at least nine dams in the Oconee Basin, seven dams in the Ocmulgee Basin, and one dam in the Ohoopee Basin to facilitate fish passage.

   Action 1: Develop a plan for establishing fish passage at barriers in the Altamaha River system.

   Regulatory Agencies/Contacts: USFWS, NMFS, FERC, USACE, Georgia Department of Natural Resources (GA DNR), dam owners and operators, and federal and state legislators.

Goal/Target: Establish fish passage at all dams in the Altamaha basin, where passage is determined to be feasible.

Progress: GA DNR has developed an American shad restoration plan for the Altamaha River Basin which includes the implementation of fishways as a restoration strategy. The plan calls for utilizing Section 18 of the Federal Power Act, which provides the U.S. Departments of Commerce and Interior mandatory conditioning authority to prescribe fish passage during the Federal Energy Regulation Commission (FERC) licensing process for hydroelectric facilities. The FERC-licensed hydroelectric facilities in the Altamaha Basin that are within the historic range of the American shad should have fish passage provisions included in their upcoming licenses, when passage is determined to be feasible.

For FERC-licensed facilities that already have a spawning population directly below them (e.g., currently East Juliette Hydroelectric Dam, Sinclair Dam), fish passage should be evaluated and implemented as soon as feasible (or upon FERC relicensing). For all other FERC-licensed facilities, fish passage should be provided in a stepwise fashion upon the establishment of spawning runs directly below these structures (upon fish passage at all downstream structures).

For non-FERC-licensed dams resource agencies should work with owners to explore passage opportunities such as fishways, breaching, or removal. Where feasible, obsolete or non-functioning barriers to migration should be removed or breached.

<u>East Juliette Hydroelectric Dam</u>

A fish passage prescription for East Juliette Hydroelectric dam has been completed. However, negotiations between the Services and project operator are still ongoing and construction of the fishway has not been initiated.

Cost: Unknown

Timeline: Unknown

Action 2: Potentially conduct experimental trap and transport operations.

Regulatory Agencies/Contacts: Georgia Department of Natural Resources (GA DNR), ASMFC, USFWS, NMFS, FERC, USACE, dam owners and operators, and federal and state legislators.

Goal/Target: Assess of upstream migratory behavior and level of passage at partial barriers and to provide access to additional spawning habitat that may be more suitable than that available below downstream barriers.

Progress: Experimental trap and transport operations are listed as a potential method for assessing migratory behavior, partial barrier passage, and allow for potential spawning at previously unavailable habitat. GA DNR has no immediate plans to initiate trap and transport activities at this time.

Cost: Unkown

Timeline: Uknown

2. **Dissolved Oxygen-**While there have not been any dissolved oxygen issues identified within the Altamaha River itself, segments of tributary rivers and streams have been identified as not having sufficient assimilative capacity to maintain dissolved oxygen levels of 5mg/L or greater at maximum permitted discharge levels under low flow conditions.

   Action 1: Develop a regional water plan that recommends appropriate water management practices to ensure healthy aquatic ecosystems.

   Regulatory Agencies/Contacts: Georgia Department of Natural Resources (GA DNR)- Environmental Protection Division (EPD), Wildlife Resources Division (WRD), and Coastal Resources Division (CRD), state legislators, and local municipalities

   Goal/Target: Ensure water quantity remains adequate to support all life stages of American shad and other aquatic organisms in the Altamaha River.

   Progress: In 2008, the Georgia General Assembly, as part of the Statewide Comprehensive Water Management Plan, established 10 regional water planning councils that encompassed the 14 major river systems within Georgia. With technical guidance from GA EPD, these councils were tasked with developing regional water plans that outlined management practices to meet future water needs for both water quantity and water quality through 2050. In November 2011, the ten regional water plans were officially adopted by GA EPD.

   The Altamaha Council recommended a suite of surface water quality management practices in a phased approach to address water quality issues, including stream segments with limited localized dissolved oxygen assimilative capacity and insufficient wastewater permit capacity (GA EPD 2011a. These recommendations include such practices as the additional sustainable development of groundwater and surface water in areas with sufficient water supply; best management practices for water quality issues such as non-point source runoff, nutrient loadings, and TMDLs in the region; and additional educational and ordinance practices.

   For the Altamaha Region, 75 impaired stream reaches (total impaired length of 915 miles) and 2 impaired lakes (total impaired area of 390 acres) have been identified. The majority of impairments are due to low dissolved oxygen and fecal coliform. Total maximum daily loads have been completed for 71 of the impaired stream reaches and for both of the impaired lakes.

   Cost: Unknown

   Timeline: Regional water plan extends through 2050

3. **Competition and Predation by Invasive Species-**Flathead catfish and blue catfish have been introduced into that Altamaha River system through unauthorized stockings. A significant portion of both flathead catfish and blue catfish diets are comprised of fish, and due to their large adult size (>60 lbs) they have the potential to consume both adult and juvenile American shad. Flathead catfish were first documented in the Ocmulgee River in the early-1970's and have now colonized the entire Altamaha River system. Abundance of flathead catfish rapidly expanded from approximately 1980 through the late-1990's. Electrofishing catch rates by weight peaked at 274 kg/hr in 1993 and by number at 108 fish/hr in 2004. Since 2000, electrofishing catch rates have ranged from 43-108 fish/hr. The average size of the flathead catfish in the Altamaha River peaked at approximately 3.5 kg in the mid-1990's and has since decreased to approximately 1 kg. A diet analysis of flathead catfish was completed during the months of June-September of 1997 and found the dominant prey items to be centrarchid spp. and ictalurid spp (Weller and Robbins, 2001). No Alosa spp. were identified in the stomach of flathead catfish during this study, but consumed juvenile American and/or hickory shad could have been unidentifiable due to extensive digestion.

    Blue catfish were first detected in the Altamaha River in 2006 and their abundance has steadily increased. In 2011, blue catfish electrofishing CPUE was 29 fish/hr. It is expected that the abundance of this species will continue to increase for several more years. Stomach contents of 257 blue catfish were analyzed in the summer of 2010 and it was found that Alosa spp. comprised 0.4% by number of prey items consumed (Bonvechio et al. 2012). This majority of the blue catfish in this study were relatively small (59.5% < 300 mm) so as larger blue catfish become more abundant utilization of Alosa spp as a prey item may increase.

    Action 1: Management of invasive catfish species.

    Regulatory Agencies/Contacts: GA DNR

    Progress: GA DNR completed experimental electrofishing removals of flathead catfish from the Altamaha River system during the 1990s in an effort to restore native fish redbreast sunfish and bullhead spp populations that had been adversely impacted. These efforts were discontinued due to the large nature of the river, budget reductions, and shifts in angler attitudes.

    Cost: Unknown

    Timeline: Discontinued

Ogeechee River

Habitat Assessment

The Ogeechee River originates in the Georgia piedmont and flows for approximately 425 km while crossing the fall line, sandhill region, and the coast plain before emptying into the Atlantic Ocean in Ossabaw Sound. The Ogeechee River watershed encompasses approximately 14,300 km^2. Tidal influence typically extends to rkm 72 and the fresh/saltwater interface occurs approximately 56 km upstream from the mouth of the river. No manmade barriers are present the entire length of the Ogeechee River so all historical riverine and estuarine habitats remain available to juvenile and migrating adult American shad.

Threats Assessment

1. **Instream Flow**- The Georgia Environmental Protection Division (EPD) conducted resource assessments to predict resource conditions based on projection population growth and resulting water demands through 2050. Based on these predictions peak season agricultural irrigation may result in potential in-stream flow shortages in the Ogeechee Basin (GA EPD 2011b). The stream flow may fall below the in-stream flow target during summer low flow periods after meeting upstream irrigation needs.

   Action 1: Develop a regional water plan that recommends appropriate water management practices to ensure healthy aquatic ecosystems.

   Regulatory Agencies/Contacts: Georgia Department of Natural Resources (GA DNR)-Environmental Protection Division (EPD), Wildlife Resources Division (WRD), and Coastal Resources Division (CRD), USFWS, NMFS, FERC, US EPD, USACE, federal and state legislators, and local municipalities.

   Goal/Target: Ensure water quantity remains adequate to support all life stages of American shad and other aquatic organisms in the Ogeechee River.

   Progress: In 2008, the Georgia General Assembly, as part of the Statewide Comprehensive Water Management Plan, established 10 regional water planning councils that encompassed the 14 major river systems within Georgia. With technical guidance from GA EPD, these councils were tasked with developing regional water plans that outlined management practices to meet future water needs for both water quantity and water quality through 2050. In November 2011, the ten regional water plans were officially adopted by GA EPD.

   To prevent potential shortages in meeting in-stream flow needs, the plan encompassing the Ogeechee River calls for more aggressive water conservation practices and development of drought management practices for the agricultural users/permittees in the Upper Ogeechee River Basin (GA EPD 2011b). The Council also recommends in-stream flow studies (to determine what flow levels are appropriate for protecting aquatic life) and additional stream flow monitoring in the Ogeechee River Basin (to confirm the frequency and magnitude of predicted in-stream flow shortages).

Cost: Unknown

Timeline: Regional water plan extends through 2050

2. **Point Source Discharges-** In May 2011, the Ogeechee River experienced a large-scale fish kill that affected multiple species including American shad. The upper extent of the kill was below the only industrial discharge above the kill area.

   Action 1: Develop and implement permits and monitoring to avoid future fish kills.

   Regulatory Agencies/Contacts: Georgia Department of Natural Resources (GA DNR)-Environmental Protection Division (EPD), Wildlife Resources Division (WRD), US EPD, and appropriate private industrial operators.

   Goal/Target: Ensure water quality remains adequate to support all life stages of American shad and other aquatic organisms in the Ogeechee River.

   Progress: After the 2011 fish kill, GA EPD reviewed and revised the existing discharge permit for King America Finishing in attempt to prevent future fish kills related to their discharge. GA EPD has since closely monitored water quality in this area of the Ogeechee River.

   Cost: Unknown

   Timeline: Currently ongoing

Satilla River

Habitat Assessment

The Satilla River originates in Ben Hill County near the town of Fitzgerald, GA and flows for approximately 378 km before emptying into the Atlantic Ocean in St. Andrews Sound. The Satilla River watershed encompasses approximately 10,000 km^2 of Georgia's coastal plain. Tidal influence typically extends to rkm 93 and the fresh/saltwater interface occurs approximately 32 km upstream from the mouth of the river. No manmade barriers are present the entire length of the Satilla River so all historical riverine and estuarine habitats remain available to juvenile and migrating adult American shad.

Threats Assessment

1. **Competition and Predation by Invasive Species-**Flathead catfish were introduced into that Satilla River system through unauthorized stockings in the mid-1990s and blue catfish were collected by GA DNR in 2012. A significant portion of flathead catfish diets are comprised of fish, and due to their large adult size (>60 lbs) they have the potential to consume both adult and juvenile American shad.

   Action 1: Management of invasive catfish species.

   Regulatory Agencies/Contacts: GA DNR

   Progress: GA DNR initiated electrofishing removals of flathead catfish from the Satilla River in 1996 with existing manpower and funding in an effort to preserve native fish species, specifically redbreast sunfish and bullhead spp. Flathead abundance continued to increase despite these efforts, which were limited due to manpower and fiscal limitations. Native fish populations were also showing early signs of decline. In 2006, Georgia's legislature appropriated funding for dedicated positions and equipment to conduct extensive flathead catfish removal efforts on the Satilla River. Since 2007, approximately 28,000 flathead catfish weighing over 68,000 lbs have been removed from the Satilla River. Over time, these efforts have resulted in a significant reduction in the flathead catfish biomass and appear to be preserving the abundance of native species.

   Blue catfish abundance is extremely low, with only a few individual being collected in 2012 and none thus far in 2013. GA DNR suspects that these fish may have colonized the Satilla River from the Altamaha River via the intercostal water way during a high flow period, due to their relatively high tolerance to brackish water.

   Cost: Unknown

   Timeline: Ongoing

2. **Dissolved Oxygen-** Dissolved oxygen levels below 3 mg/L occur during low flow events in the months of July-September in an approximately a 30 km segment of the tidally influenced portion of the Satilla River. The Satilla River naturally has a low assimilative capacity and resulting low DO levels during summer low flow periods, therefore it may not be possible to maintain DO levels above 3 mg/L at all times. However, the actions listed below will still be beneficial.

   Action 1: Develop a TMDL implementation plan.

   Regulatory Agencies/Contacts: Georgia Department of Natural Resources (GA DNR)-Environmental Protection Division (EPD), Wildlife Resources Division (WRD), and Coastal Resources Division (CRD), state legislators, and local municipalities

   Goal/Target: Reduce organic loads to sustain acceptable DO levels.

Progress: GA DNR worked with representatives of local municipalities and conservation groups and developed a TMDL implementation plan that included a suite of management measure to reduce organic carbon, Total Nitrogen, and Total Phosphorous inputs in order to improve dissolved oxygen levels in the Satilla River.

Cost: Unknown

Timeline: Unknown

Action 2: Develop a regional water plan that recommends appropriate water management practices to ensure healthy aquatic ecosystems.

Regulatory Agencies/Contacts: Georgia Department of Natural Resources (GA DNR)-Environmental Protection Division (EPD), Wildlife Resources Division (WRD), and Coastal Resources Division (CRD), USFWS, NMFS, FERC, US EPD, USACE, federal and state legislators, and local municipalities.

Goal/Target: Ensure water quantity remains adequate to support all life stages of American shad and other aquatic organisms in the Satilla River.

Progress: In 2008, the Georgia General Assembly, as part of the Statewide Comprehensive Water Management Plan, established 10 regional water planning councils that encompassed the 14 major river systems within Georgia. With technical guidance from GA EPD, these councils were tasked with developing regional water plans that outlined management practices to meet future water needs for both water quantity and water quality through 2050. In November 2011, the ten regional water plans were officially adopted by GA EPD.

The Suwannee-Satilla-St Marys Council recommended a suite of surface water quality management practices in a phased approach to address water quality gaps, including stream segments with limited localized dissolved oxygen assimilative capacity and insufficient wastewater permit capacity (GA EPD 2011c). Specific actions to add/improve infrastructure and improve flow and water quality conditions were identified and recommended. These recommendations include such practices as the additional sustainable development of groundwater and surface water in areas with sufficient water supply; best management practices for water quality issues such as non-point source runoff, nutrient loadings, and TMDLs in the region; and additional educational and ordinance practices.

Cost: Unknown

Timeline: Regional water plan extends through 2050

3. **Instream Flow-** The Georgia Environmental Protection Division (EPD) conducted resource assessments on current and predicted resource conditions based on projected population growth and resulting water demands through 2050. These assessments concluded that instream flow shortages were present under current and future demands in portions of the Satilla Basin.

   Action 1: Develop a regional water plan that recommends appropriate water management practices to ensure healthy aquatic ecosystems.

   Regulatory Agencies/Contacts: Georgia Department of Natural Resources (GA DNR)-Environmental Protection Division (EPD), Wildlife Resources Division (WRD), and Coastal Resources Division (CRD), USFWS, NMFS, FERC, US EPD, USACE, federal and state legislators, and local municipalities.

   Goal/Target: Ensure water quantity remains adequate to support all life stages of American shad and other aquatic organisms in the Satilla River.

   Progress: The Satilla River water management plan was officially adopted by GA EPD in November 2011 and recommended a suite of management practices, including those that reduce net consumption, replace surface water use with groundwater use, and improve data on frequency and magnitude of gaps (GA EPD 2011c).

   Cost: Unknown

   Timeline: Regional water plan extends through 2050

St. Marys River

Habitat Assessment

The St. Marys River originates in the Okenokee Swamp and flows for approximately 203 km before emptying into the Atlantic Ocean in Cumberland Sound while forming the eastern portion of the border between Florida and Georgia. The St. Marys watershed encompasses approximately 3,350 km^2 of which 59% is in Georgia and 41% in Florida. Tidal influence typically extends to rkm 88 and the fresh/saltwater interface occurs approximately 33 km upstream from the mouth of the river. No manmade barriers are present the entire length of the St. Marys River so all historical riverine and estuarine habitats remain available to juvenile and migrating adult American shad.

Threats Assessment

1. **Dissolved Oxygen-** Dissolved oxygen levels below 3 mg/L occur during low flow events in the months of July-September months of July-September in an approximately a

40 km segment of the tidally influenced portion of the St. Marys River. The St Marys River naturally has a low assimilative capacity and resulting low DO levels during summer low flow periods, therefore it may not be possible to maintain DO levels above 3 mg/L at all times. However, the actions listed below will still be beneficial.

Action 1: Develop a TMDL implementation plan.

Regulatory Agencies/Contacts: Georgia Department of Natural Resources (GA DNR)-Environmental Protection Division (EPD), Wildlife Resources Division (WRD), and Coastal Resources Division (CRD), FL FWC, FL DEP, St. Johns Water Management District, state legislators, and local municipalities

Goal/Target: Reduce organic loads to sustain acceptable DO levels.

Progress: GA DNR worked with representatives of local municipalities and conservation groups and developed a TMDL implementation plan that included a suite of management measure to reduce organic inputs in order to improve dissolved oxygen levels in the St. Marys River.

Cost: Unknown

Timeline: Unknown

Action 2: Develop a regional water plan that recommends appropriate water management practices to ensure healthy aquatic ecosystems.

Regulatory Agencies/Contacts: Georgia Department of Natural Resources (GA DNR)-Environmental Protection Division (EPD), Wildlife Resources Division (WRD), and Coastal Resources Division (CRD), USFWS, NMFS, FERC, US EPD, USACE, federal and state legislators, and local municipalities.

Goal/Target: Ensure water quantity remains adequate to support all life stages of American shad and other aquatic organisms in the St. Marys River.

Progress: In 2008, the Georgia General Assembly, as part of the Statewide Comprehensive Water Management Plan, established 10 regional water planning councils that encompassed the 14 major river systems within Georgia. With technical guidance from GA EPD, these councils were tasked with developing regional water plans that outlined management practices to meet future water needs for both water quantity and water quality through 2050. In November 2011, the ten regional water plans were officially adopted by GA EPD.

The Suwannee-Satilla-St Marys Council recommended a suite of surface water quality management practices in a phased approach to address water quality gaps, including stream segments with limited localized dissolved oxygen assimilative capacity and insufficient wastewater permit capacity (GA EPD 2011c). Specific actions to add/improve infrastructure and improve flow and water quality conditions were identified and recommended. These recommendations include such practices as the additional sustainable development of groundwater and surface water in areas with sufficient water supply; best management practices for water quality issues such as non-point source runoff, nutrient loadings, and TMDLs in the region; and additional educational and ordinance practices.

Cost: Unknown

Timeline: Regional water plan extends through 2050

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Weller, R. R., and C. Robbins. 2001. Food habits of flathead catfish in the Altamaha River System, Georgia. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. 53(1999):35-41.

FIELD_NUM	SITE_NUM	Date_	WATERBODY	COUNTY	X	Y	Datum	UTM	NO_UN_COLL	NO_GAS_SPE	UNION_PRES	CORB_PRES	GAST_PRES	GASTROPOD	SNAME	LIVE
JMW080617.1	2494	6/17/2008	Ocmulgee R.	Jasper	236699	3687163	NAD 83	17 N	1	1	Y	Y	Y	N	Elliptio sp. Cf angustata	N
JMW080617.1	2494	6/17/2008	Ocmulgee R.	Jasper	236699	3687163	NAD 83	17 N	1	1	Y	Y	Y	Y	Physa sp.	Y
JMW080617.2	2495	6/17/2008	Ocmulgee R.	Jasper	236544	3684360	NAD 83	17 N	3	3	Y	Y	Y	Y	Elimia sp.	Y
JMW080617.2	2495	6/17/2008	Ocmulgee R.	Jasper	236544	3684360	NAD 83	17 N	3	3	Y	Y	Y	Y	Campeloma sp.	Y
JMW080617.2	2495	6/17/2008	Ocmulgee R.	Jasper	236544	3684360	NAD 83	17 N	3	3	Y	Y	Y	Y	Planorbiidae sp.	Y
JMW080617.2	2495	6/17/2008	Ocmulgee R.	Jasper	236544	3684360	NAD 83	17 N	3	3	Y	Y	Y	N	Elliptio hopetonensis	Y
JMW080617.2	2495	6/17/2008	Ocmulgee R.	Jasper	236544	3684360	NAD 83	17 N	3	3	Y	Y	Y	N	Elliptio sp. Cf angustata	Y
JMW080617.2	2495	6/17/2008	Ocmulgee R.	Jasper	236544	3684360	NAD 83	17 N	3	3	Y	Y	Y	N	Elliptio sp. (lanceolate)	Y
JMW120606.6	2820	6/6/2012	Lake Jackson	Jasper	235659	3696464	NAD 83	17 N	3	1	Y	Y	Y	Y	Campeloma sp.	N
JMW120606.6	2820	6/6/2012	Lake Jackson	Jasper	235659	3696464	NAD 83	17 N	3	1	Y	Y	Y	N	Alasmidonta arcula	Y
JMW120606.6	2820	6/6/2012	Lake Jackson	Jasper	235659	3696464	NAD 83	17 N	3	1	Y	Y	Y	N	Pyganodon gibbosa	Y
JMW120606.6	2820	6/6/2012	Lake Jackson	Jasper	235659	3696464	NAD 83	17 N	3	1	Y	Y	Y	N	Utterbackia imbecillis	Y
JMW120606.5	2821	6/6/2012	Lake Jackson	Jasper	237623	3699451	NAD 83	17 N	2	0	Y	Y	N	N	Pyganodon gibbosa	Y
JMW120606.5	2821	6/6/2012	Lake Jackson	Jasper	237623	3699451	NAD 83	17 N	2	0	Y	Y	N	N	Utterbackia imbecillis	Y
JMW120606.4	2822	6/6/2012	Lake Jackson	Newton	233564	3697089	NAD 83	17 N	3	0	Y	Y	N	N	Pyganodon gibbosa	Y
JMW120606.4	2822	6/6/2012	Lake Jackson	Newton	233564	3697089	NAD 83	17 N	3	0	Y	Y	N	N	Utterbackia imbecillis	Y
JMW120606.4	2822	6/6/2012	Lake Jackson	Newton	233564	3697089	NAD 83	17 N	3	0	Y	Y	N	N	Alasmidonta arcula	N
JMW120606.3	2823	6/6/2012	Yellow R.	Newton	232475	3699599	NAD 83	17 N	1	0	Y	Y	N	N	Utterbackia imbecillis	Y
JMW120606.2	2824	6/6/2012	Lk. Jackson	Newton	235353	3698341	NAD 83	17 N	3	0	Y	Y	Y	Y	Campeloma sp.	Y
JMW120606.2	2824	6/6/2012	Lk. Jackson	Newton	235353	3698341	NAD 83	17 N	3	0	Y	Y	Y	N	Pyganodon gibbosa	Y
JMW120606.2	2824	6/6/2012	Lk. Jackson	Newton	235353	3698341	NAD 83	17 N	3	0	Y	Y	Y	N	Alasmidonta arcula	Y
JMW120606.2	2824	6/6/2012	Lk. Jackson	Newton	235353	3698341	NAD 83	17 N	3	0	Y	Y	Y	N	Utterbackia imbecillis	Y
JMW120606.1	2825	6/6/2012	Lk. Jackson	Newton	235531	3699128	NAD 83	17 N	3	1	Y	Y	Y	Y	Campeloma sp.	Y
JMW120606.1	2825	6/6/2012	Lk. Jackson	Newton	235531	3699128	NAD 83	17 N	3	1	Y	Y	Y	N	Pyganodon gibbosa	Y
JMW120606.1	2825	6/6/2012	Lk. Jackson	Newton	235531	3699128	NAD 83	17 N	3	1	Y	Y	Y	N	Utterbackia imbecillis	Y
JMW120606.1	2825	6/6/2012	Lk. Jackson	Newton	235531	3699128	NAD 83	17 N	3	1	Y	Y	Y	N	Alasmidonta arcula	Y
JMW140514.2	2952	5/14/2014	Alcovy R.	Newton	237303	3704044	NAD 83	17 N	2	3	Y	Y	Y	Y	Elimia catenaria	Y
JMW140514.2	2952	5/14/2014	Alcovy R.	Newton	237303	3704044	NAD 83	17 N	2	3	Y	Y	Y	N	Elliptio angustata	N
JMW140514.2	2952	5/14/2014	Alcovy R.	Newton	237303	3704044	NAD 83	17 N	2	3	Y	Y	Y	Y	Somatogyrus alcoviensis	Y
JMW140514.2	2952	5/14/2014	Alcovy R.	Newton	237303	3704044	NAD 83	17 N	2	3	Y	Y	Y	Y	Elimia sp.	Y
JMW140514.2	2952	5/14/2014	Alcovy R.	Newton	237303	3704044	NAD 83	17 N	2	3	Y	Y	Y	N	Villosa delumbis	Y

FIELD_NUM	NUM_LIVE	NUM_FD	NUM_SHELLS	EFFORT	SITE_DESC	BEST_SOURC
JMW080617.1	0	2	0	135	~1.9 km downstream of S.R. 16. ~13.5 km W of Monticello, GA.	J. Wisniewski
JMW080617.1				135	~1.9 km downstream of S.R. 16. ~13.5 km W of Monticello, GA.	J. Wisniewski
JMW080617.2				225	~5.0 km downstream of S.R. 16. ~14.1 km WSW of Monticello, GA.	J. Wisniewski
JMW080617.2				225	~5.0 km downstream of S.R. 16. ~14.1 km WSW of Monticello, GA.	J. Wisniewski
JMW080617.2				225	~5.0 km downstream of S.R. 16. ~14.1 km WSW of Monticello, GA.	J. Wisniewski
JMW080617.2				225	~5.0 km downstream of S.R. 16. ~14.1 km WSW of Monticello, GA.	J. Wisniewski
JMW080617.2				225	~5.0 km downstream of S.R. 16. ~14.1 km WSW of Monticello, GA.	J. Wisniewski
JMW080617.2				225	~5.0 km downstream of S.R. 16. ~14.1 km WSW of Monticello, GA.	J. Wisniewski
JMW120606.6	0		1	60	On north bank in rear of Leverette Neck cove in the Alcovy River arm of lake. ~25.1 km S of Covington, GA, ~14.1 km NE of Jackson, GA.	J. Wisniewski
JMW120606.6	1			60	On north bank in rear of Leverette Neck cove in the Alcovy River arm of lake. ~25.1 km S of Covington, GA, ~14.1 km NE of Jackson, GA.	J. Wisniewski
JMW120606.6	2		0	60	On north bank in rear of Leverette Neck cove in the Alcovy River arm of lake. ~25.1 km S of Covington, GA, ~14.1 km NE of Jackson, GA.	J. Wisniewski
JMW120606.6	1		0	60	On north bank in rear of Leverette Neck cove in the Alcovy River arm of lake. ~25.1 km S of Covington, GA, ~14.1 km NE of Jackson, GA.	J. Wisniewski
JMW120606.5	4		0	80	Back of Rocky Ck. Cove on east side of the Alcovy R. arm of the lake. ~21.9 km S of Covington, GA.	J. Wisniewski
JMW120606.5	1		0	80	Back of Rocky Ck. Cove on east side of the Alcovy R. arm of the lake. ~21.9 km S of Covington, GA.	J. Wisniewski
JMW120606.4	18		0	100	Back of 4 cove on the east shore of the South River arm of the lake. ~13.1 km NE of Jackson, GA, ~24.8 km S of Covington, GA.	J. Wisniewski
JMW120606.4	18		0	100	Back of 4 cove on the east shore of the South River arm of the lake. ~13.1 km NE of Jackson, GA, ~24.8 km S of Covington, GA.	J. Wisniewski
JMW120606.4	0	0	1	100	Back of 4 cove on the east shore of the South River arm of the lake. ~13.1 km NE of Jackson, GA, ~24.8 km S of Covington, GA.	J. Wisniewski
JMW120606.3	1	0	0	60	~1.4 km downstream of SR 36 on LDB of river. ~21.8 km S of Covington, GA.	J. Wisniewski
JMW120606.2	1			60	Rear of Kitchen Neck Cove on west side of Alcovy R. arm of lake, ~900 meters down lake from bridge, ~23.4 km S of Covington, GA.	J. Wisniewski
JMW120606.2	1			60	Rear of Kitchen Neck Cove on west side of Alcovy R. arm of lake, ~900 meters down lake from bridge, ~23.4 km S of Covington, GA.	J. Wisniewski
JMW120606.2	6			60	Rear of Kitchen Neck Cove on west side of Alcovy R. arm of lake, ~900 meters down lake from bridge, ~23.4 km S of Covington, GA.	J. Wisniewski
JMW120606.2	2			60	Rear of Kitchen Neck Cove on west side of Alcovy R. arm of lake, ~900 meters down lake from bridge, ~23.4 km S of Covington, GA.	J. Wisniewski
JMW120606.1	1			240	Rear of Connally Cove in Alcovy R. arm of lake. Just south of road and marina. ~23.1 km S of Covington, GA.	J. Wisniewski
JMW120606.1	5			240	Rear of Connally Cove in Alcovy R. arm of lake. Just south of road and marina. ~23.1 km S of Covington, GA.	J. Wisniewski
JMW120606.1	2			240	Rear of Connally Cove in Alcovy R. arm of lake. Just south of road and marina. ~23.1 km S of Covington, GA.	J. Wisniewski
JMW120606.1	1			240	Rear of Connally Cove in Alcovy R. arm of lake. Just south of road and marina. ~23.1 km S of Covington, GA.	J. Wisniewski
JMW140514.2	10		0	200	Factory Shoals, ~115 meters DNS of Factory Bridge Road. ~17.2 km S of Covington, GA.	
JMW140514.2	0		2	200	Factory Shoals, ~115 meters DNS of Factory Bridge Road. ~17.2 km S of Covington, GA.	
JMW140514.2	3		0	200	Factory Shoals, ~115 meters DNS of Factory Bridge Road. ~17.2 km S of Covington, GA.	
JMW140514.2	3		0	200	Factory Shoals, ~115 meters DNS of Factory Bridge Road. ~17.2 km S of Covington, GA.	
JMW140514.2	1		0	200	Factory Shoals, ~115 meters DNS of Factory Bridge Road. ~17.2 km S of Covington, GA.	

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Aquatic Conserv: Mar. Freshw. Ecosyst. **19**: 170–177 (2009)

Published online 23 September 2008 in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/aqc.980

Post-release movements and habitat use of robust redhorse transplanted to the Ocmulgee River, Georgia[‡]

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ABSTRACT

1. Robust redhorse *Moxostoma robustum* is an imperiled, potadromous fish in the south-eastern USA. Initial recovery efforts have focused on supplementing existing populations and establishing refugial populations through extensive stocking programmes. However, assessment of the success of these programmes has not yet been conducted, and there are few reports evaluating the effectiveness of such programmes with other potadromous species.
2. Radio telemetry was employed to assess the effectiveness of a stocking programme aimed at addressing whether stocked individuals would remain in an area free of introduced predators and ascertaining the ability of stocked fish to integrate into a resident population.
3. Hatchery-reared robust redhorse were captured from refugial populations established in other river systems and were transferred to the Ocmulgee River, Georgia where a population of hatchery-reared individuals and an unknown number of wild fish reside.
4. These transferred robust redhorse exhibited an exploratory phase for the first 3 months before adopting behaviour patterns, including spawning migrations, that were consistent with those reported for wild fish in other systems. However, some individuals seemed unable to locate suitable spawning habitat.
5. Approximately half of the radio-tagged fish remained within the area free of introduced predators.
6. At least some radio-tagged robust redhorse fully integrated into the resident population as evidenced by their presence in spawning aggregations with resident individuals.
7. The effectiveness of a stocking programme is dependent upon the ability of stocked individuals to integrate into an existing population or replicate the behaviour and functionality of a resident population. Evaluations of stocking programmes should incorporate assessments of behaviour in addition to surveys to estimate abundance and survivorship and genetic assessments of augmentation of effective population sizes.

Published in 2008 by John Wiley & Sons, Ltd.

Received 24 October 2007; Revised 29 January 2008; Accepted 25 February 2008

KEY WORDS: post-release behaviour; robust redhorse; Catostomidae; stocking program assessment; radio telemetry

INTRODUCTION

The use of hatchery-reared fish has become a common and controversial conservation strategy to supplement existing or to establish new populations of threatened and endangered species (Levin *et al*., 2001; Brannon *et al*., 2004). Numerous studies demonstrate that hatchery-reared fish are not necessarily equivalent to their wild counterparts (for reviews see Munro and Bell, 1997 and Huntingford, 2004). Frequently hatchery-reared fish exhibit higher energy expenditures, higher mortality rates or lower reproductive success than wild individuals; this apparent reduced fitness has been attributed

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to both their naiveté and unfamiliarity with the local environment, such as the location of refuge, foraging, and spawning habitats (Cresswell, 1981; Helfrich and Kendall, 1982; McGinnity *et al*., 2004); the presence of predators or competitors (Olla *et al*., 1998; Kellison *et al*., 2000; Bettinger and Bettoli, 2002; Schooley and Marsh, 2007); and fluctuating or unfamiliar abiotic conditions (Bettinger and Bettoli, 2002; Ward and Hilwig, 2004). The differences in performance and survival between hatchery-reared individuals and their wild counterparts become less pronounced as hatchery-reared fish acclimatize to local conditions (for a review see Huntingford, 2004).

Often, the long-term success of a stocking effort may be defined during the acclimatization process as hatchery-reared fish become integrated into the existing population (Huntingford, 2004). For potadromous and diadromous species, integration into an existing population must include learning both the appropriate cues for initiating migratory behaviour in a particular system and the locations of suitable spawning habitat used by resident fish. Attempts to use hatchery-reared individuals as part of a conservation strategy for potadromous or diadromous fish have yielded mixed results. Despite efforts to imprint individuals to 'natal' spawning habitats, hatchery-reared salmonids and sturgeon exhibit a much greater propensity to stray or wander than wild fish (Quinn, 1993; Smith *et al*., 2002; Jonsson *et al*., 2003a,b). Hatchery-reared individuals also tend to exhibit much higher activity levels immediately after stocking than at later post-stocking times, often leading to the dispersal of a significant proportion of sexually immature stocked individuals out of the population they were meant to augment (Cresswell, 1981; Mueller *et al*., 2003).

Robust redhorse is an imperiled catostomid species listed as endangered by the state of Georgia, and has a conservation and recovery strategy heavily dependent upon the use of hatchery-reared individuals. Like many catostomid species, there is relatively little information available upon which to base an assessment of the strategy's success (Cooke *et al*., 2005). Robust redhorse was originally described in 1869, but was 'lost to science' until its 'rediscovery' in 1991 (Cope, 1869; Bryant *et al*., 1996; Ruetz and Jennings, 2000). The species seems to have been extirpated from much of its range, but native populations persist in the Piedmont and upper coastal plain regions of three Atlantic Slope rivers (the Altamaha, Savannah, and Pee Dee drainages) in North Carolina, South Carolina, and Georgia (Bryant *et al*., 1996; Ruetz and Jennings, 2000). Conservation and recovery efforts have identified the goal of locating and/or establishing six self-sustaining populations of robust redhorse as a top priority (Robust Redhorse Conservation Committee, 2002). The captive propagation and release of individuals has been the primary means by which this target is being reached. To this end, robust redhorse have been introduced to the Broad and Ogeechee rivers in Georgia and in the Wateree and Broad rivers in South Carolina. In addition, a candidate conservation agreement with assurances (CCAA) for the robust redhorse was developed as a collaborative effort between Georgia Power, Georgia Department of Natural Resources, and the US Fish and Wildlife Service to expedite the stocking of the robust redhorse into the Ocmulgee River, Georgia to supplement an existing population of unknown size (DeMeo, 2001; R. Self, South Carolina Department of Natural Resources, personal communication). However, there has been little assessment of the post-release dispersal, movements, and habitat use of robust redhorse at this time, and there has not yet been long-term monitoring of these populations. Wild adults are potadromous and make long-distance upstream migrations (>100 km) to spawning habitat in spring (Grabowski and Isely, 2006). Adult robust redhorse also demonstrate a high degree of fidelity and specificity to both spawning sites and home ranges (Grabowski and Isely, 2006, 2007). Whether hatchery-reared, stocked fish can adopt a similar behavioural pattern without imprinting on local conditions during early life history stages is unclear. This uncertainty also can be associated with the reintroduction and conservation efforts for this species in rivers where hatchery-reared individuals have been used to augment existing populations or establish new ones.

Radio telemetry was used to assess the movement patterns and habitat use of robust redhorse stocked into the Ocmulgee River. The study fish were naturalized, hatchery-reared individuals collected from stocked populations in other river systems; these individuals originated from the same evolutionarily significant unit as the reintroduced population in the Ocmulgee River. The use of these transplanted naturalized individuals enabled evaluation of the ability of stocked fish to acclimatize to a new river system and integrate into an existing population without having to account for the effects of hatchery fish adjusting to the natural conditions, such as navigating in flowing water and locating food and shelter.

METHODS

Study area

The Ocmulgee River is about 400 km long and drains approximately 9900 km^2 in the Piedmont and Coastal Plain physiographic provinces of central Georgia. It is one of two major tributaries that merge to form the Altamaha River (Figure 1). This study focused primarily on a 30-km reach of the Ocmulgee River bounded upstream by Lloyd Shoals Dam near the city of Jackson, Georgia and downstream by Juliette Dam in the town of Juliette, Georgia (Figure 1). Lloyd Shoals Dam is a main-stem hydroelectric facility and is an impassable barrier to upstream fish migration, whereas Juliette Dam is a low-head dam passable only in the downstream direction. This 30-km reach was selected by the Robust Redhorse Conservation Committee as a suitable location for establishing a refugial population because it contains suitable robust redhorse habitat, including several potential spawning sites, and was thought to be free of introduced predators (DeMeo, 2001). Predation by flathead catfish *Pylodictis olivaris* has been hypothesized to be a contributing factor in the decline of robust redhorse in the Altamaha River system since its introduction in the 1970s (Bart *et al*., 1994; Cooke *et al*., 2005). Although the species is prevalent throughout much of the system, Juliette Dam had apparently blocked its upstream movement (DeMeo, 2001). However, recent reports suggest that flathead catfish may be present and in the process of becoming established in this reach of the Ocmulgee River (J. Evans, Georgia Department of Natural Resources, personal communication). Robust redhorse were first stocked into this reach of the Ocmulgee River in 2002 and 13 095 individuals ranging from fingerlings to young adults (age 5) have been stocked as of 2005 (J. Evans, Georgia Department of Natural Resources, personal communication). These fingerlings are the progeny of broodstock captured from the Oconee River, Georgia, another component of the Altamaha River basin.

Data collection

Standard boat electrofishing techniques were used to collect adult and subadult robust redhorse from refugial populations established in the Broad River and Ocmulgee River of Georgia during March and early April 2006. Like the Ocmulgee River population, these populations were established with the progeny of broodstock collected from the Oconee River. A total of 30 adult and subadult robust redhorse were captured from the Broad River ($n=10$; 8 males, 2 females) and the Ogeechee River ($n=20$; 16 males, 4 females). Individuals captured from the Broad River were larger (513–573 mm TL, 1644–2778 g) than those from the Ogeechee River (429–502 mm TL, 1021–1843 g). All fish were transported to outdoor holding facilities at the University of Georgia.

A frequency-coded radio transmitter with trailing wire antenna (Advanced Telemetry Systems, Isanti, Minnesota) was surgically implanted into each fish. Transmitters weighed approximately 26.0 g in air and did not exceed the maximum 2.0% of the body weight of the fish as recommended by Winter (1996). The transmitters had a manufacturer guaranteed battery life of 360 days. Each fish was anaesthetized by immersion in a $140\,\mathrm{mg\,L^{-1}}$ buffered MS-222 solution. The fish was removed from this solution, placed in a surgical cradle, and kept sedated by pumping a $70\,\mathrm{mg\,L^{-1}}$ buffered MS-222 solution over the gills. A radio transmitter was implanted into the peritoneal cavity, and the whip antenna exited the body via a separate portal created by a lopher surgical needle 3–4 cm posterior to the incision (Ross and Kleiner, 1982). The entire surgery for each individual was completed in 5–7 min, and all radio-tagged fish were allowed to recover for 8 days before release.

Thirty radio-tagged robust redhorse were released into the Ocmulgee River immediately below Lloyd Shoals Dam at river kilometre (rkm) 393.95 on 19 April 2006 and subsequently were relocated weekly by boat or canoe for the duration of the transmitters' battery life. Shoals and other obstructions rendered approximately 10 rkm between Lloyd Shoals Dam and Juliette Dam and 40 rkm between Juliette Dam and Macon, Georgia navigable only by canoe when flows and water levels allowed (Figure 1). Therefore, radio-tagged robust redhorse occupying these river segments were relocated less often relative to their counterparts in more navigable portions of the river. Fish were located by using an ATS R2100 programmable scanning radio receiver (Advanced Telemetry Systems, Isanti, Minnesota[1]) with a loop antenna. The precise location of the fish was determined by disconnecting the coaxial cable from the antenna and using it as a low-sensitivity, low-gain antenna to determine the position of the tagged fish to within 1 m. When the end of the coaxial cable was dipped into the water and pointed straight downwards, the signal from a radio-tagged individual could only be detected when directly above it. Once the position of the fish had been fixed, latitude and longitude were determined with a hand-held GPS receiver and recorded. Later, fish position was converted from latitude and longitude to rkm with ArcGIS 9.2 mapping software (Environmental Systems Research Institute, Redlands, California[1]). Depth, temperature, dissolved oxygen (DO), turbidity, and bottom current velocity also were recorded at each location. In addition, the substrate composition (muddy, sandy, or rocky) and dominant available cover (none, woody debris, boulders) with which each fish was associated was assessed qualitatively.

[1] Reference to trade names does not constitute US Government endorsement of commercial products.

Data analysis

Absolute distance moved, displacement, and estimates of minimum daily movement were calculated for each radio-tagged robust redhorse by season. Absolute distance moved was defined as the absolute value of distance moved between relocations and calculated as $|P_{t+1}-P_t|$, where P_t is an individual's position in rkm at time t and P_{t+1} is that same individual's position at time $t+1$. Displacement, defined as the net distance moved, was calculated as $P_{t+1}-P_t$. Upstream movements are indicated by a positive number and downstream movements by a negative one. Seasonal absolute movement and displacement were calculated by summing for each individual over a season. Student's t-tests were used to evaluate the null hypotheses that mean seasonal displacement was not different from zero (Zar, 1996), which would suggest that movement was not directional. The hypothesis that these values differed seasonally (fixed effects) was tested with a mixed model analysis of variance (ANOVA) while controlling for individuals and position relative to Juliette Dam (random effects) (Zar, 1996). Dunnett's means separation was used to identify differences in treatment means (Zar, 1996). ANOVA was used to evaluate seasonal and positional (relative to Juliette Dam) differences in mean depth, temperature, DO, and turbidity. Seasonal and positional differences in substrate and cover were assessed with a χ^2 analysis. All means are reported $\pm$ 1 SE unless otherwise noted. A significance level of $\alpha=0.05$ was used for all tests.

RESULTS

Radio-tagged fish were relocated 1041 times between April 2006 and May 2007. Individuals were relocated from four to 83 times, averaging 37.2 ± 4.4 observations per individual. Two of the radio-tagged fish met with unknown fates. These individuals were not relocated during the course of this study and were presumed dead. An additional four fish died or shed their transmitters during this study (one in May 2006; two in August 2006; one in September 2006) and were removed from further analysis. The mortality rate for the radio-tagged robust redhorse stocked into the Ocmulgee River was 20.0%.

General movement patterns

The radio-tagged robust redhorse transplanted to the Ocmulgee River can be roughly separated into two groups: those that remained in the study reach between Lloyd Shoals Dam (hereafter referred to as upstream fish) and Juliette Dam and those that passed Juliette Dam (hereafter referred to as

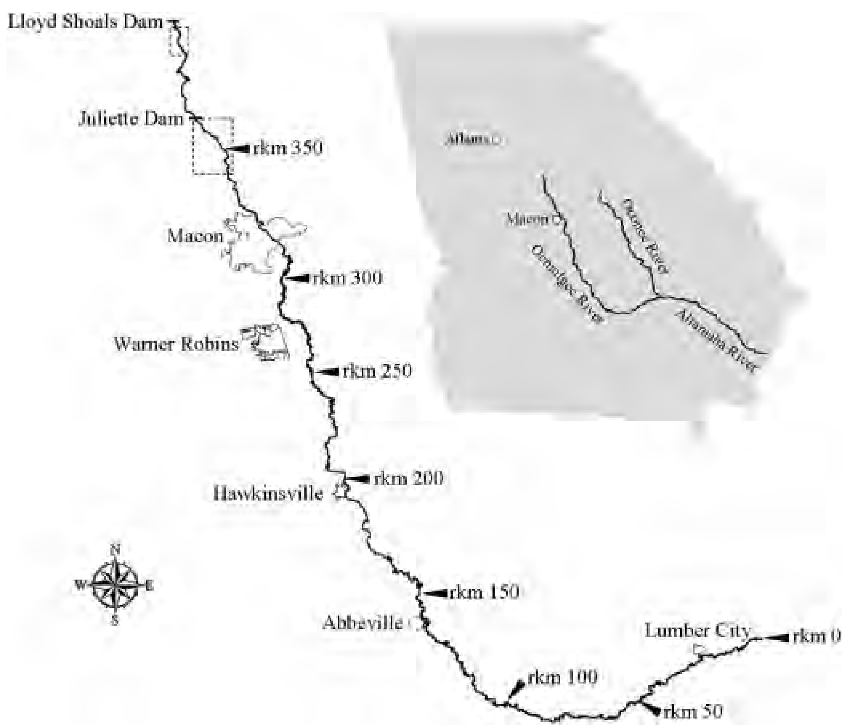

Figure 1. The Ocmulgee River from its confluence with the Oconee River at rkm 0 to Lloyd Shoals Dam at rkm 394.5. Areas highlighted by dashed lines indicate non-navigable portions of the river. Inset shows the position of the Altamaha River systems in the state of Georgia.

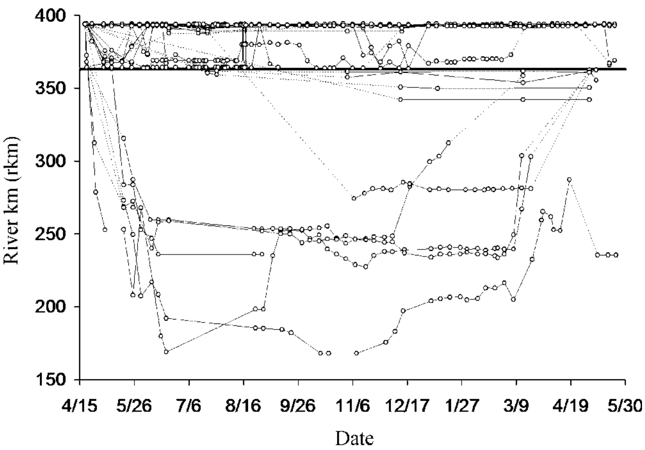

Figure 2. Location (rkm) of radio-tagged robust redhorse released in the Ocmulgee River, Georgia April 2006–June 2007. Location of Juliette Dam is represented by the solid horizontal line at rkm 362.5. Dashed lines indicate periods where that individual was not found.

downstream fish). Eighteen of the 28 surviving individuals remained upstream of Juliette Dam. These fish seemed to undergo an exploratory period that lasted until mid-June 2006, and made frequent movements between Lloyd Shoals Dam and Juliette Dam (Figure 2). The majority of upstream fish seemed to establish home ranges near their release point after this initial exploratory period. A few individuals made seasonal shifts in home range, spending summer, fall and winter near Juliette Dam and moving up to Lloyd Shoals during spring (Figure 2). In late July and early August, the oxygenation system at Lloyd Shoals Dam failed, which resulted in hypoxic conditions for several kilometres downstream. During this period, the radio-tagged robust redhorse left this area and resettled in positions either in the non-navigable portion of the river or near Juliette Dam and returned to their previous locations within 2 weeks after DO levels had returned to normal. The 10 downstream fish exhibited a similar exploratory period of consistent downstream movement interspersed with erratic upstream movements. During this period, individuals below Juliette Dam were located as far downstream as rkm 167.95. Most of the downstream fish seemed to complete their exploratory period by mid-June 2006, but two individuals apparently did not establish long-term home ranges (Figure 2). All remaining analyses excluded these exploratory periods from consideration.

Habitat-use patterns

In general, radio-tagged robust redhorse remained within the confines of the main channel of the Ocmulgee River regardless of their position relative to Juliette Dam. However, there were two notable exceptions. On 10 May 2006, a fish was located in the Towaliga River, a small tributary of the Ocmulgee River approximately 5.5 km upstream of Juliette Dam. This individual moved back into the Ocmulgee River some time before it was relocated again on 24 May 2006. During high water events in mid-January 2007, one downstream fish was found on the floodplain about 50 m from the edge of the main river channel. This fish was not found in association with any smaller streams or tributaries of the Ocmulgee.

The habitat occupied by radio-tagged robust redhorse differed by season and/or their position relative to Juliette Dam. The type of substrate fish were associated with was related to position relative to Juliette Dam ($\chi^2 = 170.7$; d.f. = 2; $P < 0.0001$) but did not differ by season ($\chi^2 \leqslant 7.5$; d.f. = 6;

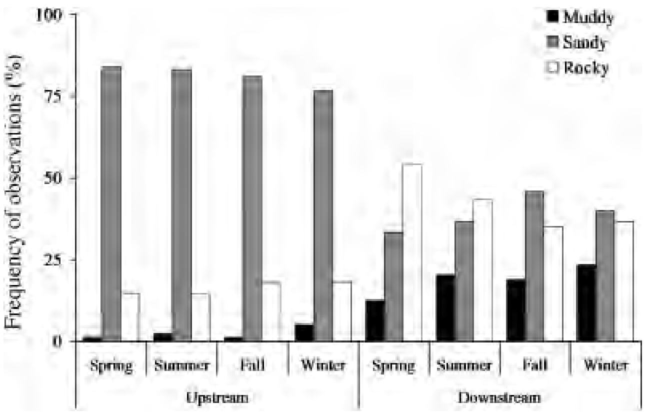

Figure 3. Seasonal frequency of observations over muddy, sandy, and rocky substrates of stocked radio-tagged robust redhorse upstream and downstream of Juliette Dam in the Ocmulgee River, Georgia, April 2006–June 2007.

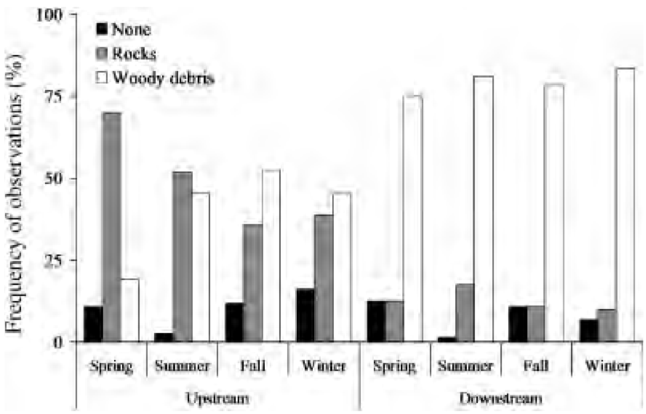

Figure 4. Seasonal frequency of observations of the cover (none, rocks, woody debris) used by stocked radio-tagged robust redhorse upstream and downstream of Juliette Dam in the Ocmulgee River, Georgia, April 2006–June 2007.

$P \geqslant 0.27$). Upstream fish were found primarily in association with sandy substrate (82.0%), whereas relocations of downstream fish were split among mud (20.0%), sand (39.0%), and rocky or gravel (41.0%) substrates (Figure 3). Likewise, the available cover a radio-tagged fish was likely to associate with was related to position relative to Juliette Dam ($\chi^2 = 108.1$; d.f. = 3; $P < 0.0001$). Downstream fish were located primarily in proximity to woody debris (80.0%), but their upstream counterparts were found primarily near rocks (51.9%) and woody debris (39.5%). Regardless of position relative to Juliette Dam, radio-tagged robust redhorse demonstrated seasonal shifts in the available cover with which they associated ($\chi^2 = 101.6$; d.f. = 9; $P < 0.0001$). A larger number of individuals were observed in association with rocks during spring (63.0%) than other seasons (28.1–46.7%) (Figure 4). Downstream fish were consistently found in deeper ($F_{7,856} = 19.33$; $P < 0.0001$) and faster-flowing ($F_{7,507} = 6.68$; $P < 0.0001$) water than their upstream counterparts regardless of season. On average downstream fish were located in water that was 2.53 ± 0.09 m deep and flowing at $0.21 \pm 0.02 \text{ m s}^{-1}$, whereas upstream fish were found in 1.82 ± 0.03 m of water with a current velocity of $0.11 \pm 0.01 \text{ m s}^{-1}$. Both upstream ($F_{3,693} = 4.25$; $P = 0.006$) and downstream ($F_{3,163} = 8.45$; $P < 0.0001$) fish exhibited seasonal differences in water depth and tended to be located in the deepest water during winter. Current velocity at locations occupied by radio-tagged robust redhorse upstream ($F_{3,89} = 0.017$; $P < 0.41$) or downstream ($F_{3,118} = 0.004$; $P = 0.94$) of Juliette Dam did not differ seasonally.

Seasonal movement patterns

These seasonal changes in habitat association seem to correspond to seasonal movement patterns of the radio-tagged robust redhorse. Radio-tagged robust redhorse exhibited seasonal differences in absolute movement ($F_{3,90} = 5.50$; $P = 0.002$) and were most active in the summer ($t_{90} \leqslant 3.21$; $P \leqslant 0.002$) when mean absolute movement was 49.0 ± 9.2 km (Figure 5). Individuals exhibited about the same level of activity across the other three seasons ($t_{90} \leqslant 0.00$; $P \geqslant 0.89$), moving approximately 16–17 km in autumn, winter, and spring. However, this movement was not directed upstream or downstream. Displacement also varied

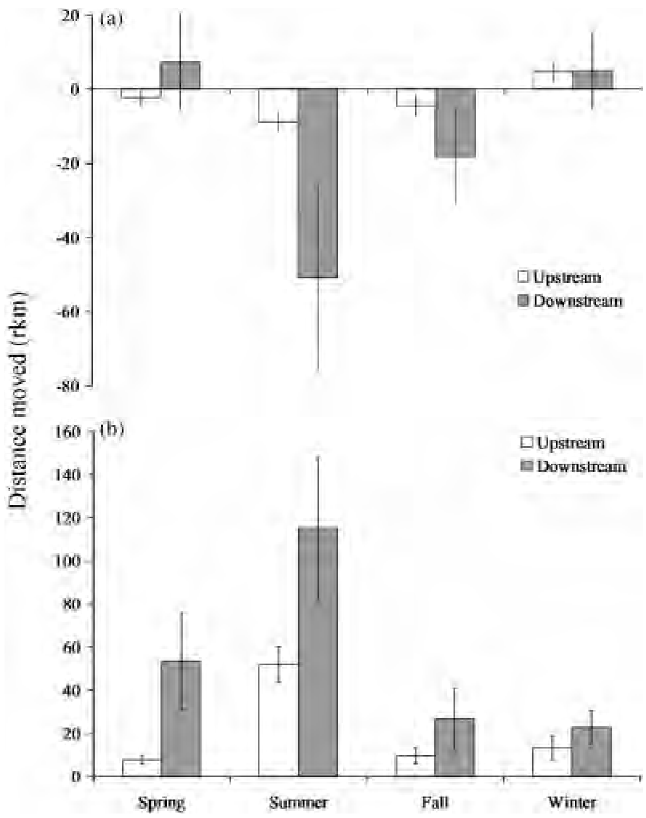

Figure 5. Mean seasonal displacement (a) and absolute movement (b) of stocked radio-tagged robust redhorse upstream and downstream of Juliette Dam in the Ocmulgee River, Georgia, April 2006–June 2007. Error bars represent standard error.

seasonally ($F_{3,90} = 3.19$; $P = 0.03$) with spring being the only season where net movement was upstream. Displacement for the other three seasons did not differ statistically from zero ($t_{90} \leqslant 0.90$; $P \geqslant 0.08$) (Figure 5).

DISCUSSION

Radio-tagged fish transplanted to the Ocmulgee River adopted behavioural patterns that were consistent with those reported for wild fish (Grabowski and Isely, 2006) within 90–120 days of their release. Before they were fully acclimatized to the Ocmulgee River, the radio-tagged fish exhibited an exploratory pattern of movement and behaviour, mostly in the downstream direction. A similar pattern was noted in younger, hatchery-reared robust redhorse stocked directly from rearing facilities in 2002 at the same location on the Ocmulgee River (Jennings and Shepard, 2003). These juveniles were still exhibiting consistent downstream movements 80 days after release when the radio-transmitters reached the end of their battery life. Approximately one-third of study fish passed Juliette Dam during the course of the 2002 study (Jennings and Shepard, 2003). Examples of similar periods of exploratory behaviour in stocked individuals can be found for numerous taxonomically diverse species including razorback sucker *Xyrauchen texanus* (Mueller *et al*., 2003), brown trout *Salmo trutta* (Aarestrup *et al*., 2005), and paddlefish *Polyodon spathula* (Pitman and Parks, 1994). However, the length of the exploratory period observed in the individuals transplanted to the Ocmulgee River suggest that many of these studies cited may have been of insufficient duration to determine if the study fish eventually settled into a pattern of behaviour typical of a wild fish.

After the radio-tagged robust redhorse completed their exploratory phase, differences in their habitat-use patterns seemed to be dependent upon their position relative to Juliette Dam. However, hydrologic and geomorphic differences between the two areas are the most probable explanation for the observed differences in habitat use. The Ocmulgee River above Juliette Dam is characteristic of a large Piedmont river with high gradient, shallow water, primarily gravel and sand substrate, and frequent shoals. Below Juliette Dam particularly downstream of Macon, Georgia, the Ocmulgee River becomes a coastal plain river and has a relatively low gradient, a meandering channel, predominantly sand and mud substrate, and frequent sand bars and deep pools that are typical of coastal plain rivers. A similar pattern was observed in the Savannah River where fish exhibited different habitat selection depending upon their position relative to a dam that served as a division between the piedmont and coastal plain regions of the river (Grabowski and Isely, 2006). Regardless of their position relative to Juliette Dam, radio-tagged robust redhorse were consistently found in the main channel associated with current, deep water, and physical structure, particularly woody debris. Occasionally, individuals left the main channel during high water events. This movement and habitat-use pattern is similar to the habitat preferences previously described for this species (Jennings and Shepard, 2003; Grabowski and Isely, 2006; R. Heise, North Carolina Wildlife Resources Commission, personal communication). In the Ocmulgee River, robust redhorse seem to be able to find suitable non-spawning habitat in both piedmont and coastal plain habitats that meet species-specific minimum standards of cover, depth, current velocity, and water quality.

Although the upstream-downstream differences seen in habitat use by radio-tagged robust redhorse probably are an artefact of differences of habitat quality and availability, the observed seasonal differences in movement and habitat use were consistent with those described for wild radio-tagged robust redhorse in other systems (Grabowski and Isely, 2006; R. Heise, North Carolina Wildlife Resources Commission, personal communication). The robust redhorse stocked into the Ocmulgee River eventually adopted behaviour patterns in which individuals were mostly sedentary and spent the majority of their time within a relatively small linear home range. This was demonstrated by the low mean seasonal absolute movement and dispersal, and the small seasonal ranges during spring, fall and winter. Late spring and early summer was the only exception to this sedentary lifestyle as fish generally became more active and most individuals initiated upstream migrations, presumably for the purpose of locating spawning habitat.

Despite many tagged robust redhorse making upstream movements in the spring, only two were observed as part of an aggregation of spawning resident fish. These two fish were found in shoal habitat approximately 1.0 rkm downstream of Juliette Dam. It was not possible to determine if the other radio-tagged fish below Juliette Dam participated in spawning activities. The radio-tagged robust redhorse above Juliette Dam did move upstream into Lloyd Shoals during spring. However, visual surveys by divers did not find suitable spawning habitat as described by Freeman and Freeman (2001) and Grabowski and Isely (2007) in the areas occupied by these individuals. This habitat in the form of mid-channel gravel bars is present above Juliette Dam; however, this study was conducted during a period of severe drought in central Georgia. Gravel bars upstream of Juliette Dam similar to those used by robust redhorse in other rivers (Freeman and Freeman, 2001; Grabowski and Isely, 2007) that potentially could have served as spawning habitat for robust redhorse were left exposed during spring and early summer. On the other hand, rocky shoal habitat similar to that used by spawning fish below Juliette Dam was readily available to the upstream individuals during the course of this study but did not seem to be used. Other hatchery-reared catostomids, such as razorback sucker (Marsh *et al*., 2005; Modde *et al*., 2005), have been observed associated with spawning aggregations of wild counterparts. However, the proportion of transplanted individuals able to successfully locate and participate in a spawning aggregation was not addressed in these studies.

The radio-tagged robust redhorse transplanted to the Ocmulgee River suffered a 20% mortality rate. This rate is comparable with mortality rates of wild radio-tagged robust redhorse in the Savannah River (Grabowski and Isely, 2006) and with hatchery-reared pallid sturgeon *Scaphirhynchus albus* (Jordan *et al*., 2006). Determining whether death was because of complications related to the surgical procedure performed on these individuals, unfamiliarity with local conditions, or natural causes was impossible. However, the relatively low mortality of transplanted fish acclimatized to natural conditions suggest that the majority of mortality experienced by stocked fish may be related to their naiveté about life outside the hatchery environment and not to their unfamiliarity with local conditions. The radio-tagged individuals transplanted to the Ocmulgee River had been living in natural conditions in other river systems for several years before being relocated and thus had been exposed to predators, competitors, fluctuating abiotic conditions, and patchy resources.

The use of hatchery-reared robust redhorse to establish a refugial population in the Ocmulgee River seems to be a viable strategy to aid in the recovery of this species. The stocked individuals did not leave the Ocmulgee River to enter the Altamaha or Oconee rivers, even during their exploratory period. Most of the fish that passed Juliette Dam adopted a behavioural pattern similar to that seen in wild fish (Grabowski and Isely, 2006; R. Heise, North Carolina Wildlife Resources Commission, personal communication), and a few even integrated into an existing population of robust redhorse, located suitable spawning habitat, and participated in spawning within a year of release. However, the presence of introduced predators such as flathead catfish raises concerns as to how successful these individuals will be in contributing to a self-sustaining population (Bart *et al*., 1994; Cooke *et al*., 2005).

At the conclusion of this study, about two-thirds of the fish released remained in the predator-free reach of the Ocmulgee River above Juliette Dam. These upstream individuals behaved comparably with their downstream counterparts and with wild robust redhorse in other systems, but whether they will be able to estbablish a self-sustaining population remains to be seen. In addition to concerns about the arrival of flathead catfish in this portion of the river, results indicate that radio-tagged robust redhorse in this portion of the river did not spawn successfully. They did initiate upstream spring migrations, presumably in preparation for spawning, but the fish either did not find suitable spawning habitat as described by Freeman and Freeman (2001) and Grabowski and Isely (2007) or environmental cues necessary to trigger spawning were absent. In other systems, such upstream migrations end at a spawning aggregation (Grabowski and Isely, 2006), but whether such aggregations occur in the Ocmulgee above Juliette Dam is unclear.

The results of this study suggest hatchery-reared individuals can be used to establish or augment a population of potadromous riverine fish. However, the results also demonstrate the importance of long-term monitoring programmes, including behavioural assessments for determining the success of stocking programmes. Relatively few stocking programmes, regardless of whether they are for economically important species or non-game species, are critically assessed beyond the level of a count survey to determine if the stocking has enabled the population to achieve a target size. Although this approach may be appropriate for programmes designed to augment or establish populations of recreationally or commercially important fish, ensuring the recovery and long-term viability of threatened and endangered species ultimately requires an assessment of both the genetic composition/contribution and the ecological functionality and equivalence of stocked populations before success can be declared. This study suggests that a population census may indicate that the stocking programme in the Ocmulgee River was very successful. There was high survivorship among the transplanted individuals, which would suggest that a large proportion of the individuals stocked into the river may have survived. However, relatively few of the radio-tagged individuals seemed to locate suitable spawning habitat and participate in spawning activities. Whether robust redhorse stocked in the Ocmulgee will eventually spawn in the study reach of the river remains to seen, but this population cannot be considered self-sustaining until the stocked fish are able to reproduce successfully with sufficient numbers of the offspring eventually recruiting to the adult population. These results emphasize the importance of applying multiple methodologies to assess the success of a stocking programme intended to augment or establish populations of imperiled fishes.

ACKNOWLEDGEMENTS

We thank Tyler Ferguson for his assistance with data collection in the field and Shannon Albeke and Kristin Meehan for their assistance with GIS data analysis. Funding for this study was provided by Georgia Power (Project number: 20-21-RR272-077). This manuscript benefited from the comments and suggestions of Michael Abney, Alice Lawrence, Rebecca Cull Peterson, Wayne Starnes, and Shawn Young. Cooperating agencies for the Georgia Cooperative Fish and Wildlife Research Unit are the US Geological Survey, the University of Georgia, Georgia Department of Natural Resources, and the Wildlife Management Institute. Reference to trade names does not imply endorsement by the US Government.

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Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 8:595–606, 2016
Published with license by the American Fisheries Society
ISSN: 1942-5120 online
DOI: 10.1080/19425120.2016.1243599

ARTICLE

Annual Spawning Migrations of Adult Atlantic Sturgeon in the Altamaha River, Georgia

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Abstract
The Atlantic Sturgeon *Acipenser oxyrinchus* has declined throughout its range, and the species is now protected under the U.S. Endangered Species Act. Information on the timing and extent of spawning migrations is essential for the development and implementation of effective management and recovery strategies, yet this information is lacking for most populations. The objectives of this study were to document and identify temporal and spatial patterns in the seasonal movements and spawning migrations of Atlantic Sturgeon in the South Atlantic distinct population segment. A stationary array of acoustic receivers was used to monitor the movements of 45 adults in the Altamaha River system, Georgia, from April 2011 through March 2014. Telemetry data revealed that putative adult spawners exhibited two distinct patterns of upriver migration: a spring two-step migration and a fall one-step migration. During the spring two-step migration, the adults appeared to stage in the upper Altamaha during the spring and early summer, before migrating to suspected spawning habitats in the Ocmulgee and Oconee tributaries during the fall. During the fall one-step migration, fish entered the system in late summer and migrated directly upriver to suspected spawning habitats in the Ocmulgee and Oconee tributaries. Regardless of which pattern was used during the upstream migration, all fish returned downstream and left the system by early January. Although direct evidence of spawning has not yet been obtained, the telemetry and environmental data provide strong circumstantial evidence that Atlantic Sturgeon spawning in the Altamaha population occurs only during the fall months when water temperatures are less than 25°C. These findings further illustrate the clinal variation in the life history of Atlantic Sturgeon and highlight the need to manage the species as distinct population segments with regionally specific recovery goals.

The Atlantic Sturgeon *Acipenser oxyrinchus* (family: Acipenseridae) is a large, long-lived fish that is broadly distributed along the Atlantic coast of North America. Historically, spawning populations occurred in virtually all major rivers from Ungava Bay, Canada, to as far south as the St. Johns River, Florida (Vladykov and Greeley 1963; Dadswell 2006). In total, this historical range included approximately 38 individual rivers, 35 of which supported discrete spawning populations (ASSRT 2007).

A decline in Atlantic Sturgeon abundance throughout their range has resulted in harvest restrictions and federally mandated protection. All U.S. Atlantic Sturgeon fisheries were closed in 1998 and the species was listed under the U.S. Endangered Species Act in 2012. At present, spawning

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Received March 23, 2016; accepted September 25, 2016

populations are supported in less than 20 rivers (ASSRT 2007). The healthiest populations are currently thought to reside in the Saint John and Saint Lawrence rivers, Canada (Dadswell 2006); the Hudson River, New York (Peterson et al. 2000; Kahnle et al. 2007); and the Altamaha River, Georgia (Schueller and Peterson 2010; Moyer et al. 2012). The paucity of quantified population assessments, however, makes river-specific comparisons difficult (ASSRT 2007).

Atlantic Sturgeon are anadromous, using riverine, estuarine, and marine habitats throughout their range. Although the majority of their life history is spent in marine and coastal waters, mature adults will return periodically every 1–5 years to freshwater rivers to spawn (Smith 1985). These migrations are important to optimizing reproductive success by partitioning resources at different life stages and preventing intraspecific competition (Smith et al. 1982; Bain 1997). Despite decades of research, many knowledge gaps remain regarding adult spawning migrations, particularly within the South Atlantic distinct population segment (SADPS).

Atlantic Sturgeon spawning sites have been identified in only a few river systems—mostly within northern rivers (ASSRT 2007). Within the southern portion of the range, however, spawning habitats of Atlantic Sturgeon have only been identified for the Edisto and Combahee rivers, South Carolina (Collins et al. 2000). Previous studies of spawning movements have shown that spawning occurs in the uppermost reaches of accessible river channels with moderate flows of 46–76 cm/s and depths of 11–27 m (Smith and Clugston 1997; Bain et al. 2000). The adhesive eggs are broadcast over hard-bottom substrates composed of gravel and cobble (Gilbert 1989; Smith and Clugston 1997; Sulak and Clugston 1998). Previous research, including both laboratory and field studies, suggest that water temperatures of 13–25°C are optimal for egg survival and hatching (Borodin 1925; Smith 1985; Kieffer and Kynard 1993; Hatin et al. 2002; Smith et al. 2015).

The timing of Atlantic Sturgeon spawning is highly variable at both the population and individual levels (Bemis and Kynard 1997). Most information regarding the timing of spawning has been obtained from populations at the northern end of the range, where spawning typically occurs from May to August (Bain 1997; Dadswell 2006). In rivers south of the Hudson, however, adults are often observed in riverine habitats during both spring and fall (Smith and Dingley 1984; McCord et al. 2007), and there is strong empirical evidence of fall spawning runs in Virginia (Balazik et al. 2012), South Carolina (Collins et al. 2000), and North Carolina (Smith et al. 2015).

In contrast to many of the other large river systems along the Atlantic coast, the Altamaha River system is a relatively pristine habitat for Atlantic Sturgeon (ASSRT 2007). Isolated rocky shoal habitats are abundant in the upper river above river kilometer (rkm) 160 and in both the Oconee and Ocmulgee tributaries (Litts and Kaeser 2016). Although both of these major tributaries are impounded in their upper reaches, the dams are located at or above the fall line. Consequently, migrating adults have access to virtually all historical spawning habitats dispersed over approximately 794 km of unimpounded riverine habitats (ASSRT 2007). As the largest and most undisturbed river system available to Atlantic Sturgeon within the SADPS, the Altamaha River provides a unique opportunity to better understand the spatial and temporal dynamics of the species' spawning migrations within the southern portion of its range. Consequently, the objectives of this study were to document and describe both the temporal and spatial aspects of the freshwater migrations of adult Atlantic Sturgeon in the Altamaha River system. Because the timing and locations of Atlantic Sturgeon spawning are largely unknown within the SADPS, the results of this research will be critical for future assessment of the spawning runs and habitat within the Altamaha River system.

METHODS

Study site.—The Altamaha River system, located entirely within Georgia, is formed by the confluence of the Oconee and Ocmulgee rivers (Figure 1). The main stem flows across the Atlantic coastal plain in a southeasterly direction for 207 km to the coast where it empties into the Atlantic Ocean near Darien, Georgia. Mid-channel depths average 2–3 m, with a maximum of 18 m in Altamaha Sound (Heidt and Gilbert 1978). The lower Altamaha estuary is characterized by a tidally flooded salt marsh that gradually gives way upstream to a cypress swamp. The location of the fresh–saltwater interface varies depending on flow but typically occurs between rkm 35 and 50 during normal flows (Rogers and Weber 1995). Tidal range averages 2 m, and tidal influence can persist as far upstream as rkm 60 (Sheldon and Alber 2002). Most of the Altamaha River's total discharge is contributed by the Ocmulgee (40%) and Oconee (36%) tributaries (Rogers and Weber 1995). Isolated rocky shoal habitats are found above rkm 80 in the Altamaha main stem and throughout the lower reaches of both major tributaries (Flournoy et al. 1992). Although both tributaries are impounded above the fall line, the biological effects of these dams are considered to be moderate (Dynesius and Nilsson 1994).

Fish sampling.—All methods for the capture and handling of Atlantic Sturgeon in this project were authorized under National Marine Fisheries Permit 16482 and by the University of Georgia's Institutional Animal Care and Use Committee (AUP A2013 01-012-R1). Adult Atlantic Sturgeon were captured from April to June of 2011–2013 with drift gill nets deployed in the lower portion of Altamaha Sound. These nets were constructed of multifilament meshes measuring 30.5, 35.6, and 40.6 cm (stretch measure) and were 91.44 m long and 3.05 m deep. Nets were deployed during the last 30 min of running tides and soaked continuously until the end of the subsequent slack tide—typically a period of about 1 h. Nets were tended continuously so that entangled fish could be removed immediately while the nets continued to fish. Upon capture, Atlantic Sturgeon were immediately transferred to a floating net pen (1 × 3 × 1 m)

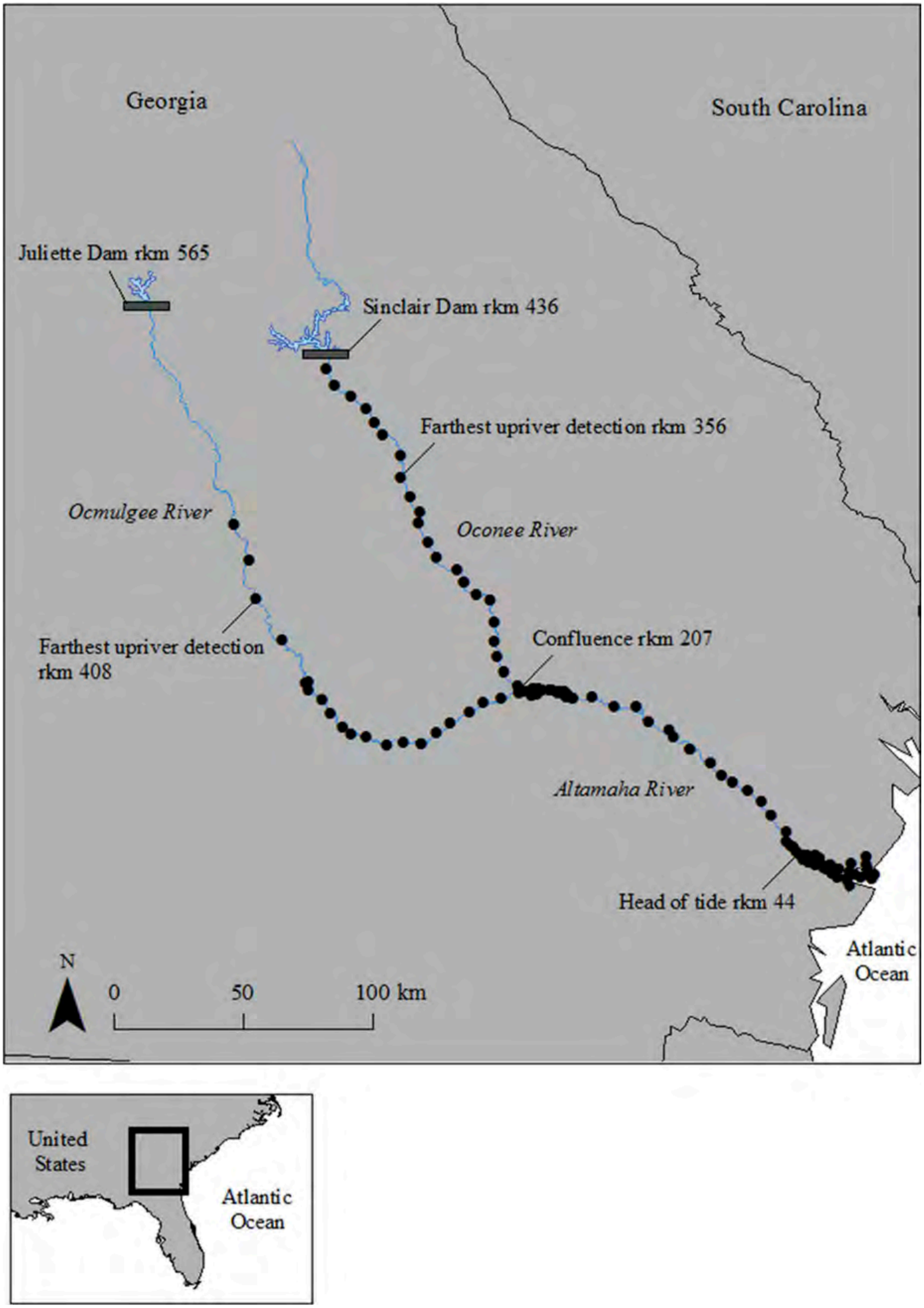

FIGURE 1. Map of the Altamaha River watershed, Georgia with inset showing relative location within the USA. Unique receiver station locations are represented by filled circles. Dams delineate the upper boundary of habitat accessible to Atlantic Sturgeon in the Ocmulgee and Oconee River tributaries. Maximum upstream detections of Atlantic Sturgeon in both tributaries and other relevant river kilometer (rkm) locations are indicated.

TABLE 1. Data associated with 42 adult Atlantic Sturgeon caught and tagged with sonic transmitters in the Altamaha River, Georgia, April 1, 2011 to March 31, 2014. Putative spawning migrations indicating spring two-step migration (S), fall one-step migration (F), or no observed migration (N), migration being defined as directed upstream movements of more than 160 km during a single year of the study.

Identifier	Release date	Fork length (mm)	Total length (mm)	Valid detections	Putative spawning migration pattern		
					Year 1	Year 2	Year 3
ATS-1	Apr 21, 2011	1,584	1,792	27,275	S	S	S
ATS-2	Apr 22, 2011	1,630	1,850	28,806	F	S	S
ATS-3	Apr 25, 2011	1,520	1,690	7,465	F	F	N
ATS-4	Apr 25, 2011	1,430	1,585	8,968	F	N	N
ATS-5	Apr 26, 2011	1,720	1,955	18,191	N	S	N
ATS-6	Apr 29, 2011	1,494	1,610	24,268	S	N	S
ATS-7	Apr 29, 2011	1,590	1,825	7,990	N	N	S
ATS-8	Apr 29, 2011	1,535	1,660	12,471	N	F	F
ATS-9	May 3, 2011	1,755	1,980	72	N	N	N
ATS-10	May 3, 2011	1,680	1,880	16	N	N	N
ATS-11	May 4, 2011	1,440	1,600	22,343	F	F	F
ATS-12	May 4, 2011	1,600	1,795	131	N	N	N
ATS-13	May 4, 2011	2,030	2,310	15,085	F	N	N
ATS-14	May 9, 2011	1,490	1,700	16,197	S	S	S
ATS-15	May 9, 2011	1,900	2,160	3,489	N	N	N
ATS-16	May 10, 2011	1,710	2,010	72	N	N	N
ATS-17	Apr 21, 2012	1,600	1,790	5,122		F	F
ATS-18	May 14, 2012	1,710	2,040	5,703		N	F
ATS-19	May 17, 2012	1,930	2,220	998		N	N
ATS-20	May 17, 2012	1,460	1,640	1		N	N
ATS-21	May 18, 2012	1,880	2,120	12,853		N	N
ATS-22	May 21, 2012	1,660	1,870	186		N	N
ATS-23	May 23, 2012	1,950	2,240	1		N	N
ATS-24	May 25, 2012	1,940	2,220	60,276		F	N
ATS-25	May 31, 2012	2,000	2,130	120,420		F	N
ATS-26	Jun 11, 2012	1,640	1,940	3,158		F	N
ATS-27	Jun 15, 2012	1,650	1,870	1,323		N	N
ATS-28	Apr 25, 2013	1,460	1,650	2,277			F
ATS-29	Apr 30, 2013	1,255	1,442	62,226			S
ATS-30	Apr 30, 2013	1,495	1,680	5,415			F
ATS-31	Apr 30, 2013	1,450	1,580	1,449			F
ATS-32	May 1, 2013	1,500	1,692	30			N
ATS-33	May 1, 2013	1,595	1,790	1			N
ATS-34	May 1, 2013	1,310	1,466	2,636			N
ATS-35	May 7, 2013	1,480	1,660	8,513			F
ATS-36	May 7, 2013	1,640	1,840	208			N
ATS-37	May 7, 2013	1,420	1,600	9,235			S
ATS-38	May 7, 2013	1,670	1,860	12,487			F
ATS-39	May 8, 2013	1,430	1,620	2,065			F
ATS-40	May 8, 2013	1,450	1,570	2,451			F
ATS-41	May 8, 2013	1,440	1,640	3,932			F
ATS-42	May 8, 2013	1,390	1,520	9			N

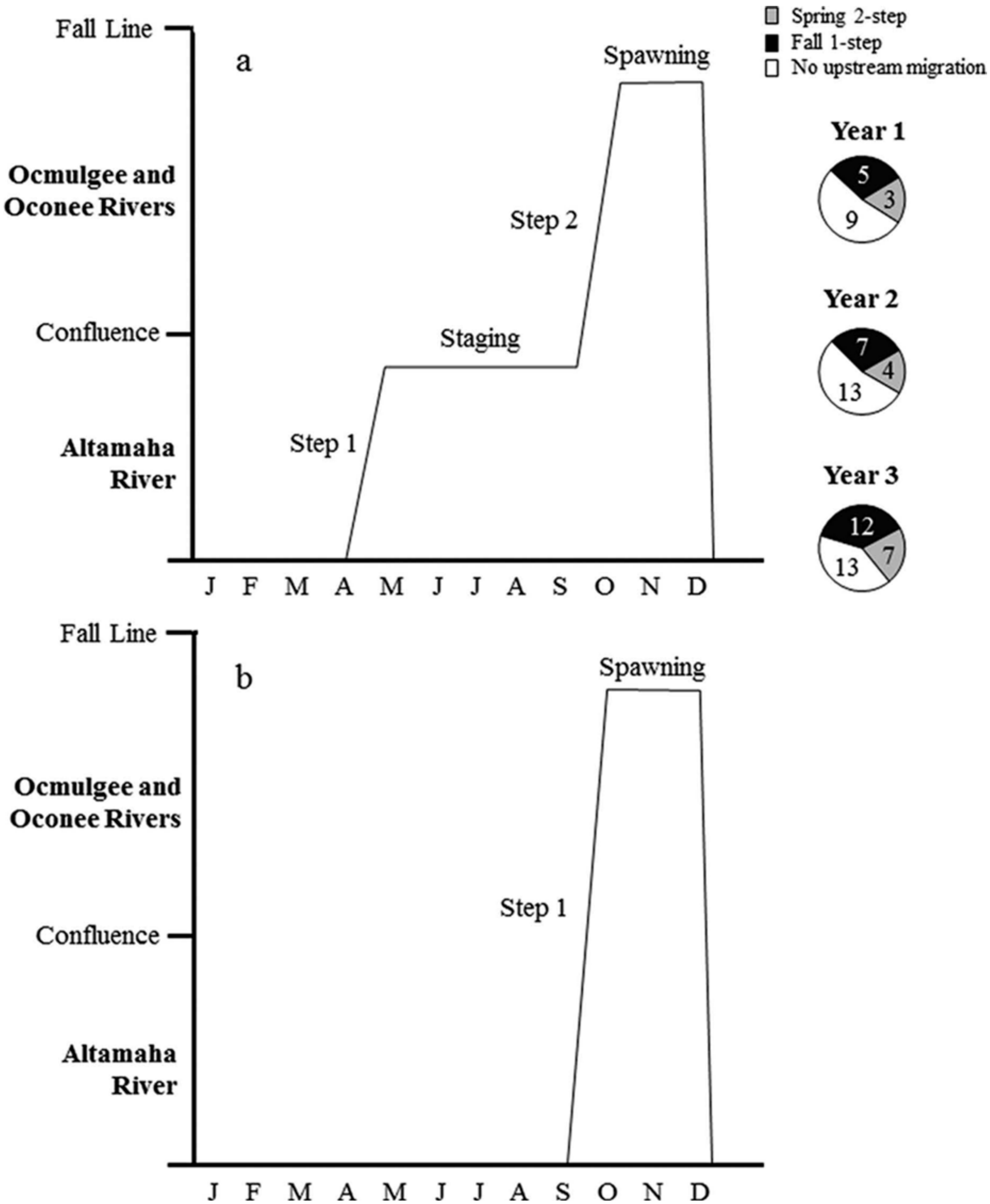

FIGURE 2. General representation of putative **(a)** spring two-step and **(b)** fall one-step spawning migrations of Atlantic Sturgeon in the Altamaha River system, Georgia. Pie charts show prevalence of each migration strategy documented using acoustic telemetry from study year 1 (April 1, 2011 to January 31, 2012), year 2 (April 1, 2012 to January 31, 2013), and year 3 (April 1, 2013 to January 31, 2014).

stationed near the vessel where they were allowed to recover until netting activities had been completed. After all nets had been retrieved, the captured fish were examined for internal and external tags. If none were found, a passive integrated transponder tag was inserted into the body musculature beneath the fourth dorsal scute. Measurements of total length, fork length, and weight were recorded. Coded VEMCO (Halifax, Nova Scotia) acoustic transmitters (V16-6 H; 69 khz; tag delay 30–90 s; estimated battery life = 1,633 d) were then surgically implanted into each individual fish using the surgical methods described by Moser et al. (2000) and Boone et al. (2013). Following surgeries, the fish were returned to the net pen and monitored for 5–10 min until they had fully recovered before being released at their original capture site.

Passive acoustic telemetry.—To monitor movements of acoustically tagged fish, a station array consisting of 112 acoustic receivers (VEMCO VR2W) with omnidirectional hydrophones was deployed over a total of 670 km throughout the Altamaha River system (Figure 1). Receivers were placed at sites approximately 10 km apart, except at the confluence of the Ocmulgee and Oconee rivers and in Altamaha Sound, where they were placed at 2–3-km intervals to provide finer resolution of fish movements in these areas. The submerged receivers were attached to anchored buoys and deployed so that they were suspended approximately 1 m from the river bottom in an upright position. To ensure efficient retrieval of the receivers, anchors were tethered with 32-mm stainless steel cable to the nearest structure. Within riverine habitat, receivers were positioned in the main channel and tethered to trees on the adjacent bank. In open water habitats, such as Altamaha Sound, receivers were tethered to channel markers or pilings. Range testing at receivers revealed an average tag detection radius of approximately 400 m (range = 200–800 m). Although detection range is known to vary depending on water depth, sea state, bottom substrates, and the degree of receiver biofouling (Heupel et al. 2008), we observed similar detections ranges at all sites evaluated, regardless of habitat type. Because the channel widths of the Altamaha, Oconee, and Ocmulgee rivers average only 160 m, 89 m, and 77 m, respectively, the minimum detection range of the receivers was more than sufficient to ensure bank-to-bank coverage of the river channel throughout the entire study reach. Once deployed, the receivers were downloaded at least every 3 months throughout the study, except when environmental conditions made the river unnavigable.

Data processing.—At the conclusion of each field season, all telemetry data were carefully reviewed to identify and remove any spurious detections that were obvious based on the spatial and temporal chronology of individual fish movements. Simultaneous detections of a single transmitter at two geographically separate locations, for example, were removed. Mean daily locations of each transmittered fish were determined by calculating mean river kilometer, based on all telemetry detections during each 24-h period after the fish was released. From these mean daily values, mean weekly river-kilometer values for individual fish were then calculated to construct box plots of weekly river distributions for every fish that made significant (>160 km) upstream movements. When mean weekly river-kilometer values were unavailable because of limited fish movement, the last known position of the fish was used for that particular week. To simplify data processing, study year was defined by the beginning date of the project, rather than calendar year. Thus, study year 1 was defined as April 1, 2011 to March 31, 2012; study year 2 as April 1, 2012 to March 31, 2013; and study year 3 as April 1, 2013 to March 31, 2014.

Mean weekly temperature for the Altamaha River was obtained from the Georgia Coastal Ecosystems Long Term Ecological Research hydrographic monitoring station at rkm 20 near Darien, Georgia.

RESULTS

Over the 3 years of the study, 45 adult Atlantic Sturgeon were captured and tagged with acoustic transmitters. The size range of the tagged fish was 1,255 to 2,030 mm FL, with a mean of 1,618 mm (SD, 178). Forty-two of the fish (93%) were detected by stationary receivers within the study area after their release, and 26 of these (58%) made putative spawning migrations within the Altamaha River during at least one year of the study (Table 1). The other 19 individuals either left the study area or never migrated more than 160 km upstream. Of the 26 fish that made putative spawning migrations within the Altamaha system, valid detections varied from 1,449 to 120,420, yielding a combined total of 493,788 individual detections over the course of the study.

Although each individual migration was unique, most fish adhered to one of two common movement patterns with regard to the timing and duration of their upriver migration: (1) an early migration initiated in spring or early summer that occurred in two discrete steps (Figure 2a), or (2) a late migration in late summer or early fall that occurred in only one continuous step (Figure 2b). The early two-step migrants typically entered the river from April to May but remained at mid-river sites for several weeks or months during the summer before resuming their upstream migration in the fall. The late-year one-step migrations, however, were typically initiated in August or September and were generally nonstop. Seven of the eight fish (88%) that made upriver migrations in multiple years used the same migration pattern; however, one individual exhibited different patterns in different years. Regardless of which migration pattern was used during upstream migration, all fish exhibited a rapid and continuous downstream migration in December and early January.

Over the 3 years of the study, the percentage of adult spawners that used the two-step pattern was remarkably consistent: year 1 = 3 of 8 fish (38%), year 2 = 4 of 11 (36%), and year 3 = 7 of 19 (37%). The first step of these two-step migrations was typically characterized by a rapid upstream movement to mid-river sites located above the head of tide (rkm 44). Once there, the fish exhibited little movement (<1 km/d) throughout the summer, even as water temperatures exceeded 30°C (Figure 3). Specific locations of these over-summering sites were variable, although several sites were used repeatedly by

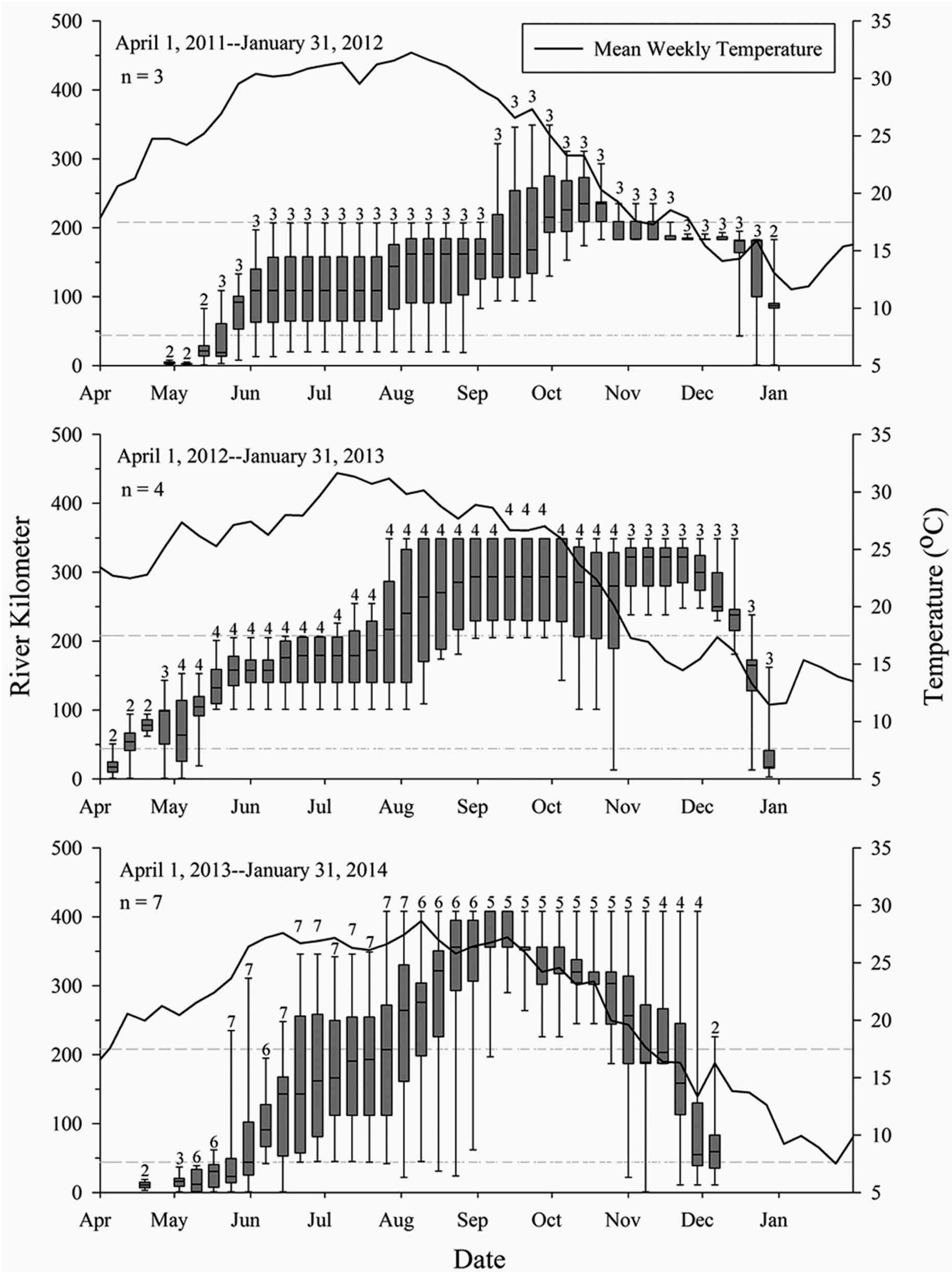

FIGURE 3. Box plots of mean weekly locations of Atlantic Sturgeon that made spring two-step migrations in the Altamaha River system, Georgia, where the box ends = 25th and 75th percentiles of ultrasonic tag detections, the line within box = median, error bars (whiskers) = minimum and maximum river kilometer (rkm) detections, and the number above the error bar = number of individual fish represented. Dashed lines denote head of tide at rkm 44 and the confluence at rkm 207. Mean weekly water temperature is from LTER GCE-7 mooring in the lower Altamaha River.

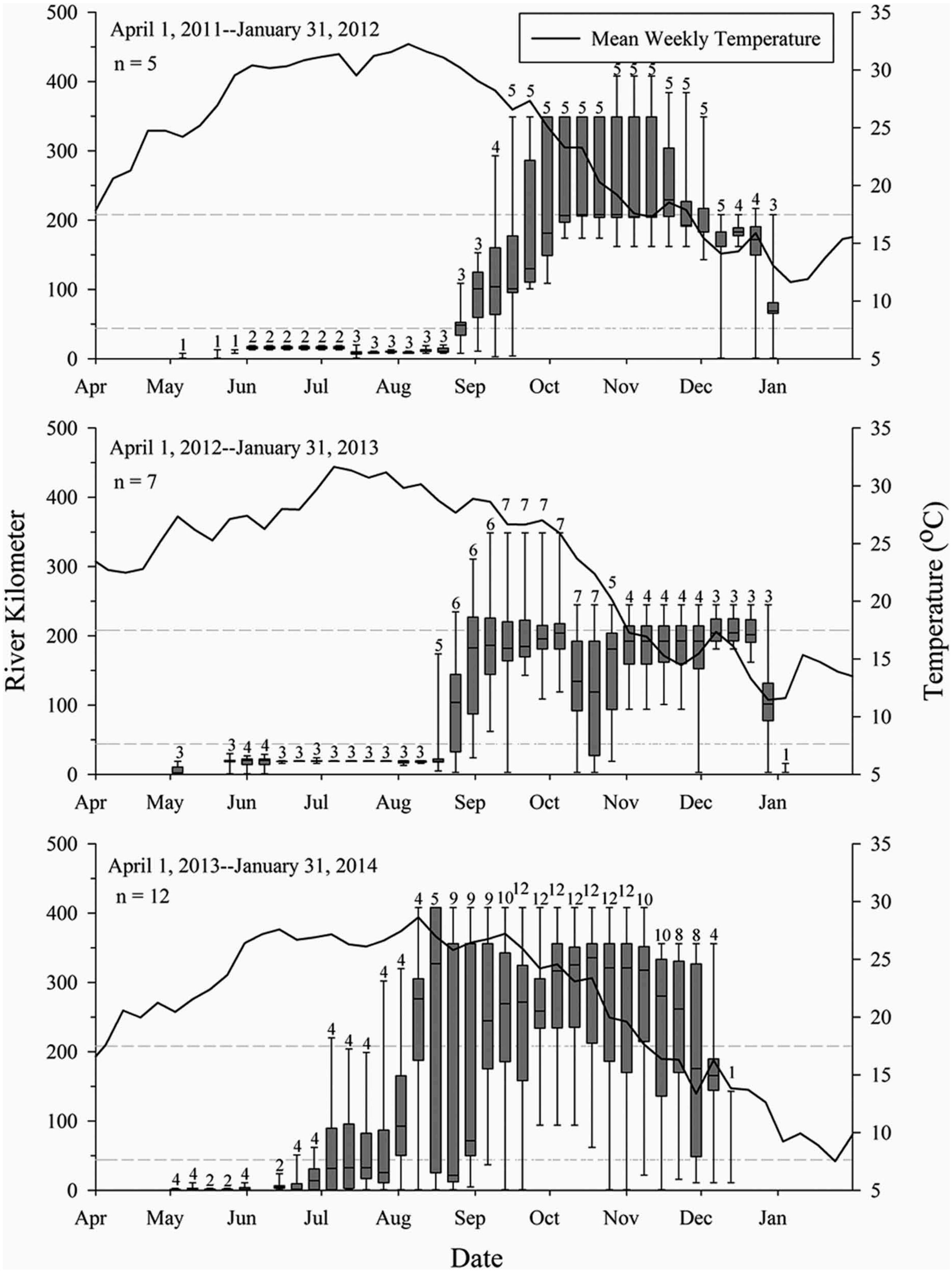

FIGURE 4. Box plots of mean weekly locations of Atlantic Sturgeon that made fall one-step migrations in the Altamaha River system, Georgia, as explained in Figure 3.

different fish throughout the study. Regardless of which specific oversummering sites were used, the median of mean weekly detections always occurred between the head of tide and confluence (Figure 3). The second step of these spring migrations occurred in late August or early September as the fish left their oversummering sites and moved upstream to sites above the confluence in either the Ocmulgee or Oconee tributaries. These movements were rapid and direct and always occurred as water temperatures began to decline from summer highs.

In contrast to the two-step migration pattern exhibited by spring migrants, the majority of migrating fish used a fall one-step pattern: year 1 = 5 of 8 (62%), year 2 = 7 of 11 (64%), and year 3 = 12 of 19 (64%; Figure 4). These fall migrations were characterized by a long (>200 km), single-step migration from the estuary upstream to tributary reaches above the confluence. These migrations typically were also initiated in late August or early September as the mean weekly water temperature began to decline from summer maxima (Figure 4). Although these one-step migrants typically mixed with the two-step migrants as they moved upriver, movement patterns of one-step fish were distinctly different in that they lacked any staging or resting period. Once the fall one-step migrants reached their presumed spawning areas above the confluence, the median of their mean weekly locations were virtually identical to those of the two-step migrants throughout the remainder of their stay in freshwater.

Regardless of migration pattern, all adult migrants remained near or above the confluence throughout the fall before returning back downriver between late November and early January as water temperatures approached their annual minimums (Figures 3, 4). In years 1 and 2 of the study, the last detection in Altamaha Sound occurred on January 4. In year 3, the last detection occurred on December 15. Downstream migrations were typically rapid and direct, occurring over only a few weeks (e.g., one fish travelled 330 km in only 8 d before exiting the system).

Summary data of seasonal movements indicated that the tagged fish were present in the Altamaha system from April to December in each year of the study (Figures 3, 4). Seven (16.7%) individuals left the study area within a few days of being tagged and did not return to the Altamaha. Of the 26 fish (42%) that made significant upstream migrations (>160 km), 8 migrated upstream in at least 2 years of the study and 4 migrated upstream in all 3 years (Table 1). The extent of these upstream migrations varied among individuals and study years. Although some individuals were detected upriver in multiple years, there was no evidence of site fidelity. A few of the upriver sites, however, were visited by several fish in every year of the study. This was particularly true for the reach extending from the confluence to rkm 350 in the Ocmulgee River. The number of fish entering the Oconee and Ocmulgee tributaries was also variable among years. More migrations penetrated the Ocmuglee River (42%) than the Oconee River (24%), while some penetrated both tributaries (18%) or remained in the main stem (16%). Of the fish that made multiple migrations, six out of eight (75%) used different rivers in different years. Although no fish were detected in the Oconee River in year 1 and only one fish was detected there in year 2, 15 individuals were detected there in year 3. The maximum extent of these upriver migrations was documented at rkm 408 on the Ocmulgee River and rkm 356 on the Oconee River (Figure 1). In total, these migrations covered 557 of the 794 km (70%) of the free-flowing habitats within the Altamaha system.

After leaving the Altamaha River, 36% (15/42) of the tagged Atlantic Sturgeon were detected on receiver arrays in other river systems, including the Ogeechee and Satilla rivers in Georgia (authors' unpublished data); the Savannah, Cooper, Sampit, and Waccamaw rivers in South Carolina (William Post, South Carolina Department of Natural Resources, personal communication); and the Nassau River in Florida (Eric Reyier, Kennedy Space Center Ecological Program, personal communication). These coastal movements required a minimum linear distance travelled of 80 km (Ogeechee River) to 350 km (Winyah Bay in South Carolina). Although the timing and duration of detections in these systems were variable, movements within these river systems were limited to nonspawning habitats within the estuaries and lower-river reaches.

DISCUSSION

Although the telemetry data obtained in our study do not provide direct evidence of Atlantic Sturgeon spawning, the timing and extent of adult movements in relation to the seasonal temperature regime provide strong circumstantial evidence that these movements were, in fact, spawning migrations. Previous habitat surveys on the Altamaha system have documented an abundance of suitable spawning substrates throughout both the Ocmulgee and Oconee tributaries (Litts and Kaeser 2016), and telemetry data revealed that these tributaries represented the upstream terminus for 32 of the 38 (84%) adult migrations that were identified in this study.

Our results showed that the timing of upstream migrations placed adult Atlantic Sturgeon over hard substrates in the upper Altamaha system in early to mid-October, just as water temperatures dropped below 25°C. Although the optimal temperature range for early life stages has not been established empirically, aquaculture studies have reported successful incubation of eggs at temperatures of 15–20°C (Dean 1895; Smith et al. 1980; Chapman and Carr 1995), with high mortality at water temperatures ≥25°C (Chapman and Carr 1995). In the Hudson River, ripe broodstock are typically captured at water temperatures of 23°C, albeit during spring months (Mohler 2003). Recent estimates of water temperatures at fall capture sites have been reported in Virginia (20–23°C; Balazik et al. 2012) and North Carolina (24.3–25.3°C; Smith et al. 2015); although these temperatures are near the upper end of the optimal range for early life stages, they compare favorably with the putative spawning migrations observed in our study.

Putative spawning migrations described in this study adhered to one of two distinct patterns: a spring two-step or a fall one-step. Although dual migration patterns have been described previously for other sturgeon species (Bemis and Kynard 1997)—and more recently for Atlantic Sturgeon (Balazik and Musick 2015)—the results of our study are unique in that we documented the use of two distinct migration patterns that synchronized the arrival of adult fish at presumed spawning grounds in early fall.

The migration patterns we documented indicate that there is only one spawning population of Atlantic Sturgeon in the Altamaha River represented by two patterns of movement, contrary to the previously hypothesized population structure. The observed fall synchronization of the two migration patterns may help to explain the persistent confusion regarding the timing and frequency of Atlantic Sturgeon spawning within the SADPS (e.g., Smith et al. 1984; Smith 1985; Collins et al. 2000). Recent authors have suggested that many populations (including those in Georgia) may have sympatric but distinct spring and fall races of Atlantic Sturgeon (Balazik and Musick 2015); however, we found no evidence to support that hypothesis in the Altamaha River. Instead, our results suggest that the presence of Atlantic Sturgeon in the lower reaches of the Altamaha River during the spring months is not indicative of a separate spring spawning race, but merely the first step of a two-step migration pattern that is used by approximately one-third of the adult population. However, because we only sampled adults during the late spring, we could have missed a hypothetical run of early spring spawners. Consequently, the possible coexistence of separate spring and fall spawning runs remains unresolved; however, previous length-at-age analyses of river-resident juveniles in the Altamaha River (Peterson et al. 2008; Schueller and Peterson 2010), Ogeechee River (Farrae et al. 2009), Satilla River (Fritts et al. 2016), and Savannah River (Bahr and Peterson 2015) have found no evidence of bimodal distributions within the juvenile cohorts of Atlantic Sturgeon in these rivers, as would be expected if separate spawns occurred in both spring and fall. Instead, our results showed that although many adults entered their natal rivers in spring, they did not immediately migrate upriver to potential spawning habitat, but rather appeared to stage in freshwater as they awaited cooler, more favorable water temperatures in the fall before resuming their upstream migrations. Regardless, the results of this study should help define the sampling parameters for future assessments of spawning runs within the Altamaha and other SADPS rivers—a critical need for quantitatively evaluating species recovery.

An important finding from the 38 putative spawning migrations documented over study years 1–3, was that adult Atlantic Sturgeon consistently used at least 70% of the free-flowing habitats available to them within the Altamaha system, including likely spawning habitats in both major tributaries. The Ocmulgee River was used extensively in all 3 years of the study (61% of putative spawners) while the Oconee River was used in 2 years (42% of putative spawners). Movements in the Oconee River were more sporadic and dispersed, some individuals moving upstream as far as rkm 356 (149 rkm above the confluence) and only 80 rkm below the Sinclair Dam. In contrast, movements of adults in the Ocmulgee River were less variable and largely restricted to the lowermost 150 km, though one individual moved upstream as far as rkm 408 (201 km above the confluence). Follow-up observations from concurrent research conducted in fall of 2015 documented several likely spawning adults at rkm 544–546 on the Ocmulgee, a site located approximately 140 rkm upstream of the uppermost detection obtained from the stationary receivers (Peterson, personal communication). Although these observations were merely anecdotal, they further illustrate how spawning site selection can vary widely in response to annual variations in environmental conditions.

From a management standpoint, annual variation in the migrations of adult Atlantic Sturgeon underscores the importance of maintaining all historical migratory pathways in recovery efforts for the species. Because the Altamaha River is undammed below the fall line, migrating adults have unrestricted access to all historical spawning sites, including approximately 587 km of free-flowing habitats in the Ocmulgee and Oconee tributaries. The results of our study should provide the framework for future studies of spawning dynamics and factors affecting survival during early life stages by providing detailed information regarding both the temporal and spatial extent of adult Atlantic Sturgeon migrations within the Altamaha system. This information is urgently needed to better understand how specific environmental variables (e.g., flow) influence spawning success and subsequent year-class formation within the SADPS. Once spawning is confirmed, subsequent evaluations of spawning habitats should also help delineate critical habitats in the Altamaha River and elsewhere—a key step in species recovery under the U.S. Endangered Species Act.

Understanding clinal variation in Atlantic Sturgeon ecology has important management implications for species recovery. Previous studies indicate that spawning in northern rivers occurs in early summer as temperatures increase from their winter lows (Dovel and Berggren 1983; Van Eenennaam et al. 1996; Bain 1997). For river systems south of the Hudson River, Balazik and Musick (2015) suggest that Atlantic Sturgeon spawning runs are likely comprised of distinct spring and fall races that constitute a dual-spawning strategy. In this study, however, telemetry data revealed that putative spawning migrations in the Altamaha occur only during the fall as water temperatures decline from their summer highs. These contrasts in study results further illustrate the extent of clinal variation in the life history of Atlantic Sturgeon. More importantly, however, they underscore the need to manage the species as distinct population segments with regionally specific recovery goals. Within the SADPS, future research is needed to document spawning events and early life stages and, subsequently, to identify the specific characteristics of spawning sites by incorporating the spatial and temporal information from this study with modern habitat mapping techniques. Future studies are also needed to better understand how clinal variation in Atlantic Sturgeon ecology affects population dynamics and, hence, the regionally specific factors limiting species recovery.

ACKNOWLEDGMENTS

Funding for this project was provided by the National Marine Fisheries Service. We thank Bill Post (South Carolina Department of Natural Resources) for his role in securing and administering project funding. We appreciate the field assistance we received from Ryan Harrell, Jason Garritt, Brandon Boehm, Alex Cummins, Derek Bahr, and Samantha Bahr. We also thank Michael Bednarski and David Higginbotham for their assistance with data analyses and field logistics. The contributions of Wade Sheldon and Adam Sapp were vital to the collection and analyses of annual temperature data.

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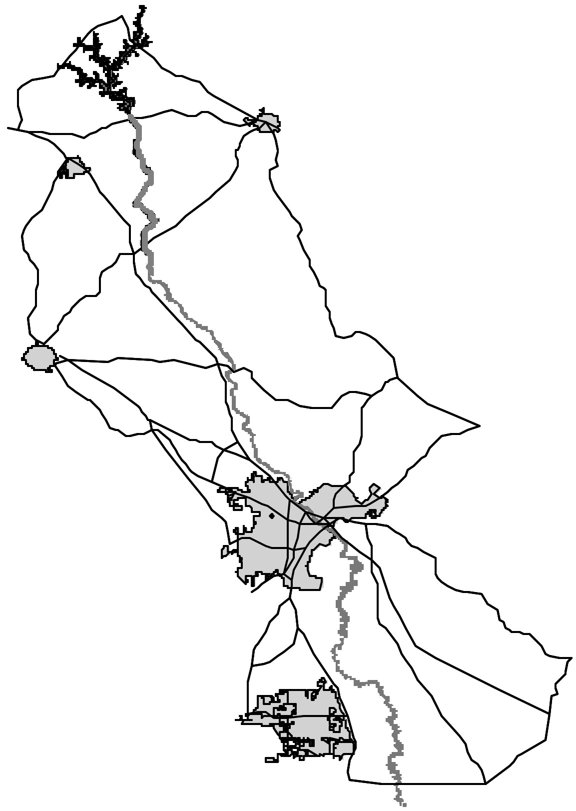
Movement and habitat use of hatchery-reared juvenile robust redhorse *Moxostoma robustum* released in the Ocmulgee River, GA



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December 2003

Executive Summary

Robust redhorse are large catostomids that once were abundant in medium- to large rivers in the Atlantic slope. Currently, only three extant populations are known, and efforts to recover the species include the establishment of refugial populations. A Candidate Conservation Agreement with Assurances for the robust redhorse, *Moxostoma robustum* (CCAA), was developed as a collaborative effort between Georgia Power, Georgia Department of Natural Resources, and the US Fish and Wildlife Service to expedite the reintroduction of the robust redhorse into the Ocmulgee River, Georgia. This report documents the movement patterns and habitat use of 30 hatchery-reared, Phase II robust redhorse stocked in the Ocmulgee River and monitored via radio telemetry in support of Conservation Actions of the CCAA. The objectives for this work were to assess habitat used by the stocked fish, estimate the proportion of stocked fish that remained in study reach (i.e., between Lloyd Shoals Dam and Juliette Dam), and to determine how far downstream the stocked fish would migrate. During spring and summer 2002, the stocked fish were tracked for 104 days with a programmable scanning radio receiver. The tagged fish moved downstream gradually, with occasional upstream or lateral movements. Fifteen of the 30 tagged fish traveled less than 0.1 river kilometer (RKM) per day, nine fish traveled between 0.1 and 1.0 RKM per day, and six fish traveled between 1.0 and 2.0 RKM per day. Transmitter batteries began to fail on 82 days post-stocking. One fish died during the first 30 days of the study, and the remaining 29 ultimately were distributed throughout the study reach and beyond. As of 82 days post-stocking, 19 fish (66%) remained upstream of Juliette Dam, and 10 had moved downstream beyond Juliette Dam. The farthest signal was relocated near Warner Robbins, GA, which is about 115 RKM downstream of the release site. The tagged fish were associated most

frequently with woody debris cover (70%) and over gravel/cobble substrates (70%). The high survival of stocked fish and their propensity to stay within the study reach suggest that the use of hatchery-reared, Phase II robust redhorse to establish a refugial population in Ocumulgee River between Lloyd Shoals Dam and Juliette Dam has been effective short-term strategy.

Introduction

Much has been written about the imperilled robust redhorse *Moxostoma robustum* since its discovery in the Oconee River during the summer of 1991. Initially, nothing was known about this species, but research conducted in the intervening 12 years has answered many questions about the biology and ecology of these fish (Barrett 1997; Ruetz 1997; Walsh et al. 1998; Dilts 1999; Jennings et al. 2000; Ruetz and Jennings 2000; Weyers 2000; Freeman and Freeman 2001; Weyers et al. 2003). Unfortunately, many questions remain, and chief among them are 1) the fate of wild-spawned larvae and hatchery-produced juveniles and 2) their eventual contribution to the adult populations. Currently, questions about habitat use and movement patterns of juvenile robust redhorse hinder interpretations of the available size-class data. These questions also confound management decisions about when and where to release hatchery-reared fish and how best to monitor their fate.

Radio-telemetry has been used effectively to monitor natural behavioral processes (i.e., home range, movement patterns, and habitat use) for various free-ranging animal populations (White and Garrott 1990), including fishes (Winter 1996). Radio telemetry is especially useful for tracking fishes because fish movements can be quickly and continually monitored (Minor and Crossman 1978). For example, telemetry was used to estimate seasonal movement patterns of the endangered razorback sucker (*Xyrauchen texanus*) in the middle Green River, Colorado (Modde and Irving 1998). Also, telemetry methods were used to determine habitat use and movement patterns of hatchery-reared razorback suckers released in various parts of the Colorado River in Arizona, California, and Utah (Bradford and Gurtin 2000; Mueller et al. 2003).

Efforts to conserve robust redhorse within the species' historic range led to the establishment of the Robust Redhorse Conservation Committee (RRCC) in 1995. The RRCC exists by a memorandum of understanding signed by the Georgia Power Company (GPC), the Georgia Department of Natural Resources (GA DNR), the United States Geological Survey (USGS), and the United States Fish and Wildlife Service (USFWS), among others. The main objectives of the RRCC's recovery efforts are: 1) to establish refugial populations to serve as future broodstock, and 2) to eventually develop reproducing populations throughout the species' known historic range (RRCC 1995; 2000). In pursuing these objectives, the RRCC has coordinated the stocking of hatchery-reared juvenile robust redhorse into suitable rivers within the species' historic range.

As part of the recovery effort, GPC and the USFWS entered into a Conservation Agreement to establish a refugial population of robust redhorse in the Ocumulgee River, Georgia (Department of Interior 2001). The agreement also calls for an assessment of the fate of the stocked hatchery fish, whose success in the wild was thought to depend on the availability of suitable habitat and a refuge from the predation threat posed by the highly piscivorous flathead catfish *Pylodictis olivaris* that inhabits the Ocmulgee River.

In this report, we present results of a radio telemetry study of the movement patterns and habitat use of hatchery-reared juveniles released into the Ocmulgee River in Georgia. Our objectives for this study were to determine 1) general habitats used by the hatchery-reared robust redhorse released in the Ocmulgee River, 2) the proportion of stocked fish that remained in the study reach, and 3) how far downstream the stocked fish moved.

Material and Methods

Study site

Hatchery-reared robust redhorse were released into a 30-river kilometer (RKM) reach of the Ocmulgee River, GA (Figure 1). This reach was bordered by two dams and met the criteria (i.e., suitable habitat and without flathead catfish) established by the RRCC for the establishment of a refugial population. Lloyd Shoals Dam (which impounds Lake Jackson) served as the upstream boundary of the study reach, and the low-head Juliette Dam served as the downstream boundary (Figure 1). Woody debris, boulders, and a variety of substrates (gravel/cobble, sand, mud) were abundant and occurred throughout the site. Further, Juliette Dam blocks the upstream movement of flathead catfish, which are not present in the project site. Flathead catfish predation has been hypothesized as a contributing to the current status of the robust redhorse population in Oconee River (Evans 1994).

Transmitters

Behavior of fishes tagged with radio transmitters does not seem to be affected if the weight of the transmitter in air is # 2 % of the weigh to the fish (Winter 1996). Our estimate of the size of transmitter that would be suitable for use with the hatchery-reared robust redhorse to be released in the Ocmulgee was based on estimated weights provided by personnel from GA DNR. The radio transmitters (Advanced Telemetry Systems® model 1440) used in this study weighed -2.1 g in air and were 19 mm long by 8.7 mm wide; the trailing whip antenna was 15 mm long (Figure 2). The transmitters broadcasted a radio signal (i.e., an intermittent beep at a rate of 35 pulses per minute and

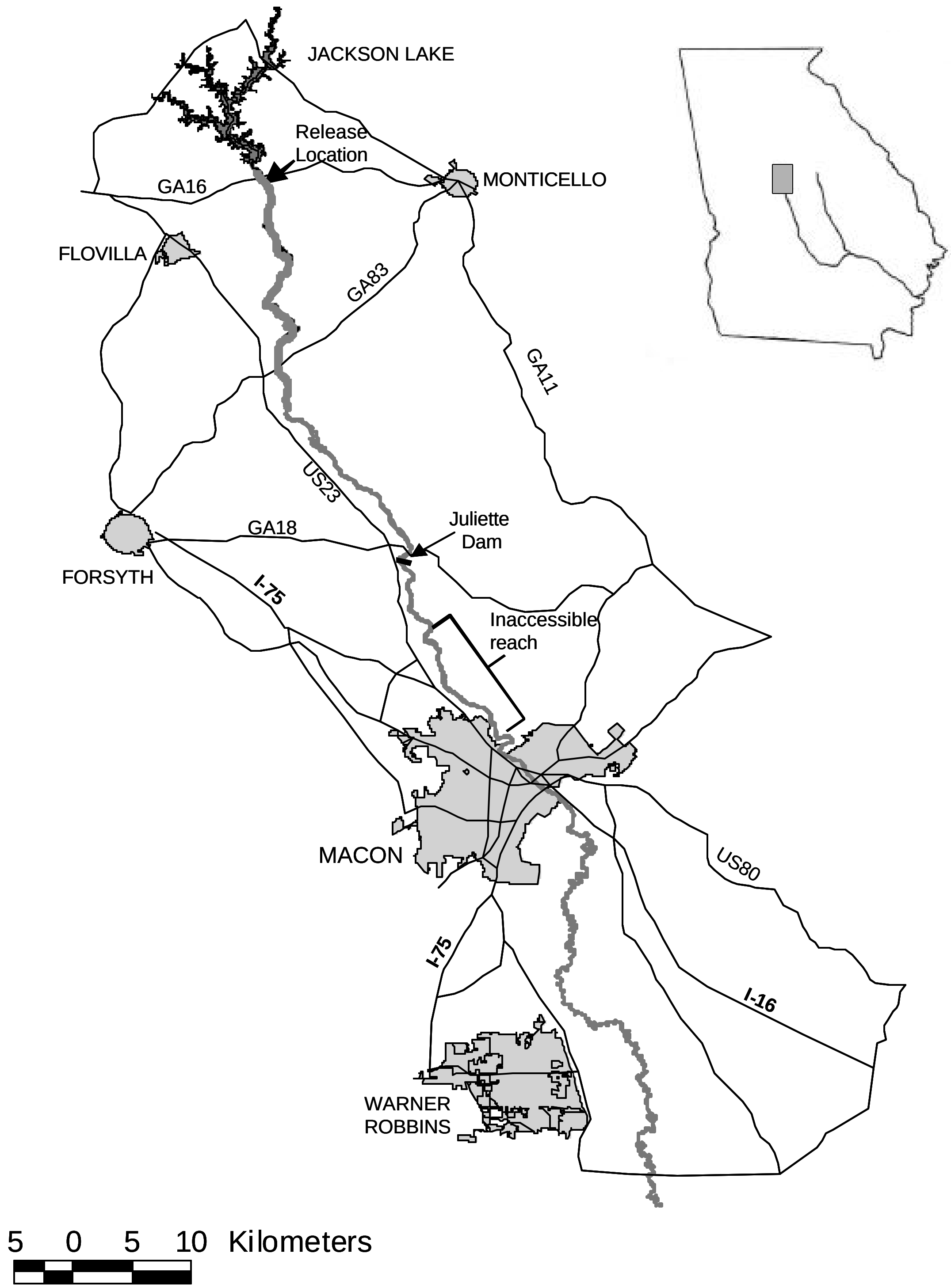

Figure 1. Map of Georgia that shows the location of the Ocmulgee River and a close-up of the reach of river where hatchery-reared Phase II robust redhorse were tracked with radio telemetry equipment during spring and summer 2002.

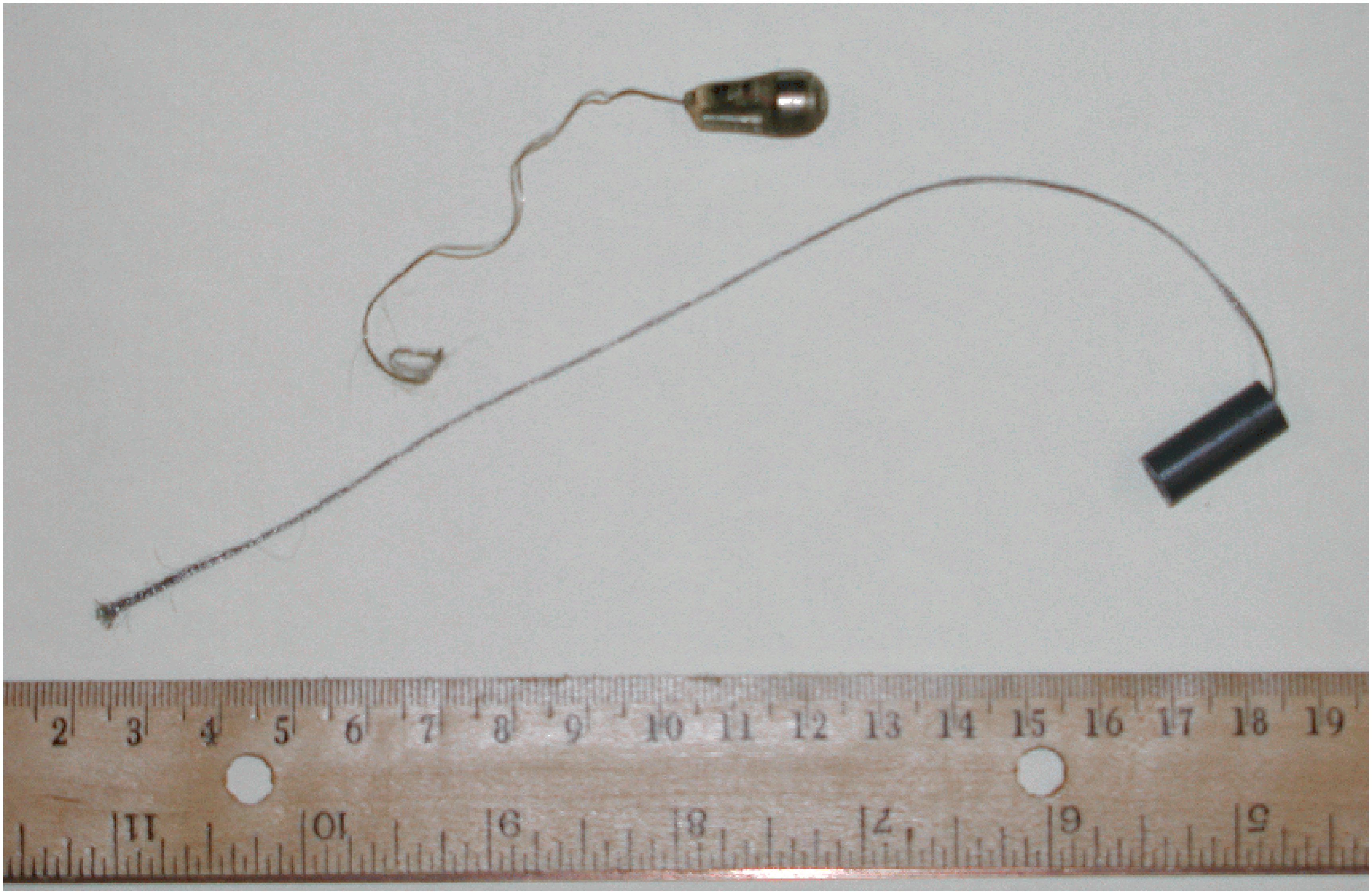

Figure 2. Photograph of real (left) and artificial (right) transmitters implanted in robust redhorse as part of the assessment of their habitat use and movement patterns in the Ocmulgee River, Georgia during spring and summer 2002.

pulse width of 15 m^{-s}) in the frequency range between 40-41 Mhz. The battery life on each transmitter was warrantied for 83 days. The small size of these transmitters did not permit the addition of circuitry for mortality switches or duty cycles that would have conserved battery power and extended the life of the transmitters.

Artificial transmitters that were similar in size, weight, and shape to the ATS model 1440 were used as surrogates to evaluate mortality associated with our implant procedure; the "control" fish were kept at the Whitehall Fisheries Laboratory at the University of Georgia in Athens, GA. The artificial transmitter had a polyvinylchloride (PVC) body and a cylindrical stainless steel core; a Teflon-coated wire was attached to simulate a trailing whip antenna (Figure 2).

Collection and transport of fish

On March 19, 2002, 70 phase II robust redhorse were harvested from GA DNR's McDuffie Fish Hatchery (McDuffie County, near Thompson, GA). These fish were placed into aerated hauling tanks and transported (about a 2.5 hour trip) to Lloyd Shoals boat ramp on the Ocmulgee River, about 300 m downstream of Lake Jackson. There, 30 fish were selected randomly, anaesthetized (see methods below), surgically implanted with radio transmitters, allowed to recover, and released into the Ocmulgee River. The remaining 40 fish were transported (about 1.5 hour trip) to the University of Georgia's Whitehall Fisheries Laboratory in Athens. There, 30 of the 40 fish were randomly selected and surgically implanted with artificial transmitters. The surgical procedures performed on the control fish was the same as that performed on the fish released in the Ocmulgee River.

Anesthesia methods

All fish were anesthetized similarly in preparation for receiving real or artificial transmitters. Each fish was anesthetized with a solution of 140 mg tricaine methyl-sulfonate (MS-222) per liter of water. The fish was considered to be anesthetized when it failed to maintain an upright orientation in the water column and did not respond to contact. The immobilized fish were transferred to a surgery cradle housed in a 53-L rectangular ice chest containing a water pump and about 10 L of water with a sedative dose (70 mg per liter) of MS-222 (See Courtois 1981). Once on the cradle, a small tube connected to the water pump was fitted into the fish's mouth, and aerated water containing the sedative dose of MS-222 was pumped over the fish's gills throughout surgery (Courtois 1981). After surgery, tagged fish were allow to recover from the anesthesia (i.e., they could maintain upright orientation in the water column and flee from attempted contact) in a second 53-L rectangular ice chest containing anesthesia-free water before they were released or placed in holding tanks for observation.

Transmitter implantation method

Transmitter implantation was conducted similarly for field and lab fish. Each anesthetized fish was positioned ventral side up on the surgery cradle (Figure 3). A No. 22 scalpel blade was held cutting side up and used to make about a 2.5 cm-long incision that began posterior to the pectoral fins. A groove director was used during this process to prevent the cutting of internal organs. Once the incision was made, a soluble, powdered formulation of the antibiotic oxytetracycline was sprinkled into the incision to prevent infection (Figure 4). Next, the shielded needle technique (Ross and Kleiner

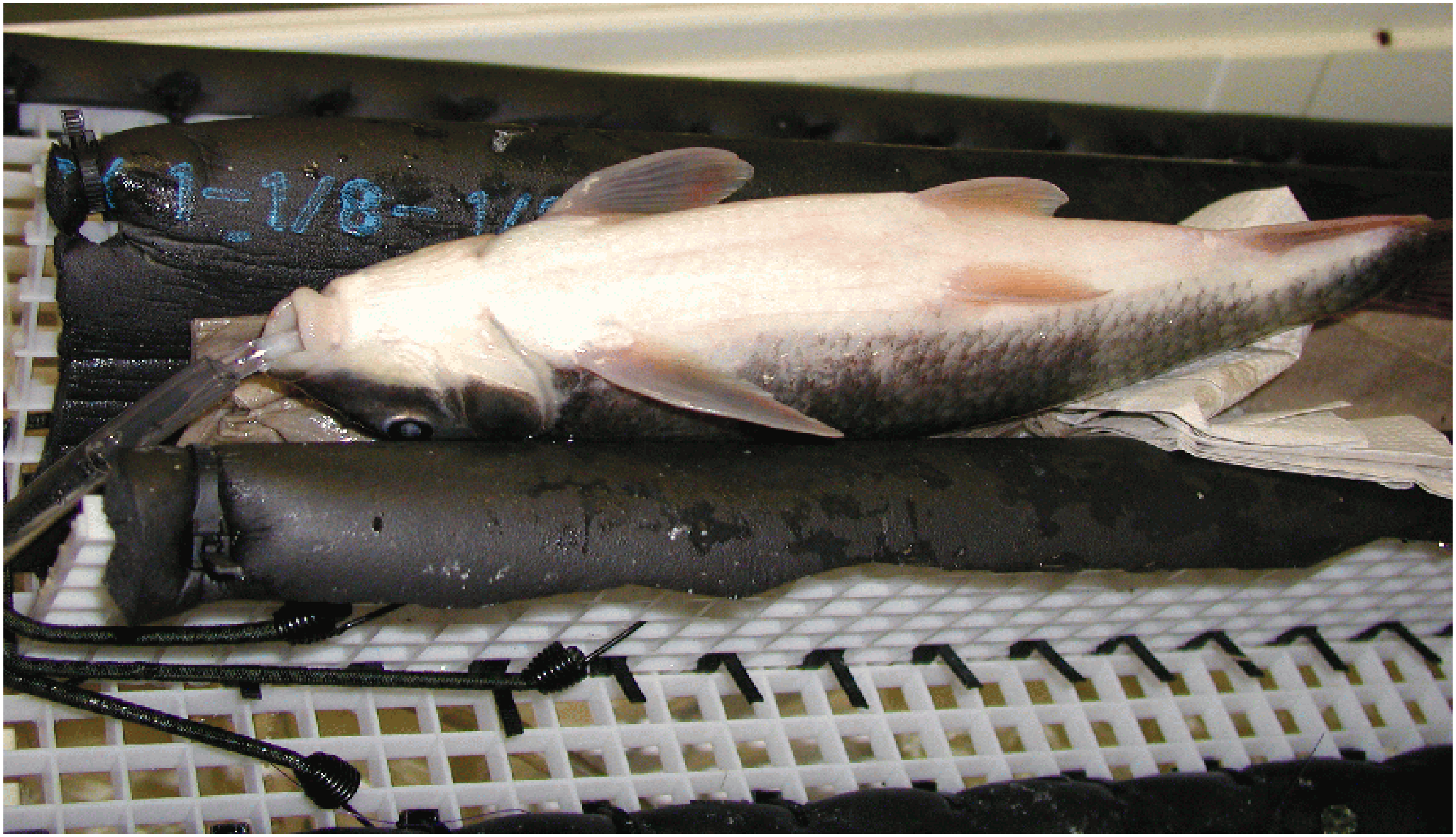

Figure 3. Photograph of hatchery-reared, Phase II robust redhorse positioned ventral side up on a surgery table and waiting to be implanted with a radio transmitter.

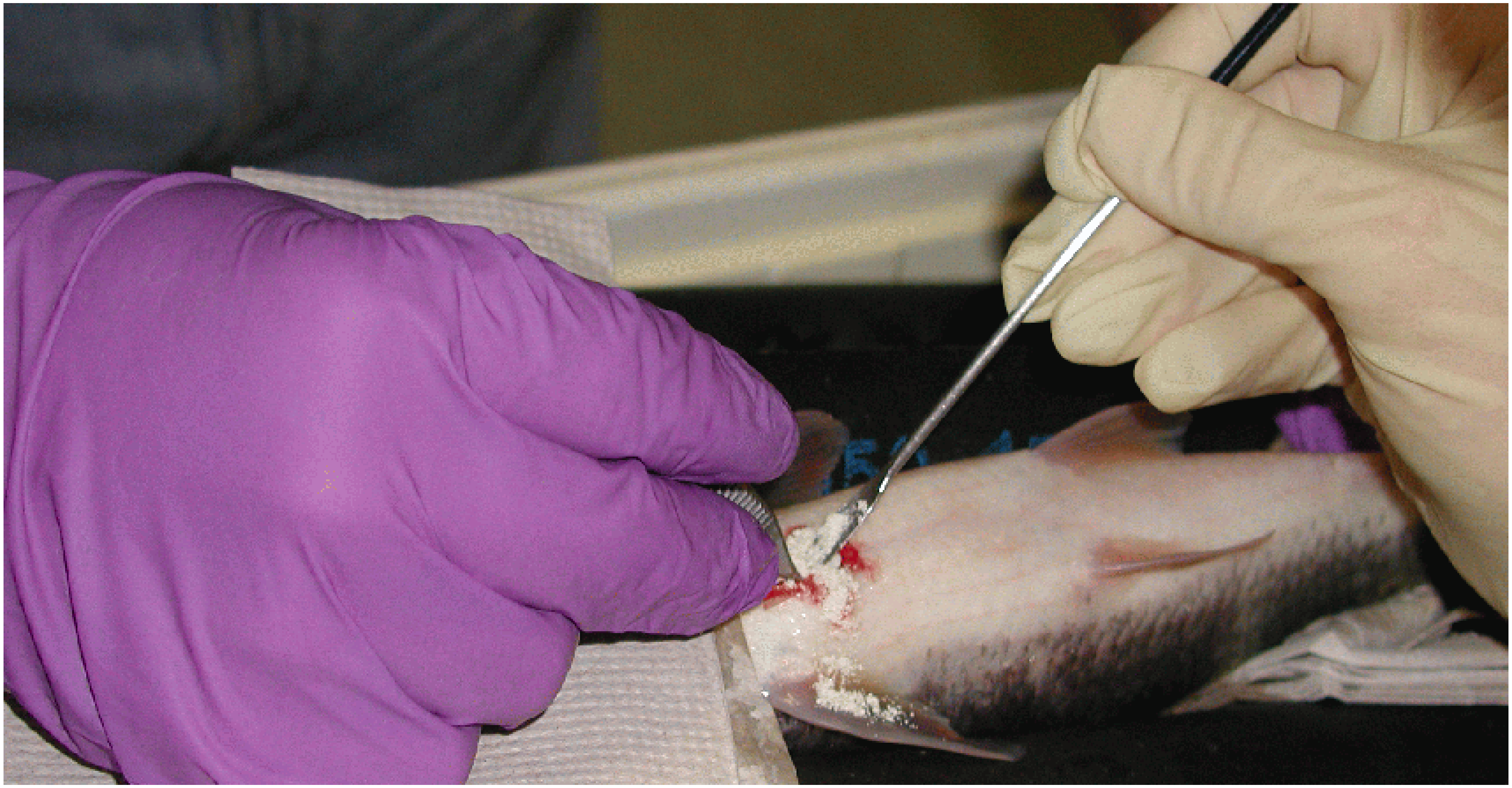

Figure 4. Photograph of hatchery-reared, Phase II robust redhorse with an incision in its ventral abdominal wall through which powdered tetracycline (antibiotic) is being added to reduce the risk of infection.

1982) was used to thread a whip antennae through the incision to exit point about 3.0 cm away from the posterior terminus of the incision. The transmitter was coated with a thin film of oxytetracycline powder and placed into the peritoneal cavity of the fish. Before the incisions was closed with sutures, a thin film of cyanoacrylate glue (i.e., crazy glue) was applied to the exterior of the incision to serve as a short-term water seal during the initial stages of wound healing (Dr. R. Borderson, UGA Veterinarian - personal communication). The incision was closed (usually with two or three sutures) with Olsen-Hegar needle holders and a FS-1 cutting needle equipped with Ethicon 2-0 Polydioxanone II absorbable suture material (Figure 5). A new sterile scalpel and package of suture material was used for each fish. All other surgical equipment was sterilized in 95% ethanol.

Post-implantation treatment of lab fish

Thirty juvenile robust redhorse were implanted with artificial transmitters with the procedures described above (i.e., same anesthesia, surgery, and recovery as the fish tagged and released into the Ocmulgee River). After surgery and recovery, these fish were randomly placed in one of three tanks (n=10 tagged fish in each tank) with a common recirculating system. The remaining 10 fish were not tagged, but they were randomly placed in the three tanks that held the tagged fish. All lab fish were fed trout chow and meal worms at a rate of about 3 percent of body weight per day. These fish were monitored daily for mortality throughout the duration of the study.

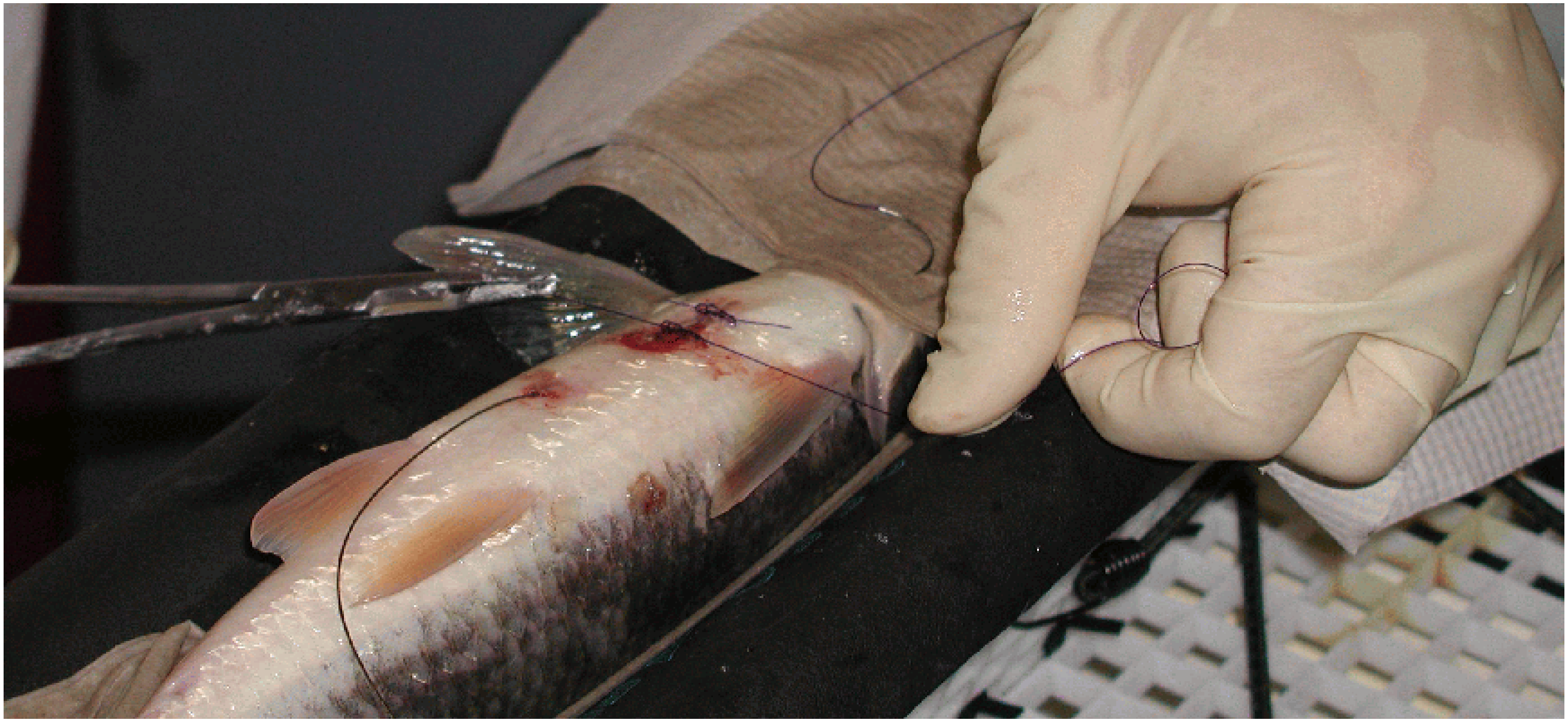

Figure 5. Photograph of hatchery-reared, Phase II robust redhorse that has two sutures used to close the incision through which a radio transmitter was implanted.

Fish tracking

The radio-tagged fish in the study were tracked with an Advanced Telemetry Systems (ATS) model R2100 programmable scanning radio receiver fitted with a hand-held loop antenna. The signal sensitivity of the loop antenna was from 400 meters to within four meters of the transmitter; within four meters of the transmitter, signal strength was equal in all directions. When this occurred, the antenna's coaxial cable was disconnected from the loop antenna and could be used effectively (i.e., signal strength was directional) to fix to the transmitter's (and the fish's) position. The coaxial cable as antenna could fix the transmitter's position to within one meter, at which time the associated fish was considered to have been located. Once each fish was located, latitude and longitude coordinates were taken with a Trimble® Scout global positioning unit, and habitat variables were measured.

Fish were tracked daily for the first 10 days post release; thereafter, they were tracked weekly (up to five days per week) as conditions permitted. Tracking was conducted mainly by boat, and occasionally on foot or by truck as necessitated by shallow river conditions. Finally, a remote monitoring station (i.e., Yagi antenna connected to an ATS R2100 programmable scanning receiver and an ATS Data Collection Computer) was placed behind a fenced enclosure (i.e., Georgia Power's Lake Juliette Water Intake Structure) adjacent to the Ocmulgee River. This remote monitoring station was about 4 RKM downstream of Juliette Dam and was used to continuously monitor for fish leaving the study site. A single radio transmitter was placed about 100 yards inland from the monitoring station, and it served as a reference signal to evaluate the performance of the telemetry equipment at the remote monitoring station. The expanding stretch of river between the release site and fish farthest downstream was considered the “target reach”. Water-level permitting, tagged fish were tracked weekly over the entire target reach.

Habitat and water quality measurement

Cover and substrate types were assessed and recorded for located fish; standard water quality variables also were measured and recorded for each located fish. The dominant substrate (e.g., gravel, sand, mud) associated with the fish’s location was estimated by probing a 1-meter radius of the substrate with a metal pole. The dominant cover (e.g., woody debris, boulders) associated within a three meter radius of the location was visually assessed. If visible cover was not apparent within the 3-meter radius of the location, the cover type was recorded as “none”. Depth (m) was measured with a graduated staff gauge. Water temperature (EC) and dissolved oxygen (mg/L) were measured with a YSI® (Yellow Springs Instrument Company) model 59 dissolved oxygen - temperature meter. Current velocity (m/s) was measured with a Marsh McBirney® current meter. Turbidity (ntu) was measured with a Hach® portable turbidity meter.

Data analysis

For each fish, distance traveled was estimated by plotting latitude and longitude locations on Delorme ® 3-D TopoQuads (Georgia) software. The rate of average daily travel was calculated by dividing the total RKM traveled by the number of days tracked for a given fish. Substrate and cover data were analyzed to ascertain frequency of occurrence of a specific cover type across all observations (i.e., all fish combined) and individually (for each fish).

Results

Sample population and transmitter implantation

All the robust redhorse sampled from McDuffie Fish Hatchery exceeded the minimum weight (210 g) necessary to comply with the # 2% transmitter-to-body weight guidelines recommended for radio telemetry studies. Mean weight of the tagged fish was 424 g (s.d.=49.5); mean total length (TL) was 300 mm (s.d.=11.6). Generally, the fish became immobile within two minutes of being placed in the anesthesia. The surgeries typically were completed in less than six minutes, and recovery from anesthesia occurred in about two minutes after the fish was placed in holding tank containing anesthesia-free water.

Fish survival

Almost all of the 70 (field-released and hatchery-held) radio-tagged robust redhorse used in this study were alive at the end of the 83 day field season. Twenty nine of the 30 (97%) tagged fish released in the wild were deemed to be alive when the transmitter batteries started failing on day 82 post-stocking. The single observed mortality among fish in the river was an individual that remained close to the release point and was relocated in the same location for two or three consecutive contacts over many days. An Aqua-Vu® underwater camera was used to confirm the fate of this fish 30 days after it was released. All the other fish displayed random (upstream, lateral, downstream) movement patterns that suggest independent locomotion. Of the 30 fish that received artificial transmitters and were held in the laboratory, 28 (93%) were alive and well at the end of the 82 day study. Survival was 100% among the 10 fish that were held in the lab but did not receive artificial transmitters. The 38 fish held in the lab remained alive and well until mid-October 2002 at which point they released into the Ocmulgee River just below Lloyd Shoals Dam.

Fish movement, habitat, use and associated water quality

Fish tracking was begun on March 19, 2003 and continued through June 30, 2003. There were 338 contacts with individual fish, the last of which was occurred on June 9th, 2003. This date coincides with the ATS's warranty for expected battery life for this model 1440 transmitter. On average, each fish was located 10 times (s.d.=5; n=30) after being released in the Ocmulgee River. Fish movement was generally downstream, with intermittent lateral or upstream movement. Typically, fish were found in the deepest, apparently-fastest water available. The average depth in such areas was 2.1 m (s.d. = 0.8; n=229) and average current velocity was 0.3 m^{-s} (s.d. = 0.3 m^{-s}; n= 183). Mean water temperature was 18.7 EC (s.d.=4.5; n=170), mean dissolved concentration was 0.9 mg/L (s.d.=4.4; n=169), and an average turbidity of 13.0 ntu (s.d.= 0.8; n=182).

The tagged fish remained at or near the release site for about two or three days post-stocking before beginning gradual downstream movement. All the tagged fish remained within a kilometer (i.e., above Georgia Highway 16) of the release site (Figure 6). During the next 20 days (i.e., day 4-24 post-stocking), most of the fish began to disperse downstream, sometimes in small groups of two or three individuals. This apparent "mini- schooling" behavior was observed throughout the study as some fish were found in groups of 2-3 individuals (within five meters of each other) far as 15 RKM downstream from the release site. Most downstream movement was in small (1-3 RKM per day) increments during the 2-3 days between radio contact, but there were a few individuals that traveled large distances downstream. Specifically, most of the tagged fish could be found within10 RKM (i.e., remained above GA Hwy 83) of the study site 30 days post-stocking; however, a few individuals had traveled much farther downstream. In fact, one individual had traveled the entire length of the study reach and was located just above the Juliette Dam (Figure 6).

The pattern of gradual downstream movement continued through the remainder of the study, and movement patterns seemed to be similar for individual fish and those in mini-schools. In addition to the general downstream movements, there were occasional lateral and upstream movements, and sometimes one mini-school would pass another mini-school (in either direction) without much apparent interaction. Both groups of fish seemed to move to an area, remain there for a few days, then move to the next area. The fish that moved the farthest distances downstream apparently did not remain in any one area for long. By 60 days post-stocking, most of the tagged fish were between Georgia Hwy 16 and Hwy 83. Three fish had traversed the entire study reach, and gone as far downstream as the Macon, GA (Figure 7).

The transmitters' batteries began failing about 82 days post-stocking and did so en masse. At this time, only a few fish could be contacted, despite many individual contacts the previous week. Further, extensive tracking downstream (as far as Warner Robin, GA) did not detect any of the fish that had been contacted upstream the previous week. By 82 days post stocking, most of the stocked fish remained within the study reach and were spread out between Hwy 16 and Juliette Dam (Figure 8). At this time, 10 fish had been detected below Juliette Dam, and six of these had traveled past Macon. The farthest downstream signal was found near Warner Robbins, GA, about 115 RKM downstream from the release site (Figure 8).

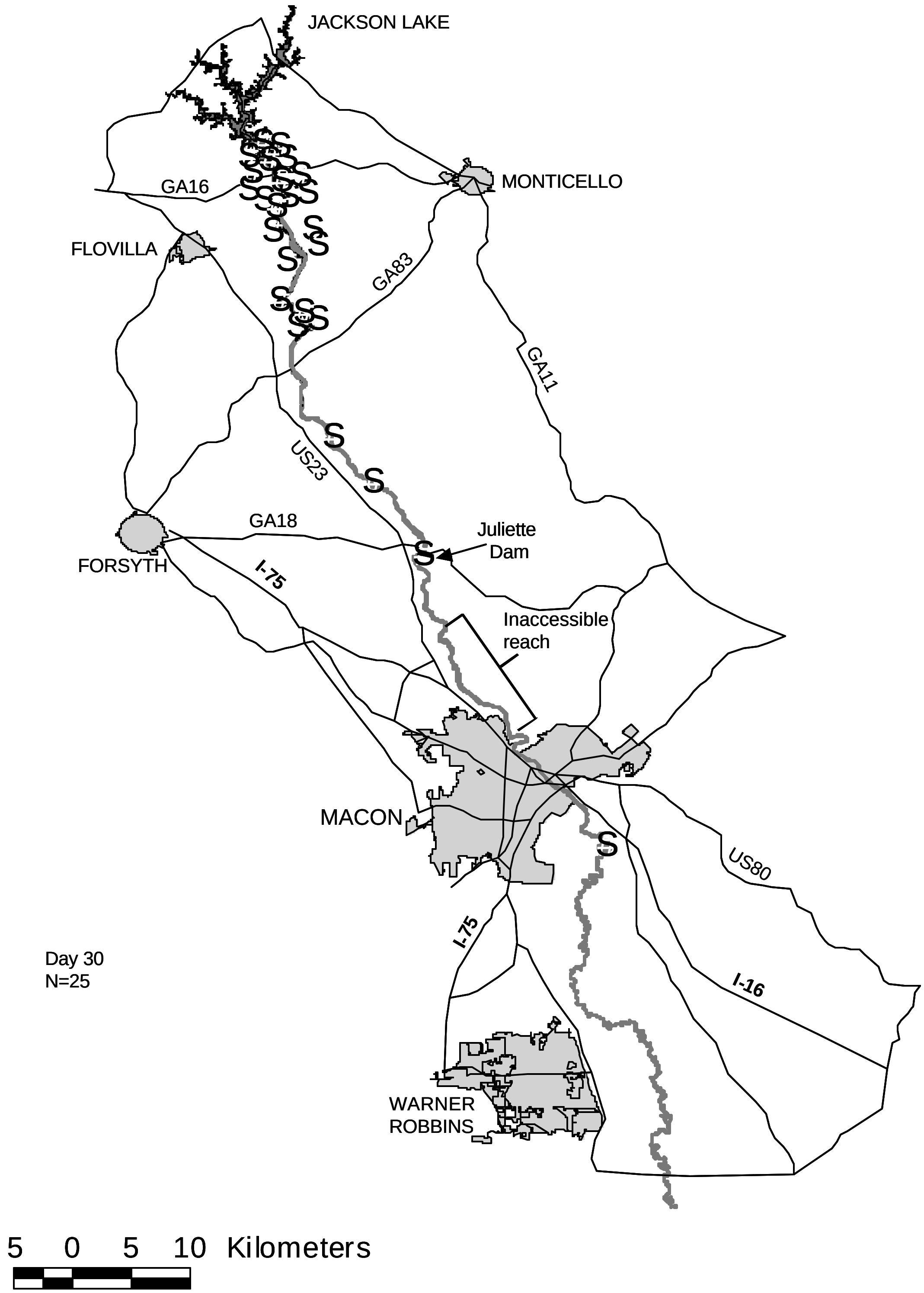

Figure 6. Map of the Georgia that shows the location of the Ocmulgee River and distribution of tagged, hatchery-reared, Phase II robust redhorse 30 days post-stocking. Individual fish are indicated with the symbol " • ".

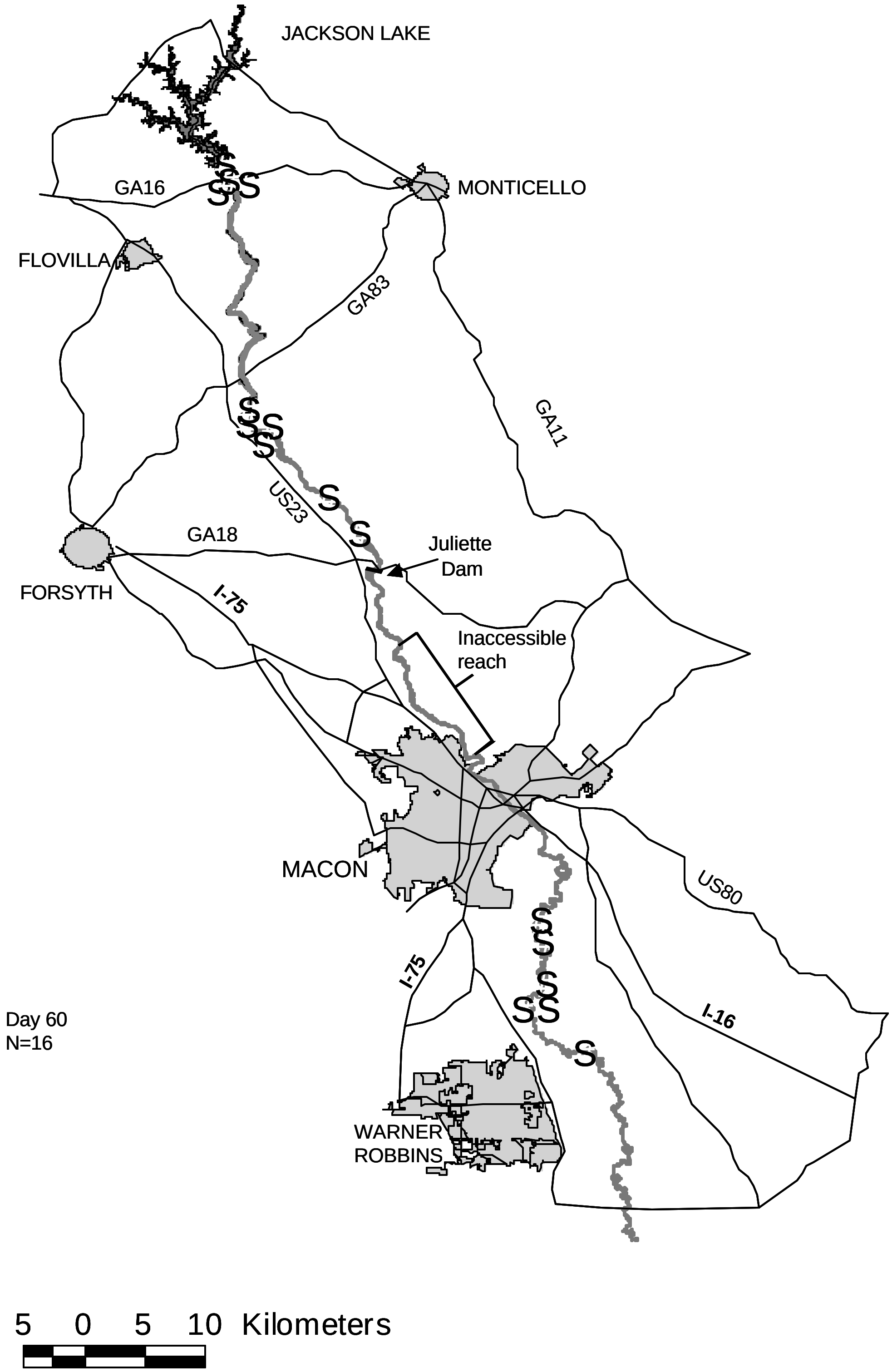

Figure 7. Map of the Georgia that shows the location of the Ocmulgee River and distribution of tagged, hatchery-reared, Phase II robust redhorse 60 days post-stocking. Individual fish are indicated with the symbol "•".

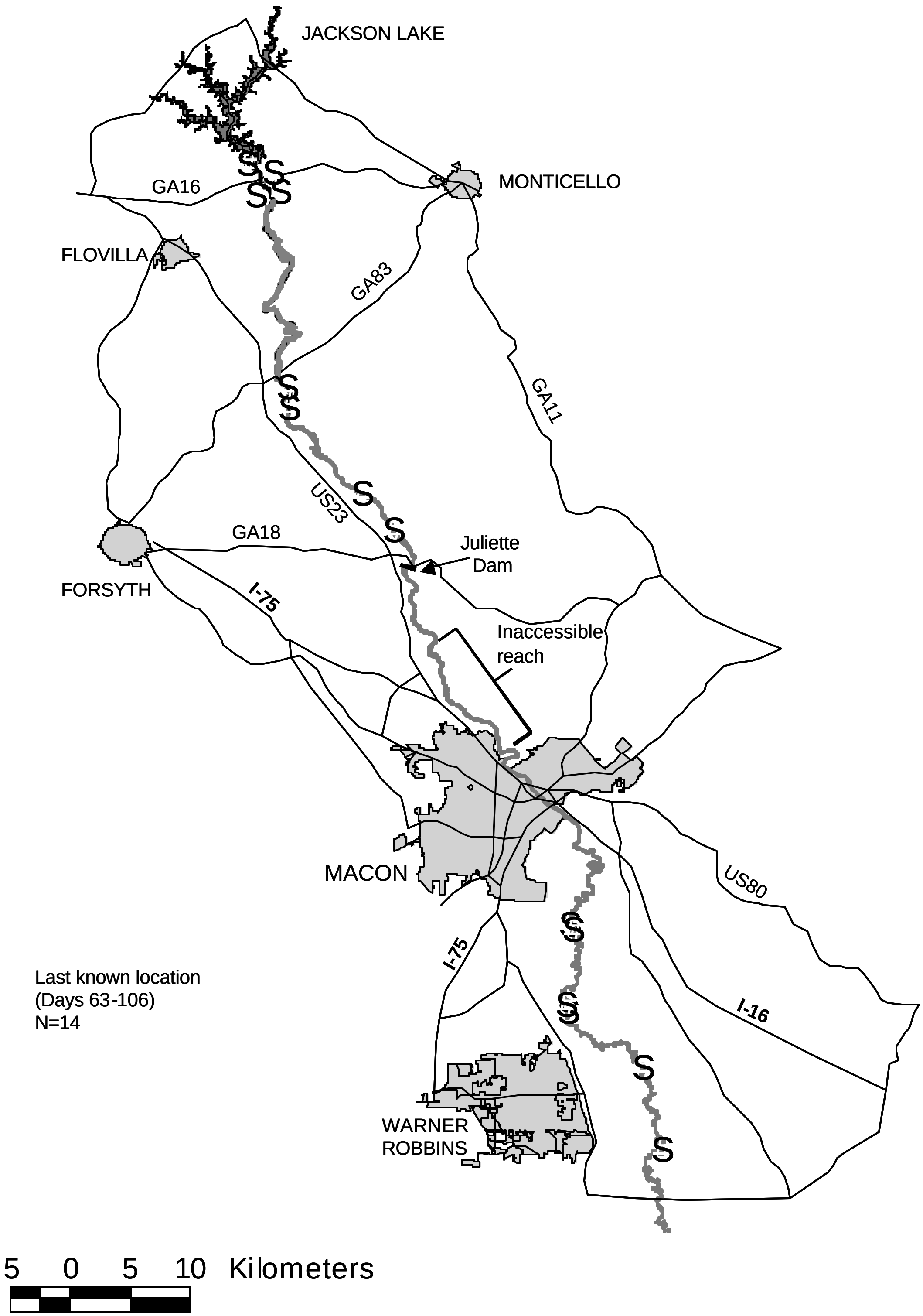

Figure 8. Map of the Georgia that shows the location of the Ocmulgee River and distribution of tagged, hatchery-reared, Phase II robust redhorse 82 days post-stocking. Individual fish are indicated with the symbol "• ".

During the study, half (n=15) of the tagged fish did not exhibited much daily movements (0.0 - 0.1 RKM); a third (n=10) of the tagged fish exhibited relatively short (0.1 - 1.0 RKM) daily movements. A small percentage (< 20%) of this tagged fish (n=5) made more extensive (1.0 - 2.0 RKM) daily movements compared with the others (Figure 9). Excluding the single confirmed mortality, most (65%) of the tagged fish (n=19) remained in the study site (i.e., upstream of Juliette Dam) through day 82 of the study.

The cover types with which the relocated tagged fish were associated varied, but a consistent pattern was evident. Generally, tagged fish were encountered most frequently (70%) near woody debris; the absence of cover (i.e., open water) was the second most-encountered (18%) cover type associated with relocated tagged fish (Figure10). This pattern also held among individuals, 86% (including those adjacent to and downstream of Macon) of whom were relocated most often near woody debris cover (Figure 11).

Patterns of associations between the relocated fish and the substrates with which they were associated also was predictable. Most often (70% of encounters), tagged fish were associated with gravel/cobble substrates (Figure 12); mud was the second-most (17%) substrate encountered with relocated fish. Among individual fish, 79% were located most often near gravel/cobble substrate. Half (3 of 6) of the tagged fish near or downstream of Macon were found most often near gravel/cobble substrates.

Discussion

During the spring and summer of 2002, we successfully documented the movements and habitat use patterns of hatchery-reared, radio-tagged robust redhorse released in the Ocmulgee River, Georgia

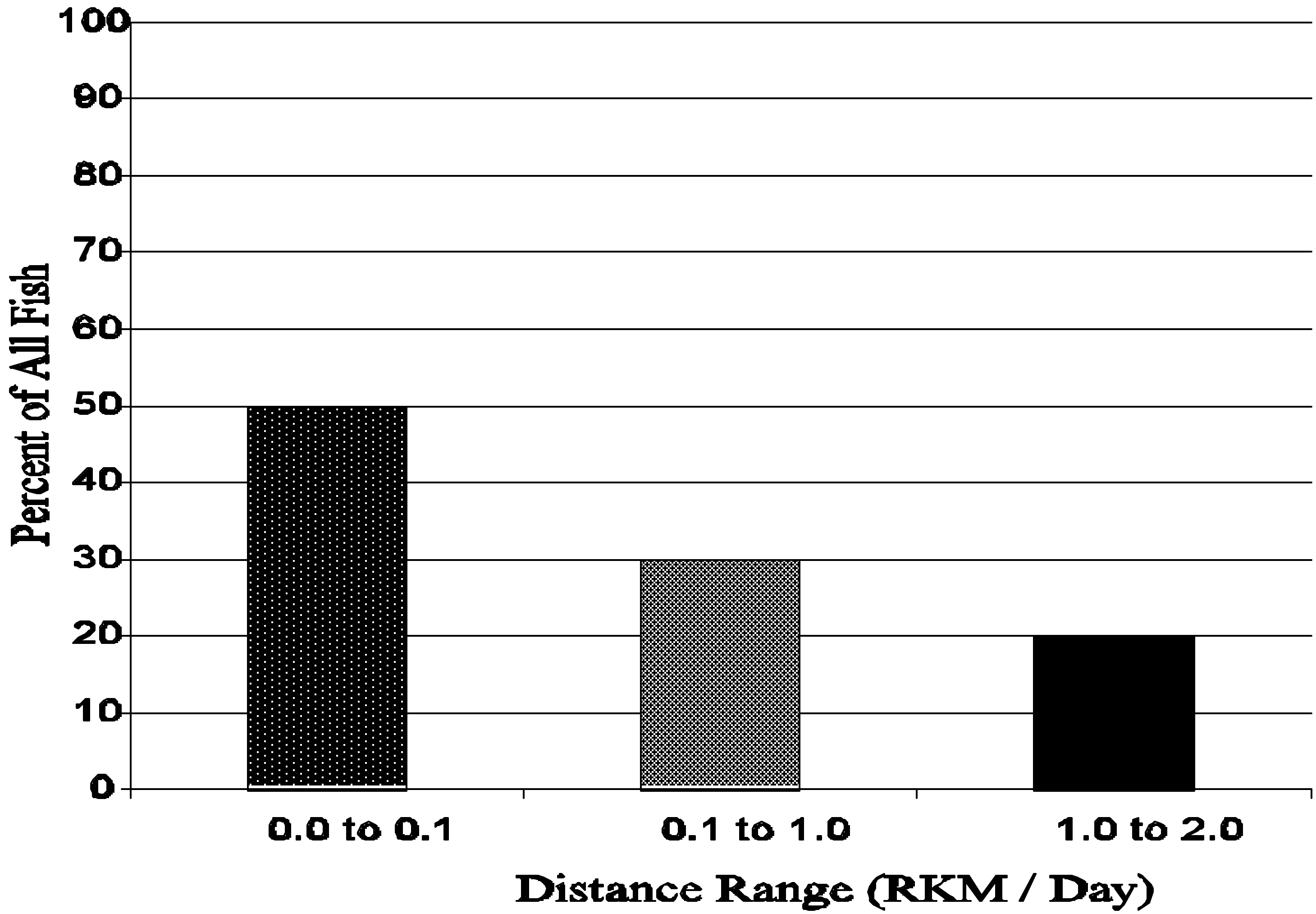

Figure 9. Mean daily movement rate (river kilometer per day) during spring and summer 2002 for tagged, Phase II robust redhorse stocked in the Ocmulgee River, Georgia.

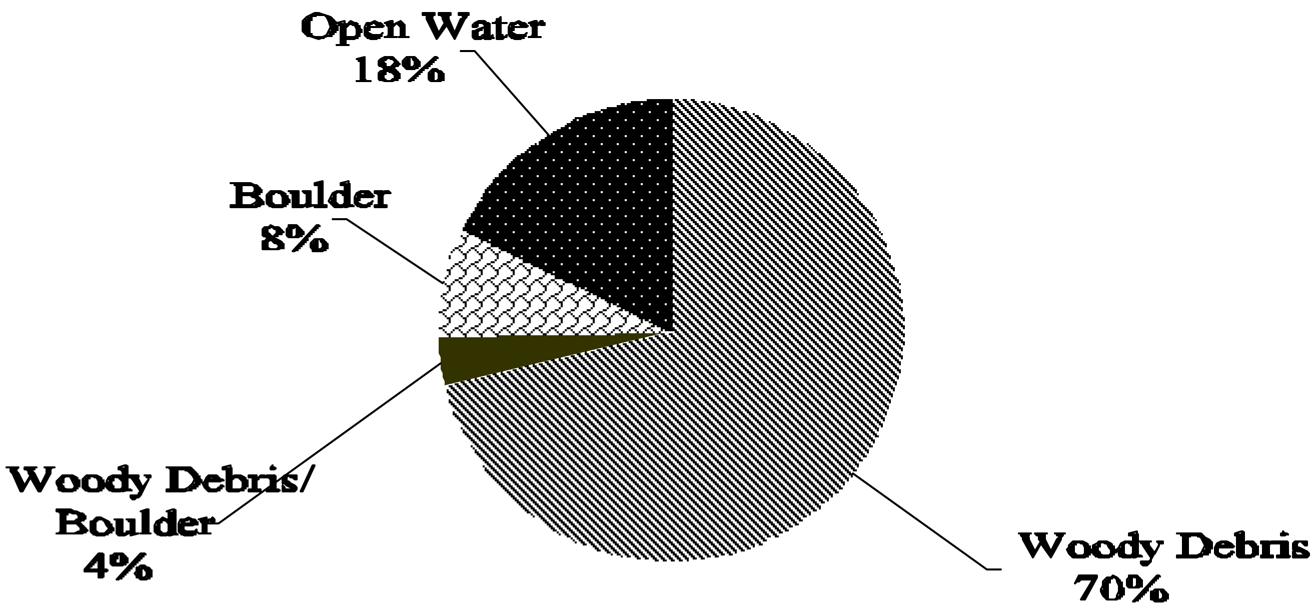

Figure 10. Graph representing the frequency of occurrence for the various cover types with which relocated hatchery-reared, Phase II robust redhorse were associated.

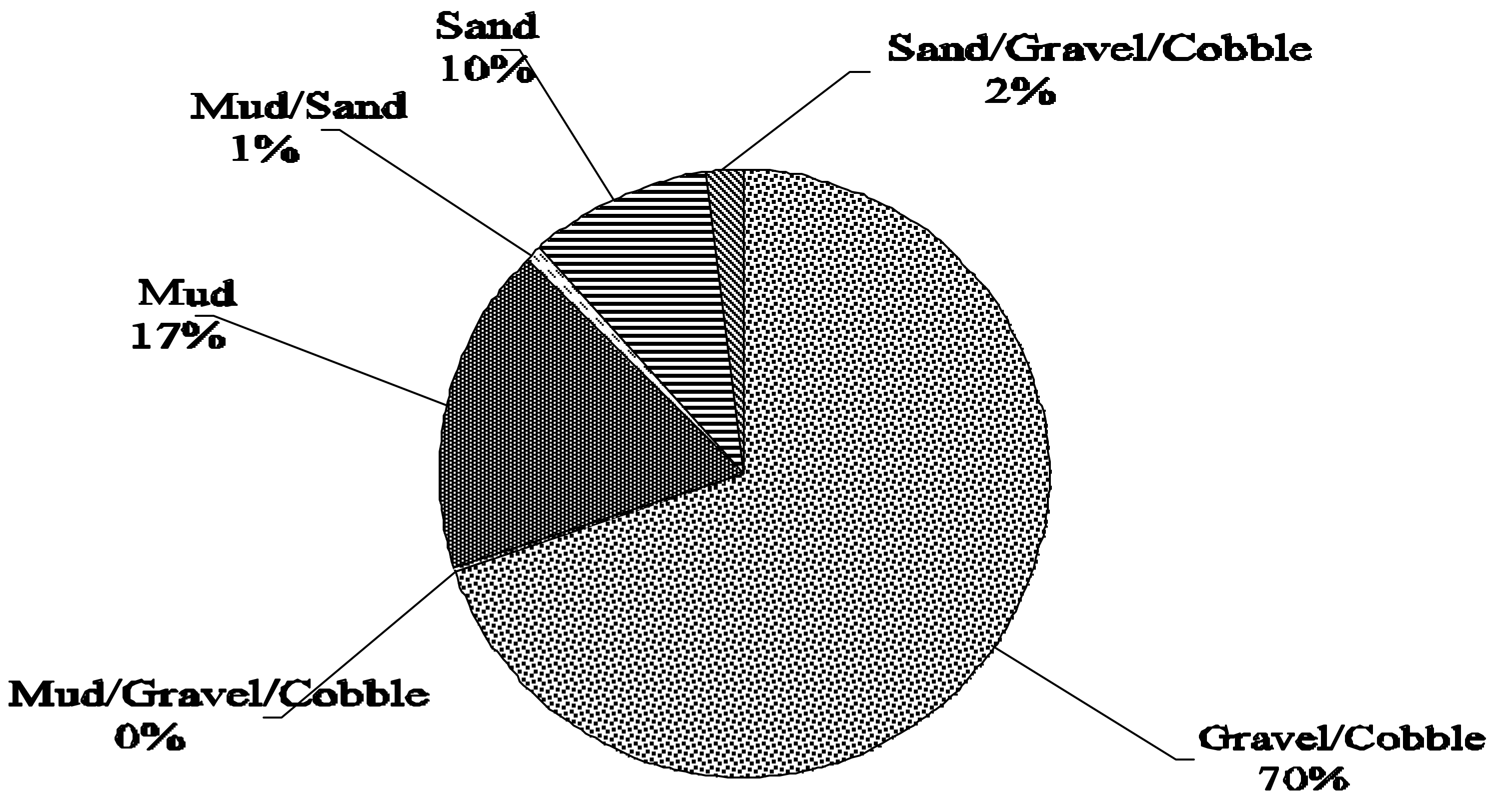

Figure 11. Graph representing the frequency of occurrence for the various substrate types with which relocated hatchery-reared, Phase II robust redhorse were associated.

Figure 12. Photograph of large, woody debris in the Ocmulgee River, Georgia with which the relocated hatchery-reared, Phase II robust redhorse was most (70% of the time) associated.

during spring 2002. Generally, the movement patterns and habit used estimated during this study were similar to those observed for other hatchery-reared robust redhorse released in the Oconee River during 1999 (Hess et al. in prep). Further, the habitat use of the hatchery-reared juveniles in the Ocmulgee and Oconee rivers is similar to that observed for wild adults in the Oconee River (Hess et al. in prep; Jennings et al. 2000).

Daily movement rates varied among individuals, about half of whom moved relatively short distances (i.e., #1 RKM); the remainder moved relatively longer distances (i.e., > 1 RKM) daily, including a few who averaged about 2 RKM daily. Why some fish disperse greater distances downstream than others is unknown, but other sucker species have shown movement patterns similar to those observed during the present study. Golden redhorse *M. erythrurum* and black redhorse *M. duquesnei* were "semi-mobile" in their movement patterns in warm-water streams in Missouri (Funk 1955). Fish-specific movement was common, but species movement was considered minor for both redhorse species (Funk 1955). Similarly, certain hatchery-reared razorback suckers moved throughout the study site while others were more sedentary and remained in the same general location (Bradford and Gurtin 2000). The more sedentary fish may be making generalized movement in response to local availability of cover or food (e.g., Mueller et al. 2003). In the case of hatchery-reared fish, those undertaking extreme downstream dispersal may be experiencing flow-related disorientation reported among pond-reared fish stocked in flowing environments without being preconditioned to flowing environments (e.g., Mueller et al. 2003). Whatever the reason, the movement patterns of hatchery-reared robust redhorse in this study seemed to be similar to the movement patterns of other redhorses and to that of the imperiled razorback sucker found in western rivers.

Tagged robust redhorse in this study were found associated with similar cover and substrate types as naturally-produced individuals in the Oconee River, GA (e.g., Jennings et al. 2000). Specifically, the fish in this study were found most often (83%) in association with large woody debris and most frequently (70%) associated with gravel/cobble substrates. Observations of substrate distribution in the river suggest that the reach of river between Lloyd Shoals Dam and Macon contained more long stretches of shoals and gravel/cobble substrates than was found in the reach of river below Macon. Despite the relatively limited distribution of gravel/cobble substrates downstream of Macon, three of the six fish in that area were found associated with gravel substrates. The association of robust redhorse with gravel/cobble substrates documented in this project has been reported for other redhorses (e.g., Yoder and Beaumier 1986; Bunt and Cook 2001) and other suckers (Jenkins and Burkhead 1994).

Open water (or the absence of any other obvious cover type) was the most abundant cover throughout the stretch of river from Llyod Shoals Dam to Warner Robbins, yet, only 18% of the contacts were for tagged fish in open water. These fish may have been in route from one habitat type (e.g., feeding) to another (e.g., resting). Many suckers and probably robust redhorse need clean substrates to be able to feed (Jenkins and Burkhead 1994). Perhaps the habitat use and movement patterns observed in this study (and others) suggest that robust redhorse inhabit fast water because the swift current keeps the substrates silt-free, which facilitates their feeding. When not feeding, robust redhorse may seek refuge from strong currents by positioning themselves downstream of fallen logs (Figure 12) or boulders (Figure 13) that are large enough to deflect the current (i.e., current break).

Figure 13. Photograph of large boulders in the Ocmulgee River, Georgia with which the relocated hatchery-reared, Phase II robust redhorse was most (70% of the time) associated.

These fallen current deflectors may provide robust redhorse a place to rest and conserve energy for more demanding tasks such as feeding in strong currents.

Only one confirmed mortality was recorded during the 82-day field portion of this study. The high survival of the tagged fish was confirmed by a similar survival rate among the control fish implanted with artificial transmitters. Though low, the observed mortality may have been related to stress associated with the harvest, transport, transmitter implantation, or being stocked. None-the-less, the estimated 97% survival recorded during this study can be used (assuming similar handling procedures throughout) to determine the number of individual needed to establish a target population size during other attempts to establish or augment refugial populations.

The results of this short-duration study suggests that hatchery-reared, juvenile robust redhorse could be used effectively to establish a refugial population that would remain within the study reach for at least 3-4 months. Our ability to track the radio-tagged ended about 82 days post stocking, when the transmitter batteries began failing. At this time, most (66%) of tagged fish were still in the study reach. Further, the slow downstream movement (i.e., < 0.1 RKM daily) undertaken by half of the tagged fish suggest that a sizeable portion of them would have remained in the study reach for at least another month. A small proportion of the tagged fish did disperse at a higher rate (i.e., 2 RKM daily) compared to the more sedentary group (i.e., < 1 RKM daily) of fish. Some of these fast dispersing fish eventually left the study site and were last contacted about 115 RMK downstream of the release site. Whether all of these movement patterns were seasonal (i.e., spring and summer) and may change during other seasons (i.e., fall and winter) are unknown. However, preconditioning pond-reared fish to flowing water prior to their release in riverine environments can reduce the rate and eventual distance of downstream dispersal. For example, the short-term (i.e., 23 days) downstream movement of razorback suckers pre-conditioned to flow for 2-3 days prior to being released was about 4X < fish that were not exposed to flow before being released into the river (Mueller et al. 2003).

Conclusions

Hatchery-reared, Phase II robust redhorse stocked in the Ocmulgee River Georgia just downstream of Lloyd Shoals Dam Fix remained near the stocking site for a few days post-stocking, then gradually dispersed downstream. The fish seemed able to find suitable habitat within the study reach, and most remained there through the end of the 82-day study. Why some of the robust redhorse in the present study left the designated reach is uncertain, but another study of hatchery-reared razorback suckers attributed long-range downstream dispersal to disorientation caused by inexperience with flowing water. Most fish in the present study were found near woody debris or over gravel substrates. This habitat associated may be related to the fish feeding over gravel substrates and resting behind woody debris or large boulders that deflect swift water currents. The high survival of stocked fish and their propensity to stay within the study reach suggest that the use of hatchery-reared, Phase II robust redhorse to establish a refugial population in Ocumulgee River between Lloyd Shoals Dam and Juliette Dam has been effective short-term strategy. How long the tagged fish will remain in the area or whether they establish a self-sustaining population are unknown, but the slow-dispersal rate of most of the fish is encouraging.

Acknowledgments

Georgia Power Company provided the funding for this work. Numerous individuals from many agencies were instrumental in producing and rearing the fish used in this study. Jimmy Evans and Wayne Clarke collected broodstock from the Oconee River. Greg Looney used the broodstock to produced fertilized eggs that were stocked as fry at GA DNR's McDuffie Fish Hatchery. Wayne Clarke helped with the transport of the fish, and Scott Hendricks assisted with surgical implantation of the radio transmitters in the fish that were released at Llyod Shoals Dam. Tom Reinert prepared the maps used in this report. Bryant Bowen, Stuart Carlton, and Diarra Mosley provided invaluable technical support during all aspects of the project.

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Host Identification and Glochidia Morphology of Freshwater Mussels from the Altamaha River Basin

Jennifer A. Johnson[1], Jason M. Wisniewski[2], Andrea K. Fritts[1], and Robert B. Bringolf[1,*]

Abstract - Recovery of imperiled freshwater mussels requires knowledge of suitable host fishes and other early life-history traits. We provide quantitative host information for 6 mussel species from the Altamaha River Basin, GA, 3 of which previously had no host information. Glochidia of *Alasmidonta arcula* (Altamaha Arcmussel) metamorphosed on 2 species of suckers (*Moxostoma* spp.); *Elliptio hopetonensis* (Altamaha Slabshell) on *Lepomis macrochirus* (Bluegill), *Pimephales promelas* (Fathead Minnow), and *Micropterus salmoides* (Largemouth Bass); *E. shepardiana* (Altamaha Lance) on 2 species of Bullheads (*Ameiurus* spp.) and *L. macrochirus*; *Lampsilis dolabraeformis* (Altamaha Pocketbook) on Bluegill and Largemouth Bass; and *L. splendida* (Rayed Pink Fatmucket) and *Villosa delumbis* (Eastern Creekshell) on Largemouth Bass. We also provide descriptions of glochidia morphology for the above mussel species and *E. spinosa* (Altamaha Spinymussel). Glochidia were correctly identified to species in 88.7% of cases by discriminant function analysis of 3 shell dimensions. Glochidia morphology may be useful for identification of glochidia attached to wild fish, thereby providing additional host information.

Introduction

Freshwater mussels (family Unionidae) provide critical ecosystem services and often dominate the benthic biomass in minimally impacted streams (Strayer et al. 2004). Live mussels and empty shells provide habitat for other invertebrates and fish, and as filter feeders, they influence nutrient cycling by linking the wa-

Introduction

Freshwater mussels (family Unionidae) provide critical ecosystem services and often dominate the benthic biomass in minimally impacted streams (Strayer et al. 2004). Live mussels and empty shells provide habitat for other invertebrates and fish, and as filter feeders, they influence nutrient cycling by linking the water column and the substrate (Spooner and Vaughn 2006). Nearly 300 species of unionids occur in North America, but unfortunately they are highly imperiled, with approximately 70% of North American species being considered of conservation concern (Neves et al. 1997, Williams et al. 1993). Factors thought to contribute to the decline of mussels include sedimentation, pollution, urbanization, and habitat fragmentation (Williams et al. 1993). Because nearly all mussel larvae (glochidia) are obligate parasites on fish, declines in host fish populations may also contribute to mussel declines.

The Altamaha River in Georgia (drainage area = 36,976 km^2) is inhabited by approximately 18 mussel species, of which 7 are endemic (Johnson 1970). At least 3 of the endemic species, *Alasmidonta arcula* Lea (Altamaha Arcmussel), *Pyganodon gibbosa* Say (Inflated Floater), and *Elliptio spinosa* Lea (Altamaha Spinymussel), are declining (Dinkins et al. 2004, Keferl 1981, O'Brien 2002a, Skelton et al. 2002, Wisniewski et al. 2005), and *E. spinosa* was listed as

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endangered in 2011 under the US Endangered Species Act. Fish hosts of mussel species in the Altamaha River are poorly known, and of the 3 declining endemic species, limited host information is available only for *A. arcula*. Identification of host fishes allows managers to determine if appropriate host species are present in the river, and knowledge of suitable hosts is also necessary for captive propagation of mussels, which can produce juveniles for population augmentation or toxicity testing. The Georgia State Wildlife Action Plan (2005; http://www.georgiawildlife.com/conservation/wildlife-action-plan) identified knowledge of early life histories of mussels endemic to the Altamaha River Basin as a high priority need for recovery of these species. Description of glochidia morphology also is necessary to identify patterns of glochidia occurrence on wild fishes, to inform phylogenetic relationships among species, and to provide additional characters for identification. In this study, we identify host fish and describe glochidia morphology of 7 mussels from the Altamaha River Basin: *A. arcula*, *E. spinosa*, *E. hopetonensis* Lea (Altamaha Slabshell), *E. shepardiana* Lea (Altamaha Lance), *Lampsilis dolabraeformis* Lea (Altamha Pocketbook), *L. splendida* Lea (Rayed Pink Fatmucket), and *Villosa delumbis* Conrad (Eastern Creekshell).

Methods

Mussel collection

Gravid female mussels were collected from the mainstem Altamaha River in 2008–2009 (Table 1) by visual and tactile searches with SCUBA and snorkel. All species except *A. arcula* and *E. spinosa* were collected downstream of Oglethorpe Bluff Landing, ≈12 km north of Jesup, GA (Fig. 1); *A. arcula* and *E. spinosa*

Table 3. Summary of host trials by species of mussel from the Altamaha River, GA. Metamorphosis success is reported as mean ± 95% confidence interval. Period = period in days of juvenile release, # = number of fish used.

Mussel species/ fish species	Common name	Metamorphosis success (%)	Juveniles produced	Period	#
Elliptio hopetonensis					
Lepomis macrochirus	Bluegill	3.7 ± 1.0	49	7–8	8
Pimephales promelas	Fathead Minnow	3.1 ± 0.7	55	7	4
Micropterus salmoides	Largemouth Bass	0.8 ± 0.4	16	7	4
Acipenser fulvenscens	Lake Sturgeon	0	0	-	3
Cyprinus carpio	Common Carp	0	0	-	4
Ictalurus punctatus	Channel Catfish	0	0	-	3
Elliptio shepardiana					
Ameiurus nebulosus	Brown Bullhead	45.2 ± 35.8	378	11–17	2
Ameiurus natalis	Yellow Bullhead	18.9	17	11–14	1
Lepomis macrochirus	Bluegill	2.2 ± 1.4	4	11–12	6
Moxostoma robustum	Robust Redhorse	0.1 ± 0.06	1	17	3
Acipenser fulvenscens	Lake Sturgeon	0	0	-	2
Hypentelium nigricans	Northern Hogsucker	0	0	-	2
Nocomis leptocephalus	Bluehead Chub	0	0	-	4
Lepomis microlophus	Redear Sunfish	0	0	-	5
Pimephales promelas	Fathead Minnow	0	0	-	5
Notropis hudsonius	Spottail Shiner	0	0	-	1
Notemigonus crysoleucas	Golden Shiner	0	0	-	1
Notropis lutipinnis	Yellowfin Shiner	0	0	-	15
Elliptio spinosa					
Acipenser fulvenscens	Lake Sturgeon	0	0	-	4
Cyprinus carpio	Common Carp	0	0	-	4
Ictalurus punctatus	Channel Catfish	0	0	-	4
Lepomis auritus	Redbreast Sunfish	0	0	-	4
Lepomis macrochirus	Bluegill	0	0	-	3
Micropterus salmoides	Largemouth Bass	0	0	-	4

Pimephales promelas	Fathead Minnow	0	0	-	5
Notropis hudsonius	Spottail Shiner	0	0	-	1
Notemigonus crysoleucas	Golden Shiner	0	0	-	1
Notropis lutipinnis	Yellowfin Shiner	0	0	-	15
Elliptio spinosa					
Acipenser fulvenscens	Lake Sturgeon	0	0	-	4
Cyprinus carpio	Common Carp	0	0	-	4
Ictalurus punctatus	Channel Catfish	0	0	-	4
Lepomis auritus	Redbreast Sunfish	0	0	-	4
Lepomis macrochirus	Bluegill	0	0	-	3
Micropterus salmoides	Largemouth Bass	0	0	-	4
Minytrema melanops	Spotted Sucker	0	0	-	4
Morone chrysops	White Bass	0	0	-	1
Morone saxatilis	Striped Bass	0	0	-	4
Pimephales promelas	Fathead Minnow	0	0	-	2
Lampsilis dolabraeformis					
Micropterus salmoides	Largemouth Bass	74.8 ± 3.6	1209	19–29	4
Lepomis macrochirus	Bluegill	1.5 ± 0.1	23	10–19	22
Acipenser fulvenscens	Lake Sturgeon	0	0	-	3
Ictalurus punctatus	Channel Catfish	0	0	-	2
Notemigonus crysoleucas	Golden Shiner	0	0	-	5
Pimephales promelas	Fathead Minnow	0	0	-	4
Lampsilis splendida					
Micropterus salmoides	Largemouth Bass	43.0 ± 5.5	2352	13–24	5
Villosa delumbis					
Micropterus salmoides	Largemouth Bass	73.1 ± 1.5	4673	12–24	18

Results

Host trials

Juvenile *A. arcula* (61 individuals total, %M = 4.6) were produced by all 4 individuals of *Moxostoma robustum* Cope (Robust Redhorse) and 4 *A. arcula* juveniles (%M = 0.8) were produced from 1 of the 7 *Moxostoma rupiscartes* (Striped Jumprock). No juvenile *A. arcula* were produced from 26 other fish species tested (Table 2). Juvenile *E. hopetonensis* were produced from Bluegill (%M = 3.7), *Pimephales promelas* (Fathead Minnow; %M = 3.1), and Largemouth Bass (%M = 0.8), but 3 other species were non-hosts (Table 3). Juvenile *E. shepardiana* were produced by *Ameiurus nebulosus* Lesueur (Brown Bullhead; %M = 45.2), *A. natalis* (Yellow Bullhead; %M = 18.9) and Bluegill (%M = 2.2%). A single *E. shepardiana* juvenile was produced from a Robust Redhorse (%M = <0.1%), and no juveniles were produced from 8 other fish species (Table 3). Juvenile *L. dolabraeformis* were produced from Largemouth Bass (%M= 74.8%) and Bluegill (%M = 1.5), but no juveniles were produced from 4 additional fish species (Table 3). Largemouth Bass also produced juvenile *L. splendida* (% M = 43) and *V. delumbis* (%M = 73.1); no other fish species were tested with *L. splendida* and *V. delumbis* (Table 3). None of the 10 fish species tested produced juvenile *E. spinosa* (Table 3). Eight fish species sloughed 100% of the attached *E. spinosa* glochidia within 3 days after initial glochidia exposure (data not shown), but 4 *E. spinosa* glochidia remained attached on *Acipenser fulvescens* (Lake Sturgeon) and 5 on *Lepomis auritus* (Redbreast Sunfish) until 5 days after attachment.

Glochidia morphology and shell ultrastructure

Glochidia height ($F_{5,149}$= 161.3, P < 0.0001), length ($F_{5,149}$ = 323.5, P < 0.0001), and hinge length ($F_{5,149}$ = 530.4, P < 0.0001) all varied significantly among the 6 efforts to identify additional hosts should continue.

O'Brien (2002b) reported the only other published host information for Altamaha mussel species. In that study, juvenile *E. hopetonensis* were produced from Eastern Mosquitofish and Bluegill, but not from Largemouth Bass. In the present study, juvenile *E. hopetonensis* were produced by Bluegill, Largemouth Bass, and Fathead Minnows. O'Brien (2002b) reported that *L. dolabraeformis* juveniles were produced from Eastern Mosquitofish and Largemouth Bass, but not from Bluegill. In the present study, juvenile *L. dolabraeformis* were produced on Largemouth Bass and Bluegill to a lesser extent.

One of the objectives for this study was to identify a host fish for the federally endangered *E. spinosa*. Unfortunately, suitable hosts for *E. spinosa* remain unknown at this time. The major limiting factor in our trials was the inability to collect gravid females. In 2009 and 2010, record high flows in the Altamaha limited search efforts in April–June, the period when gravid *E. spinosa* had been collected by other investigators (P. Johnson, Alabama Department of Conservation and Natural Resources Alabama Aquatic Biodiversity Center, Marion, AL, pers. comm.). Future host trials with *E. spinosa* will depend upon a source of gravid females. One option is to collect *E. spinosa* throughout the year and relocate them to a centralized location where the chances of recapture are greater. Another option is to attach external sonic tags or passive integrated transponder (PIT) tags to the mussels to enhance the chances of recovery during periods of gravidity. Additionally, *E. spinosa* may be collected throughout the year and returned to a culture facility to determine if they will undergo fertilization and brooding in captivity.

A number of factors can influence metamorphosis success in host trials, including those in the present study. Mussels may have higher metamorphosis rates on fish with which they co-occur than fish of the same species from other basins (Strayer 2008). Metamorphosis success also appears to be higher on smaller and younger fish than older and larger fish of the same species even if the larger fish

Presence of Altamaha shiner (*Cyprinella xaenura*) and Ocmulgee shiner (*Cyprinella callisema*) within several Chattahoochee-Oconee National Forest streams, September 2003

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December 2004

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Introduction

In August 2003, resource managers from the Chattahoochee-Oconee National Forest (CONF) requested assistance from the U.S. Forest Service, Southern Research Station, Center for Aquatic Technology Transfer (CATT) to document the presence of the State Endangered (Johnson 1999) and Forest-sensitive Altamaha Shiner (*Cyprinella xaenura*) and the Forest-sensitive Ocmulgee Shiner (*Cyprinella callisema*) in several Forest watersheds. Past surveys had demonstrated the occurrence of these species in several streams on or near the Forest (CONF unpublished data). In September 2003, a crew from the CATT surveyed ten sites on nine streams using backpack electrofishing techniques to determine fish species presence in the Little River, Upper Ocmulgee River, and Upper Oconee River watersheds (Figure 1) on the CONF, GA during September 2003 (Table 1). Stream-specific maps are included for all streams surveyed (Figures 2-7).

Methods

Sampling methods were designed in coordination CONF biologists to mimic methods used during previous shiner inventories. We used 700 volt AC backpack electrofishing equipment to document species presence in each reach. The number of electrofishing units used was based on stream width: 1 unit for streams 1-5 m wide; 2 units for streams 5-20 m, and 3 units for streams greater than 20 m wide. We assigned one dipnetter to each electrofishing unit. When the bankfull width was 5 m – 15 m, sample reach length was 20-times mean bankfull channel width. A minimum of 100 m and maximum of 300 m was sampled. We attempted to include at least two fast water (riffle/run) and two slow water (pool/guide) units per reach.

We sampled several reaches that had previously been inventoried and new reaches were selected by CONF biologists. All stream reaches were at least 100 m upstream from any road crossings except when private land holdings restricted upstream sampling. When we sampled downstream from a road crossing the upstream end of the survey site was at least 100 m downstream of the road crossing. Reaches were sampled by single-pass removal. Fishes captured were identified to species, recorded using a Husky fex21 field data computer, and then released in the sample reach. Fish that could not be identified in the field were preserved in 10% formalin and returned to the lab for identification. Dr. Bud Freeman's lab at the University of Georgia identified preserved specimens.

Results

We captured a total of 41 fish species in 9 families in the 9 streams we inventoried (Table 2, Appendix A). Ocmulgee shiners were present in 9 of the 10 sites sampled and Altamaha shiners were present at 5 sites (Table 2). Species richness varied from a high of 24 species (Big Sandy Creek) to a low of 11 species at two sites (Stalking Head Creek and Falling Creek). Redbreast sunfish (*Lepomis auritus*) and yellowfin shiner (*Notropis lutipinnis*) were present at all 10 sample sites. The least common fish were v-lip redhorse (*Moxostoma collapsum*), spotted sucker (*Minytrema melanops*), spotted sunfish (*Lepomis punctatus*), chain pickerel (*Esox niger*), and bluefin stoneroller (*Campostoma pauciradii*) found at one site each. American eels (*Anguilla rostrata)* were found at two sites. Five Catostomidae species were found at seven different sites and Murder Creek (below highway 16) showed the greatest sucker diversity with four species. Striped jumprock (*Scartomyzon rupiscartes)* was present at five sites, possibly being the most locally abundant sucker species.

Discussion

The methods described in this report may yield 80-100% of species present in stream fish communities. However, the methods also may underestimate species richness, particularly for centrarchids and cyprinids (Meador et al. 2003). Longer stream reaches may need to be sampled to capture a larger proportion of species in areas with low population density or low habitat diversity, and even then uncommon or rare species may not be captured (Angermeier and Smogor 1995, Angermeier et al. 2002). In addition, sites on Apalachee River, Murder Creek (Hillsboro Rd.), and Little River streams were too large for us to effectively sample with backpack electrofishers.

Despite limitations, we documented Ocmulgee shiners at one previously sampled site (Murder Creek; Hillsboro Road) where they had been absent in the past (Table 3). In addition, we captured Ocmulgee shiners at six sites and Altamaha shiners at two sites that had not been previously sampled (Table 4). Our results suggest that these and other Forest sensitive species may be more widely distributed within Forest streams than previously realized. Managers should take this into account when planning activities that have the potential to influence water quality and habitat. Further surveys are needed to more fully describe distributions of fish species on CONF managed lands. We recommend that the CONF work with the CATT to develop a comprehensive strategy for gathering inventory information and establish a monitoring plan for all Forest sensitive and threatened and endangered aquatic species.

With only minimal commitment of time and expense, it is possible to greatly expand the utility of such baseline inventories. We recommend that the total number of each species be tallied and that at least a sub-sample of each species be measured and possibly weighed. Such information, when coupled with knowledge of both current and historical conditions, would provide the basis for meeting many of the requirements of NEPA, NFMA, and other legislation.

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Table 1. Description of fish sample site locations on CONF, September 2003.

Stream	Date	Location	Bankfull Width (m)	Reach Length (m)	Shock Start Location
Rose Creek (Figure 6)	9/9/03	downstream of highway 15 bridge, private land	10	200	300 m downstream of bridge
Apalachee River (Figure 2)	9/9/03	end of Trembling Bridge Road - bridge frame in place but not functional	25*	180	40 m downstream of bridge, 80 m downstream of side channel
Murder Creek (Figure 5)	9/9/03	downstream of highway 16 bridge	17	300	400 m downstream of bridge
Wise Creek (Figure 3)	9/10/03	100 m upstream of confluence with Ocmulgee River	16	300	100 m upstream of confluence with Ocmulgee River
Stalkinghead Creek (Figure 7)	9/10/03	100 m upstream of forest road 1020 (Felton McMichael Rd.) bridge	7	170	100 m upstream of forest road 1020 bridge
Murder Creek (Figure 5)	9/10/03	59 m upstream of bridge on Hillsboro Rd.	25	97	59 m upstream of bridge on Hillsboro Rd.
Little River (Figure 5)	9/10/03	150 m upstream of Rock Eagle Rd. crossing	20	300	150 m upstream of Rock Eagle Rd. crossing
Big Sandy Creek (Figure 3)	9/11/03	on quad map where gravel road crosses creek more than 1km upstream of railroad crossing; road now washed out; hiked in short distance; turn off hwy 23 north after mile 17 gravel road on right across from Watson Rd., private land	15	300	at old road crossing on quad map-road washed out no longer in use
Caney Creek (Figure 4)	9/11/03	end of 903d road at turnaround	8	160	start where 903d would cross stream if no dead end
Falling Creek (Figure 4)	9/11/03	end of road 904 at turnaround	9	180	start where 904 would cross stream if no dead end

* only two shockers used; right bank of 25 m wide section shocked before entering side channel on left that was less than 20 m wide.

Table 2. Species present at sample sites on CONF streams, September 2003. 'X' equals presence.

Common Name	Rose Creek	Appalachee River	Murder Creek	Little River	Big Sandy Creek	Wise Creek	Falling Creek	Stalking Head Creek	Caney Creek	Murder Creek	Total Number of Streams Where Present
American eel					X			X			2
pirate perch		X	X	X						X	4
redfin pickerel	X	X		X							3
chain pickerel					X						1
golden shiner			X								1
rosyface chub	X		X	X		X			X	X	6
silverjaw minnow					X		X		X		3
eastern silvery minnow	X		X							X	3
spottail shiner	X	X	X	X	X	X			X	X	8
carp	X										1
bluehead chub	X	X	X	X	X		X	X	X	X	9
bluefin stoneroller					X						1
altamaha shiner			X	X	X		X			X	5
ocmulgee shiner	X	X	X	X	X	X	X		X	X	9
yellowfin shiner	X	X	X	X	X	X	X	X	X	X	10
creek chubsucker					X			X			2
spotted sucker			X								1
brassy jumprock			X								1
striped jumprock	X		X	X	X	X					5
v-lip redhorse			X								1
Scartomyzon spp.							X				1
channel catfish	X	X		X		X					4
yellow bullhead	X	X									2
snail bullhead			X	X	X		X	X	X	X	7
margined madtom		X	X	X	X	X					5
mosquitofish	X	X	X	X	X	X					6
redeye bass			X	X	X		X		X	X	6
shoal bass						X		X			2
largemouth bass	X				X						2
warmouth			X	X	X					X	4
black crappie	X				X						2
green sunfish					X						1
bluegill	X	X		X	X	X		X		X	7
spotted sunfish								X			1
redear sunfish	X	X									2
pumpkinseed			X			X					2
longear sunfish					X	X					2
redbreast sunfish	X	X	X	X	X	X	X	X	X	X	10
blackbanded darter	X	X	X	X	X	X	X		X	X	9
tessellated darter		X							X		2
turquoise darter			X		X			X		X	4
christmas darter				X			X	X	X	X	5
Total species	18	15	22	19	24	14	11	11	12	16	

Table 3. Comparison of Altamaha and Ocmulgee shiner presence/absence at site locations from September 2003 and previous sample years. Site numbers are from the Altamaha & Ocmulgee shiners sites map provided by CONF. See Table 1 for site location descriptions.

Stream	**Previous**		**Altamaha shiner**		**Ocmulgee shiner**	
	Sample	**Site #**	**Previous**	**2003**	**Previous**	**2003**
Big Sandy Creek	9/02/1998	7	Present	Present	Present	Present
Rose Creek	9/27/1970	12	Absent	Absent	Present	Present
Murder Creek Hwy 16	9/21/1999	4	Present	Present	Present	Present
Murder Creek Hillsboro Rd.	7/19/1993	10	Present	Present	Absent	Present

Table 4. Altamaha and Ocmulgee shiner presence/absence at new locations sampled in September 2003. See Table 1 for site location descriptions.

Stream	**Altamaha Shiner**	**Ocmulgee Shiner**
Apalachee River	Absent	Present
Wise Creek	Absent	Present
Stalking Head Creek	Absent	Absent
Little River	Present	Present
Caney Creek	Absent	Present
Falling Creek	Present	Present

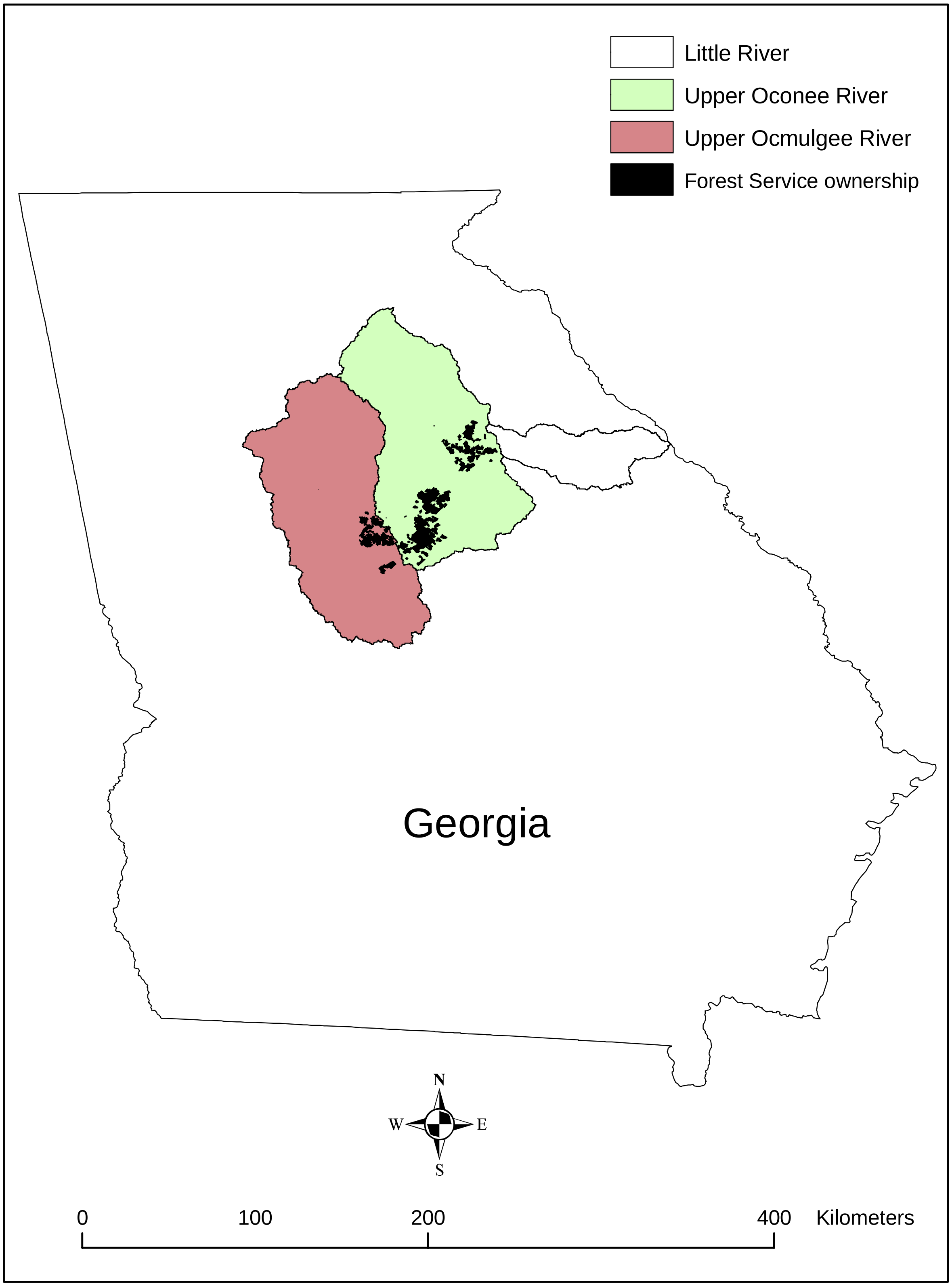

Figure 1. Watersheds sampled on the Chattahoochee-Oconee National Forest, September 2003.

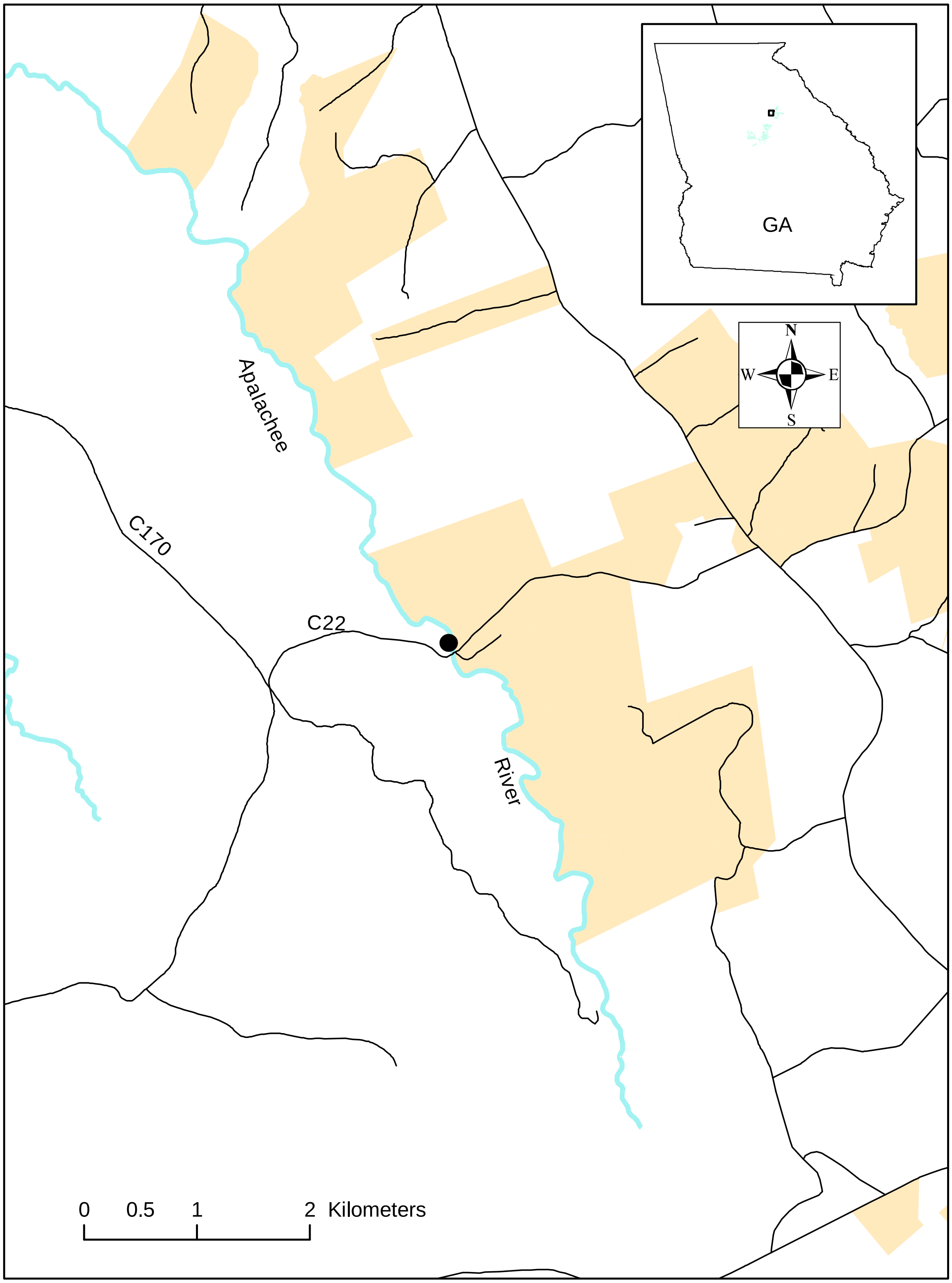

Figure 2. Chattahoochee-Oconee National Forest (shaded), Apalachee River sample site, September 2003. Closed circle represents sample site.

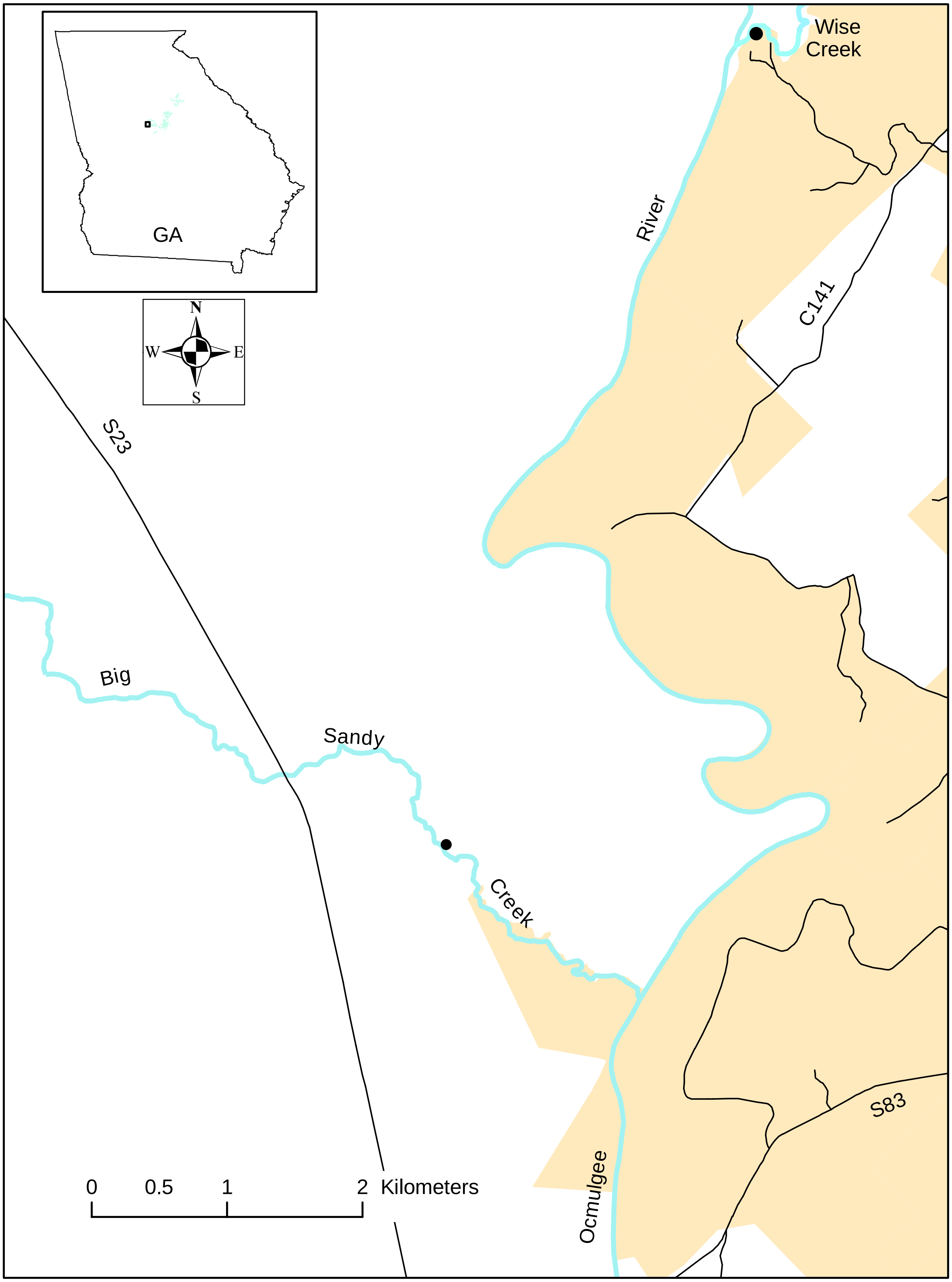

Figure 3. Chattahoochee-Oconee National Forest (shaded), Big Sandy Creek and Wise Creek sample sites, September 2003. Closed circles represent sample sites.

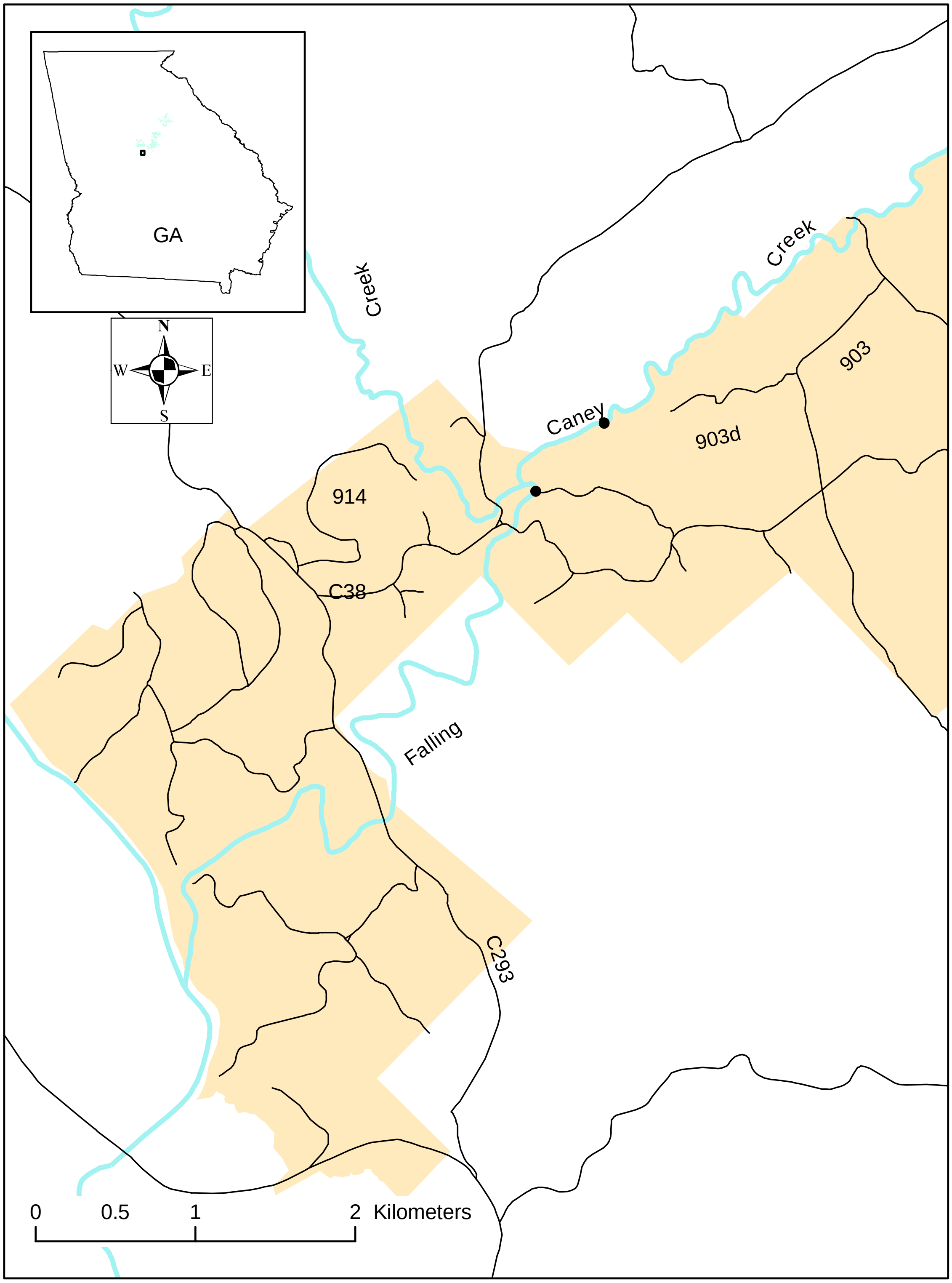

Figure 4. Chattahoochee-Oconee National Forest (shaded), Falling Creek and Caney Creek sample sites, September 2003. Closed circles represent sample sites.

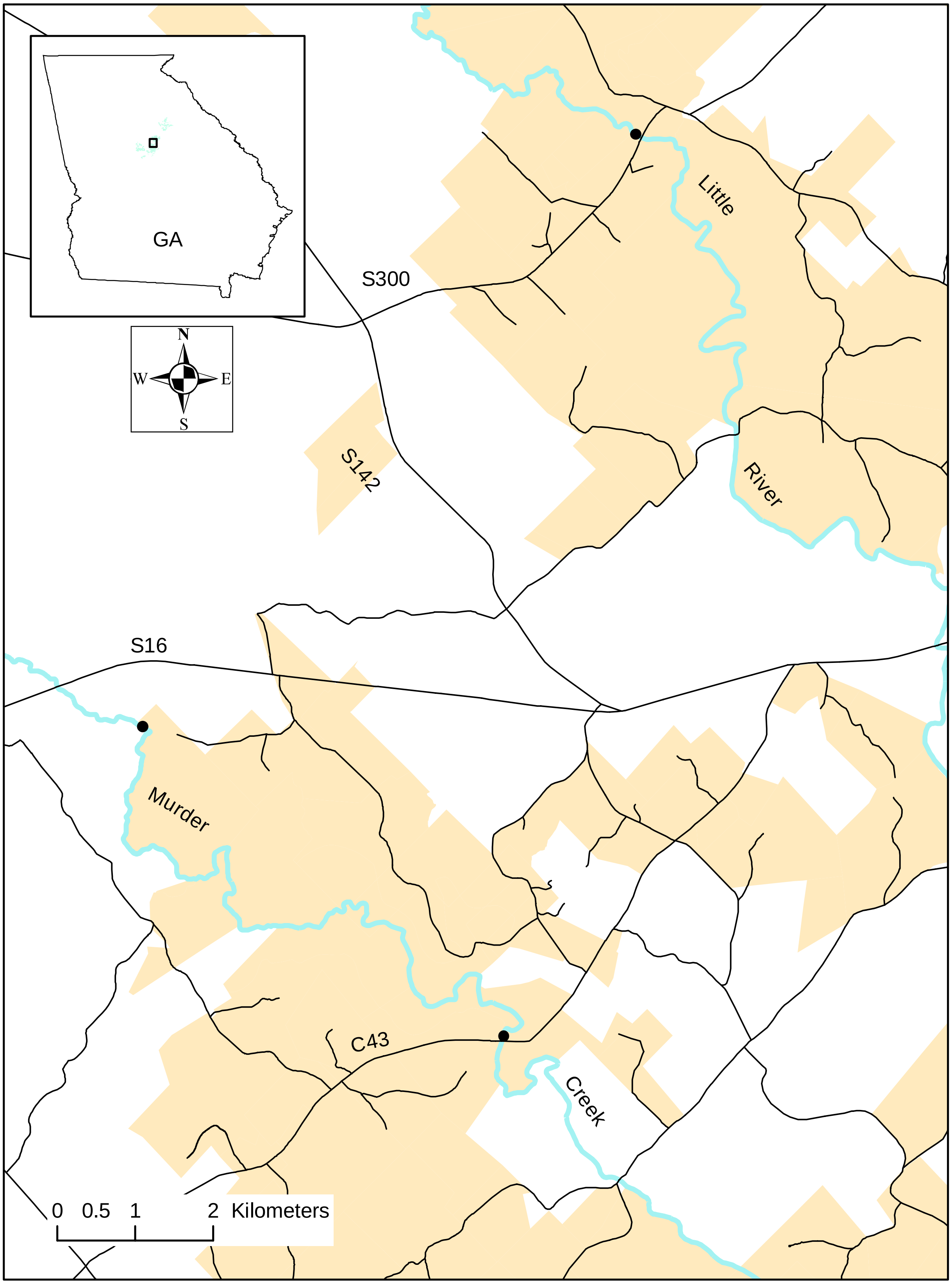

Figure 5. Chattahoochee-Oconee National Forest (shaded), Murder Creek and Little River sample sites, September 2003. Closed circles represent sample sites.

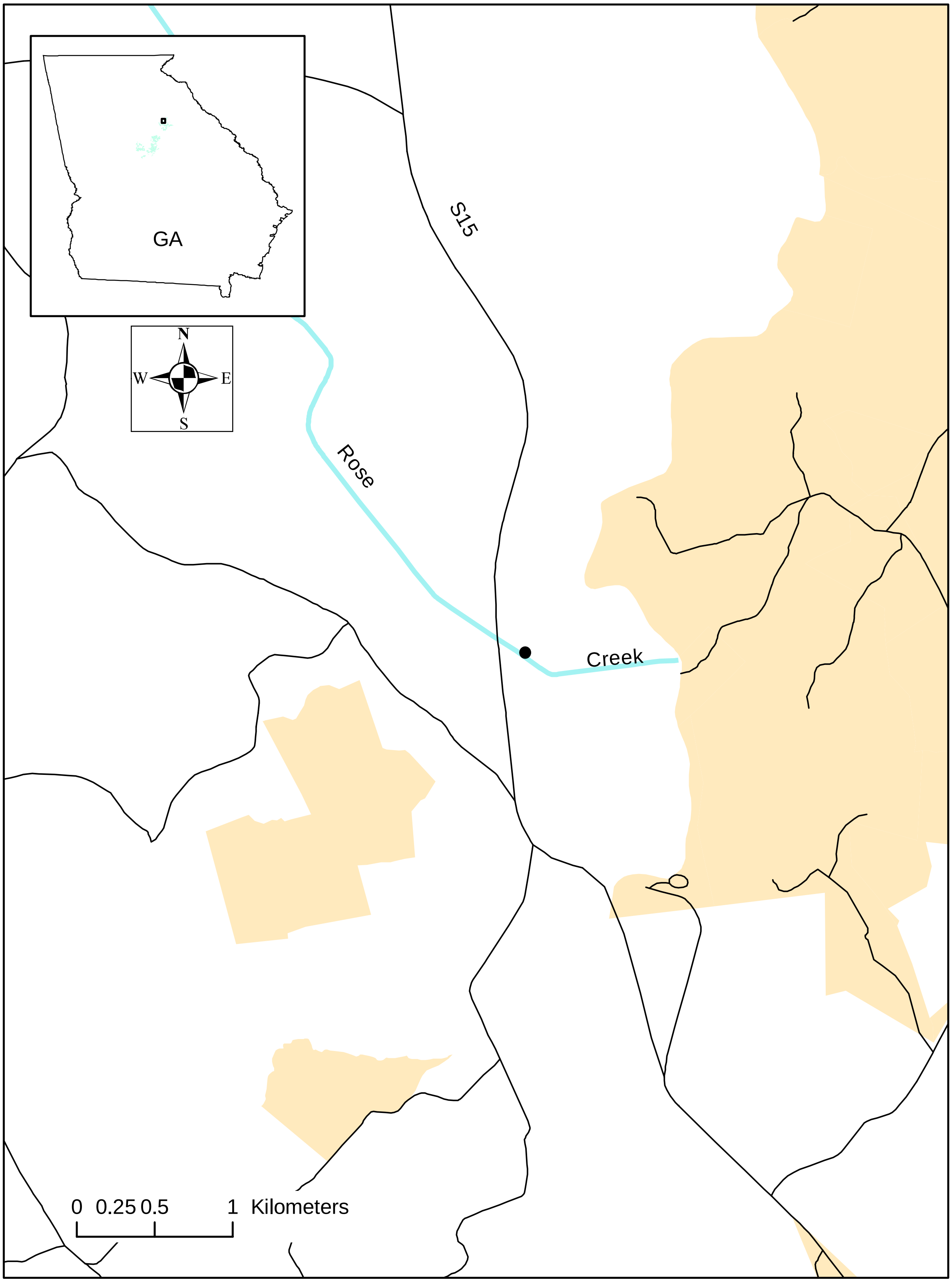

Figure 6. Chattahoochee-Oconee National Forest (shaded), Rose Creek sample site, September 2003. Closed circle represents sample site.

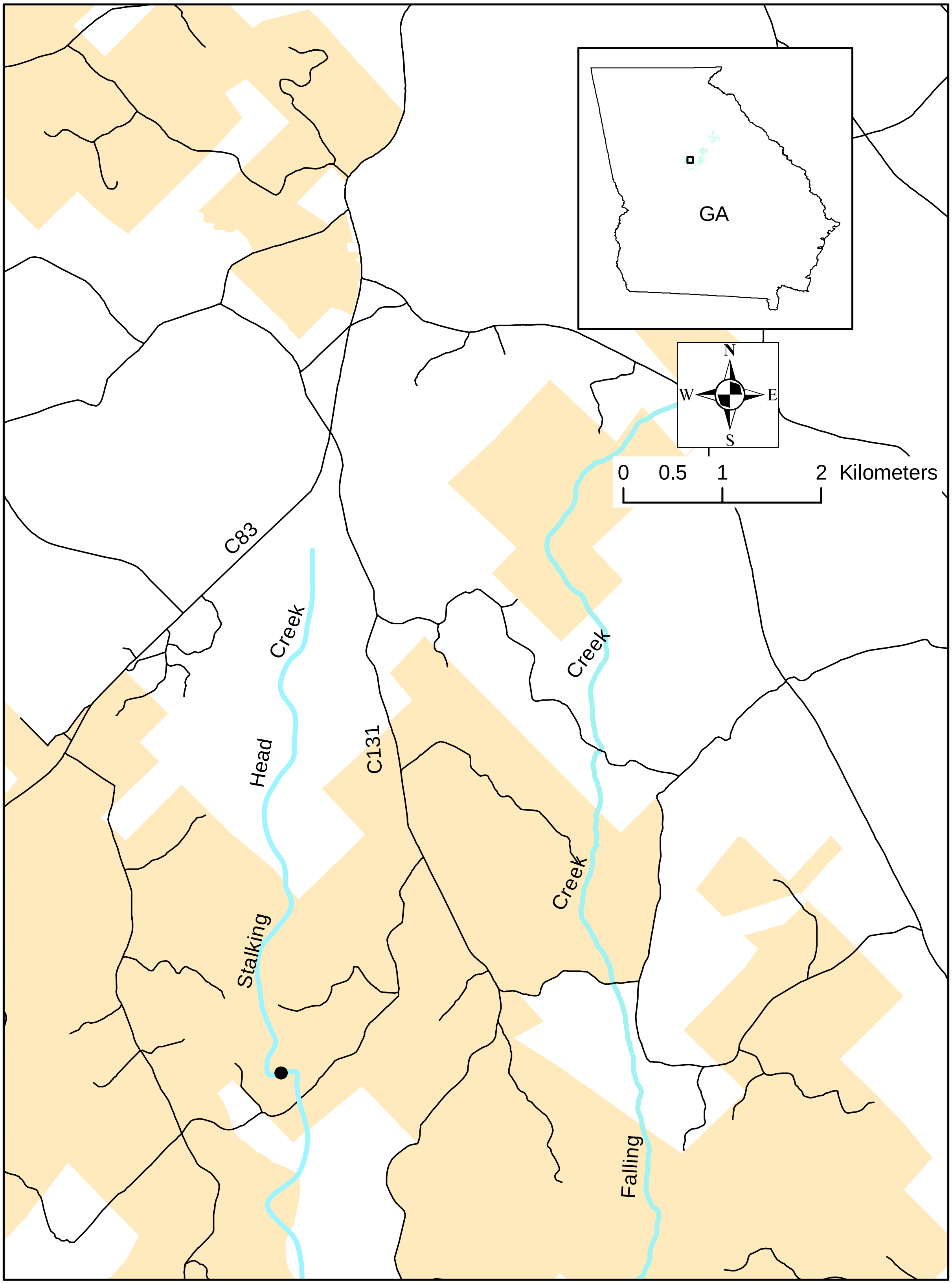

Figure 7. Chattahoochee-Oconee National Forest (shaded), Stalking Head Creek sample site, September 2003. Closed circle represents sample site.

Appendix A. Species and family fish list of fish species captured in CONF streams in September 2003.

Family		**Species**	
Anguillidae	Freshwater Eels	*Anguilla rostrata*	American eel
Aphredoderidae	Pirate perch	*Aphredoderus sayanus*	pirate perch
Esocidae	Pikes	*Esox a. americanus*	redfin pickerel
		Esox niger	chain pickerel
Cyprinidae	Minnows	*Notemigonus crysoleucas*	golden shiner
		Hybopsis rubrifrons	rosyface chub
		Ericymba buccata	silverjaw minnow
		Hybognathus regius	eastern silvery minnow
		Notropis hudsonius	spottail shiner
		Cyprinus carpio	carp
		Nocomis leptocephalus	bluehead chub
		Campostoma pauciradii	bluefin stoneroller
		Cyprinella xaenura	Altamaha shiner
		Cyprinella callisema	Ocmulgee shiner
		Notropis lutipinnis	yellowfin shiner
Catostomidae	Suckers	*Erimyzon oblongus*	creek chubsucker
		Minytrema melanops	spotted sucker
		Scartomyzon brasseus	brassy jumprock
		Scartomyzon rupiscartes	striped jumprock
		Moxostoma collapsum	v-lip redhorse
Ictaluridae	Catfishes	*Ictalurus punctatus*	channel catfish
		Ameiurus natalis	yellow bullhead
		Ameiurus brunneus	snail bullhead
		Noturus insignis	margined madtoms
Poeciliidae	Live bearers	*Gambusia holbrooki*	mosquitofish
Centrarchidae	Sunfishes and Basses	*Micropterus coosae*	redeye bass
		Micropterus cataractae	shoal bass
		Micropterus salmoides	largemouth bass
		Lepomis gulosus	warmouth
		Pomoxis nigromaculatus	black crappie
		Lepomis cyanellus	green sunfish
		Lepomis macrochirus	bluegill
		Lepomis punctatus	spotted sunfish
		Lepomis microlophus	redear sunfish
		Lepomis gibbosus	pumpkinseed
		Lepomis megalotis	longear sunfish
		Lepomis auritus	redbreast sunfish
Percidae	Perch and Darters	*Percina nigrofasciata*	blackbanded sunfish
		Etheostoma olmstedi	tessellated darter
		Etheostoma inscriptum	turquoise darter
		Etheostoma hopkinsi	Christmas darter

USE OF HIERARCHICAL OCCUPANCY MODELS TO ESTIMATE THE SEASONAL DISTRIBUTION AND HABITAT USE OF STOCKED ROBUST REDHORSE *MOXOSTOMA ROBUSTUM* IN THE UPPER REACHES OF THE OCMULGEE RIVER, GEORGIA

by

WILLIAM AUSTIN PRUITT

(Under the Direction of Cecil Jennings)

ABSTRACT

The robust redhorse *Moxostoma robustum* is an imperiled fish that inhabits large Atlantic slope rivers in Georgia and the Carolinas. To establish a refugial population, GA Power Company stocked robust redhorse in the upper Ocmulgee River, Georgia. I used occupancy modeling to estimate seasonal habitat use of the current population of stocked fish within the project site. Modeling results revealed robust redhorse have a conditional detection probability of 0.183(±0.128) and an occupancy rate of 0.033 (±0.046) throughout the project site. Further, the Upper Ocmulgee River population was found most frequently in areas with coarse substrates and high velocity year round. Although this habitat use pattern is different than that of the nearby Oconee River population, habitat characteristics differ between the two rivers. I conclude that robust redhorse were residing in shoals inaccessible to researchers or have left the headwaters entirely and reside in the Coastal Plain portion of the Ocmulgee.

INDEX WORDS: Catostomidae, suckers, Piedmont, site occupancy, presence, conditional detection, rare species, sonar imagery

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B.S., University of Tennessee, Knoxville, 2008

A Thesis Submitted to the Graduate Faculty of the University of Georgia
in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2013

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December 2013

ACKNOWLEDGEMENTS

First and foremost, I thank my advisor, Dr. Cecil Jennings for taking me on as his student and for his insight, wisdom, guidance, patience, and support throughout this project. I also thank my committee members, Dr. Jim Peterson and Dr. Brenda Rashleigh for their much-needed expertise in the data analysis, their suggestions, comments, support, and words of encouragement. I especially thank Peter Dimmick, Patrick Ely, Rebecca Cull Peterson, and Steve Zimpfer for their extensive assistance during the long sampling days on the river. I also thank Zach DeWolf, Sara Duquette, Justin Dycus, Joshua Hixson, Kristen Kellock, Joseph Kirsch, Matt Nordgren, Seth Sullivan, and Dr. Erika Wolf for additional help during field sampling. In addition, I thank Dr. Colin Shea and John Hook for technical support and Thom Litts, Adam Kaeser, and Tanner Williamson for gathering sonar imagery and for technical assistance in ArcGIS. Lastly, I thank my loving family for their unwavering support and encouragement through my years spent as a graduate student.

Funding for this project was provided by Georgia Power Company and the Georgia Cooperative Fish and Wildlife Research Unit. Vehicles and boats used during my research were provided by United States Geological Survey and the University of Georgia. I thank the D.B. Warnell School of Natural Resources for support and providing facilities and computers during my research.

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CHAPTER 1

INTRODUCTION

Discovery of Robust Redhorse

The robust redhorse (*Moxostoma robustum*) is a large fish that historically occupied medium to large rivers in the Piedmont and upper Atlantic Coastal Plains of Georgia, North Carolina, and South Carolina (Cope 1869, Bryant *et al*.1996). In response to the robust redhorse's limited distribution and population decline attributable to extensive habitat loss and the introduction of invasive species, the fish became state listed as endangered in Georgia (Bryant *et al*. 1996, Grabowski and Jennings 2009). The robust redhorse was first described from the Yadkin River, North Carolina in 1869 (Cope 1869); however, additional specimens remained unnoticed by ichthyologists for over a century (Bryant *et al*. 1996) as a result of the species not being collected or being misidentified. In 1991, a catostomid matching Cope's original description was found in the Oconee River, GA, and subsequent taxonomic observations of collected specimens confirmed that the fish in question was similar to that described by Cope (1869). Eventually, the Oconee River catostomid was confirmed as a robust redhorse, which had remained unrecorded for over 120 years (Bryant *et al*. 1996, Ruetz and Jennings 2000). Soon after robust redhorse was found in the Oconee River, other Atlantic slope rivers such as the Savannah, Yadkin, and Pee Dee were surveyed for the mystery fish.

The "rediscovery" in the Oconee River led to the formation of the Robust Redhorse Conservation Committee (RRCC), which is a multi-stakeholder partnership formed by state and federal agencies, non-governmental organizations, and private industries in Georgia, North Carolina, and South Carolina under a Memorandum of Understanding. Concerned with the potential extinction of robust redhorse, the RRCC set goals to determine the current status of the species, identify conservation and habitat needs, and coordinate efforts to address those needs. As a result, extensive captive propagation and stocking programs were implemented to re-introduce or augment populations throughout their presumed historic range in Coastal Plain ecoregions of Georgia and the Carolinas (robustredhorse.com, accessed November 2012). The persistence of wild and stocked populations in the Coastal Plain portions of the Oconee, Savannah, and Yadkin/Pee Dee rivers have been extensively monitored during the last decade (robustredhorse.com, accessed November 2012). However, the fate of stocked populations in the upper reaches of the Ocmulgee River, Georgia has not been documented.

Decline of Robust Redhorse

Historic robust redhorse abundance remains unknown; however, hypothesized contributors to the range-wide decline of aquatic fauna in the southeastern United States includes increased sedimentation, habitat degradation, and fragmentation related to the construction and operation of dams (Kinsolving and Bain 1993). Dams and impoundments affect riverine fishes, including large river catostomids, by creating physical boundaries, large fluctuations in discharge, temperature change, and the alteration of natural flow conditions (Kinsolving and Bain 1993). The introduction of large non-native predators, such as flathead catfish (*Pylodictis olivaris*) also may have contributed to the decline of robust redhorse populations during the latter portion of the twentieth century. Flathead catfish are voracious, generalist predators, known to consume many species that may not occur in the fish's diet within its native range when introduced into a new body of water (Pine *et al*. 2005). Within the Ocmulgee River, introduced flathead catfish potentially prey upon juvenile and adult suckers such as notchlip redhorse (*Moxostoma collapsum*) and robust redhorse, as well as native catfishes such as snail bullheads (*Ameiurus brunneus*) and flat bullheads (*Ameiurus platycephalus*) (Bart *et al*. 1994).

Restoration of extirpated robust redhorse populations is part of a larger effort to preserve native and historic ichthyofauna in the Carolinas and Georgia. Although restoration efforts may aid in the re-establishment of extirpated robust redhorse populations, the ability of stocked individuals to survive and reproduce remains unclear. Catostomids, like other non-game species, have the potential to become threatened, endangered or extinct without notice because they usually received inadequate attention compared to economically or recreationally valuable fish species (Ricciardi and Rasmussen 1999; Cooke *et al*. 2005). To develop an effective conservation strategy, an understanding of catostomid biology is crucial, especially in cases where a population status is unknown (Cooke *et al*. 2005). In situations where traditional methods cannot be used or have little utility (e.g., low population size or capture probability), the application of new techniques (e.g., occupancy models) may augment the current knowledge of the ecology and life history of robust redhorse and allow managers to make more informed decisions regarding the conservations actions needed to preserve and ensure the persistence of the species.

Objectives

The primary goal of this study was to evaluate the relative influence of various environmental characteristics on robust redhorse habitat use and spatial distribution in an experimental population established in the Ocmulgee River, GA. Why this population was established in this river is explained in the “Problem Statement” section that comes later in this thesis. My primary goal was achieved by assessing the occurrence of robust redhorse within the upper reaches of the Ocmulgee River, Georgia to address the following objectives.

- Determine if robust redhorse are naturally reproducing and recruiting.
- Identify the relative importance of in-stream habitat, mesohabitat, water quality, and seasonality on robust redhorse occupancy at the river reach and sampling unit levels.
- Quantify the degree of influence of the most important habitat characteristics, water quality variables, and various biotic interactions on robust redhorse detection and site occupancy.
- Use detection and occupancy rates to determine where sampling effort, monitoring programs, and management actions should be directed for the Ocmulgee population of robust redhorse.

Ultimately, I employ the results of these efforts to assess the utility of hierarchical occupancy modeling for determining detection probabilities and site occupancy of robust redhorse. This modeling framework can be applied to future robust redhorse research should these methods yield more realistic results of robust redhorse population status than traditional estimates. With better population estimates, scientists can more accurately interpret the true outcome of reestablishment efforts for robust redhorse than previous estimations. Managers will also be able to better determine if self-sustaining populations are a realistic goal for the species. In addition, this study will provide seasonal spatial distribution data of other catostomids throughout the project site.

CHAPTER 2

LITERATURE REVIEW

Species Description

The robust redhorse is a large riverine sucker that is distinguishable from other large redhorses (Genus *Moxostoma*) by its overall size (adults average 500-760 mm TL and 8+ kg) and stout body shape. Further, the presence of large, molariform, pharyngeal teeth, distinctive plicate lips, and bright red pigmentation on the caudal fin distinguish robust redhorse from other redhorse species (Jenkins and Burkhead 1993; Evans 1994; Bryant *et al*. 1996). Robust redhorse are characterized by a light, copper-to-bronze color on its dorsal and lateral surfaces and white on the ventral surfaces (Bryant *et al*. 1996). Similar to other catostomids, sexual differentiation is most easily accomplished during spring spawning activities when males develop secondary sexual characteristics such as nuptial tubercles, which are often located on the rostrum, anal fin, and ventral portion of the caudal fin (Jenkins 1970). Females typically are more rotund than males, particularly while gravid. Further, the manual expulsion of gametes during spawning season can be used to differentiate males from gravid females (Jenkins 1970). Similar to other catostomids, robust redhorse are a benthic species that feed primarily on a variety of aquatic invertebrates, but adults may use their large, molariform, pharyngeal teeth to crush shells of mollusks (Jenkins and Burkhead 1994).

Spawning Characteristics of Robust Redhorse

Spawning aggregations are often the focus of sampling efforts when attempting to capture robust redhorse. Spawning activities begin in spring and continue for approximately two weeks when water temperature averages 20-24 °C (Ruetz and Jennings 2000). Robust redhorse are broadcast spawners and spawn over loose gravel substrates, where embryos are left to develop and hatch in the interstitial spaces (Ruetz and Jennings 2000). In the Savannah River, robust redhorse are the last catostomid to spawn on mid-channel gravel bars below the New Savannah Bluff Lock and Dam (Grabowski and Isely 2007). The arrival of robust redhorse to spawning grounds occurs after spotted suckers (*Minytrema melanops*), northern hogsuckers (*Hypentelium nigricans*), carpsuckers (*Carpiodes spp.*), the undescribed brassy jumprock (*Scartomyzon sp. cf. lachneri*), and notch-lip redhorse have ceased spawning activities (Grabowski and Isely 2007). This behavior prevents the destruction of nest sites and is thought to result in robust redhorse having the lowest risk of interspecific, nest-site superimposition (Grabowski and Isely 2007).

Robust redhorse spawn in what is known as the redhorse triad (also called the "tremoring trio"); a termed used by Martin (1986) and Jenkins and Burkhead (1994) when examining the spawning behaviors of other members of the genus *Moxostoma*. The triad consists of a single female that is flanked by two males (Jenkins and Burkhead 1994). As a result of the vigorous quivering of the triad during spawning in combination with swift currents on the spawning grounds, the gravel within a nest site is swept free of debris and silt. Eggs are fertilized and deposited in the gravel, where they are buried by subsequent spawning acts and later abandoned (Jenkins and Burkhead 1994). Males typically spend more time than females within the spawning aggregation; they defend a new territory each day (depending on prevailing conditions, such as water level and fluctuations in discharge; Grabowski and Isely 2008). Males are able to expend sperm over relatively long periods of time, which enables them to partake in multiple spawning bouts with multiple females (Grabowski and Isley 2008). Females, however, spend less time in the spawning aggregation and exhaust their egg supplies within 1-2 days of initial spawning activity (Grabowski and Isley 2008). In the Savannah River, robust redhorse reached maturity at a later age and had larger adult size, longer life span, and presumably higher fecundity than other catostomids (Grabowski *et al*. 2008).

Early Life Stages of Robust Redhorse

The formation of the RRCC initiated research on all life stages of robust redhorse to better understand overall life history, conservation needs, and to determine if a "critical period" existed for the imperiled catostomid. The capture of adult brood stock, captive propagation, and the rearing and stocking of captive fish have provided useful information on the physiology and biology of robust redhorse at various life stages. Numerous captive propagation studies used the early life stages of robust redhorse to test effects of fine sediments on larval survival to emergence (Jennings *et al*. 2010), effects of water flow on larval fish (Weyers *et al*. 2003), larval fish swimming performance (Ruetz and Jennings 2000), juvenile growth and survival when fed a variety of feeds (Higginbotham and Jennings 1999), physiological tolerance (Walsh *et al*. 1998) and flow preferences of juvenile fish (Mosley and Jennings 2007). As a result, the larval and juvenile stages of robust redhorse have been hypothesized to be critical stages for the species' survival and ultimate persistence.

One critical stage for robust redhorse is the time when developing embryos and larval fish are left in the gravel until exodus (also called swim-up or emergence). Larval survival to emergence (STE) is largely dependent on the amount of fine sediments present in the substrate (Jennings *et al*. 2010). Although the spawning site may be swept clean of sediment by the spawning triad during the deposition of gametes, the interstitial spaces in the gravel are left vulnerable to sedimentation for several days after eggs have been deposited and fertilized. Survival to emergence is predicted to be 63.5% when fine sediments are absent, and STE is ≤ 8% when treatments contained >25% fine sediment. Increased sedimentation through the historic loss of riparian buffers may have contributed to declines in robust redhorse populations, and reduction of fine sediments in spawning grounds would significantly increase survival to emergence (Jennings *et al*. 2010).

Juvenile robust redhorse are tolerant of short-term variations of temperature, heightened salinity, variations in pH, and low dissolved oxygen (DO) in isolation (Walsh *et al*. 1998). However, a combination of these environmental factors (e.g., increasing temperatures in addition to reduced DO levels during egg development and emergence to free-swimming larva) during early life stages may contribute to the overall species decline through the loss of entire age classes. Increased sedimentation, the overall increase of water temperature, and the increased occurrence of hypoxic conditions attributed to the construction and operation of hydropower facilities since the 1950s have also contributed to the overall species decline (Walsh *et al*. 1998).

The pulsed, high-velocity flows that occur downstream of hydropower dams have also been hypothesized to reduce robust redhorse survival at early life stages through physical displacement of eggs or larvae and reducing growth of those larvae. In general, the swimming performance of larvae increases with total body length when exposed to relevant velocities to those observed on the Oconee River (Ruetz and Jennings 2000). However, the habitat on the Oconee River is diverse, and the effects of discharge are dynamic. Consequently, the ability of larval robust redhorse to maintain position in the water column or access low-velocity areas during dam release is unknown (Ruetz and Jennings 2000).

Similarly, through the use of modified aquaria, egg hatching success and larval growth and survival was evaluated when exposed to pulsed, high-velocity flows and steady, low-velocity flows for several weeks (Weyers *et al*. 2003). Hatch success and body length after emergence remained similar between treatments, but larvae exposed to pulsed high-velocity flows exhibited slower growth and had lower survival than larvae that were not exposed to pulsed flows. Altered flow regimes associated with hydropower generation have negative effects on the growth and survival of larval robust redhorse (Weyers *et al*. 2003).

Determining the fate of young robust redhorse proved challenging, primarily because of very low detection rates of both stocked and wild-born juveniles. Imperfect detection of the younger age classes of robust redhorse may be attributed to sampling gear bias, targeting incorrect juvenile habitat, limited reproduction occurring within the system, or any combination thereof (Jennings *et al*. 1998; Grabowski *et al*. 2009). Most juvenile robust redhorse sampling has concentrated on river meanders, where sandbars and lateral scours are present (Jennings *et al*. 1998). Flow preferences of juveniles held in a series of mesocosm experiments were modeled, and results revealed that juvenile robust redhorse showed a variation in flow preferences associated with seasonal changes, as well as a high affinity structure regardless of season (Mosley and Jennings 2007). In winter and early spring, juveniles avoided sections of the mesocosms with moderate flow. The preferred habitats during these seasons were a combination of backwaters and eddy. Fish were more active in springtime when fish traveling through sections of moderate flow to reach eddies for refuge. Fish also exhibited a high affinity for structure (e.g., walls, crevasses, stand pipes). The use of backwaters and structure during the study suggests that naturalized, juvenile robust redhorse in the wild may use natural structure (i.e. large woody debris, rocks) as refuge from predators or fast flows, as well as food availability in foraging areas (Mosely and Jennings 2007).

Adult Robust Redhorse

To test the viability of stocking hatchery-reared fish into historic rivers as a tool to augment existing populations, additional investigations used radio telemetry to examine post-release behavior and seasonal movements of captive-reared robust redhorse (Grabowski and Isely 2006; Grabowski and Jennings 2009). Although most stocked robust redhorse participated in spawning behaviors with their wild counterparts, some stocked redhorse were unable to locate suitable spawning habitat, presumably because of the lack of habitat, drought or behavioral differences (Grabowski and Jennings 2009). Mature fish from a known spawning site in the Savannah River were sexed, tagged with radio transmitters, and monitored through radio telemetry and underwater cameras to determine monthly, biweekly, and daily movements throughout the year (Grabowski and Isely 2006). Robust redhorse traveled downstream to deep pools and slow flow areas in the late fall and winter months.

Adult fish also were highly associated with complex structure and large woody debris, similar to the findings for juveniles later supported by Mosley and Jennings (2007). During spring observations, adult fish undertook long migrations (>100 river kilometers) upriver to gravel bars for spawning (Grabowski and Isely 2006). However, soon after spawning, the fish retreated downstream to the same over-wintering areas from which they began their spring migration. During the course of the study, robust redhorse displayed fidelity to both wintering and spawning sites. Such behavior affects efforts to detect fish seasonally and to locate previously overlooked suitable spawning and potential wintering areas (Grabowski and Isely 2006).

Rare Species, Presence-Absence, and Occupancy Modeling

Site occupancy modeling approaches have become a widely used and effective method for estimating species occurrence (MacKenzie *et al*. 2002; MacKenzie *et al*. 2006). Occupancy modeling has been used in a variety of management settings for many different species including birds (e.g., Kroll *et al*. 2007; Nichols *et al*. 2007; Royle *et al*. 2007), amphibians (e.g., Bailey *et al*. 2007; Farmer *et al*. 2009; Weir *et al*. 2005), mammals (e.g., Rodhouse *et al*. 2010; Urban and Swihart 2009) and fish (Albanese *et al*. 2007; 2011; Wenger and Freeman 2008).

Site occupancy is the proportion of units that a species of interest is occupying and is often used as a metric of the current status of a population (MacKenzie *et al*. 2003). Site occupancy can also be interpreted as the probability that a sample unit is occupied. A sample unit is a patch of potential habitat for the species of interest based on either spatial location or various habitat characteristics that define that unit (MacKenzie *et al*. 2002). These units are surveyed multiple times to determine if a site is occupied or not occupied through visual detections, auditory surveys, or by actual capture through active or passive techniques (MacKenzie *et al*. 2002). Hence, for each sampling occasion, a binary code is used to classify site occupancy in one of two ways: a) the site is occupied by a species and the species is detected (1), or b) the site is either unoccupied or the species is present, but not detected (0). The capture history at a given site is described by a series of 1s and 0s (e.g., a capture history of 110 refers to a site in which the species was detected during the first two sampling occasions, but not detected on the third sampling occasion; MacKenzie *et al*. 2002). Generally, habitat characteristics at each site are recorded to facilitate the formation of inferences about the effects of environmental variables' on species occupancy of a site. In aquatic systems, these characteristics may include variables such as temperature, soil or substrate type, distance to nearest cover or refuge, location, the size of the patch, and many others.

Sampling Design for Occupancy Models

There are many possible sampling designs for occupancy estimations, but design is dependent on the species of interest, the goal of the project, and available time and funding. Single-season sample designs may be useful, but provide only a snapshot of species occupancy over time. To take this into account, multi-season sampling designs (e.g., robust design, see Figure 1) are used most often when resource/habitat use may change through time for the species of interest (MacKenzie 2005). These models require data collection at numerous resource units over several sampling seasons, where sample season length and time between seasons depends on life history characteristics of the focal species (MacKenzie 2005).

Generally, once a rare species is detected, similar sites become highly prioritized for sampling while other areas are sampled less intensely or ignored. This practice produces inaccurate estimates in species abundance and distribution (MacKenzie *et al*. 2002). If prime or heavily used resource units are the only targeted sites, the accuracy of calculated occupancy across a landscape may be negatively affected (MacKenzie 2006). This is the case with most previous robust redhorse research, where many studies have concentrated on spring spawning aggregations, with less focus on other habitat types during other seasons. As a general strategy for rare species investigations, a greater number and diversity of units should be sampled less intensively, rather than fewer units sampled more intensively (MacKenzie and Royle 2005).

Imperfect Detection

In rare species studies, researchers must deal with species that are difficult to detect. Imperfect detection refers to the presence of a species or individual within a study site that remains undetected by researchers (MacKenzie 2005). The issue of imperfect detection is often a result of the rarity, cryptic nature (e.g., cryptic coloration or secretive behavior) of the species or the tendency of the focal species inhabiting hard to sample areas. Imperfect detection of a species must be considered when studying rare species and was incorporated into a zero-inflated binomial occupancy model by MacKenzie et al. (2002). Although imperfect detection was considered, the model does not account for abundance at occupied units. Occupancy modeling can be used to compare and contrast abundance estimates for rare versus common species (e.g., Royle and Dorazio 2006, Wenger and Freeman 2008). Incorporating imperfect detection and abundance, modeling occupancy for rare species can be achieved with current computer software such as Program MARK (available: http://warnercnr.colostate.edu/~gwhite/mark/ mark.htm) and the Program Presence (available: http://www.mbr-pwrc.usgs.gov/software/ presence.html).

Although logistic regression methods can be used to model the relation between habitat characteristics and a species' occupancy, regression methods can introduce bias because they only include habitat effects on occupancy when a species is present or not present, but do not account for non-detection, or imperfect detection (when a site is occupied by a species yet remains undetected; MacKenzie *et al*. 2002; Mackenzie and Bailey 2004). Large amounts of non-detections within the data are common in rare species studies, and the bias introduced by Type 2 error is often overlooked. Modeling site occupancy (versus logistic regression) incorporates non-detections and its associated bias to provide a single modeling framework that may provide useful information in rare species distributions (MacKenzie *et al*. 2002; Mackenzie and Bailey 2004). Thus, such an approach may be useful and efficient method for assessing the range-wide status, distribution, and dynamics of robust redhorse populations.

CHAPTER 3

PROBLEM OVERVIEW

The Ocmulgee River Population

The RRCC and the implementation of a Candidate Conservation Agreement with Assurances (CCAA) program have prioritized captive propagation and the subsequent reintroduction of hatchery-reared robust redhorse to reestablish self-sustaining populations (Grabowski and Jennings 2009) in the Ocmulgee River, GA. As part of the Ocmulgee River CCAA, Georgia Power Company, Georgia Department of Natural Resources (GADNR) and the United States Fish and Wildlife Service (USFWS) collaborated to advance robust redhorse reestablishment and accomplish two objectives: 1) establish a refugial population of robust redhorse in the project site between Lloyd Shoals Dam and a low-head dam in Juliette, GA, and 2) increase understanding of habitat requirements and life history of robust redhorse (Department of Interior 2001). As outlined in the "Conservation Actions" of the CCAA in 2001, the project site was stocked, and studies to examine the movement, abundance, distribution, survival, and recruitment of the stocked fish are to continue until scientific evidence supports the conclusion that the Ocmulgee population is not in need of augmentation or monitoring (Department of Interior 2001). Stocking in the Ocmulgee River began in 2002; since then, more than 13,000 robust redhorse ranging from fingerlings to 5-year old adults have been stocked into the project site as of 2005 (J. Evans, Georgia Department of Natural Resources, personal communication; Grabowski and Jennings 2009). Stocking ceased as a result of anecdotal evidence of reproduction by stocked robust redhorse within the project site (Joe E. Slaughter, Georgia Power Company, personal communication). Radio telemetry has been used to make substantial progress in the project site by investigating post-stocking habitat use and dispersal (Jennings and Shepard 2003) and spawning migration and seasonal habitat use of stocked fish (Grabowski and Jennings 2009).

Difficulties with Traditional Sampling for Robust Redhorse

Mark-recapture techniques to estimate population size were first used by G.J. Petersen in 1896 and F.C. Lincoln in 1930 (Southwood and Henderson 2000); the techniques are commonly used to estimate population size of fishes (e.g., Williams *et al*. 2002). However, mark-recapture methods can produce biased abundance estimates when capture probabilities are very low (e.g., cryptic species; MacKenzie 2006) or high heterogeneity in capture probabilities is not taken into account. To date, most robust redhorse sampling has been concentrated around spawning aggregations in spring; this sampling protocol violates the assumptions needed to estimate abundance via closed mark-recapture methods, and resultant estimates may be biased (Grabowski *et al*. 2009).

Given low abundance, benthic habits, cryptic behavior, and imperfect detection of robust redhorse, there are potential problems with accurately determining current distributions or population sizes. Robust redhorse often reside in waters deeper than 2 meters (Grabowski and Isely 2006; Grabowski and Jennings 2009), thus standard boat electrofishing techniques have been relatively unproductive and have yielded few fish. Targeted fish may evade the electrical field in deep waters or become trapped in submerged, woody debris after immobilization (Grabowski *et al*. 2009). Grabowski *et al*. (2009) applied a combination of tracking radio-tagged fish and boat-mounted electrofishing sampling techniques to establish capture rates for robust redhorse and concluded that tagged robust redhorse exhibited little response to boat electrofishing. The results of their study on the Ocmulgee River suggest that robust redhorse had a capture probability of 0.031 with a 95% Bayesian credibility interval of 0.002–0.111 when using boat electrofishing techniques. Note that detection probability is the probability of detecting at least one individual of the focal species given the species is present in a given sampling unit (i.e., abundance and ease of capture influences detection probability), whereas capture probability is the probability of capturing one individual in a population of a given size (i.e., abundance or population density does not influence capture probability; Williams *et al*. 2002). The best predicting models used in the Grabowski *et al*. (2009) study resulted in population estimates with large confidence intervals, which proves that obtaining a precise robust redhorse abundance estimate is challenging. Because capture probabilities are low and variable, abundance is low, and robust redhorse are patchily distributed, obtaining a reasonable population estimate would require substantial effort. Grabowski *et al*. (2009) determined that the use of radio-tagged fish was effective as a guide for estimating capture rates and suggested that underestimation in abundance and the large variances associated with capture-mark-recapture studies of rare species can be avoided by the use of other approaches such as occupancy modeling that accounts for imperfect detection.

Implementation of Occupancy Models

Given the low capture probabilities after considerable sampling efforts on the Ocmulgee River (Grabowski *et al*. 2009), the occupancy methods suggested by MacKenzie *et al*. (2002, 2006) were a potentially useful approach to estimate site occupancy for this robust redhorse population. When detection probability is imperfect, the model described by MacKenzie *et al.* (2002) can be used as the basis for estimating site occupancy during a single season. The probability that a site is occupied throughout the study can be calculated using probabilities of occupancy and detection. For example, if a site is visited twice in a season, there are four possible capture histories for that site, and probability of each capture history is estimated as: a probability of total sites occupied (ψ) can be seen as

Capture history	Probability of capture history
11	$\psi_i * p_{i1} * p_{i2}$
01	$\psi_i * [1 - p_{i1}] * p_{i2}$
10	$\psi_i * p_{i1} * [1 - p_{i2}]$
00	$\psi_i * [1 - p_{i1}] * [1 - p_{i2}] + (1 - \psi_i)$

where Ψ_i is the probability that a species is present at site *i*; p_{it} is probability that a species will be detected at site *i* at time *t*, given the species is present. Note a capture history of 00 does not imply that the site is unoccupied; instead, the species may be present but was undetected during the time of sampling estimated as $\psi_i * [1 - p_{i1}] * [1 - p_{i2}]$ above. Here, detection probabilities and the presence of the species are site specific and may be a function of covariates such as habitat characteristics, season, and site size.

Four assumptions and limitations exist for the occupancy estimator and include:

1) A species' occupancy status at each site does not change over the course of the survey (i.e., the population is closed during the survey, also called the "closure assumption");

2) Occupancy is either constant across sites, or occupancy is modeled as covariates;

3) Detection probability constant across sites, or is a function of site survey covariates and there is no unmodeled heterogeneity in detection probability;

4) Detection of a species and detection histories at each location are independent.

CHAPTER 4

METHODS

Site Description

The study was conducted in a 29-km stretch of the Ocmulgee River bounded upstream by Lloyd Shoals Dam and downstream by East Juliette Dam in the Piedmont physiographic region of Georgia (Figure 2). Lloyd Shoals Dam (LSD) is a Georgia Power Company-regulated hydropower facility that marks the headwater of the Ocmulgee River. Lloyd Shoals Dam was completed in 1911 and impounds the Yellow, Alcovy, and South rivers to form Jackson Lake. Jackson Lake is approximately 1922 hectares (19.2 km^2) that exhibited extreme signs of eutrophication through symptoms of fish kills, algal blooms, and anoxia in the 1960s (Kamps 1989). By the next decade, projects to improve wastewater treatment in the South and Yellow rivers were implemented to greatly reduce phosphorus loading (Kamps 1989). Since the 1970s, water quality within Lake Jackson has improved greatly.

The downstream terminus of the project site was Juliette Mill Dam (JMD), a low-head mill dam between Juliette and East Juliette, GA. Downstream from JMD, the Ocmulgee River is unimpounded and flows unimpeded to the Altamaha River and Atlantic Ocean. Immediately below LSD, the Ocmulgee River is characterized by large shoal complexes and long, sandy runs with copious amounts of woody debris. Below JMD, the Ocmulgee River crosses the Fall Line and enters the upper Atlantic Coastal Plain near Macon, GA. Here, the gradient decreases and the river channel transforms into a series of tight meanders until its eventual confluence with the Oconee River, which forms the Altamaha River.

Sample design

The study area was divided into seven reaches based on accessibility and changes in habitat type. Each reach was stratified into 25 sample units based on habitat characteristics (shoal, meander, run), local water velocity, and substrate composition (Figure 2). Each sample unit was designated as a distinct sample site during fish surveys and for subsequent data analysis (see occupancy modeling below). Site boundaries were geo-referenced so field researchers could determine the length of the sample site and revisit each site every sampling period. The study area was visited in four seasons: spring 2010, summer 2010, fall 2010, and spring 2011. Using this multi-season sampling design, each of the 25 sample sites were visited twice per season (i.e., each unit was sampled eight times during the study). The spring 2010 season occurred from May 10th to May 30th (21 days); summer 2010 occurred from June 28th to August 3rd (37 days) fall 2010 occurred from September 23rd to November 11th (50 days); and spring 2011 occurred from March 25th to May 24th (61 days). Ideally, sample seasons should be relative short time periods provide an estimate of what is happening in a system during a particular season (e.g., spring 2010).

Logistical limitations restricted days spent sampling as time progressed from the spring 2010 and spring 2011 seasons. Because of these problems beyond my control, a seasonal effect was not included in the occupancy and detection models for this study, thus violating the closure assumption. When the closure assumption is violated, occupancy estimates may appropriately reflect the average across all sites, but there may be a large variance (MacKenzie et al. 2006).

Fish Sampling

Boat-mounted electrofishing techniques were used to sample robust redhorse and all other catostomids in accordance with survey sampling protocol outlined for this species by the RRCC (2002). Specifically, the boat-electrofishing protocol mandates a minimum of 20 minutes (1200 seconds) of pedal time per kilometer of river (RRCC 2002). Sample sites were sampled via electrofishing during daylight hours, usually between 09:00 and 17:00 hours. During each sampling occasion, pedal time was recorded at the end of each site, and sampling intensity was calculated by dividing the pedal time (seconds) by the length (km) of the sampled site. Electrofishing for catostomids was conducted with one of two available aluminum electrofishing boats of different size and shape, depending on availability and water conditions. Because each boat had a unique size and shape, each was rigged with different booms and cables and was equipped with different-sized gasoline generators, a standard current of 4-6 amps was used while electrofishing. Amperage was adjusted during sampling if fish were evading capture or if the electric current was causing severe damage or mortality of sampled fish. On each sampling occasion, the sampling crew was comprised of one driver and one netter. The netter worked the electrofishing pedal and gathered immobilized fish with a long (~2.5m) dipnet.

As suggested by Graboswki and Isley (2006), Grabowski and Jennings (2009) and Grabowski *et al*. (2009), areas containing large amounts of cover (woody debris or boulders) and deep flowing waters (such as lateral scours or deep chutes near boulders) were targeted in lieu of shallow, sandy areas without submerged structure or cover. Lateral scours refers to the outside bends of meanders where water usually is flowing most swiftly and causes significant erosion. Lateral scours often produce large amounts of woody structure, where trees along the bank have fallen into the stream channel as a result of stream bank erosion (Bain and Stevenson 1999). If available and accessible, lateral scours and shoal complexes were the preferred areas to sample each season. A shoal refers to a portion of the river that is shallower than the surrounding portions. In the Piedmont, shoals are often formed by bedrock outcrops and boulder extending into the river channel. Because of their shallow depths, shoals are often areas of swift current that can create chutes, plunge pools, and turbulent waters that often free of fine substrates like silt and sand. During each sampling occasion, samplers traveled with the flow of the river, adjacent to the banks where water was deep and woody debris was most abundant and where shoals were present. During much of the sampling seasons, shoals were either dewatered or largely exposed, which made these areas difficult to sample. However, in the higher water levels that occurred during spring, shoals and gravel bars with their adjacent areas were sampled intensely. These areas were of particular interest in spring because robust redhorse and other catostomids use these types of habitats for spawning (Grabowski and Isely 2007; Grabowski *et al*. 2008). Because lateral scours and shoals were targeted heavily, all inferences on robust redhorse habitat use are restricted to these habitats.

Data on all catostomids were collected to compare, contrast, and better understand the seasonal habitat use and distribution of all suckers in the upper reaches of the Ocmulgee River. Fish sampling and handling for this project were carried out as outlined in the University of Georgia's Animal Use Permit #A2010 11-607-YI-A0. Each robust redhorse captured was checked for coded wire tags (field sampling detector FSD-I, Northwest Marine Technologies, Inc®) and Passive Integrated Transponder (PIT) tags (Mini-Portable Reader 2 and PIT tags, Destron-Fearing Corporation®). All tag-related information (e.g., location of coded wire tags and the tag identification number for PIT tags) was recorded. If a tag was not detected, a uniquely-numbered PIT tag was implanted immediately caudo-laterally to the dorsal fin, on the fish's right side. The total length (TL-mm) and weight (g) were determined for each fish and recorded. A Valor 3000 Xtreme scale (Ohause Corporation®) rated up to 6 kilograms was used to determine mass. Additional information such as sex, breeding condition or anomalies was also noted. All fish were released in the vicinity of their capture. For the duration of the study, any recaptures were noted as well as length, weight, tag number, and location of the tag.

Water Quality Data

Water quality measurements included water temperature, dissolved oxygen concentration, water clarity, current velocity, and discharge. With the exception of discharge, all water quality measurements were averaged between two measurements; one at the upstream boundary of the sampling unit prior to electrofishing, and one at the downstream terminus of the sampling unit after electrofishing. A YSI® model 55 temperature and dissolved oxygen meter was used to measure water temperature (ºC) and dissolved oxygen (mg//L). A Hach® Model 2000 Flow-Mate water velocity meter was used to measure water velocity (m/s) in an area that best represented where the majority of sample effort took place. A weighted 15.2 cm Secchi disk was used to determine clarity by averaging the depth in meters (to the nearest $1/10^{th}$ of a meter) at which the disk was no longer visible and the depth at which the disk reappeared after being retrieved. Additional data recorded included discharge (m^3/s) from the United State Geological Survey (USGS) gauge #02210500 located between LSD and GA HWY 16.

Habitat Data

To estimate the size of each sample site, a 2009 NAIP aerial photograph for Jasper County, GA (Georgia GIS Clearinghouse, available: data.georgiaspatial.org) was imported into

Environmental Systems Research Institute's (ESRI®) ArcGIS software. The measuring function of the software then was used to calculate length (m) and width (m) of each site. Three widths were recorded at approximately ¼, ½ and ¾ of the sample unit length, and averaged to obtain a mean width for each site.

Preliminary reconnaissance visits to the project area between LSD and JMD revealed that obtaining accurate estimates of substrate types and quantifying woody debris were very difficult and time consuming in the Ocmulgee River, where nearly 30 kilometers of wide, shallow, and rocky areas must be surveyed. To overcome limitations of directly separating and quantifying in-stream habitat, I used a remote sensing technique developed by Kaeser and Litts (2010). This method employs an inexpensive and time-efficient Hummingbird® Side Imaging system with a boat-mounted transducer to obtain a geographic information system (GIS) layer of high-resolution images of the stream channel. These images of the channel provided information such as substrate types, course structure within the water column, and relative depth. In the fall of 2010, an on-the-ground survey was conducted where known gravel bars could be seen and waded during a low-flow period. The gravel bars were outlined by walking the boundaries of each bar and tracing the path with a Garmin® eTrex hand-held GPS unit. The areas of these gravel bars were calculated in ArcGIS by creating a polygon from the path traced in the handheld GPS unit. The average size of the gravel was noted and compared to subsequent sonar surveys as a ground-truth. Substrates were classified into the following categories based on diameter: silt, sand (<10 mm), gravel (10-64 mm), cobble (64-256 mm), boulder (>256 mm), and bedrock (an adaptation of Gordon et al. 1992).

All accessible portions of the study area between a large series of shoals near 40-Acre Island and JMD were surveyed with side-scan sonar by a Georgia Department of Natural

Resources (GA DNR) field crew in the winter of 2011 during high water levels. Sampling during high or peak flows allows for the mapping of the entire streambed and banks. The upper Ocmulgee River from below 40-Acre Island downstream to Bridges Island (a small, privately owned island 1.1 km upstream of JMD) was surveyed with a Hummingbird 1197c Side Imaging system during a flood event on February 6, 2011. A small aluminum john boat was rigged with a custom wooden mount on the front of the boat, fixed with the sonar transducer on the bottom and a GPS antenna on the top. The front mounted transducer reduced the chance that the prop-wash from the boat motor interfered with the sonar imagery. The sonar survey used dual frequencies of 455 and 800 kHz. Generally, a frequency of 455 kHz employs a wider beam and allows for the image capture of distant stream banks and its associated woody debris and substrates. Conversely, a frequency of 800 kHz results in a narrower beam where distant banks and substrates may not be in the field of view, but areas in close proximity to the boat are displayed in higher resolution (Thom Litts, GA DNR, personal communication). During the survey, the boat traveled downstream at approximately 8 km/hour. This speed was slow enough to allow for greater image quality, but fast enough to cover the area without any distortions (e.g., objects in the stream bed appear to be distorted and elongated when traveling too slowly).

Most of the sonar data obtained in February 2011 by the GA DNR sonar team was collected during the largest flood event on the Ocmulgee since 2010. Despite the high water levels, the 9-km reach of river between HWY 16 and 40-Acre Island was still too shallow, rocky, and dangerous to map with side scan sonar. Although surveying during a high-water event is preferable, the flood resulted in the water column becoming saturated with suspended particles and sediments. The particles interfered with the sonar beam; and as a result, distinguishing the difference between coarse sand, fine gravel, and coarse gravel was extremely difficult. For the purpose of this study, all rocky substrates with a diameter of 10mm or greater were combined into one “coarse substrates” category, which included gravel, cobble, boulder, bedrock, and unknown rock. In contrast, felled trees and other woody debris were distinct enough to allow for confident assessment of the quantity of woody structure within the project site. Woody structure was defined as any piece of submerge wood with a minimum diameter of 15 cm (6 in) and a length of 91 cm (3 ft).

The raw sonar data were imported into ArcGIS to create image mosaics (raw images were combined with recorded latitude and longitude; this procedure created one solid image of the location and shape of the Ocmulgee River). The sonar images obtained with the side-scanning imaging units allowed me to first calculate the area of the streambed, then identify and quantify woody debris and various substrate types within each sample site. ArcGIS was used to digitize (i.e., outline) woody structure, as well as classify (bedrock, large gravel, fine gravel, cobble, boulder, unknown rocky), and quantify (m^2) substrates that were distinguishable. These habitat models were used in the occupancy analysis as predictor variables.

On September 9, 2011, the side scanning sonar survey was conducted on the ~ 2 km portion of river between LSD and HWY 16 that was not surveyed previously. This area was of particular interest because the majority of robust redhorse detections to date took place in this reach of river. A Hummingbird® unit identical to the one used in the GA DNR February survey was not available. However, the similar Lowrance® LSS-1 Structure Scan unit was available. A custom mount on the front of an aluminum boat was constructed in a comparable fashion to the GA DNR rig. Ideally, the survey would have taken place during a high-water event for ease of imaging both stream banks and all woody debris normally associated with each bank. However, the survey took place when discharge was less than 300 ft^3/second (8.5 m^3/second), which made image capture from both banks very difficult with a single pass. If the entire stream bank and its associated woody structure was not captured, an under estimation of woody structure could occur. To account for this, a frequency of 455 kHz was used to map as much of the substrate and stream banks as possible in the shallow water, and multiple passes were used to capture images of the river banks. The same techniques described above were used to quantify woody debris and determine substrate types in ArcGIS.

Statistical Analysis

All fish, habitat, and water quality data of interest (e.g., season, substrate composition, water temperature, turbidity, discharge, dissolved oxygen) were included as predictor variables in the detection and occupancy models. Prior to model construction, Pearson correlation coefficients were calculated for all pairs of potential predictor variables to estimate the strength of correlations among variables. Strong correlations between predictor variables in the same model may result in multicollinearity and potentially unreliable or biased parameter estimates for the detection and occupancy models. Therefore, only uncorrelated variables ($|r|<0.6$) were included within the same candidate model.

My primary goal was to evaluate site occupancy of robust redhorse. However, to obtain an accurate estimation of occupancy, I had to account for imperfect detection first. Habitat characteristics such as current velocity, substrate type, and available cover can often influence the detection of a stream fish species (Bailey and Peterson 2001). Occupancy models account for variation in detection and occupancy by incorporating various environmental covariates. I hypothesized that detection would vary with current velocity, woody debris, secchi depth, and sampling intensity (Table 1) and that occupancy would vary by current velocity, the proportion of coarse substrates within the streambed, and water temperature (Table 2).

A global model (i.e., all predictor variables for detection and occupancy were used in a single model) was constructed in Program MARK (White and Burnham 1999). Prior to model fitting, all continuous predictor variables were standardized with a mean of zero and standard deviation of one to facilitate model fitting in MARK. Next, a large set of models (n=128) that consisted of all possible combinations of the predictor variables used in the global model was created. The parameter estimates and standard errors for each individual model were examined as a screening procedure to evaluate goodness-of-fit. Models with estimates or standard errors that were unrealistically high or low (e.g., 0.000000, 999999.9) indicated a lack-of-fit and were removed and excluded from further analysis. All remaining models were considered the candidate set of models.

I used an information-theoretic approach to evaluate the relative fit of each candidate occupancy model. I used Akaike's Information Criterion (AIC) as adjusted for a small sample size (AICc; Burnham and Anderson 2002) to determine the relative fit of each model. I determined the best fitting candidate models for site occupancy by calculating Akaike weights (w_i; Burnham and Anderson 2002) based on each model's AICc value. Akaike weights range from zero to one, where the model with the largest weight indicates the best fitting model (Burnham and Anderson 2002). To assess the relative support one candidate model had over another, I used the ratios of Akaike weights (Burnham and Anderson 2002), where each model's weight was divided by the weight of the best-predicting model (also referred to as percent maximum in MARK). I constructed a confidence set of models that included all models with Akaike weights that were within 10% of the best-approximating candidate model's Akaike weight (similar to the 1/8th rule proposed by Royall 1997). I based all inferences on the confidence set of occupancy models.

Although each model in the confidence set is considered plausible, parameter estimates for the same predictors generally differ among models. Therefore, AIC model averaging was used to incorporate this uncertainty by weighting the parameter estimates and standard errors from each model in the confidence set to create composite model averaged estimates and standard errors (following Burnham and Anderson 2002). Model-averaged estimates calculated from the confident set of models were used to estimate the average conditional detection probability and robust redhorse occupancy across all sampled units. I also used model averaged estimates to evaluate the magnitude of the effect all predictor variables in the composite model on: (1) conditional detection probability, and (2) occupancy.

To facilitate interpretation, odds ratios and their 95% confidence intervals for each model averaged parameter estimate were calculated (Hosmer and Lemeshow 2000; Congdon 2001). Because the data were standardized, parameter estimates for continuous predictor variables corresponded to a one standard deviation change for each predictor variable. For clearer interpretation, scaled odds ratios (SOR) estimators were calculated. An odds ratio (OR) ranges from zero to infinity; an OR < 1 indicates an event (e.g., occupancy) is less likely to occur, an OR >1 indicates that an event is more likely to occur, and an OR = 1 indicating that there is no change in the likelihood of an event when the value of the predictor variable changes. The OR 95% confidence intervals were calculated, and intervals encompassing one were considered imprecise (Congdon 2001).

CHAPTER 5

RESULTS

Predictors Variables and Descriptors of Sampling Units

Water temperature, secchi depth, dissolved oxygen content, and water velocity were variable throughout the sampling seasons. Seasonal water temperature ranged from 14.9 °C in late fall to 31.2 °C in the summer (Table 3). Secchi depth (i.e., water clarity) was greatest in the fall sample season (4.5 m) and lowest in the rainy spring seasons (0.3 m; Table 3). Water velocity ranged from 0.0 to 1.1 m/second and discharge from LSD during sampling days ranged from 8.5 to 118.9 m^3/second (Table 3). Mean sampling intensity for the entire study was 1697 seconds/rkm as compared to the 1200 seconds/rkm minimum requirement in the robust redhorse sampling protocol (RRCC 2002).

In general, substrate composition was relatively uniform in the majority of sampling units below Nelson Island; primarily consisting of sand with a few areas containing gravel, boulders, and bedrock. In most sampling units, the proportion of coarse substrates (the area of coarse substrates in a given unit divided by the streambed area of that sampling unit) was less than 20% (Figure 3). Only four units had more than 20% coarse substrates, and two of them were located in the upstream portion of the project site. The unit immediately below LSD had the largest proportion of coarse substrates at over 77% (Figure 3). On average, the downstream sampling units contained less coarse substrates; however, the exceptions were one lateral scour containing a large amount of bedrock and a small shoal complex farther downstream (Figure 3). The quantity of woody debris (m^2/rkm) varied throughout the river and had a general inverse relationship with the presence of coarse substrates (Figure 3). Woody debris tended to be more abundant in the long, sandy runs present in the downstream portion of the project site than in the portion of river between LSD and HWY 16. The Pearson correlation procedure revealed sampling unit width and the proportion of coarse substrates, and sampling unit length and the amount of woody structure the only highly correlated ($|r|>0.6$)potential predictor variables.

Fish Captures

A total of 4,415 catostomids from four genera and at least six species were captured during the study (Table 4). In addition to robust redhorse, suckers encountered in the upper Ocmulgee River included notchlip redhorse, spotted sucker, as well as the brassy jumprock, striped jumprock, and two undescribed carpsuckers. Catch was relatively similar across all seasons: 26.2% (n=1155) of the suckers were netted in Spring 2010, 23.9% (n=1054) were netted in Summer 2010, 28.1% (n=1242) were netted in Fall 2010, and 21.8% (n=964) were netted in Spring 2011 (Table 5).

Only 0.2% (n=7) of the suckers captured in the study were robust redhorse. Of the seven robust redhorse netted, 2 were netted in the spring of 2010, and 5 were netted in the spring 2011 season. Although there were not physical captures of robust redhorse in the summer 2010 season, two fish were visually detected (one detection on each of the two sampling occasions). These observations were included as detections in the occupancy modeling. However, because the fish were not netted, they were not added to the total number of robust redhorse captured. Of all collected catostomids, notchlip redhorse represented 60.0% (n=2649) of the catch, spotted suckers made up 31.3% (n=1384), brassy jumprocks were 7.5% (n=331) of the catch, and striped jumprocks were 0.9% (n=331). Carpsucker spp. consisted of 0.1% (n=3) of the Catostomid catch and was the only sucker species found in fewer numbers than robust redhorse (Table 5).

Throughout the course of this study, robust redhorse were detected in two of 25 sampling units in the upper Ocmulgee River. Robust redhorse were detected in Unit 1 (immediately below LSD) on both sampling occasions in Spring 2010 and Summer 2010. The Fall 2010 season yielded no detections of robust redhorse in any of the 25 sampling units. In Spring 2011, robust redhorse was detected in Unit 2 (103 m away from the downstream terminus of Unit 1) during the first sampling occasion and detected in Unit 1 during the second sampling occasion.

Confidence Set of Models

The confidence set of 41 models had Akaike weights that ranged from 0.067 to 0.007 (Table 6a, b, c). The best approximating model had an Akaike weight of 0.067, and included secchi depth in the detection component and velocity and water temperature in the occupancy component. The second best approximating model had a model weight of 0.065 (ΔAICc = 0.056), and included secchi depth in the detection component and only velocity in the occupancy component. All other models had a ΔAICc score of 0.275 or higher.

The model-averaged estimates revealed that robust redhorse had a conditional detection probability (the probability of detecting the species given it was present in the sampling unit at the time of sampling) of 0.183 (±0.128) with the average sampling effort during this study (1697 seconds/rkm) (Table 7). Model-averaged estimates and odds ratios revealed sampling intensity (amount of time spent electrofishing per river kilometer) and current velocity were positively related to conditional detection of robust redhorse, where for every one standard deviation increase in sampling intensity and velocity, detection probability decreases. Conversely, woody structure and secchi depth were negatively related to conditional detection, where for every one standard deviation increase in woody structure and secchi depth increase, detection decreases (Table 8). None of the odds ratio 95% confidence limits for parameters influencing detection encompassed zero, and were not considered imprecise. Although odds ratio confidence limits for all parameters were positive, the lower 95% confidence limit for secchi depth was very close to zero (0.0004).

Based on the model average estimates for conditional occupancy, robust redhorse had a site occupancy of 0.033 (± 0.045) across all sampling units (Table 7). As revealed by model-averaged parameter estimates and odds ratios, current velocity and the proportion of coarse substrates within the streambed were positively related with occupancy, where for every one standard deviation increase in velocity and coarse substrates, occupancy increases. Conversely, water temperature was negatively related, where for every one standard deviation increase in water temperature, occupancy decreases (Table 9). None of the odds ratio 95% confidence limits for parameters influencing detection encompassed zero, and were not considered imprecise. Although odds ratio confidence limits for all parameters were positive, the lower 95% confidence limits for velocity (0.00002) and temperature (0.002) were very close to zero. In addition, the upper confidence limit for velocity

CHAPTER 6

DISCUSSION

This study marks the first attempt to use occupancy models as a means to determine seasonal distribution and habitat use of robust redhorse. Although tracking of radio-tagged fish has provided invaluable information regarding robust redhorse movements and individual habitat use, other studies have not incorporated imperfect detection to determine the likelihood of robust redhorse occupancy and detection probability. In the case of robust redhorse, occupancy models provide a means to estimate the probability that the species will be present in any given habitat unit based on the characteristics of that habitat unit. Once habitat characteristics are determined for a given reach of river, researchers can use this information for the stratification or allocation of potential sampling units.

Distribution of Robust Redhorse

Compared to the other catostomids occupying the project site, robust redhorse appeared to have a very restricted distribution. Robust redhorse was confirmed present in 8% of the sampling units (8%); whereas, other large-bodied catostomids (excluding carpsuckers) occurrence ranged from 92 – 100% of sampling units in a wide range of habitat types. Robust redhorse, on the other hand, were only detected within the two uppermost units of the project site, immediately below Lloyd Shoals Dam. Robust redhorse, although not the rarest fish within the project site, had the most limited distribution. Regardless of season, all detections of robust redhorse were within 500 meters of one another; suggesting the Ocmulgee population has a very restricted home range.

Detection of Robust Redhorse

As expected, sampling intensity was the most precise predictor variable and had the largest positive influence on detection probability of robust redhorse. Sampling during this study followed the protocol outlined for robust redhorse (RRCC 2002). Mean electrofishing time exceeded the minimum time (20 minutes of pedal time per river kilometer) recommended in the RRCC (2002) by 8.3 minutes. This amount of time is ample for sampling catostomids in this portion of the Ocmulgee River. In general, pedal time was highest in areas containing shoals. Units not containing shoals had a relatively linear electrofishing path, where field personnel sampled one bank (usually the outside bends of the river where the water was deepest and wood was most abundant) rather than spending time in the middle of the river (areas of consisting of shallow sand without cover). In addition to the same technique mentioned above, all areas in and adjacent to shoals were also sampled. Also noteworthy is the fact that sampling intensity was highest on sampling occasions when robust redhorse were detected. This was a site-specific effect, where sampling intensity was greater in shoal units because targeted habitat (e.g., bedrock shoals) usually spanned the entire width of the sampling unit, which resulted in higher effort per river kilometer (Figure 6). Conversely, sampling intensity was less in lateral scour units, where the targeted habitat (i.e., woody debris) was usually confined to the stream banks (Figure 6). Because of the sampling methods and imprecise confidence intervals, sampling intensity is not a reliable predictor of robust redhorse occupancy.

Current velocity had a relatively strong positive relationship with detection, where for every 0.25m/s increase in current velocity, detection is 1.18 times more likely. Although there is a positive relationship with detection, velocity may not be a good predictor for detection as a result of site conditions when robust redhorse were captured. The presence of shallow, rocky shoals below Lloyd Shoals Dam only allowed sampling when water was being released from Lake Jackson. As a result, all sampling occasions in units where robust redhorse were detected were on days where water velocities were highest. So, robust redhorse may not actually be more likely to be detected in fast water, rather they were detected in units that only allowed sampling when waters velocities were at higher the average velocities.

Secchi depth also had a negative relationship with detection, where for every 0.20 m increase in secchi depth (visibility) detection was 2.05 times less likely. Although there was a general negative relationship observed, secchi depth was deemed to be an imprecise predictor of conditional detection probability as a result of the wide confidence intervals for the parameter estimate and odds ratio, and sampling conditions that included zero. Secchi depth was generally lower on sampling occasions when robust redhorse were detected below LSD because samplers were only able to access the sampling unit during days of relatively high discharge. The higher discharge from the dam resulted in higher turbidity, which reduced the ability to see and net fish. However, these days were also the only time field crews detected robust redhorse. Therefore, secchi depth may not be a good predictor for robust redhorse detection.

Woody structure provides refuge for numerous fish species, but stunned redhorse may avoid detection or capture when swept underneath or entangled in woody debris (Grabowski *et al*. 2009). In general, woody debris had a negative relationship with conditional detection probability of robust redhorse. Scaled odds ratios revealed for every 2 m^2 of woody structure per rkm, robust redhorse are 1.24 times less likely to be detected. Although the lack of robust redhorse captures could be a result of entanglement in woody structure, field observations and abundant captures of other catostomids in and around woody structure during the course of the project makes this unlikely.

Detection probability for any given fish species is a function of capture probability (i.e., the probability of collecting an individual of that species) and fish abundance (Bayley and Peterson 2001). Rare species (e.g., robust redhorse) may have much lower detection probabilities than more common species (e.g., notchlip redhorse and spotted sucker) because of their low numbers, cryptic behavior, difficult habitat to sample, gear inefficiency, or other such reasons. For example, Grabowski *et al*., 2009 report very low capture probability for robust redhorse (0.031), even when the electrofishing crew knew how many tagged fish were present in a 2 km reach of river. Using model-averaged estimates, my results showed that conditional detection probability (i.e., the probability of detecting a species given that it is present within the sampling unit) for robust redhorse is extremely low. Using a model-averaged estimate from the confidence set of models, robust redhorse conditional detection probability was 0.183 (±0.128), assuming average observed sampling conditions. The detection estimate shows that samplers have an 18.27% chance of detecting at least one individual any given unit during a sampling event if robust redhorse are present in that unit at the time of sampling.

All detections of robust redhorse were only in Units 1 and 2, where the habitat was virtually devoid of woody structure. If robust redhorse have a high affinity for woody debris (Jennings *et al*. 1996; Evans1998; Grabowski and Isely 2006; Mosely and Jennings 2007; Grabowski and Jennings 2009) and detection is higher than previously estimated, then why were more robust redhorse not captured during the study? Other factors such as low site occupancy may help explain why robust redhorse have not been detected in the downstream portion of the study area where large amounts of woody debris are present throughout (Figure 7).

Occupancy of Robust Redhorse

This study's detection estimates revealed that robust redhorse in the upper reaches of the Ocmulgee River are not nearly as difficult to detect as previously assumed. However, the limiting factor associated with the low encounter rates and low total catch for robust redhorse for the duration of this study can be linked to site occupancy of the upper Ocmulgee population. Using the model-averaged estimates, the predicted presence (occupancy) of robust redhorse within all accessible units in the upper reaches of the Ocmulgee River was 0.033 (±0.045).

As revealed by the occupancy estimates, robust redhorse presence is 3.3 % within the all accessible units regardless of habitat type. However, a distinction must be made between shoal and non-shoal habitats. Of the 25 sampling units, only two contained some sort of large shoal complex, and one of these was Unit 1, the unit where most robust redhorse were detected. Although only two sampling units contained a substantial amount of shoals, the purpose of making the distinction between units with shoals and units without shoals was so that inferences could be made about the probability of robust redhorse potentially occupying the shoal habitats that were inaccessible to researchers.

In addition, the low occupancy estimate (0.033) and its relatively high standard error (±0.045) may be a result of a violation of the closure assumption. Robust redhorse were able to colonize or leave sampling units during the course of the study (i.e., occupancy could change from season to season). Each of the 25 sampling units may have a different rate of occupancy, but if detection of robust redhorse is constant across all units, the occupancy estimate may appropriately reflect the average occupancy for the pooled units, but with a large variance. The occupancy estimate of 0.033 represents the average occupancy across all units, but occupancy rates within shoal units may be considerably larger.

Robust redhorse were captured in the shoal unit (Unit 1) below LSD on five out of eight (5/8) sampling occasions. Although robust redhorse occupancy is extremely low for the project area as a whole, occupancy in shoal units is likely much higher. In Unit 1, detecting robust redhorse on 5 out of 8 sampling occasions can be translated to a 62.5% detection probability for that unit. This higher detection estimate is not likely the result of a higher capture probably, but may be the result of local abundance within Unit 1. For instance, robust redhorse may not be extremely difficult to detect, but may only occupy very specific habitat types within the upper Ocmulgee River where they are locally abundant. Occupancy information for robust redhorse within Unit 1 can be used to assume that occupancy in other shoals within the project area may be similar. The majority of shoal habitat in the upper Ocmulgee River between LSD and JMD is located in a non-navigable, 9-km reach of river (between HWY 16 and Nelson Island) that was not sampled during this study. This reach of river is of relatively high gradient and is known for its large complexes of bedrock shoal habitat with fast, turbulent water, and coarse substrates interspersed throughout the shoals. Robust redhorse may occupy these shoal habitats at a similar rate as seen below LSD, yet remain inaccessible by researchers.

Similar to the effect of shoals, the results of these occupancy models also suggest a strong positive effect of the proportion of coarse substrates in the streambed on robust redhorse presence. Although the presence of shoals in Piedmont river systems is often associated with the presence of shallow cobble, boulders, bedrock, gravel and other coarse substrates, not all areas containing coarse substrates are considered to be shoals. For instance, gravel bars and bedrock may be present, but this does not suggest that a shallow, turbulent shoal complex is also present. Scaled odds ratio for the influence of coarse substrates suggests that for every 10% increase in coarse substrates in the streambed, robust redhorse presence is 1.21 times more likely. Unit 1 had the most robust redhorse detections and also was the sampling unit that contained the highest proportion (~78 %) of coarse substrates at (Figure 3). In general, the remainder of accessible portions contained sand as the dominant substrate with the majority of units containing < 15% coarse substrates; Unit 9 had ~56 % coarse substrate and was the exception. Additionally middle sampling units (11-15) were in a reach of the river where the stream morphology changes from long runs to a series of meanders, and Unit 13 contained 46% coarse substrates. This meander section had relatively swift water and lateral scours where bedrock, boulders, and gravel were more abundant. Despite having tight meanders typical of Coastal Plain rivers, this reach contained relatively little wood (Figure 3) and the fewest number of captured catostomids captured downstream of Nelson Island (Figure 4).

Many shoals were available to fish within the project site, but most of the substrate in the accessible portions of the upper Ocmulgee consisted of long, sandy runs with large amounts of woody debris present along the deep, flowing scours near the bank. Robust redhorse have a high affinity for woody structure and pool habitats in non-spawning seasons in lower Oconee River (Jennings *et al*. 1996), lower Savannah River (Grabowski and Isley 2006), and Ocmulgee River (Grabowski and Jennings 2009). However, the results of this study showed something quite different. Robust redhorse were not captured in close proximity to woody structure during this study, and the sampling unit where robust redhorse were detected the most (Unit 1) had the lowest amount of woody debris per river kilometer (Figure 3). The occupancy estimates revealed the likelihood of robust redhorse presence in the upper reaches of the Ocmulgee River decreased as woody debris increased. This 2010-2011 study is one of the first to document robust redhorse habitat use in the Piedmont physiographic regions, and these observations are indicative of differential habitat use between robust redhorse populations in the Piedmont and habitat use observed in Coastal Plain drainages. For instance, sampling units containing shoals and abundant course substrates were virtually devoid of woody habitat, but such sites were where all of the robust redhorse in the Piedmont were captured. Robust redhorse were first described from the Piedmont section of the Pee Dee River (Cope 1869), and the species is known to make long spawning migrations between the Coastal Plain and the Piedmont (or as far upstream as possible; Cook *et al*. 2005; Grabowski *et al*. 2007; Grabowski and Jennings 2009). Most extant natural populations occur in the Coastal Plain sections of the rivers, and information about habitat use in Piedmont sections of rivers is scarce. The apparent affinity for coarse substrates in Piedmont sections may be new information that was otherwise unavailable because so few populations exist in Piedmont sections.

The upper Ocmulgee River population of robust redhorse is unique because after sampling > 22 kilometers of river twice per season for four seasons, robust redhorse were only found in or adjacent to the shoals in the first 0.65 km of the Ocmulgee River below LSD. However, robust redhorse in other Georgia drainages (e.g., Oconee and Ogeechee) may demonstrate different habitat use because the morphologies of these rivers also are different. The Ogeechee River's narrow, tightly meandering channel flows at an elevation of only around 61 m above sea level below Louisville, GA. The Ocmulgee River is comparable to the Oconee River, but the Oconee River population of robust redhorse is only present below Lake Sinclair, where the elevation is around 76.2 m above sea level near the Fall Line in Milledgeville. The Oconee population is unable to enter the Piedmont portion of the stream that was accessible prior to dam construction. The Ocmulgee project site for this study begins at an elevation of around 143 m immediately downstream of LSD and drops to about 110 m just upstream of JMD. Elevation on the Ocmulgee River does not match that of the Ogeechee and Oconee rivers until after Macon, GA where the Ocmulgee crosses the Fall Line, exits the Piedmont, and takes on the morphology that is typical of other Atlantic Coastal Plain rivers. The Ocmulgee River is unique because unlike the Oconee, a population of robust redhorse exists in the Piedmont and Coastal Plain portions of the river. If a wild population of robust redhorse historically occurred in the Ocmulgee, they could undertake long migrations between the Piedmont and Coastal Plain freely prior to dam construction. The current population of fish can traverse over JMD (Grabowski *et al.* 2009) and be in Coastal Plain habitats used during non-spawning seasons. However, these "outmigrants" are unable to return to the high-gradient Piedmont habitats above JMD; the result is that the project site is no longer accessible. There is evidence from other GA rivers that "outmigrants" would return to the Piedmont portion of the river to spawn if such habitats were accessible.

The Broad River is the only other Georgia river system that has a population of robust redhorse that is at a comparable elevation (about 110m) and relative position to the Fall Line as the project site on the Ocmulgee. The Broad River is located in northeast Georgia within the Piedmont physiographic region of the state. Although the Broad is above the Fall Line, the river is narrower and contains less wood and shoal habitat than the project site on the upper Ocmulgee. The Broad is also different from the Ocmulgee because it eventually drains into Clarks Hill Reservoir on the Savannah River. The Broad River is formed by the confluence of the Hudson River and the Middle Fork Broad between Royston and Ila, GA. In the Broad and Hudson rivers, robust redhorse have access to upstream shoals and numerous mid-channel gravel bars for spawning purposes, in addition to having the reservoir available during non-spawning periods (RRCC 2010; 2011). In 2010, tagged robust redhorse spawned on gravel bars in the Hudson and Broad rivers 81-88 km upstream of Anthony Shoals (a large shoal complex located at the mouth of where the Broad River of Clarks Hill Reservoir) (RRCC 2010), and then 83% of the tagged fish migrated downstream 10-12 km into Clarks Hill Reservoir in the summer (RRCC 2011). The Broad River population attempts to migrate downstream (as they would have historically), but encounters a reservoir first and therefore cannot access the Coastal Plain habitats used by robust redhorse in the lower Oconee and Savannah rivers. However, these fish can leave the reservoir and return to the Piedmont habitats during spawning season and do so annually.

So, if thousands of robust redhorse have been stocked into the upper Ocmulgee River, why were only eight fish captured during the course of this study? One explanation was mentioned above. The results of this study suggests that the upper Ocmulgee population may be encountered most frequently in habitats containing large amounts of coarse substrates year-round rather than large amounts of woody debris in the sandy runs. All shoal portions of the project site are likely available to robust redhorse, but are not accessible by researchers. Over 96% of the shoals between LSD and JMD are located in the 9-km portion of river that was unable to be sampled in 2010 and 2011. Therefore, robust redhorse may be residing in and adjacent to the numerous shoals that occupy a 9-km, inaccessible reach of river. However, until robust redhorse can actually be located within this portion of the Ocmulgee that contains the overwhelming majority of shoal habitats, whether great numbers of robust redhorse inhabit shallow, rocky areas of the river year-round is uncertain.

There is a possibility that the Ocmulgee population contains two subgroups, which exhibit distinct behavioral patterns as observed in a population of robust redhorse within the Pee Dee River in North Carolina (Fisk 2010). Using radio-tagged robust redhorse in the Piedmont and Coastal Plain portions of the Pee Dee, Fisk (2010) observed a "resident" and a "migratory" subgroup. Resident fish (n=20) remained within the Piedmont section and made localized movements for spawning purposes, and migratory fish (n=7) took part in long seasonal migrations and spent most of their time in Coastal Plain habitats; they only returned to the Piedmont to spawn (Fisk 2010). The Ocmulgee population may contain similar subgroups as the Pee Dee population. The robust redhorse captured during the course of this study may be considered a residential subgroup that rarely ventures far from spawning grounds regardless of season. Although the Ocmulgee population may exhibit similar behaviors as the Pee Dee Population, the two rivers systems differ in the fact that the study area on the Pee Dee has connectivity between Coastal Plain and Piedmont habitats, whereas the Ocmulgee River project site is not accessible to fish within the Coastal Plain. The migratory subgroup of stocked robust redhorse may have traversed over JMD in search of Coastal Plain habitats during non-spawning seasons; however, once outside of the project area, fish cannot traverse the dam in the upstream direction.

Out migration to areas below JMD is a probable explanation for the low number of detections is robust redhorse stocked into the project site. In two other studies on the Ocmulgee, around one third of tagged juvenile (Jennings and Shepard 2003) and adult (Grabowski and Jennings 2009) robust redhorse in the project outmigrated over JMD. Recall that once below the dam, robust redhorse cannot get back upstream above the dam to recolonize the study site. Below JMD, the effects of the hydro-peaking and large discharge fluctuations from LSD are less intense, and other migration barriers (e.g., dams) do not exist in the river. Also important to note is that the Ocmulgee River below JMD remains within the Piedmont, contains numerous shoals, and generally the same morphology seen in the project site between LSD and JMD. The river remains in the Piedmont region for an additional 40 km from JMD downstream until it reached the Fall Line in Macon, GA. So, although fish may find suitable Piedmont habitat once they travel over JMD, they cannot access the high-gradient portions of the river above JMD that they may have had access to during historic migrations.

Thousands of robust redhorse of mixed ages were stocked into the upper reaches of the Ocmulgee River, but their fate remains unknown. There is the possibility that the one-third of the stocked fish exiting the project site, as reported in previous years (Jennings and Shepard 2003; Grabowski and Jennings 2009), has increased with time, and the majority of stocked fish have traversed over JMD since those studies were completed. Many of these fish may have encountered habitat similar to their Coastal Plain Oconee counterparts by swimming downstream out of the project site. In the river below JMD, robust redhorse still have access to the Coastal Plain meanders and woody debris during non-spawning seasons, but can still participate in long spawning migrations into the Piedmont shoal habitats between JMD and Macon that contain coarse substrates. Although robust redhorse appear to be using (and potentially spawning) in the Piedmont portion of the river between JMD and Macon after they travel over JMD, the use of shoals below JMD may be because the fish are incapable of upstream movement pass JMD. As a result, whether fish would inhabit the high-gradient shoals that exist between LSD and JMD and would stay in the study reach is unknown.

Upper Ocmulgee River Spawning Aggregation

On the first sampling occasion (May 10th) in Spring 2010, 5-6 individual robust redhorse were visually detected (2 were captured) in the first set of shallow shoals immediately downstream of LSD (Unit 1). Water temperature was 22.9 °C. Although several fish were shocked on the spawning shoals, only one large male and one female were captured. Evidence of spawning included the presence of nuptial tubercles on the male's rostrum and anal fin. Two weeks later (May 24th), the spawning aggregation had dispersed, and one individual was detected visually (fish was surfaced during electrofishing, but was not captured) in turbulent waters immediately downstream of the spawning shoals. Individual single robust redhorse were detected in the deep, swift waters of the dam tailrace along the western riverbank during both Summer 2010 sampling occasions. In the Fall 2010 season, robust redhorse were not detected in any sampling unit on any sampling occasion.

The Spring 2011 sampling season was when most robust redhorse were captured. Individuals were not found in Unit 1 during the first sampling occasion of spring 2011, but a single male robust redhorse was captured along the eastern shoreline without canopy and without submerged structure or cover at the very beginning of Unit 2 on April 7th. Water temperature was 15.8 °C, and the male robust redhorse appeared to be coming into spawning condition, as several small nuptial tubercles were starting to develop on the rostrum. Two weeks later, (April 28th), a spawning aggregation of about six individuals was encountered in the same set of shoals where fish were found the previous year. Water temperature on this sampling date was 20.7 °C. Although about six fish were spotted, only four individuals were landed, all of which were males in spawning condition. All fish lacked protective slime coats, and their anal fins and ventral portions of the caudal fin were eroded away, which revealed that spawning activity or some sort of territorial defense had taken place. In addition, the two smallest males were missing scales from their flanks and had the posterior portion of their dorsal fin missing (Figure 5). Although sample size was low, the high male:female sex ratio followed that observed by Grabowski *et al*. (2007). The lack of slime-coat, missing scales, and tattered fins of the two smaller males has also been observed in other spawning catostomids (Jenkins and Burkhead 1993; Grabowski and Isley 2007) and may be a result of spawning attempts in the upper reaches of the Ocmulgee River.

Although robust redhorse were captured in the first set of shoals below LSD as part of a "spawning aggregation" in both spring sampling seasons, the question of whether successful reproduction occurred there still remains. This particular set of shoals was only submerged during large discharge events from LSD. When water levels returned to normal flow, this set of shoals was either dewatered or covered with very shallow, slow water where the substrate was covered by a layer of silt and sediment (Figure 8). If gametes were actually released in this area, the eggs and larval robust redhorse could be exposed, smothered or heated by warm water, which would cause mortality as described in Jennings *et al*. (2009). Also, visits to this set of shoals during normal flows revealed that typical spawning habitat that consists of loose gravel substrates (Jennings *et al*. 1996; Grabowski *et al*. 2007; Grabowsk and Isely 2007) was not present in this particular area. Instead of midstream gravel bars seen in the Oconee (Jennings, *et al*. 1996) and Savannah (Grabowski *et al*. 2007; Grabowski and Isely 2007) rivers, the area where most robust redhorse captures took place in the upper Ocmulgee consisted of mostly bedrock with some loose cobble scattered on or around the bedrock shoals. So, although territorial defense is occurring at this "spawning aggregation," whether active reproduction is taking place is unknown, and robust redhorse may be taking part in "futile spawning runs" until they reach LSD and settle for substandard spawning substrates.

Capture of Other Catostomids of the Upper Ocmulgee

At least six species of the family Catostomidae occur in the ~30 rkm headwater portion of the Ocmulgee River, including robust redhorse, notchlip redhorse, spotted sucker, brassy jumprock, striped jumprock, and two species of carpsucker. The number of captures in each sampling unit (Table 10, Figure 4) varied with species.

The notchlip redhorse was the most abundant sucker species and was found at least once in every sampling unit within the project site (Table 10). However, notchlip redhorse were generally scarce in the upstream portion of the project site and were more abundant in the downstream portion of the project site (Figure 4). The species was captured most frequently in long sandy runs, where the river was shallow midstream and deeper closest to the bank. These areas were generally characterized by moderate flows and abundant woody debris. In general, notchlip redhorse were not captured in shallow, swift, and rocky habitats inhabited by jumprocks.

Spotted suckers were also detected in all sampling units at least once (Table 10), but exhibited different habitat use and spatial distribution than the notchlip redhorse (Figure 4). Spotted suckers were distributed relatively evenly throughout the project site, but their numbers were greatest in the three most downstream units, where the river widens and slows just before the low-head mill dam in Juliette. Spotted suckers also had a high affinity to woody structure and occurred most frequently in deep areas with low flows. Sexual differentiation during non-spawning seasons was easiest for the spotted sucker; sexually mature males had visible “scars’ remaining on their rostrums into the fall season.

In general, the jumprocks (*Scartomyzon spp.*) were found most frequently in areas with swift water and were often found associated with rocky substrates. Brassy jumprocks were found in greater numbers than striped jumprocks and were detected in 92% of the sampling units at least once during the study (Table 10). Brassy jumprock abundance was the highest immediately downstream of LSD in sampling Unit 1 (Figure 4), where water velocity was consistently greater than 0.75 m/second and the proportion of streambed occupied by coarse substrates was greater than 0.77. This sampling unit was also where the majority of robust redhorse were captured or detected. In the spring seasons, Unit 1 was sampled intensely, and groups of 10-20 brassy jumprocks were observed frequently in one small area of turbulence just below shoals. Brassy jumprocks were present throughout the project site, with the exception of the two most downstream sampling units. However, they were found in the greatest number just below LSD. Although brassy jumprocks were located in sites containing long sandy runs, they seemed to be confined to specific microhabitats within those runs. Specifically, they tended to occur in small areas of comparatively high water velocity, particularly in lateral scours where shoals, boulders or cobble were nearby.

Striped jumprocks were present in 44% of the sampling units (Table 10) and were found primarily in shoals, rocky outcrops, and other areas characterized by coarse substrates and high water velocities. Like brassy jumprock, most striped jumprock captures occurred in sampling Unit 1 just below LSD. However, rather than finding this species in deep, turbulent waters in the middle of the stream, striped jumprocks occurred in swift, shallow waters (<0.5m) over loose cobble, bedrock or rocky substrates. Striped jumprocks were detected most often in the fall when water clarity was highest and water levels were lowest. The small overall size and specific habitat use of striped jumprocks may have influenced the relatively low numbers of detections of this species when sampling with boat electrofishing techniques.

Only the undescribed carpsuckers *Carpiodes spp.* were found in fewer numbers than robust redhorse (Table 10). On a sampling occasion later that spring, one individual (assumed to be a quillback *Carpoides sp. cf. cyprinus*) was found in the accessible unit just below Nelson Island in a deep flowing run, and two more individuals (believed to have been highfin carpsuckers *Carpiodes sp. cf. velifer*) were found about 7 km downstream in a shallow sandy run under woody debris. These two fish were in spawning condition (nuptial tubercles present on the rostrum, head, paired fins, and rear margins of scales on the dorsum and sides of the fish). These two individuals were presumably migrating upstream to spawn in or near the inaccessible shoals near 40-Acre Island. Other carpsuckers were not encountered until the next spring (2011), when a single quillback was captured in the silted, no-flow waters underneath the Juliette Road. Bridge approximately 200 meters upstream of JMD.

CHAPTER 7

CONCLUSIONS

Considering imperfect detection and the overall lack of captures for robust redhorse, occupancy modeling was somewhat useful in determining detection probabilities and probable habitat use for this rare species. However, parameter estimates were generally imprecise and unreliable. Some of the most useful information regarding the Ocmulgee population was gathered from field observations (e.g., captures, sampling conditions) and habitat types as observed through side-scanning sonar imagery. The extremely low occupancy estimate for robust redhorse (0.033 ±0.128) is believable because robust redhorse were only observed in two of 25 units, both immediately downstream of LSD in the immediate vicinity of shoals. This occupancy rate of 3.3% can be used to make inferences regarding robust redhorse occupancy within the non-navigable portion of the river. However, the occupancy rates in the inaccessible habitats in the area between HWY 16 and Nelson Island shoals should not be considered to be identical to the occupancy estimates gathered from the accessible units as a whole. For instance, the current estimates include large areas that are primarily sandy runs with abundant woody debris. However, the majority of habitats within the non-navigable portion consist of shoals. Considering robust redhorse were found almost exclusively in shoal habitats during the course of the study, one may assume that robust redhorse are more likely to inhabit the inaccessible shoals as well. Although shoals in the inaccessible portion of river appear to be similar to those where robust redhorse were captured, Units 1 and 2 are unique. These units are located immediately below a hydropower dam, where conditions are dynamic and hydropeaking occurs during high water levels in the winter and early spring months. This dam is also a migration barrier, where fish taking part in spawning runs may swim past shoal complexes downstream only to have further migration blocked by the dam, and fish may "settle" into the first set of shoals below the dam. Therefore, although the upper reaches of the Ocmulgee River contain numerous shoal habitats that could be used for reproduction by many catostomids, including the robust redhorse, true occupancy estimates for the entire study area cannot be determined until the inaccessible portion of the river can be sampled.

Abundant shoal habitat is available in the project site, but only a few of those areas were accessible for electrofishing and are located at the most upstream shoals within the project site. This situation confirms previous research (e.g., Graboswki and Isley 2006, Fisk 2010) that implied robust redhorse have high site fidelity to spawning areas used in the past or they may continue upstream until some barrier (e.g., dams) prevents further migration. The shoals directly below JMD (outside of the project site) could also serve as a potential spawning ground for robust redhorse. Local residents have reported "large fish with bright red fins hanging out in groups" in the area just below JMD during April and May. These reports suggest that robust redhorse may have moved out of the project site into a reach of river that is still within the Piedmont ecoregion, but fish still have access and connectivity to the downstream Coastal Plain habitats. From there, fish make long migrations upstream until a barrier (i.e., JMD) prevents further upstream movement or until suitable spawning habitat is found. The robust redhorse population observed between LSD and JMD in the current study was not found in association with woody debris and was found most frequently in shoals and areas containing abundant coarse substrates year round. However, this inference was made on less than 10 fish, and the species as a whole may use habitat types seasonally in a fashion similar to those seen in other robust redhorse studies (e.g., Grabowski and Isely 2006; Mosely and Jennings 2007; Grabowski and Jennings 2010). In those studies, fish used gravel bars and shoals in spring, but retreated to deep areas containing large amounts of woody debris during non-spawning months. Along the Ocmulgee, suitable spawning habitat may be present between LSD and JMD, but much of the meandering habitat used in non-spawning seasons in the Coastal Plain is not present in the upper reaches of the Ocmulgee. To better understand the Ocmulgee River population of robust redhorse, a similar study from JMD downstream to Macon would be useful. This reach of river is located in the Piedmont region where robust redhorse have access to numerous shoals, as well as un-impounded waters flowing into the Coastal Plain region where fish may have similar habitats to their Oconee River conspecifics. In addition, if fish have traversed over JMD, the Coastal Plain habitats may be used by robust redhorse, but fish cannot return to the project site to use high-gradient shoals between LSD and JMD.

Another focus of this project was to determine if any natural reproduction and recruitment were occurring in the Ocmulgee River. Although robust redhorse were captured in probable spawning aggregations, the success of that activity remains unknown. The observed spawning aggregation took place just below Lloyd Shoals Dam, where springtime flows were often higher than in other seasons. However, the daily and weekly fluctuations in discharge from the dam can leave the shoals susceptible to sedimentation, changes in water quality or dewatering, potentially rendering spawning attempts unsuccessful (Ruetz and Jennings 2000; Weyers *et al*. 2003; Jennings *et al*. 2010).

The status of the Ocmulgee population remains unclear because abundance could not be estimated with the low capture rates experienced during this study. However, this study did demonstrate that even with limited date, useful information about the apparent occupancy, detection, and habitat use of a rare species can inform management, and may be used to study other populations of robust redhorse or other rare suckers (e.g., sicklefin redhorse, Carolina redhorse; *Moxostoma spp*).

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TABLES

Table 1. Interpretation of predictor variables used to estimate the conditional detection probability of robust redhorse in the upper Ocmulgee River, 2010-2011.

Predictor	Interpretation
Sampling Intensity	The amount of time spent electrofishing per kilometer of river may influence the probability of detecting a species.
Woody Structure	Fish may seek refuge in woody debris or may become entangled in woody structure after being immobilized, therefore influencing the conditional detection of robust redhorse in the upper Ocmulgee River.
Secchi Depth	The turbidity /water clarity on any given day may influence detection by affecting the netter's ability to see and captured immobilized fish, and/or allow fish to avoid the sampling equipment, thus leaving the sampling area.
Current Velocity	Immobilized fish may be swept away in areas of high water velocity, therefore affecting the detectability of that fish species.

Table 2. Interpretation of predictor variables used to estimate the probability of occupancy of robust redhorse in the upper Ocmulgee River, 2010-2011.

Predictor	Interpretation
Temperature	Robust redhorse may occupy different spatial locations in the river based on water temperature or seasonal temperature differences; therefore, water temperature may influence the conditional occupancy of robust redhorse.
Coarse Substrates	In spring months, robust redhorse may move into areas containing large amounts gravel or pebble substrates; therefore, the proportion of coarse substrates in the streambed of a sampling unit may influence robust redhorse occupancy.
Current Velocity	In relation to other catostomids, robust redhorse may reside in faster flowing portions of the stream. Also, in spring months, robust redhorse may move into the faster flowing waters in search of spawning habitat; therefore, water velocity may influence conditional occupancy.

Table 3. Mean (standard errors) of water quality data recorded on each sampling occasion during all sampling seasons in the upper Ocmulgee River, 2010-2011.

Season	Temperature (°C)	Dissolved Oxygen (mg/L)	Velocity (m/s)	Discharge (m^3/s)	Secchi Depth (m)
All	23.85 (4.40)	6.94 (1.02)	0.33 (0.24)	28.30 (28.99)	1.18 (0.92)
Spring 2010	23.64 (1.07)	7.37 (0.96)	0.39 (0.17)	41.46 (38.44)	1.15 (0.49)
Summer 2010	29.89 (0.83)	6.33 (0.66)	0.29 (0.26)	14.30 (7.63)	1.98 (1.03)
Fall 2010	20.92 (3.82)	7.55 (1.07)	0.25 (0.23)	21.13 (25.19)	2.24 (1.01)
Spring 2011	20.90 (2.75)	6.51 (0.78)	0.40 (0.28)	36.30 (27.31)	1.84 (0.69)

Table 4. Total number of various catostomid species captured (n) in the upper reaches of the Ocmulgee River in 2010 and2011, the number of each species weighed (sub-sample n), and their mean and range of total length in mm.

Species	n	sub-sample n	Mean TL	Range
Moxostoma robustum Robust Redhorse	7	7	491.71	477-509
Moxostoma collapsum Notchlip Redhorse	2649	472	395.36	61-520
Minytrema melanops Spotted Sucker	1384	403	370.44	133-772
Scartomyzon rupricartes Striped Jumprock	39	18	174.78	83-253
Scartomyzon sp. cf. lachneri Brassy Jumprock	331	189	383.13	161-474
Carpioides spp. Carpsucker spp.	3	1	438.00	NA

Table 5. Number of captured catostomids in the upper Ocmulgee River during each sampling season in 2010 and 2011, the total number captured, and each species' percentage of the total catch.

	Mo. robustum Robust Redhorse	*Mo. collapsum* Notchlip Redhorse	*Mi. melanops* Spotted Sucker	*Sc. rupricartes* Striped Jumprock	*Sc. sp. cf. lachneri* Brassy Jumprock	*Carpioides spp.* Carpsucker spp.
Spring 2010	2	617	434	1	98	3
Summer 2010	0	726	233	2	93	0
Fall 2010	0	781	381	24	56	0
Spring 2011	5	525	336	12	84	2

Table 6a. Confident set of models (n=41) used to predict robust redhorse occupancy in the upper Ocmulgee River in 2010 and 2011. Confident set of models is comprised of the top models with models weights within 10% of the best-approximating model. Table of models includes the detection predictor variables (P), the occupancy predictor variables (Psi), the number of parameters (K), AICc, ΔAICc, model weight (w_i), and the percentage of maximum weight for each model (% max w_i).

Model						
P	Psi	K	AICc	ΔAICc	w_i	% max w_i
Intercept + Secchi	Intercept + Velocity + Temperature	5	30.143	0.000	0.067	100.0
Intercept + Secchi	Intercept + Velocity	4	30.200	0.056	0.065	97.2
Intercept + Secchi + Intensity	Intercept + Velocity	5	30.419	0.275	0.058	87.1
Intercept + Secchi + Intensity	Intercept + Coarse Substrates	5	30.501	0.357	0.056	83.6
Intercept + Secchi	Intercept + Coarse Substrates	4	30.625	0.482	0.052	78.6
Intercept + Secchi + Intensity	Intercept + Velocity + Temperature	6	30.659	0.515	0.051	77.3
Intercept + Secchi	Intercept + Velocity + Coarse Substrates	5	31.012	0.868	0.043	64.8
Intercept + Wood + Secchi	Intercept + Velocity + Temperature	6	31.208	1.064	0.039	58.7
Intercept only	Intercept + Coarse Substrates	3	31.217	1.073	0.039	58.5
Intercept + Secchi + Intensity	Intensity + Velocity + Coarse Substrates	6	31.490	1.347	0.034	51.0
Intercept + Wood + Secchi + Intensity	Intercept + Coarse Substrates	6	32.088	1.944	0.025	37.8
Intercept + Velocity + Secchi	Intercept + Velocity	5	32.092	1.949	0.025	37.7
Intercept + Velocity + Secchi	Intercept + Velocity + Temperature	6	32.270	2.127	0.023	34.5
Intercept + Velocity	Intercept + Velocity + Coarse Substrates	5	32.362	2.219	0.022	33.0
Intercept + Wood + Secchi + Intensity	Intercept + Velocity	6	32.485	2.342	0.021	31.0
Intercept + Intensity	Intercept + Coarse Substrates	4	32.553	2.410	0.020	30.0

Table 6b. Confident set of models (n=41) used to predict robust redhorse occupancy in the upper Ocmulgee River in 2010 and 2011. Confident set of models is comprised of the top models with models weights within 10% of the best-approximating model. Table of models includes the detection predictor variables (P), the occupancy predictor variables (Psi), the number of parameters (K), AICc, ΔAICc, model weight (w_i), and the percentage of maximum weight for each model (% max w_i).

Model						
P	Psi	K	AICc	ΔAICc	w_i	% max w_i
Intercept + Wood + Secchi	Intercept + Coarse Substrates	5	32.560	2.417	0.020	29.9
Intercept + Wood	Intercept + Coarse Substrates	4	32.703	2.560	0.019	27.8
Intercept only	Intercept + Velocity	3	32.746	2.602	0.018	27.2
Intercept + Velocity	Intercept + Velocity + Coarse Substrates + Temperature	6	32.795	2.652	0.018	26.6
Intercept + Velocity + Secchi	Intercept + Coarse Substrates	5	32.842	2.699	0.017	25.9
Intercept + Wood + Secchi + Intensity	Intercept + Velocity + Temperature	7	32.882	2.738	0.017	25.4
Intercept + Velocity	Intercept + Coarse Substrates	4	32.914	2.771	0.017	25.0
Intercept only	Intercept + Coarse Substrates + Temperature	4	32.920	2.777	0.017	24.9
Intercept only	Intercept + Velocity + Coarse Substrates	4	32.950	2.807	0.016	24.6
Intercept + Wood + Secchi	Intercept + Velocity + Coarse Substrates	6	32.974	2.830	0.016	24.3
Intercept + Wood + Secchi + Intensity	Intercept + Velocity + Coarse Substrates	7	33.198	3.055	0.014	21.7
Intercept + Wood	Intercept + Velocity	4	34.071	3.928	0.009	14.0
Intercept only	Intercept + Velocity + Coarse Substrates + Temperature	5	34.261	4.117	0.008	12.8
Intercept + Intensity	Intercept + Coarse Substrates + Temperature	5	34.339	4.195	0.008	12.3
Intercept + Velocity + Wood	Intercept + Velocity + Coarse Substrates	6	34.343	4.199	0.008	12.2
Intercept + Intensity	Intercept + Velocity	4	34.369	4.226	0.008	12.1

Table 6c. Confident set of models (n=41) used to predict robust redhorse occupancy in the upper Ocmulgee River in 2010 and 2011. Confident set of models is comprised of the top models with models weights within 10% of the best-approximating model. Table of models includes the detection predictor variables (P), the occupancy predictor variables (Psi), the number of parameters (K), AICc, ΔAICc, model weight (w_i), and the percentage of maximum weight for each model (% max w_i).

Model						
P	Psi	K	AICc	ΔAICc	w_i	% max w_i
Intercept + Velocity + Wood	Intercept + Velocity	5	34.487	4.344	0.008	11.4
Intercept + Wood	Intercept + Coarse Substrates + Temperature	5	34.491	4.347	0.008	11.4
Intercept + Velocity	Intercept + Coarse Substrates + Temperature	5	34.558	4.415	0.007	11.0
Intercept + Intensity	Intercept + Velocity + Coarse Substrates	5	34.614	4.471	0.007	10.7
Intercept + Velocity + Intensity	Intercept + Velocity + Coarse Substrates	6	34.624	4.480	0.007	10.6
Intercept + Velocity + Wood	Intercept + Coarse Substrates	5	34.630	4.487	0.007	10.6
Intercept + Wood + Intensity	Intercept + Coarse Substrates	5	34.692	4.549	0.007	10.3
Intercept + Velocity	Intercept + Velocity	4	34.702	4.558	0.007	10.2
Intercept + Wood	Intercept + Velocity + Coarse Substrates	5	34.721	4.577	0.007	10.1

Table 7. Predicted estimates of average conditional detection probability, and occupancy for robust redhorse across all sampling units in the upper Ocmulgee River in 2010 and 2011, their standard errors, and upper and lower 95% confidence intervals calculated using model average estimates from the confident set of 41 models.

Parameter	Estimate	SE	95 % Confidence Intervals	
			Lower	Upper
Detection Probability (p)	0.1827	0.1282	0.0054	0.9014
Occupancy (Psi)	0.0328	0.0455	0.0000	0.9975

Table 8. Model average estimates for various parameters influencing detection of robust redhorse on the upper Ocmulgee River in 2010 and 2011, with standard errors (SE), 95% confidence intervals for each estimate, odds ratios (OR), 95% confidence intervals for OR. For ease of interpretation, unit changes, scaled estimators, scaled odds ratios, and 95% confidence intervals of the scaled odds ratios are also provided.

			95 % CI of Estimate			95 % CI of OR				
Parameter	Estimate	Standard Error	Lower	Upper	OR	Lower	Upper	unit change	scaled estimator	scaled OR
Intercept	-2.408	2.486	-7.280	2.464	—	—	—	—	—	—
Velocity	0.655	1.329	-1.950	3.261	1.925	0.142	26.067	0.250	0.164	1.178
Woody Structure	-0.218	1.434	-3.029	2.594	0.804	0.048	13.379	2.000	-0.436	0.647
Secchi Depth	-3.591	2.226	-7.954	0.772	0.028	0.000	2.165	0.200	-0.718	0.488
Sampling Intensity	1.492	1.429	-1.309	4.294	4.447	0.270	73.261	2.000	2.985	19.780

Table 9. Model average estimates for various parameters influencing detection of robust redhorse in the upper Ocmulgee River in 2010and 2011, with standard errors (SE), 95% confidence intervals for each estimate, odds ratios (OR), 95% confidence intervals for OR. For ease of interpretation, unit changes, scaled estimators, scaled odds ratios, and 95% confidence intervals of the scaled odds ratios are also provided.

			95 % CI of Estimate			95 % CI of OR				
Parameter	Estimate	Standard Error	LCL	UCL	OR	LCL	UCL	unit change	scaled estimator	scaled OR
Intercept	-4.492	2.316	-9.033	0.048	—	—	—	—	—	—
Velocity	2.309	6.774	-10.967	15.586	10.068	0.000	5.9×10^{6}	0.100	0.231	1.260
Coarse Substrates	1.865	1.391	-0.862	4.591	6.454	0.422	98.584	0.100	0.186	1.205
Temperature	-2.033	2.063	-6.077	2.010	0.131	0.002	7.463	2.000	-4.067	0.017

Table 10. Total number of captures for each species, and the percentage of sites where each species was captured during all four sampling seasons in 2010 and 2011 withing the upper Ocmulgee River project site. Note: the verticle line represents the 9 km portion of river unable to be accessed by electrofishing boats.

	< Upstream Unit Number Downstream >																									
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	% Units
Moxostoma robustum Robust Redhorse	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Moxostoma collapsum Notchlip Redhorse	11	2	1	242	225	143	120	148	68	126	74	50	58	28	86	146	148	127	146	111	64	114	71	41	48	100
Minytrema melanops Spotted Sucker	64	57	26	63	57	39	48	32	16	47	12	23	17	13	36	83	76	57	53	39	38	53	142	120	132	100
Scartomyzon rupricartes Striped Jumprock	18	2	0	1	0	0	0	3	4	1	0	0	1	0	2	0	4	0	1	0	0	1	0	0	0	44
Scartomyzon. sp. cf. lachneri Brassy Jumprock	95	2	3	13	21	32	15	13	26	15	8	5	12	6	12	5	7	6	6	8	4	8	1	0	0	92
Carpioides spp. Carpsucker spp.	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12

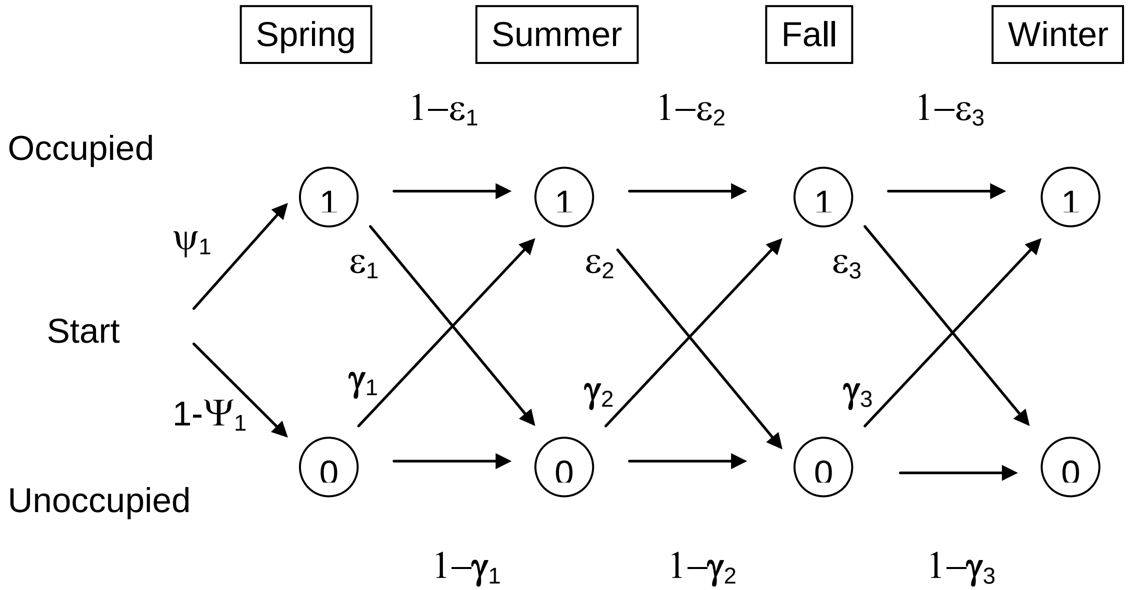

Figure 1. Schematic of the robust design, where a sampling unit is either occupied (Ψ) or unoccupied (1-Ψ). Between seasons the species can either persist (1-ε), remain absent (1-γ), or the species can colonize (γ) the unit or become locally extinct (ε) from a sampling unit from one season to the next.

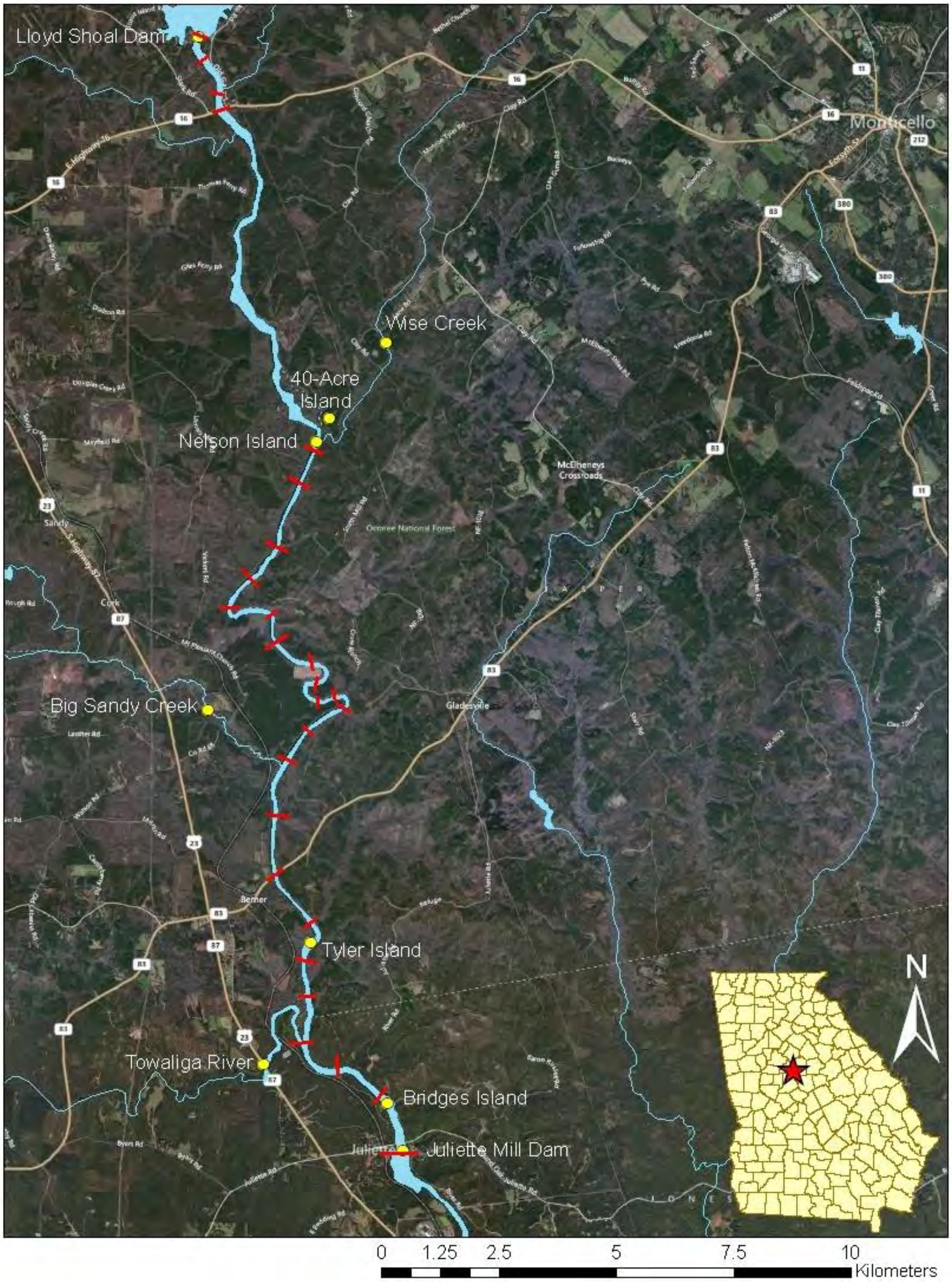

Figure 2. Reaches stratified into 25 sampling units (sites) bases on local habitat characteristics such as water velocity, substrate composition, and available habitat. Each mark represents the upstream or downstream boundary of a sampling unit in 2010 and 2011.

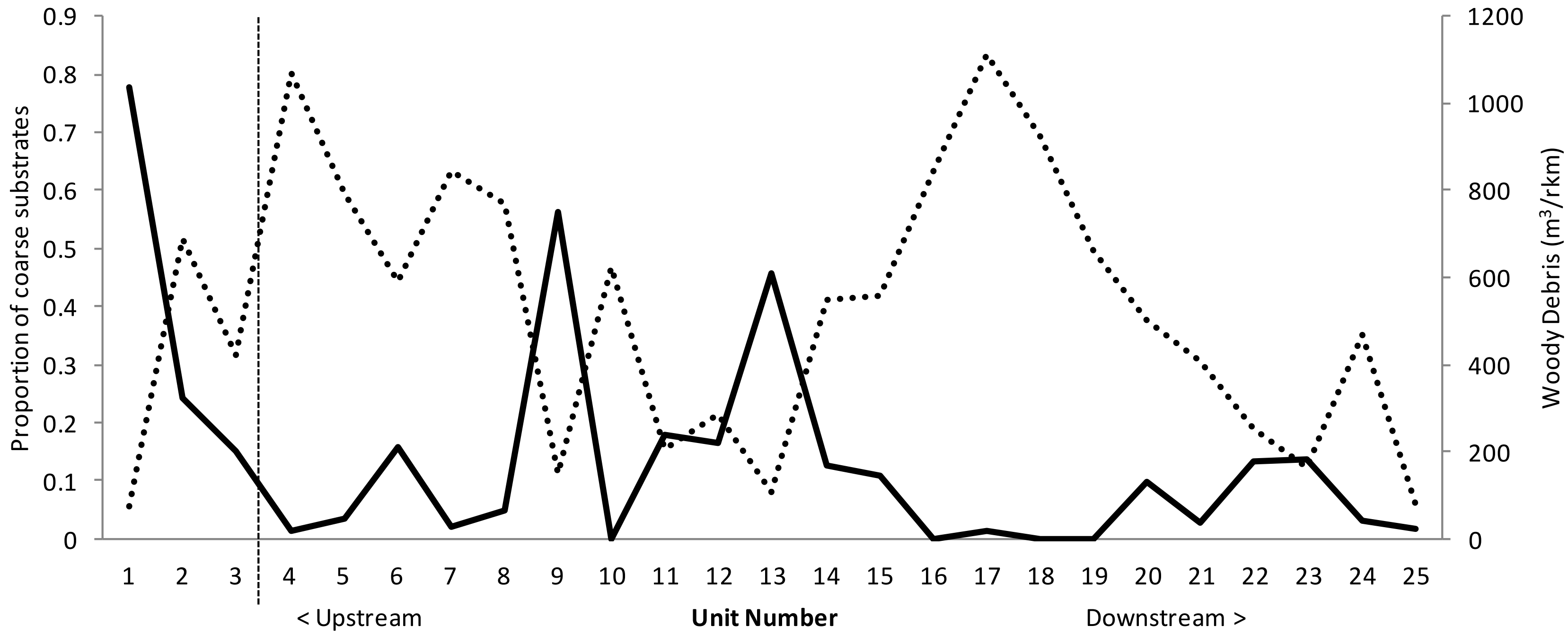

Figure 3. The proportion of coarse substrates occupying the streambed (solid line) and the quantity of woody structure (dotted line) throughout each sampling unit on the upper Ocmulgee River in 2010 and 2011, starting upstream at Unit 1 and ending downstream at Unit 25. Note the dashed line through the x-axis represents the 9 km portion of river inaccessible to sonar and electrofishing boats.

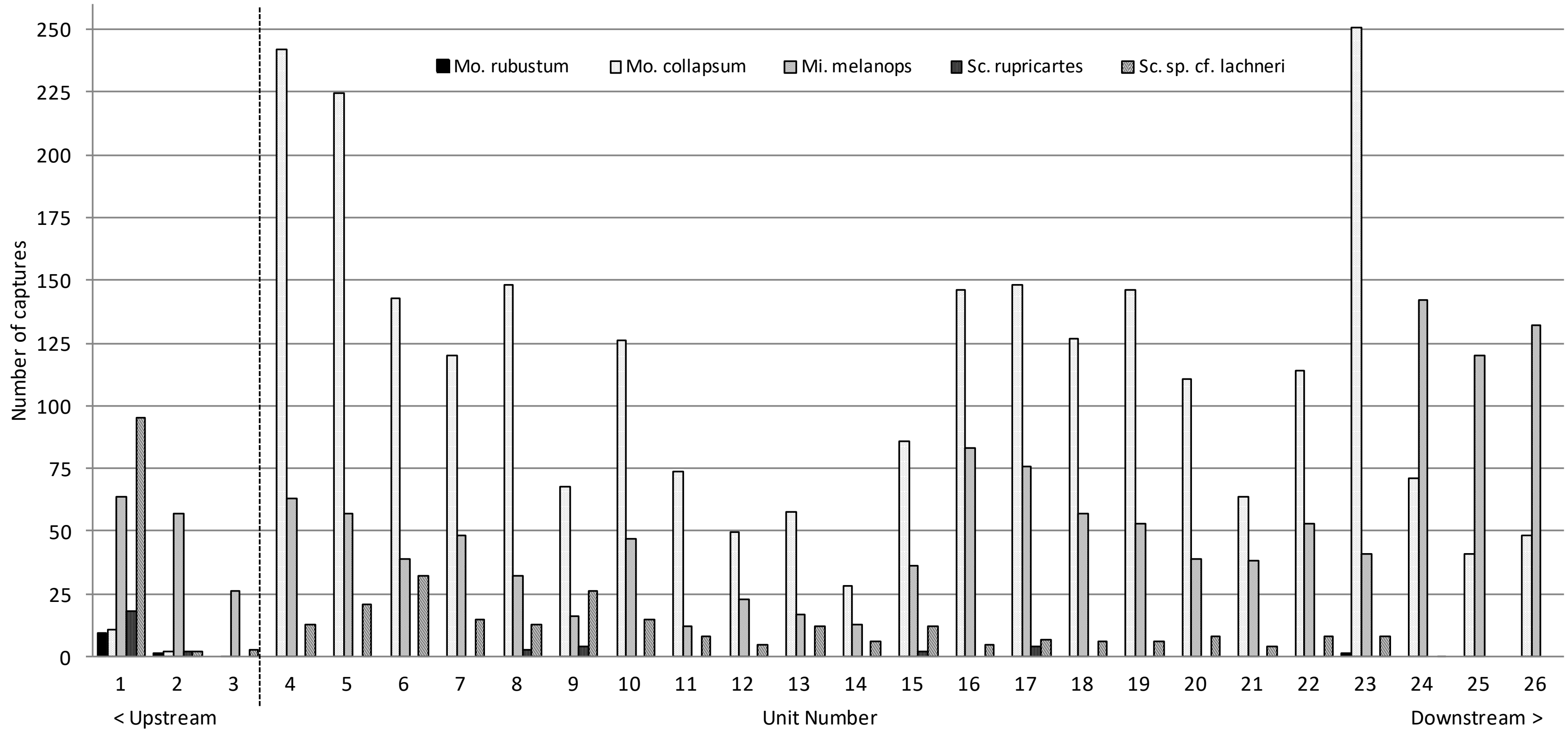

Figure 4. Total number of captures for robust redhorse *Moxostoma robustum* (solid black), notchlip redhorse *Mo. collapsum* (white with dots), spotted sucker *Minytrema melanops* (thin dark lines), striped jumprock *Scartomyzon rupriscartes* (black with white dots), and brassy jumprock *Sc. sp. cf. lachneri* (thick black bands) in each sampling unit in the upper Ocmulgee River study site in 2010 and 2011. Note: the dashed vertical line on the x axis represents the 9 km portion of river inaccessible to electrofishing boats.

Figure 5. Robust redhorse male captured on an aggregation in shoals immediately below Lloyd Shoals Dam on the Ocmulgee River in April 2011; note damaged anal and dorsal fins, and missing scales and absence of slime coat.

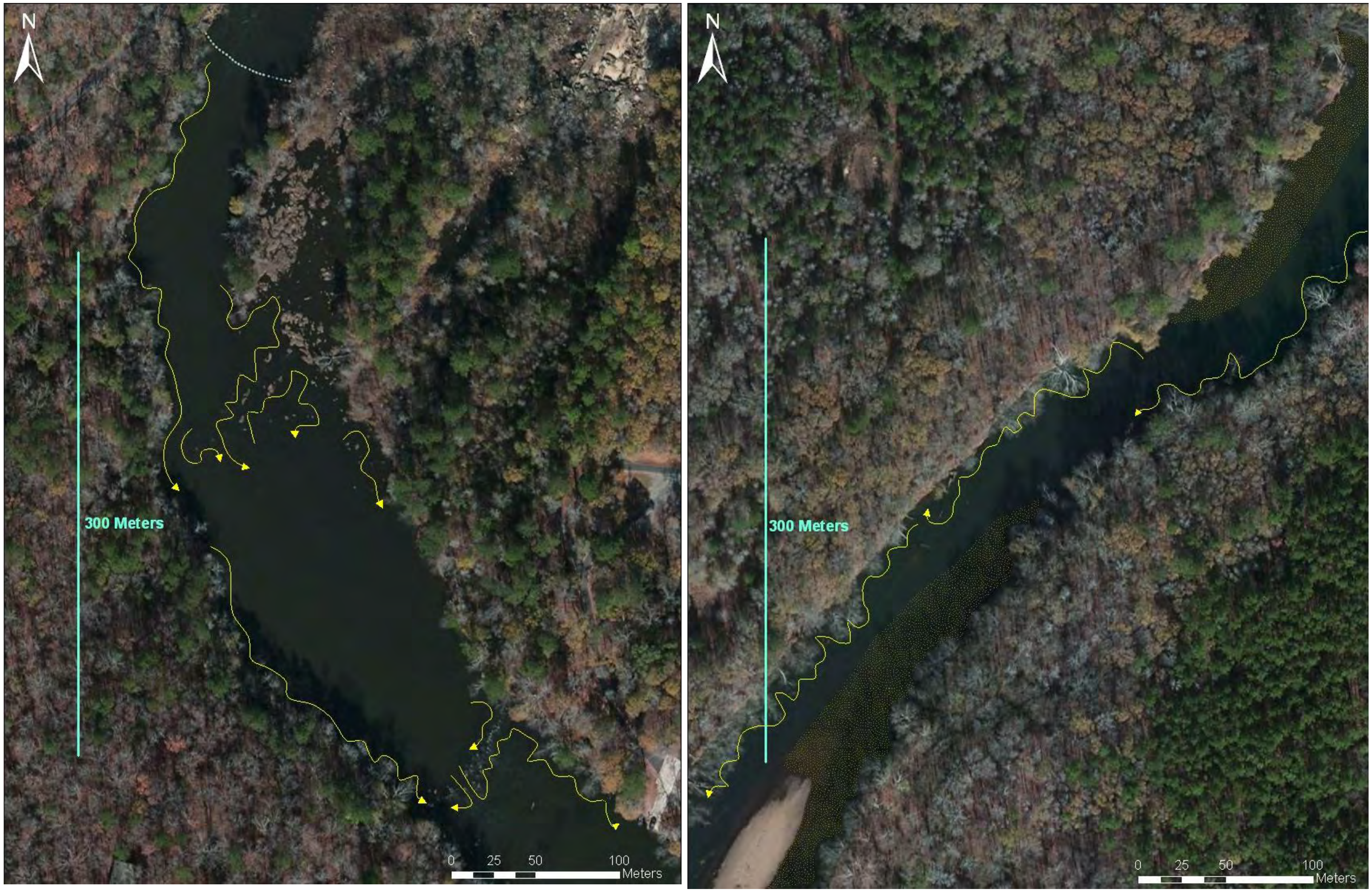

Figure 6. Graphic displaying how sampling intensity (electrofishing effort per river kilometer) was much higher in shoal units (left) than in lateral scour units (right) in the Upper Ocmulgee River, 2010-2011. Yellow lines and arrows indicate a potential electrofishing path.

Figure 7. Typical habitat containing large amounts of woody debris seen on the majority of the Ocmulgee River between Nelson Island and the confluence of the Towaliga River, 2010-2011.

Figure 8. Upstream and Downstream views of the same location of the where most robust redhorse captures took place on the Ocmulgee River in 2010 and 2011. Shoals remained exposed or stagnant during the majority of the year (as pictured), and were only under water during large discharge events from Lloyd Shoals Dam.

CURRENT STATUS OF ENDEMIC MUSSELS IN THE LOWER OCMULGEE AND ALTAMAHA RIVERS

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REFERENCE: *Proceedings of the 2005 Georgia Water Resources Conference*, held April 25-27, 2005, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. The Altamaha River Basin is well known among malacologists for its high percentage (ca. 40%) of endemic mussels. While little historical data exists to quantify changes in mussel abundance, many biologists believe that some species are declining. We assembled a large database of mussel occurrence records from surveys conducted since 1967 and used this data to assess the current status of endemic mussels in the lower Ocmulgee and Altamaha rivers. The percentage of sites occupied and the ranges of the Altamaha arcmussel, Altamaha spinymussel, and inflated floater have declined over the past 10 years. The remaining endemic mussel species occupy a large percentage of sites and appear to be stable. We recommend the development of a long-term monitoring program for Altamaha basin endemic mussels. Success of this program will require both probability-based sampling to estimate mussel density and detection probabilities along with qualitative sampling to document occurrences at new sites.

INTRODUCTION

Freshwater mussels are important components of aquatic ecosystems as they provide food for many species and filter algae and bacteria from large volumes of water. They are also important indicators of ecosystem health due to their sensitivity to human disturbances. Unfortunately, many of these species are declining as a result of incompatible land use practices, impoundment of rivers, and the introduction of non-native species

Freshwater mussels reach their greatest diversity in the southeastern United States. Ninety-eight mussel species are historically known from Georgia. Neves et al. (1997) indicated that seventy-one species are considered imperiled, with 25 species listed as threatened or endangered under the United States Endangered Species Act (USESA). Seven of Georgia's eight endemic mussel species occur only in the Altamaha Basin. Three endemics, the Altamaha arcmussel (*Alasmidonta arcula*), Altamaha spinymussel (*Elliptio spinosa*), and inflated floater (*Pyganodon gibbosa*) are thought to be declining in abundance, while four other endemic mussels appear to stable. As a result, the current status of the endemic mussels of the lower Altamaha River system was reviewed. This review will provide information to policy makers and regulatory agencies for developing conservation strategies that may affect the persistence and habitat quality of imperiled mussels.

BACKGROUND

The Altamaha River Basin is the largest basin in Georgia (36,976 km^2). Major tributaries in the basin include: the Ocmulgee, Oconee, and Ohoopee rivers (Figure 1). Although historic collections date back to the 1830's, most major surveys have been conducted since the late 1960's (Sickel 1969; Keferl 1981; O'Brien 2002; Skelton et. al. 2002). Sixteen mussel species are reported from these surveys, including seven species that are considered endemic to the basin (Table 1). Several additional, but undescribed species have also been documented from the basin but are not considered in this review (Gene Keferl pers. comm.; Skelton 2004).

The Altamaha spinymussel was recognized as a candidate for listing under the USESA in 2002. The Altamaha arcmussel and the inflated floater have also been recognized as imperiled or vulnerable to imperilment in several conservation assessments (Neves et al. 1997; O'Brien 2002). Elevation of the Altamaha spinymussel to candidate status coupled with the presumed decline of other mussel species has prompted intensive mussel surveys throughout the Altamaha River and its tributaries since 2000. Results from these surveys were compiled in order to assess the current status of the endemic mussels of the Altamaha Basin.

METHODS

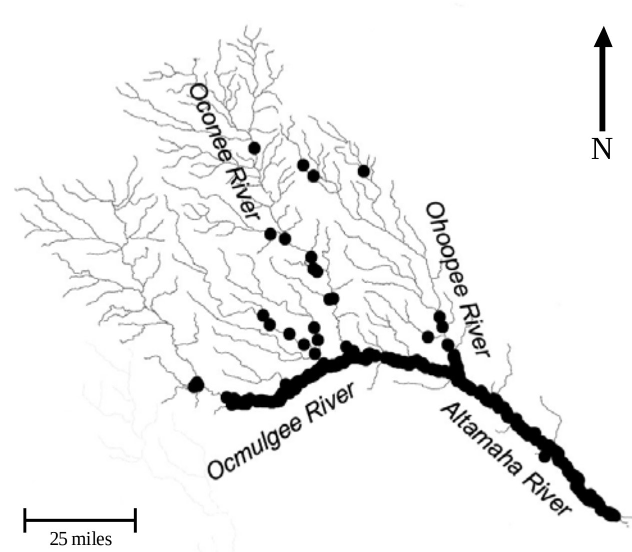
Mussel surveys conducted between 1967 and 2004 were incorporated into a GIS database (Figure 1). This database contained detailed locality information, habitat descriptions, and qualitative or quantitative data on the abundance of each mussel species collected at each survey site. This database was used to determine the percentage of sites occupied by each endemic species. The data were also used to assess changes in the linear extent of occupied habitat. All analyses were based on live individuals.

We used all collection records to calculate the percentage of sites occupied before and after 2000. Since a large number of collections occurred from 1990 to 1995 and from 2000 to 2004, we also conducted a test for a temporal change in the number of sites occupied between these two time periods (Strayer and Smith 2003). For each site that was sampled during both time periods, we determined if the site was occupied during the first period but not the second (hereafter an "extinction") or occupied during the second period but not the first (hereafter a "colonization"). We then compared the frequency of extinctions and colonizations with a chi-square test evaluated at alpha = 0.10. The assumption of the test was that sampling efforts are comparable between the two time periods. This assumption was evaluated by comparing the number of collections made at each site during the two time periods. Although timed effort was not available for all sites, we also compared the mean number of person-minutes spent searching for mussels during each collection. Lastly, gross changes in the linear extent of occupied habitat were examined by comparing the upstream and downstream extent of occurrences before and after 2000. If the upstream and downstream extent of occurrences differed by 10 km or less, the linear range of the species was not considered to have changed between the two time periods. This analysis was limited to a subset of the study area where extensive survey points were located during both time periods.

RESULTS

The database included collection records from 241 sites sampled before 2000 and 120 sites sampled after 2000. Most sites occurred between the Ocmulgee River near Jacksonville, GA and the Altamaha River near Darien, GA before 2000; however, sites sampled after 2000 extended only to Doctortown, GA. Sites also occurred in the Oconee and Ohoopee rivers and smaller tributaries prior to 2000 (Figure 1). Thus, range assessments were restricted to the linear extent of occupied habitat between Jacksonville downriver to Doctortown. Data collected from recent surveys on the Ohoopee River (Stringfellow and Gagnon 2001) and the Little Ocmulgee River (Skelton 2004) are not included in any of the quantitative analyses.

Thirty-nine sites that were sampled during the first period were resampled after 2000. These sites extended



from the Ocmulgee River near Lumber City, GA downstream to Doctortown on the Altamaha River. Fifty surveys were completed before 2000 and 51 were completed after 2000 (several sites were surveyed repeatedly). In addition, the mean person-minutes spent searching sites was similar between the two sampling periods, indicating that assumption of comparable sampling effort between the periods was met.

Overall, the percentage of sites occupied by the Altamaha arcmussel was low during both periods, but fewer sites were occupied after 2000 (Table 1). Declines were evident when considering the 39 sites that were used sampled during the early 1990s and early 2000s (Table 2). In fact, this species was presumably extirpated from more sites than any other mussel species. Prior to 2000, Altamaha arcmussels occurred upstream to approximately Jacksonville. However, after 2000, no live individuals were collected within a 15 km reach downstream of Jacksonville. The downstream extent of occupied habitat did not change between the two time periods.

The percentage of sites occupied by the Altamaha spinymussel was also low, but did not decline when all records were compared (Table 1). However, analysis of the 39 sites indicated that the spinymussel was lost from significantly more sites than it colonized between the early 1990's and the early 2000's (Table 2). The linear extent of occupied habitat of this species did not appear to change between the two time periods.

The percentage of sites occupied declined more for inflated floaters than for any other mussel species (Table 1). In addition, this species was represented at few overall sites. The inflated floater was lost from more sites than it colonized after 2000, but this was not statistically significant. The downstream extent of its range did not differ after 2000, but the upstream extent of its range decreased by 37 km.

The Altamaha slabshell, Altamaha lance, Georgia elephantear, and Altamaha pocketbook occurred at a relatively high percentage of sites before (36-56 %) and after 2000 (66-87%; Table 1). All of these species showed increases (18-49%) in the percentage of sites occupied between the two time periods (Table 1). There was no evidence to suggest that the number of sites occupied by any of these species declined among the 39 sites sampled in the early 1990’s and 2000’s (Table 2). In addition, the upstream and downstream extent of occurrences did not change after 2000 for any of these species.

DISCUSSION AND RECOMMENDATIONS

The Altamaha arcmussel, Altamaha spinymussel, and inflated floater are rare throughout the lower Ocmulgee and Altamaha Rivers. Synthesis of recent data indicates that the percentage of sites occupied within these rivers has declined since the early 1990's. The linear extent of occupied habitat in the Ocmulgee River has declined for the Altamaha arcmussel and inflated floater. While range contractions were not documented for the Altamaha spinymussel, Stringfellow and Gagnon (2001) failed to collect this species from Ohoopee River sites that were occupied in the early 1990's. Although the inflated floater is rare within the mainstem habitats that were targeted in these surveys, the habitat preferences of this species suggest that backwaters and oxbows should be targeted in future surveys. The remaining endemic species appear to be stable throughout the lower Ocmulgee and Altamaha Rivers.

We recommend the development of a long-term monitoring program for Altamaha basin mussels. The database we developed for this assessement will provide a useful foundation for such a program and should be continually updated. The presence-absence analyses we carried out may also be useful in future assessments. Because this procedure examines both colonizations and extirpations, it allows for more informed assessments than those that only compare occupancy rates at historically known sites. Future assessments can be improved by using methods that allow estimation of detection probabilities and mussel densities. Finally, our database illustrates a need for additional or updated surveys in the Oconee River, the Ocmulgee River above Jacksonville, The Altamaha River below Doctortown, and many tributary streams.

ACKNOWLEDGEMENTS

This work could not have been completed without the efforts of Eugene Keferl, Christine O'Brien, Chris Skelton, Christi Lambert, Carson Stringfellow and many others who have assisted with mussel surveys.

Table 1. Number and percent of sites occupied by Altamaha basin mussels before and after 2000. Site occupancy is based on surveys conducted at 241 sites sampled before 2000 and 120 sites sampled after 2000

		Site Occupancy			
		Pre-2000		Post-2000	
Scientific Name	**Common Name**	**Sites**	**%**	**Sites**	**%**
Alasmidonta arcula	Altamaha arcmussel	52	22	19	16
Elliptio dariensis	Georgia elephantear	87	36	80	67
Elliptio hopetonensis	Altamaha slabshell	136	56	90	75
Elliptio shepardiana	Altamaha lance	116	48	79	66
Elliptio spinosa	Altamaha spinymussel	24	10	14	12
Lampsilis dolabraeformis	Altamaha pocketbook	90	37	104	87
Pyganodon gibbosa	Inflated floater	40	17	7	6

Table 2. Presence-absence data for 39 sites that were sampled from 1990-1995 and from 2000-2004. The number of sites occupied during the first period (Present), the number of sites occupied during the first period but not the second (Extinctions), and the number of sites occupied during the second period but not the first (Colonizations) are reported each species. The frequency of colonizations and extinctions was compared using a using a X^2 test with alpha=0.10.

Common Name	Present	Colonizations	Extinctions	X^2	P-Value
Altamaha arcmussel	27	1	22	17.4	<0.001
Georgia elephantear	28	4	6	0.1	0.751
Altamaha slabshell	35	3	6	0.4	0.505
Altamaha lance	35	3	7	0.9	0.343
Altamaha spinymussel	13	3	11	3.5	0.061
Altamaha pocketbook	32	6	3	0.4	0.505
Inflated floater	12	3	9	2.1	0.150

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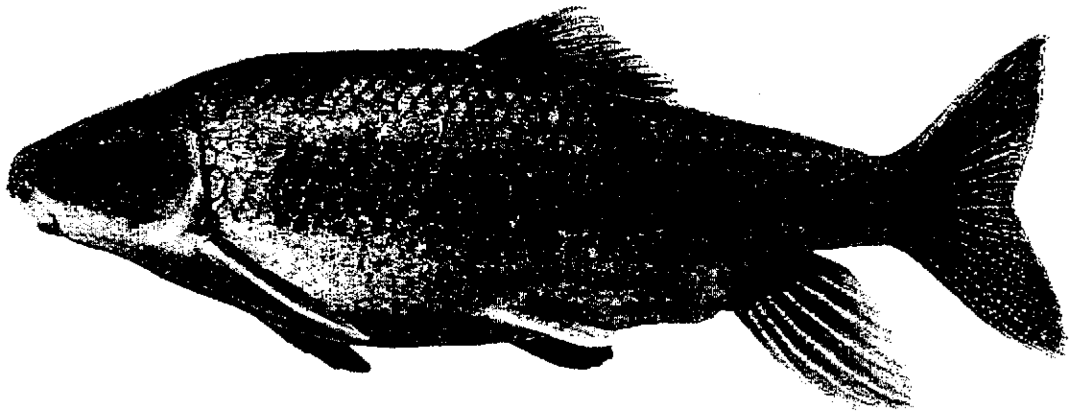
Candidate Conservation Agreement with Assurances for the Robust Redhorse Ocmulgee River, Georgia



Robust Redhorse (*Moxostoma robustum*) Dr. B. J. Freeman, Institute of Ecology, University of Georgia

Georgia Power Company
Georgia Department of Natural Resources
U. S. Fish and Wildlife Service

CANDIDATE CONSERVATION AGREEMENT WITH ASSURANCES
for the Robust Redhorse, *Moxostoma robustum*, Ocmulgee River, Georgia

Agreement Number 1448-40181-01-K-005

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I. INTRODUCTION

This Candidate Conservation Agreement with Assurances (Agreement) for the robust redhorse, *Moxostoma robustum*, has been developed as a collaborative effort between the private sector, and State and Federal resource agencies in order to expedite the reintroduction of the robust redhorse into the Ocmulgee River. The conservation actions specified in the Agreement will be implemented in accordance with the Endangered Species Act of 1973, as amended, (16 U.S.C. 1531 *et seq.*) (ESA), the U.S. Fish and Wildlife Service's Final Policy for Candidate Conservation Agreements with Assurances (64 Federal Register 32726-32736) (Final Policy), and 50 C.F.R. §§ 13 and 17. The goals and objectives of this Agreement will be accomplished through implementation of the conservation actions set forth in this Agreement. Successful implementation of this Agreement will expand the limited range of the robust redhorse, which is currently believed to be the most imminent threat to the species.

This Agreement, effective and binding on the date of the last signature below, is between Georgia Power Company (Georgia Power), the U.S. Fish and Wildlife Service (Service), and the Georgia Department of Natural Resources, Wildlife Resources Division (GADNR). Georgia Power, the Service, and the GADNR are collectively the "Parties" to this Agreement.

Property Owner: Georgia Power designates the following individual as the contact for this Agreement:

Michael C. Nichols
Environmental Laboratory Manager
5131 Maner Road
Smyrna, GA 30080

Cooperator: David Waller, Director
Georgia Department of Natural Resources
Wildlife Resources Division
2070 U.S. Hwy 278, S.E.
Social Circle, GA 30279

The GADNR designates the following individual as the contact for this Agreement:

Jimmy Evans, Senior Fisheries Biologist
Fisheries Section
1014 Martin Luther King Blvd.
Fort Valley, Georgia 31030

Service: The Service designates the following individual as the Agreement Administrator:

Sandy Tucker, Field Supervisor
U.S. Fish and Wildlife Service
257 South Milledge Avenue
Athens, Georgia 30605

This Agreement covers the following property:

That portion of the Ocmulgee River, Georgia, lying between river miles 230.9 and 250.2, bounded on the downstream end by a low head dam at Juliette, Georgia, and on the upstream end by Lloyd Shoals Dam, a Georgia Power hydroelectric facility.

II. AUTHORITY and PURPOSE

Sections 2, 7, and 10 of the ESA authorize the Service to enter into this Agreement. Section 2 of the ESA states that encouraging interested parties, through Federal financial assistance and a system of incentives, to develop and maintain conservation programs is essential to safeguarding the Nation's heritage in fish, wildlife and plants. Section 7 of the ESA requires the Service to review the programs it administers and utilize those programs to further the purposes of the ESA. By entering into this Agreement, the Service is utilizing its Candidate Conservation Programs to further the conservation of the Nation's fish and wildlife. Section 10(a)(1)(A) of the ESA and its implementing regulations authorize the issuance of "enhancement of survival" permits (Permit) for proposed and candidate species and those species which may become candidates in the future.

The purpose of this Agreement is to implement conservation measures for the robust redhorse (*Moxostoma robustum*) through the reintroduction, monitoring, and research described in the Conservation Actions section of this Agreement. In particular, the proposed reintroduction is expected to expand the range of the robust redhorse.

The use of a Candidate Conservation Agreement with Assurances is appropriate even though the robust redhorse is not listed as a formal candidate species by the Service. In providing for Candidate Conservation Agreements with Assurances, the Service did not intend to exclude species that are not officially listed as candidate species, but are nevertheless at risk if populations decline (see the Final Policy, page 32732). Instead, the Service recognizes that taking steps before a species enters a serious decline is often the most effective way to conserve that species, thereby possibly precluding the need to list the species under the ESA.

All Parties to this Agreement recognize that they have specific statutory responsibilities that cannot be delegated, particularly with respect to the management and conservation of natural resources, and the management, development and allocation of water resources. Nothing in this Agreement is intended to abrogate any of the Parties' respective responsibilities. This Agreement is subject to and is intended to be consistent with all applicable Federal and State laws.

III. EXPECTED BENEFITS

This Agreement is expected to benefit the robust redhorse by initiating research on juvenile and young adult migration and by establishing a refugial population in the Project Site. In addition, the Conservation Actions described in this Agreement are eventually expected to result in a self-sustaining robust redhorse population within the Project Site. The Parties used the best scientific data available regarding the life history, biology, and known habitat requirements of the robust redhorse in selecting the Project Site and establishing Conservation Actions to benefit the robust redhorse.

The Parties believe the following objectives are reasonable and that they will help to eliminate or significantly reduce threats to the robust redhorse contributing to the long-term conservation of the species. The benefits of the specific conservation measures described in this Agreement, when combined with those benefits that would be achieved if it is assumed that the conservation measures were also implemented on other necessary properties, are expected to help preclude or remove any need to list the robust redhorse. These objectives are specific to this Agreement:

Objective 1 - Establish a refugial population of robust redhorse in the Project Site.
Through this objective, the Parties will attempt to establish sufficient numbers of robust redhorse within the Project Site to ensure long-term survival of a refugial population through propagation, population augmentation, and monitoring. By doing so, the parties expect to reduce potential threats to the species in the event of the catastrophic loss of any of the known native populations and provide the foundation necessary for a self-sustaining population within the Project Site.

Objective 2 - Increase understanding of habitat requirements and life history of robust redhorse.
Through this objective, the Parties will, through scientific study and surveys, identify habitats utilized by juvenile robust redhorse, potential migratory movements of juvenile robust redhorse, and spawning and other important habitats.

These objectives will be accomplished through implementation of the specific conservation measures set for the Agreement. However, in accordance with the principles of adaptive management, which are discussed herein, the status of this Agreement will be evaluated to assess the Agreement's success.

IV. ADDITIONAL BENEFITS

The primary focus of this Agreement is the creation and maintenance of a new robust redhorse population within the Project Site. The knowledge acquired through implementation of this Agreement can be used to help establish other refugial and self-sustaining populations of robust redhorse in other portions of its range. In doing so, this Agreement can serve as an example to others wishing to participate in robust redhorse conservation and recovery, effectively facilitating additional recovery efforts throughout the species' historic range. This Agreement could also serve as a model for similar conservation efforts for other imperiled species.

V. PARTIES

1. Georgia Department of Natural Resources
Wildlife Resources Division
2070 U.S. Hwy 278, S.E.
Social Circle, GA 30279

The GADNR works to sustain, enhance, protect, and conserve Georgia's natural, historic, and cultural resources for present and future generations. The GADNR is a cooperator to this Agreement. In its role as a cooperator, the GADNR does not require the ESA regulatory assurances typically provided under the Final Policy for Candidate Conservation Agreements with Assurances and will not receive those assurances under this Agreement. GADNR's participation will provide the close coordination with the State that is required by the Final Policy and will ensure that the Agreement is consistent with applicable State laws and regulations. The GADNR has provided funding, personnel, and other in-kind services to further the conservation of the robust redhorse.

2. Georgia Power Company
Environmental Affairs
241 Ralph McGill Blvd N.E.
Atlanta, GA 30308-3374

Georgia Power Company, a public electric utility, has already provided approximately $1,000,000 in research funding as well as personnel and other services to support robust redhorse conservation. Georgia Power is the owner and operator of Lloyd Shoals Dam, which regulates river flows within the Project Site.

3. U. S. Fish and Wildlife Service
Ecological Services Program
1875 Century Boulevard
Atlanta, Georgia 30345

The Service works to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people. The Service is committed to expanded partnerships, which offer innovative opportunities to enhance fish and wildlife resources. The Service has provided funding, personnel, and other in-kind services to further the conservation of the robust redhorse.

VI. DEFINITIONS

The following definitions apply to this Agreement:

Enhancement of Survival Permit (Permit) - The permit issued by the Service to Georgia Power, effective on the date the robust redhorse is listed as endangered or threatened under the ESA, or in some other manner becomes subject to the ESA, allowing Georgia Power to engage in the incidental taking (as defined in 50 C.F.R. § 17.3, as it may be hereinafter amended) of robust redhorse, pursuant to 16 U.S.C. § 1539(a)(1)(A).

License - The license (No. 2336-009) issued by the Federal Energy Regulatory Commission (FERC) to Georgia Power authorizing Georgia Power to operate the Lloyd Shoals Dam (see Order Issuing New License, 62 FERC ¶ 62,201 (1993)). The License term is for 30 years and will expire January 1, 2023.

Lloyd Shoals Dam - Located in Georgia at river mile 250.2 on the Ocmulgee River in Butts and Jasper Counties, this hydroelectric facility, FERC Project No. 2336-009, is owned and operated by Georgia Power pursuant to Order Issuing New License, 62 FERC ¶ 62,201 (1993).

Project Site - The Ocmulgee River between river miles 230.9 and 250.2, bounded on the downstream end by a low head dam at Juliette, Georgia (FERC Project 7019), and on the upstream end by Lloyd Shoals Dam (FERC Project 2336-009).

Refugial Population - An introduced population of adult robust redhorse from which brood stock can be obtained for future propagation. The purpose of establishing refugial populations is to reduce the risk of losing the species because of the species' limited, known range and possible catastrophic events. A refugial population may or may not be a self-sustaining population.

Robust Redhorse Conservation Strategy - A document that describes the status and distribution of the robust redhorse, discusses problems facing the species, and describes conservation actions necessary to improve the species' status across the historic range. This strategy was developed by a 12-member stakeholder partnership, the Robust Redhorse Conservation Committee (RRCC), to guide research on the biology and status of the species and the establishment of reproducing populations within its historic range. The strategy was adopted by the RRCC on May 1, 2000.

Self-sustaining Population - A population of robust redhorse exhibiting successful recruitment to the adult population. Successful recruitment means reproduction and growth over a period of years to maintain robust redhorse genetic diversity and population numbers for a specific reach of river. It is currently believed that robust redhorse are sexually mature after six years. Genetic diversity refers to the ability of the population gene pool to respond to long term changes in the environment and reduce the frequency of expression of deleterious traits.

VII. BACKGROUND

The "Robust Redhorse Conservation Strategy" dated May 1, 2000, is included as Appendix I of the Agreement and contains detailed information on the robust redhorse and ongoing conservation activities. The Conservation Strategy, as it may be amended in the future, is hereby incorporated into this Agreement by reference.

1. Species Description

The robust redhorse is a large, heavy-bodied sucker that attains total lengths greater than 700 mm and weights up to 8 kg. This species has large molariform pharyngeal teeth specialized for crushing hard-bodied prey, such as mussels, and is the only sucker species within its range with this character. The robust redhorse is bronze on the back and sides becoming pale or white ventrally. Juveniles will have intense red in the caudal fin, which becomes less distinctive in adults. Adult males develop large tubercles on the snout and head during the spawning season.

2. Life History

The robust redhorse spawns during April, May, and June when water temperatures reach 21 to 23 degrees Celsius. Spawning is typical of *Moxostoma* and involves spawning triads with two males fertilizing the eggs of a single female which are deposited in gravel bars. The life span of the robust redhorse is not currently known, but the oldest specimen collected to date was 27 years old (Jenkins, unpublished data). The robust redhorse is apparently a long-lived fish. It may take five to six years for stocked individuals to reach sexual maturity and begin spawning.

Studies of the species' diet are limited to field observations made during surveys and broodfish collection efforts. The few Oconee River specimens examined suggest that adult fish feed primarily on bivalves, including the Asian clam, *Corbicula* sp., an invasive species. Feeding habits and preferences of juvenile robust redhorse are poorly understood.

3. Habitat

The robust redhorse inhabits southeastern Piedmont Plateau and upper Coastal Plain sections of large South Atlantic slope rivers. Piedmont reaches are characterized by rock shoals, outcrops, and pools, particularly along the Fall Line. The upper Coastal Plain reaches typically have sandy banks and beds interspersed with a few shoals and occasional gravel bars. The upper Coastal Plain reaches also have extensive networks of swamps, oxbows, and floodplains. Woody debris and fallen trees seem to provide preferred habitat for adult robust redhorse in the Oconee River, and clean gravel bars are necessary for spawning and development of larval fish.

4. Distribution

The historic range of the robust redhorse includes Atlantic Slope drainages from the Pee Dee River in North Carolina to the Altamaha River in Georgia. The largest known population occurs in the Oconee River between Dublin, Georgia, and Big Black Creek and is estimated to consist of 600 adult fish (Jennings *et al.*, 2000). With the recent discovery of native populations in the Pee Dee River, North and South Carolina, the lower Ocmulgee River, Georgia, and the Savannah River, South Carolina and Georgia, there are four known native populations. Preliminary data on the three recently discovered populations do not allow reliable population estimates at the time of this Agreement.

The GADNR, with the assistance of the RRCC, has reintroduced robust redhorse, which were obtained from propagation efforts using adults from the Oconee River population, into the Broad and Ogeechee rivers, Georgia, from 1996 to 2000. Subsequent sampling of these rivers has confirmed that the initial stocking was successful and adults were recaptured on the Broad River in 2001. The recaptured fish represent a significant development in that the stocked fish are surviving and maturing.

VIII. PROBLEMS FACING THE SPECIES

The success of any conservation or recovery effort depends on reducing or eliminating threats to the continued existence of the species. The Service uses five criteria defined in section 4(a)(1) of the ESA to evaluate threats to species, and these criteria are briefly addressed below as they relate to current threats to the robust redhorse. In addition, the "Robust Redhorse Conservation Strategy" (see Appendix I) contains additional information concerning the threats to the species.

The limited range of the species and the historical loss of suitable habitat are the primary factors affecting the decline of the robust redhorse. The construction of dams in the 1950's and 1960's reduced available spawning habitat and altered natural stream flows. Historic land use practices, including intensive agriculture and deforestation, also played a major role in the degradation of riverine habitats through erosion and sedimentation. There is currently no evidence to support overutilization, exploitation, or disease as contributing factors to the decline of the species. The flathead catfish, a predatory species introduced to the lower Ocmulgee River and High Falls Lake, has been identified as a potential threat to the robust redhorse, but has not become established in the Project Site.

There are currently no identified inadequacies in existing regulatory mechanisms. The robust redhorse is protected by the State of Georgia as an endangered species and is a species of management concern for the Service. Existing State and Federal laws serve to protect robust redhorse and its habitat including the Lacy Act, the Federal Water Pollution Control Act (Clean Water Act), the Fish and Wildlife Coordination Act, the National Environmental Policy Act, the Federal Power Act, and the Rivers and Harbors Act. Erosion and sedimentation regulations are in place and best management practices can help protect existing habitat. No other natural or manmade threats to the robust redhorse have been identified.

In summary, the limited geographic range of the robust redhorse and the presumed low numbers of wild individuals are considered to be the most serious threats facing the species. These threats are compounded by gaps in our understanding of life history requirements for the robust redhorse, particularly the habitat requirements of juveniles. This Agreement will create the third reintroduced population and allow the collection of additional information to fill these gaps in our understanding of this species.

IX. DESCRIPTION OF THE PROJECT SITE

1. Project Site

The Project Site includes approximately 19 miles of stream channel in the Ocmulgee River, between Lloyd Shoals Dam and a low head dam at Juliette, Georgia, between river miles 250.2 and 230.9. The Project Site is within the Altamaha River drainage and is approximately 120 river miles from the Ocmulgee River's confluence with the Oconee River. The watershed above Lloyd Shoals Dam encompasses approximately 1,492 square miles and is largely urban. Lloyd Shoals Dam, which impounds Jackson Lake, provides peaking power to meet electrical power demands. Several tributaries enter the Project Site, however, they provide limited habitat value for robust redhorse and are not part of the Project Site.

2. Water Quality and Quantity

Although there are known water quality problems upstream of the Project Site, the Parties believe these problems do not represent significant threats to the establishment of a robust redhorse population within the Project Site. The lake impounded by Lloyd Shoals Dam, Jackson Lake, may improve water quality within the Project Site by trapping sediment washed downstream from the developed portion of the watershed. In addition, a weir immediately downstream of Lloyd Shoal Dam greatly improves dissolved oxygen concentrations in the Ocmulgee River (Hendricks 1997), such that the waters of the Ocmulgee River between Lloyd Shoals Dam and the Towaliga River at river mile 233.1 meet the water quality criteria established by the State of Georgia for fishing. The water quality improvements in this portion of the Ocmulgee River have increased the diversity of the existing riverine fish community, and helped expand the distribution of important sport fish species (J. Evans, GADNR, personal communication).

Fishery and in-stream flow studies were conducted within the Project Site during the late 1980's and early 1990's as part of the Federal Energy Regulatory Commission (FERC) relicensing of the Lloyd Shoals Dam. These studies indicated that a 400 cubic feet per second (cfs) minimum flow would enhance aquatic resources downstream of Lloyd

Shoals Dam. The GADNR and the Service recommended, and FERC approved, minimum flow releases of 400 cfs, or inflow, from the Lloyd Shoals Dam. The minimum flow releases were adopted to support fish population and aquatic community attributes suggesting a good to excellent fishery resource (FERC 1993).

The historic effects of erosion and sedimentation in the Project Site are not perceived as significant threats to the robust redhorse or its habitat in the Project Site. The threats to robust redhorse habitat from sedimentation have been reduced in recent years by extensive reforestation in the watershed. In addition, water quality has been improved through the construction of the aeration weir and increased minimum flows below Lloyd Shoals Dam. Therefore, the Parties believe reintroduction of robust redhorse within the Project Site will not be adversely affected by water quality problems.

3. Fishery

The habitat in the Project Site consists of typical Piedmont riverine characteristics, such as gravel bars, shoals and sandy runs. The Ocmulgee River currently supports a healthy and diverse fish community that includes at least two species of riverine sucker, silver redhorse, *Moxostoma anisurum*, and "brassy jumprock", *Scartomyzon sp. cf. lachneri*. These species share habitats with the robust redhorse at other sites.

4. Watershed

The U. S. Forest Service's Oconee National Forest controls a significant portion of the watershed draining directly into the Project Site, and this area is well vegetated. Although water quality within the Project Site is relatively good, several tributaries of the Project Site (e.g., Herds Creek, Lee Creek, and Wise Creek) have been designated as partially supporting their designated uses. Erosion and sedimentation have impacted small stream habitats in these tributaries as indicated by fish surveys conducted by the GADNR, and GADNR is evaluating water quality impacts in these creeks. These tributaries are not expected to have a significant influence on the success of the Agreement. Work by the GADNR and other entities in these drainages is of interest to this Agreement but outside of its scope.

5. Withdrawals

The Flovilla, Jackson, and Jenkinsburg Water and Sewer Authority is permitted to withdraw 3.5 million gallons per day (mgd) below Lloyd Shoals Dam (Georgia Power 1991). These withdrawals are not thought to have significant impacts on the Project Site, because they are not located where they may affect riverine suckers, including the robust redhorse.

In summary, the Project Site was chosen because it is a large Piedmont and upper Coastal Plain river physiographically similar to other river reaches where robust redhorse have been located. The Project Site also has acceptable water quality and quantity, suitable gravel bars for spawning, plentiful food supply, low densities of non-native predators, and is known to support a diverse and healthy fish community.

X. CONSERVATION ACTIONS

In order to accomplish the objectives of this Agreement, the Parties agree to undertake the conservation actions described below. These actions are in addition to activities described in the Robust Redhorse Conservation Strategy, including research on habitat and life history requirements, recruitment, population genetics, development of culture techniques, and surveys for additional native populations. The Conservation Actions described below are consistent with the Parties' goal of establishing a new robust redhorse population within its historic range. The anticipated new population of robust redhorse will increase the number of wild individuals, provide information on the life history and biology of the species, and serve as a refugial population should one or more of the known wild populations be lost due to a catastrophic event. The following conservation actions are specific to the Project Site, and the responsible Party is identified for each action. Where responsibility for a specific action has not been designated or assigned, the Parties agree to implement such measures through additional agreement, as appropriate, or through modification of this Agreement.

1. Stock the Project Site

    The GADNR will stock the Project Site with approximately 4,000 hatchery-reared robust redhorse fingerlings each year for five years. Once this Agreement becomes effective, the first stocking will occur during the following fall or spring season when water temperatures permit. The long-term goal of this action is to establish a refugial population from Oconee River parental stock that consists of a minimum of five year-classes. The Parties recognize, however, that variations from this goal may occur due to unforeseen circumstances and natural events and that these actions may require adaptive management changes, such as extending the stocking duration. For instance, monitoring and research may later indicate that stocked robust redhorse permanently leave the Project Site or that the Project Site is unsuitable for establishing a refugial or reproducing population.

    GADNR is responsible for producing, tagging, and stocking the fish for this project. For the purposes of this Agreement, the hatcheries that will provide robust redhorse fingerlings will be determined each spring by the GADNR in coordination with the other Parties as each hatchery prioritizes pond space for rearing other fish species.

    The Service will continue to provide a fish culturist and other in-kind services such as transporting eggs to hatcheries, as needed, to assist in the Oconee River spawning activities. The Service, in association with its on-going work on the robust redhorse, has developed protocols that will be used in the production of fingerlings from eggs collected from Oconee River robust redhorse. Production of fingerlings typically consists of broodfish collection and spawning, incubation, and hatching of eggs; rearing of larval fish to fingerling size; collection and tagging of juvenile fish for stocking; and transport and release of fish in the Project Site. The number of fingerlings needed for this action represents 10% of typical annual production from the Oconee River.

2. Study the movement of introduced juvenile robust redhorse

Georgia Power will fund two surveys, one in year 1 and one in year 3, on the movement of introduced juvenile robust redhorse. Radio transmitters will be attached to a subset of the stocked fish and their movements monitored. Georgia Power will provide funding not to exceed $75,000 per survey (see Table 1). The research will be conducted by the USGS Research Unit at the University of Georgia. If the USGS Research Unit is unable to continue this work, Georgia Power will select another qualified contractor with approval of the Parties; such approval shall not be unreasonably withheld. The results of surveys will be provided to the other Parties in accordance with Section XI, Monitoring and Reporting.

3. Monitor abundance and distribution of introduced robust redhorse

Georgia Power will conduct or fund six surveys in order to monitor abundance and distribution of juvenile and adult robust redhorse within Project Site. These surveys will be conducted in alternate years, under clear, low-water conditions, and until an adult population of at least five year-classes is established, or until the monitoring or research indicate that the stocked robust redhorse largely moved out of the Project Site or that the Project Site is determined unsuitable for establishing a refugial population. Georgia Power will provide funding not to exceed $20,000 per survey for the Agreement duration to fund these actions (Table 1). The results of surveys will be provided to the other Parties in accordance with Section XI, Monitoring and Reporting.

4. Estimate population size

Following the establishment of an adult refugial population in the Project Site, Georgia Power will fund three surveys to measure population size utilizing the mark-recapture methods used to estimate the population size of the Oconee River robust redhorse population. The population estimate will be conducted by the USGS Research Unit at the University of Georgia. If the USGS Research Unit is unable to continue this work, Georgia Power will select another qualified contractor with approval of the Parties; such approval shall not be unreasonably withheld. Georgia Power will provide funding necessary to complete these surveys, not to exceed $50,000 per survey (see Table 1). The results of surveys will be provided to the other Parties in accordance with Section XI, Monitoring and Reporting.

XI. MONITORING AND REPORTING

The Parties will use the following guidelines in evaluating and adjusting the Conservation Actions as described in the Adaptive Management section. Overlap in the timetable is due to uncertainties with forecasting possible success. Georgia Power will prepare an annual Progress Report that will identify progress in implementing Conservation Actions. The report will be provided to the Service and the GADNR by December 31 of each year. Following the distribution of the annual Progress Report, the Parties will discuss the results and coordinate the next year's activities under this Agreement.

1. Establishment of a juvenile refugial population - Years 2 through 6

   To fulfill Conservation Action 2, Georgia Power will identify the location and presence of reintroduced juvenile robust redhorse through the telemetry studies identified above. In addition, Georgia Power will conduct or fund electrofishing sampling efforts, that will include a minimum of two to four days in alternate years as described in Conservation Action 3, to identify the habitat and locations used by juvenile or young adult robust redhorse. Success will consist of capture of individuals from three year-classes by year 6. Migration downstream will be evaluated through the telemetry studies, and appropriate changes to conservation actions may be proposed under the adaptive management provisions by the Parties to this Agreement.

2. Establishment of an adult refugial population - Years 6 through 11.

   After year 6, Georgia Power, with the assistance of the GADNR and the Service, will identify the location and presence of adult robust redhorse in the Project Site as described in Conservation Action 3. Sampling will include a minimum of two to four days conducted with water temperatures ranging from 20° Celsius to 25° Celsius. Success will consist of the collection of 3 or more adults of each sex from at least three year-classes. The Parties determined this success rate after considering that robust redhorse adults are difficult to collect with conventional electrofishing gear, even under ideal river conditions. The Project Site is considerably more difficult to sample than the Oconee River, with some sections inaccessible to electrofishing boats, and the ability to collect 3 adults of each sex within two to four days is comparable to catch rates in other rivers where populations of adult robust redhorse exist.

2\. Establishment of a self sustaining population - Years 10 through 15.

   Georgia Power will identify the location and presence of spawning adults as described in Conservation Action 3. Sampling will include a minimum of two to four days conducted in the spring with water temperatures ranging from 20 ° Celsius to 25° Celsius. Success will consist of collection of non-tagged juveniles and/or adults, which would indicate naturally-reproduced individuals (i.e., successful reproduction). Additionally, population estimates will be made using mark-recapture methods as indicated in Conservation Action 4. The carrying capacity and target population number for the Project Site are unknown at this time.

XII. FUNDING CONSERVATION ACTIONS

Funding, both in the form of monetary and in-kind services, for the Conservation Actions will be provided by Georgia Power, as set forth in the Conservation Actions section and summarized in Table 1. Additional resources may be applied to this project from other sources, but these are outside the scope of this Agreement. The Service has provided technical assistance in the Agreement and permit application development and in providing in-kind services described herein. The GADNR will also provide in-kind services as described herein.

Implementation of this Agreement is subject to the requirements of the Anti-Deficiency Act and the availability of appropriated funds. Nothing in this Agreement will be construed by the Parties to require the obligation, appropriation, or expenditure of any funds from the U.S. Treasury. The Parties acknowledge that the Service will not be required under this Agreement to expend any federal agency's appropriated funds unless and until an authorized agency official affirmatively acts to commit such expenditures as evidenced in writing.

XIII. ADAPTIVE MANAGEMENT

The Parties agree that adaptive management provisions are necessary to ensure that the Parties can take advantage of changing conditions or new information affecting the conservation of the robust redhorse and the ultimate success of this Agreement. Adaptive management provisions are especially necessary when, as here, certain biological information is being developed, specifically information on the habitat occupied by juvenile robust redhorse.

Georgia Power will evaluate annually the effectiveness of the Conservation Actions in a report to the GADNR and the Service as described in Section XI, Monitoring and Reporting, and recommend any necessary changes. The Parties may initiate requests to modify the Conservation Actions as provided for in the Duration section of this Agreement. Requests to modify this Agreement will be initiated through written notification to all Parties and will remain within the scope of this Agreement. Specific areas where adaptive management may occur include adjustments to stocking rates, survey frequency, sampling techniques, duration of stocking, and monitoring period. Appendix II contains some potential examples of circumstances where adaptive management may be appropriate.

XIV. NOTIFICATIONS

In the event that any of the Parties detect conditions that may adversely affect robust redhorse in the Project Site, such conditions will be reported to Georgia Power, the GADNR, and the Service. Such conditions may include, but are not limited to, evidence of fish kills, spills or releases of material that may affect that reach of the Ocmulgee River covered by the Agreement, increase in flathead catfish density, or significantly increased sedimentation within the Project Site.

Georgia Power agrees to provide the Service with an opportunity to rescue robust redhorse individuals before any authorized take occurs as described in the Enhancement of Survival Permit. Such notification that authorized take will occur must be provided to the Service at least 30 days in advance of implementing the action and will include a description of the action to be taken and measures to reduce the authorized take. Rescue actions undertaken by the Service shall not unreasonably interfere with the implementation of Conservation Actions under this Agreement.

By signature of this Agreement, Georgia Power agrees to notify the Service if ownership of the covered property is to be transferred to another owner and to provide such notice 30 days in advance of the transfer. If Georgia Power transfers ownership of the enrolled property, the Service will regard the new property owner as having the same rights and obligations as Georgia Power if the new property owner agrees to become a Party to the Agreement. Actions taken by the new participating property owner that result in the take of the robust redhorse would be authorized if the new property owner maintains the terms and conditions of the Agreement. If the new property owner does not become a Party to the Agreement, the new owner would neither incur responsibilities under the Agreement nor receive the ESA regulatory assurances that accompany the Agreement and Permit.

After any notification of change in ownership, the Service will contact the new or prospective owner to explain the existing Agreement and to determine whether the new property owner would like to continue the original Agreement or enter a new Agreement. When a new property owner continues an existing Agreement, the Service will honor the terms and conditions of the existing Agreement.

XV. LANDOWNER ASSURANCES

Through this Agreement, the Service provides Georgia Power assurances that if the robust redhorse is listed under the ESA and the Agreement has been implemented in good faith by Georgia Power, the Service will not require additional conservation measures nor impose additional land, water, or resource use restrictions beyond those Georgia Power voluntarily committed to under the terms of the original Agreement. Georgia Power requested and is hereby granted the following additional assurance that is specific to its needs:

The Service will not impose or require Georgia Power to alter its operation of Lloyd Shoals Dam for the benefit of the robust redhorse for the duration of this Agreement, including alteration of the flow regime specified in the FERC license.

These assurances will be authorized through issuance of an enhancement of survival permit under section 10(a)(1)(A) of the ESA, which will authorize incidental take of robust redhorse consistent with the terms of the Agreement. The Permit is incorporated as Appendix III of this Agreement and will become effective on the date that the robust redhorse is listed as threatened or endangered or in some other manner becomes subject to the ESA in the future. At that date, Georgia Power will be authorized take of robust redhorse in conjunction with implementation of the Conservation Actions specified in the Agreement. The take is expected to be in the form of mortality, harm, and harassment associated with reintroducing, surveying, and monitoring released individuals and their offspring. The Service has determined that this level of take will not jeopardize the species' continued existence.

The Permit will not be revoked for any reason except those set forth in 50 CFR 13.28(a)(1-4) or unless continuation of the permitted activity would be inconsistent with the criterion set forth in 50 CFR 17.22(d)(2)(iii) and the inconsistency has not been remedied in a timely fashion.

The assurances provided apply only to the robust redhorse inasmuch as the Agreement is being properly implemented. The assurances provided shall in no way limit the Service's retention of its obligations and authorities for consultation under section 7(a)(2) of the Endangered Species Act relative to future FERC relicensing activities at Lloyd Shoals Dam or other Federal actions that may occur within the Project Site that may affect the robust redhorse or other listed, proposed, or candidate species.

The Parties agree and understand that entering into this Agreement does not preclude or otherwise remove the Service's authority to list the robust redhorse as a threatened or endangered species under the ESA should the Service determine that listing the robust redhorse is necessary pursuant to section 4 of the ESA.

XVI. UNFORESEEN CIRCUMSTANCES

1. Changed circumstance provided for in this Agreement.

   If additional conservation and mitigation measures are deemed necessary to respond to changed circumstances and were provided for in the Agreement, Georgia Power will implement the measures specified in the Agreement.

2. Changed circumstances not provided for in the Agreement.

   If additional conservation and mitigation measures are deemed necessary to respond to changed circumstances and such measures were not provided for in the Agreement, the

Service will not require any conservation and mitigation measures in addition to those provided for in the Agreement without the consent of Georgia Power, provided the Agreement is being properly implemented.

3. Unforeseen circumstances.

(A) In negotiating unforeseen circumstances, the Service will not require the commitment of additional land, water, or financial compensation, or additional restrictions on the use of land, water, or other natural resources beyond the level otherwise agreed upon for the robust redhorse (*Moxostoma robustum*) without consent of Georgia Power.

(B) If additional conservation and mitigation measures are deemed necessary to respond to unforeseen circumstances, the Service may require additional measures of Georgia Power where the Agreement is being properly implemented, but only if such measures are limited to modifications within the Project Site, if any, or to the Agreement's Conservation Actions for the robust redhorse, and maintain the original terms of the Agreement to the maximum extent possible. Additional conservation and mitigation measures will not involve the commitment of additional land, water, or financial compensation, or additional restrictions on the use of land, water, or other natural resources otherwise available for development or use under the original terms of the Agreement without the consent of Georgia Power.

(C) The Service will have the burden of demonstrating that unforeseen circumstances exist, using the best scientific and commercial data available. These findings must be clearly documented and based upon reliable technical information regarding the status and habitat requirements of the robust redhorse. The Service will consider, but not be limited to, the following factors:

(a) Size of the current range of the robust redhorse;
(b) Percentage of range adversely affected by the Agreement;
(c) Percentage of range covered by the Agreement;
(d) Ecological significance of that portion of the range affected by the Agreement;
(e) Level of knowledge about the affected species and the degree of specificity of the species' conservation program under the Agreement; and
(f) Whether failure to adopt additional conservation measures would appreciably reduce the likelihood of survival and recovery of the affected species in the wild.

XVII. DURATION

The term of this Agreement will be for a period of 22 years consistent with the term of the existing FERC license for the Lloyd Shoals Dam (FERC No. 2336) which will expire in 2023. The Parties believe that this is the minimum time necessary to establish a reproducing adult population of robust redhorse containing multiple year classes and for stability in the population numbers to be achieved and assessed by the Parties.

1. Continuation

If the goals of the Agreement are met or if the Parties agree that sufficient progress is being made toward the conservation of the robust redhorse, this Agreement may be continued without modification for another term to which the Parties must all agree.

2. Amendments

Amendments to this Agreement can be proposed by any Party to the Agreement and must be provided to the other Parties in writing. All Parties will have at least 60 days to evaluate proposed amendments, and all amendments must be approved in writing by each Party. Amendment of this agreement requires the consent of all Parties. The Agreement may be amended to include, or separate Memoranda of Understanding and/or Cooperative Agreements may be developed with, additional Parties as necessary to ensure implementation of specific conservation measures contained in this Agreement.

3. Termination

(A) Georgia Power may terminate this Agreement prior to the expiration date, with good cause, even if the terms and conditions of the Agreement have not been realized. However, the Permit would also be terminated at the same time. Georgia Power will submit a letter to the Parties providing 60 days notice of its desire to terminate the Agreement. Georgia Power will remain responsible for any outstanding conservation actions identified in the Conservation Actions section of the Agreement for which it is responsible until the early termination date. Conditions required by the Permit and the assurances provided by the Permit will remain in effect until the early termination date.

(B) The GADNR may withdraw from this Agreement at any time by submitting a letter providing 60 days notice indicating its desire to withdraw from the Agreement. The GADNR will remain responsible for any outstanding conservation actions identified in the Conservation Actions section for which it is responsible until the termination date.

(C) Nothing in this Agreement shall restrain or limit any Party from taking additional conservation actions not described in this Agreement, at it's own expense, to protect or conserve the robust redhorse, provided that such measures are consistent with the conservation goals of the Agreement.

XVIII. NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) COMPLIANCE

Survey, collection, or research activities associated with implementation and maintenance of this Agreement will not constitute a significant Federal action as defined in NEPA and are given a categorical exclusion designation under 516 DM 2, Appendix 1.10.

XIX. FEDERAL AGENCY COMPLIANCE

During the performance of this Agreement, the Parties agree to abide by the terms of Executive Order 11246 on nondiscrimination and will not discriminate against any person because of race, color, religion, sex, age or national origin. No member or delegate to Congress or resident Commissioner shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom, but this provision shall not be construed to extend to this Agreement if made with a corporation for its general benefit.

XX. SIGNATURES

Christopher M. Hobson
Vice President, Environmental Affairs
Georgia Power Company

David Waller
Director
Georgia Department of Natural Resources,
Wildlife Resources Division

Sam Hamilton
Regional Director
U. S. Fish and Wildlife Service

XXI. LITERATURE CITED

Evans, J. personal communication (see page 6)

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Hendricks, A.S. 1997. Continued evaluation of an oxygenating weir below the Lloyd Shoals Project 1995-1996. Report to the Federal Energy Regulatory Commission. Georgia Power Environmental Laboratory, Smyrna, Georgia.

Jennings, C., B. J. Heff, and J. Hilterman, 2000. Population dynamics of robust redhorse (*Moxostoma robustum*) in the Oconee River, Georgia. Completed for the USGS Biological Resources Division. University of Georgia Research Work Order 52.

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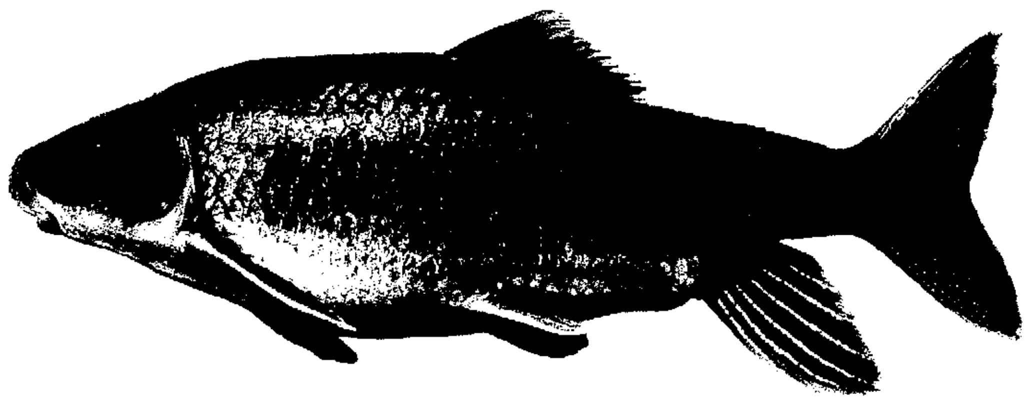
APPENDIX I

Robust Redhorse Conservation Strategy

Robust Redhorse Conservation Strategy



Robust Redhorse (*Moxostoma robustum*) Dr. B. J. Freeman, Institute of Ecology, University of Georgia

Georgia Department of Natural Resources

South Carolina Department of Natural Resources

North Carolina Wildlife Commission

Georgia Power Company

Duke Power Company

Carolina Power and Light

South Carolina Aquarium

South Carolina Electric and Gas

Georgia Wildlife Federation

U. S. Fish and Wildlife Service

U. S. Geological Survey Biological Resources Division

U. S. Forest Service

U. S. Army Corps of Engineers

Georgia River Network

Conservation Strategy
For
Robust Redhorse (*Moxostoma robustum*)

Prepared by
Mike Nichols
Environmental Laboratory
Georgia Power Company

For

Robust Redhorse Conservation Committee
February 25, 2003

Approvals:

Greg Looney, Chairman Robust Redhorse Conservation Committee

Date: May 6, 2003

Robust Redhorse Conservation Strategy

I. INTRODUCTION

The robust redhorse (*Moxostoma robustum*) was described by Edward Cope in 1870 from specimens collected in the Yadkin River, North Carolina. The species was essentially lost to science until 1991 when five specimens were collected by Georgia Department of Natural Resources, Wildlife Resource Division (WRD) biologists downstream of Sinclair Dam on the Oconee River near Tombsboro, Georgia. As of 2002, wild individuals are known to exist in the Oconee and Ocmulgee rivers in Georgia, the Savannah River of Georgia and South Carolina and the Pee Dee River of North and South Carolina. The species is considered to be very rare and is classified as endangered by the Georgia Department of Natural Resources (Freeman, 1999). Recovery efforts have been initiated by a diverse group of stakeholders that comprise the Robust Redhorse Conservation Committee (RRCC). The RRCC was established in 1995 through a Memorandum of Understanding ("MOU") among stakeholders including state and federal agencies, conservation organizations, and the private sector. The MOU establishes a mechanism for conducting research on the robust redhorse, coordinating conservation actions, and sharing information on its status. The primary goals of the RRCC are to develop an understanding of the biology and status of this species, and to reestablish reproducing populations within its historic range. Current members of the RRCC include U. S. Fish and Wildlife Service, Georgia Department of Natural Resources, South Carolina Department of Natural Resources, U. S. Army Corps of Engineers, Georgia Power Company, Duke Power Company, CP&L—A Progress Energy Company, South Carolina Electric and Gas Company, U. S. Geological Survey Biological Resources Division, North Carolina Wildlife Resources Commission, U. S. Forest Service, Georgia Wildlife Federation, Georgia River Network, and the South Carolina Aquarium.

The Parties to this Robust Redhorse Conservation Strategy ("the Strategy") intend the Strategy will promote voluntary conservation initiatives and stakeholder partnerships for conserving the robust redhorse as a logical outgrowth of conservation efforts taken by the Parties since 1991. The Parties view the Strategy as a guide for decision making, allocation of resources, and a summary of research objectives. As such, this Strategy is intended to be consistent with, and in the spirit of, the Endangered Species Act. The Endangered Species Act contains provisions designed to encourage creative partnerships between public and private sectors and among government agencies to conserve imperiled species and their habitat (Endangered Species Act, 2(a)(5)). An example of this type of provision is the Candidate Conservation Agreement with Assurances (Conservation Agreement) as described in 64 Federal Register 32706 (1999).

Participation in the RRCC and decision making is described in policies developed by the RRCC. These policies where adopted by consensus during the RRCC annual meeting held October 16-18, 2002 (RRCC, 2002) and are the means for implementing the Strategy.

II. PURPOSE

The purpose of this Conservation Strategy is to assure the continued survival of the robust redhorse within its historic range. This document describes the status and distribution of the species, discusses problems facing the species, and presents conservation actions to be implemented.

III. STATUS AND DISTRIBUTION

A. Systematics and taxonomy

Five large catostomids were collected by Georgia Department Natural Resources biologists from the Oconee River, Georgia, near the mouth of Commissioner Creek on August 8, 1991. Meristic characteristics did not correspond precisely to any known species and average length exceeded all catostomid species known to occur in the Altamaha River drainage. Dr. Bud Freeman, curator of the Georgia Museum of Natural History Fish Collection, and Dr. Henry Bart, then curator of the Auburn University fish collections, independently indicated the fish might belong to what was then believed to be an undescribed species known to ichthyologists by only two existing specimens: one collected from the Savannah River, Georgia-South Carolina in 1980; and a second from the Pee Dee River, North Carolina, in 1985. Dr. Bob Jenkins, Professor of Biology at Roanoke College, determined that the specimens matched the description of a large North American sucker first described by Edward Cope in 1870.

The catostomid in question is now believed to have been described by Edward Cope in 1870 based entirely on a large stout specimen collected in 1869 from the Yadkin River (Pee Dee drainage), North Carolina and given the scientific name *Ptychostomus robustus* (*Ptychostomus* is synonymous with the present genus *Moxostoma*). Cope's original type specimen was lost long ago and later workers erroneously labeled much smaller specimens of another species as types. Hence the scientific name *P. robustus* was misapplied by later revisers of the Catostomidae to a smaller species. This smaller species, sympatric with the larger more robust form, has since 1956 been known in the scientific literature, incorrectly, as *Moxostoma robustum* – the smallfin redhorse. As a result of these investigations, the scientific name *Ptychostomus (Moxostoma) robustus* will be transferred as *Moxostoma robustum* (Cope) (robust redhorse) to the species known from the Oconee, Pee Dee, and Savannah River specimens (Jenkins and Freeman, and Evans in preparation; Jenkins, in preparation).

The robust redhorse is a long-lived, large, heavy-bodied sucker that attains total lengths greater than 700 mm and weights up to 8 kg. The oldest specimen that has been aged is believed to have been 27 years old. This species has large molariform pharyngeal teeth specialized for crushing hard-bodied prey such as mussels, and is the only species within its range with this character. The robust redhorse is bronze on the back and sides becoming pale or white ventrally. Adults are faintly striped along lower sides. Juveniles will have intense red in the caudal fin and anal fins, which becomes less distinct in adults.

Adult males develop large tubercles on the snout and head during the spawning season. The robust redhorse is distinguished from other Atlantic Slope suckers by coloration, large head, large adult size, and the straight margin of the lower lip often with the medial plicae extending more posterial than marginal plicae (i.e., a pronounced "flap" on the lower lip in adults). Members of the genus *Moxostoma* differ from the genus *Scartomyzon* by having 12-13 caudal peduncle scale rows rather than 15 or 16 .

B. Status, distribution, and habitat requirements

1. Existing Conditions

The robust redhorse is presently found in piedmont and upper coastal plain sections of the Oconee and Ocmulgee rivers, Georgia, the Savannah River, Georgia / South Carolina, and the Pee Dee River, South Carolina/North Carolina. The RRCC considers the extant populations to be Evolutionary Significant Units (ESUs) based on current genetic information. The RRCC will continue to manage identified ESUs as distinct populations in order to maintain the genetic diversity of the species across its historic range (See RRCC, 2002}.

Introductions have occurred in the Broad River and a population is now believed to exist in this river and the downstream reservoir, Clarks Hill Reservoir, Georgia. Introductions are also occurring in the Ogeechee River, and in a segment of the Ocmulgee River, Georgia.

The recent discovery of robust redhorse in the Savannah, the lower Ocmulgee, and Pee Dee rivers, which have been extensively sampled for other species, suggests that this species can be difficult to collect, or may have been overlooked or improperly identified in the past.

2. Distribution

The historic range of the robust redhorse is believed to include Atlantic Slope drainages from the Pee Dee River in North Carolina to the Altamaha River in Georgia. Individuals have been recorded from natural populations in the Pee Dee River, North Carolina, the Savannah River, Georgia / South Carolina, and the Oconee and Ocmulgee rivers, Georgia since 1991

A population of unknown size exists in the Pee Dee River, North Carolina/South Carolina, in the lower segment of the Yadkin-Pee Dee River system which this species historically occupied. Three specimens from the Pee Dee River have been collected in a 28-mile reach of the river in the piedmont/coastal plain regions of North Carolina/South Carolina below Blewett Falls Dam during 2000-2001.

Six native fish were captured from the Savannah River between October 1997 and October 1998. One was captured downstream from the New Savannah Bluff Lock and Dam in October 1997. Four fish were captured from the Augusta Shoals area in June

1998 and an additional fish was captured near the US 301 bridge in October 1998. Subsequently, twenty-three adults in spawning condition were collected in May 1999 from the Savannah River in the Augusta shoals area and four from below the New Savannah Bluff Lock and Dam. The size of the Savannah River population is uncertain at this time and is being investigated.

The Oconee River population is known from a 70 mile reach between Milledgeville and Dublin, Georgia (Evans, 1994). The population estimate was re-evaluated during 1999 and is believed to consist of 600 adult fish in the reach between Dublin, Georgia, and Big Black Creek (Jennings et al., 2000). An unknown but probably smaller number exist between Big Black Creek and Milledgeville.

The RRCC reintroduced the robust redhorse into the Broad River (located in the Savannah River drainage) and the Ogeechee River in Georgia. Approximately 32,000 age 0 and age 1 fingerlings from multiple year classes have been introduced into the upper Broad River, Georgia, between 1995 and 1998. Forty-five of these fish, ranging in length from 30 to 40 cm, have been recovered 60 miles downstream in Clark Hill Reservoir (C. Jennings, personal communication).

Reintroductions are also occurring in the Ogeechee River, and a segment of the Ocmulgee River, Georgia.

3. Life history

Most of the information available concerning the life history of this species has been generated from research conducted on the Oconee River. The robust redhorse spawns during April, May, and June when water temperatures reach 21 to 23 degrees Centigrade, although spawning may occur over the range from 18 to 25 degrees Centigrade. Spawning is typical of *Moxostoma* and involves spawning triads with two males fertilizing the eggs of a single female, which are deposited in gravel substrate. Shallow water conditions in the Oconee River occasionally allow visual observation of spawning fish, but there are indications of spawning activity at greater depths as well (Freeman et al., 1998). Adult fish are large (modal total length 66 cm, range from 42 cm to 72 cm). Juveniles less than 40 cm in length have not been collected from the Oconee River.

The requirements for successful recruitment of robust redhorse are not fully understood. The requirements for successful emergence of yolk-sac larvae from gravel beds include absence of fine sediment (Dilts, 1998). The subsequent food requirements and preferred habitats of juvenile robust redhorse are poorly understood. The recruitment rates in the Oconee River appear to be low, but need to be examined in the context of the population size and the long life span of the robust redhorse. Recruitment and population dynamics in the Ocmulgee, Savannah, and Yadkin-Pee Dee populations are not presently well documented. Possible migration of juveniles and adults are also not well understood. These are priority subjects of current research.

Diet studies of adults are limited. The few specimens examined from the Oconee River suggest that adult fish feed primarily on bivalves, including the Asiatic clam (*Corbicula* sp.). The life span of robust redhorse is believed to be 25 to 30 years and the major known population is believed to be composed of numerous year classes (Jenkins, unpublished data).

4. Habitat requirements

The robust redhorse inhabits Piedmont Plateau and upper Coastal Plain sections of South Atlantic slope rivers. Piedmont reaches are characterized by rock shoals, outcrops, and pools, particularly along the Fall Line. The upper Coastal Plain reaches typically have sandy banks and beds interspersed with shoals and gravel bars. The upper Coastal Plain reaches also have extensive networks of swamps, oxbows, and floodplains. Woody debris and fallen trees seem to provide preferred habitat for adult robust redhorse in the Oconee River. Clean gravel bars are necessary for spawning and development of larval fish.

5. Site specific habitat and biological information

Site specific information should be evaluated when reintroduction is planned(See RRCC, 2002) Site characteristics recommended for consideration include:

Habitat
- Suitable flow
- Spawning areas consisting of suitable gravel substrate
- Adequate food supply
- Accessibility for sampling and monitoring
- Available river miles for sustaining a refugial or reproducing population
- Presence of woody debris providing cover for adults

Fishery issues
- Predatory fish presence and densities
- Genetic composition of stocked fish and isolation from other populations
- Impacts on native species (other endangered species)
- Impacts on commercial and sport fisheries
- Presence of historic fishery data, including surveys for robust redhorse
- Biomass or abundance of non-native species

Watershed criteria
- Presence of hydropower operations and low-head dams
- Significant water withdrawals
- Current water quality issues summarized in 305(B) reports
- Historic water quality data
- Non-point source management plans and practices
- NPDES permitted discharges which may influence water quality
- Active river or watershed protection group capable of monitoring and influencing land use
- Land use patterns (urban, forested, agriculture, feed lots)

- Presence/absence of sand and gravel operations

C. Research status and needs

1. Initial studies

Research regarding the status and re-establishment of robust redhorse populations has been underway since 1992. The Robust Redhorse Conservation Committee has coordinated research and management of the robust redhorse since 1995. Early research focused primarily on the Oconee River population, with emphasis on the following areas:

- flow requirements for young of year fish;
- larval fish densities;
- recruitment rates for the existing population;
- gravel substrate requirements for successful spawning;
- the process for collecting adult brood fish, collecting and fertilizing eggs, and rearing juvenile fish for reintroduction; and
- surveys for additional populations within the historic range.

The process for propagating fish has been established, although difficulty continues to be experienced with survival rates from the post yolk sac larval stage to harvestable juveniles after one or two years. This may be related to nutritional or habitat requirements during this stage. The rate of survival of year 1 fingerlings from eggs of artificially spawned robust redhorse has increased from 11 per cent in 1995 to 67 percent in 1997. The production of year 2 fingerlings from ponds, however, has been variable. The low production rate in 1996 (7.7% from fry to year 2 harvest) has resulted in an emphasis on using year 1 fingerlings for introductions. There is speculation that the survival of larval fish past the yolk sack stage in the hatchery environment is affected by nutritional requirements and food availability (Shelton, 1998). The propagation of robust redhorse is described in RRCC policies (See RRCC, 2002)

Larval fish (13 to 20 mm in length) are capable of swimming speeds in the range from 7 to 12 cm per second and exhibited avoidance behavior of high flow rates in laboratory systems (Ruetz and Jennings, 1997). The flow velocities in the Oconee River from hydroelectric and natural events are not believed to significantly restrict young of year habitat because habitable areas exist with flow velocities less than 7 cm per second even during varying flow conditions (Ruetz and Jennings, 1997). Beginning in 1997, the operation of Sinclair Dam on the Oconee River, Georgia, provides run of river flows from May 1 through June 10, removing potential negative effects of hydro-peaking during the spawning and early rearing period. The Flow Advisory Team, a subcommittee of the RRCC, is responsible for evaluating the effect of the flow regime on robust redhorse.

Research indicates that emergence (swim-up) success is reduced in gravel substrate with significant percentages of fine sediments. Fifteen percent fine sediment to gravel ratio resulted in fifty percent survival measured as the emergence rate of fry. It is projected from laboratory data that successful larval emergence rate in the Oconee River is approximately eight percent (Dilts 1998).

Larval fish densities have been assessed since 1995 as part of an on-going task to estimate the reproductive and recruitment success of robust redhorse in the Oconee River (Jennings et al, 1996). Multiple gear types including push-nets, D-ring nets, light traps, and seines have been used to sample larval and post-larval fish. Estimated densities at specific sampling locations are based on low sample numbers of robust redhorse and are variable. Prior to implementing the license flow agreement for Sinclair Dam in 1997, densities ranged from 0 to 13.4 larvae per 1000 cubic meters during May 1995 and 0 to 3.4 larvae per 1000 cubic meters during May and early June, 1996. Subsequent to implementing run-of-river flows in the spring, densities ranged from ? to 33 larvae per 1000 cubic meters during May 1997, and from ? to 10 larvae per 100 cubic meters during May 1998. (Do not have numbers for 1999). The low number of individuals collected and the variation in the natural hydrology of the Oconee River have made interpretation of results difficult, but the collection of greater numbers of other larval and post-larval catostomids suggests that the recruitment rates are unusually low.

The population number in the Oconee River was re-evaluated in 1999-2000 in order to assess its current status (Jennings et al, 2000). This study evaluated the capture data collected from 1994 through 1999 and implemented a capture-recapture study to provide parameters for use in the Jolly-Seber population model. The population is estimated to consist of 607 (standard error = 138) robust redhorse greater than 417 mm total length in the Oconee River between Dublin and a point one river mile above Black Creek. This assessment indicated that new individuals were recruited to the population annually (ranging from 5 to 57% of the estimated population in each of four years evaluated). Survival of robust redhorse from year to year was high (average of 0.68) but variable.

2. Current research

Current research is focused on robust redhorse culture, genetics, and biological requirements. Research projects include:

- Locating and characterizing spawning sites;
- Evaluating collection methods for juvenile fish, and locating preferred habitat(s);
- Evaluating the genetic variability of existing populations; and
- Assessing abundance, mortality rate, and recruitment rate for the known populations.
- Study of movement of wild adults and cultured juveniles
- Evaluating population status in river systems in the historic range; and
- Evaluation of mass marking of fry and fingerlings

IV. PROBLEMS FACING THE SPECIES

Species warrant listing under the Endangered Species Act if the species is endangered or threatened throughout all or a significant portion of its range due to any one of the following five listing criteria:

- present or threatened destruction, modification, or curtailment of its habitat or range;
- overutilization for commercial, recreational, scientific, or educational purposes;
- disease or predation;
- inadequacy of existing regulatory mechanisms; or
- other natural or manmade factors affecting its continued existence.

A. Habitat

Current research indicates that habitat modification is one of the primary factors affecting the decline of robust redhorse. Historic land use practices including intensive farming and deforestation led to excessive erosion and subsequent sedimentation, and caused dramatic changes in riverine habitats. Reproduction by this species appears to be sensitive to sedimentation (Dilts, 1998). Mollusks, presumed to be a major food source for the robust redhorse, would also have been severely impacted by sedimentation (Stansbery, 1971) (although Asiatic clams, a food source, have proliferated). Although direct cause and effect relationships have not been determined, water quality degradation from point and non-point sources may also have contributed to historic declines.

The members of the RRCC are pursuing habitat restoration opportunities within the affected watersheds, including habitat restoration, restoration of degraded stream channels, and the development of conservation agreements. Specific activities include development of a policy on habitat restoration addressing potential funding, partnerships, and activities (See RRCC, 2002). Water quality concerns are addressed primarily through the federal and state permitting process.

It is possible fisheries workers have missed the robust redhorse in collections and the current range of the species may be underestimated as a result. Because of the robust redhorse's benthic habitat and the depth of rivers, additional populations may exist within the historic range but remain undetected.

B. Over-utilization

Other factors affecting the decline of robust redhorse may include historic over-harvesting in the late 1800s during the spawning season when the fish are vulnerable. There appears to be no current over-utilization for commercial, recreational, or educational purposes.

C. Disease or predation

Robust redhorse from the Oconee River and Savannah River have been examined for the presence of parasites and infectious diseases by the US Fish and Wildlife Service's Warm

Springs Fish Health Center. No evidence of infectious disease has been identified in fluid or tissue samples collected from wild fish (Heil, 1997, 1998).

The introduction of non-native species such as the flathead catfish has influenced the abundance of native fish species (Evans, 1991), and may impact robust redhorse populations through predation on juveniles. Flathead predation on young robust redhorse is suspected to be a significant factor in limiting recruitment into the Oconee River or other river populations, however, the extent of any predation is unknown. Flathead catfish have been introduced in nearly all of the large southeastern rivers within the historic range of the robust redhorse. Effective control of the flathead catfish may not be possible, and it is unclear whether removal efforts would have a significant long-term impact on flathead catfish or robust redhorse populations. The flathead catfish is a potential concern for the RRCC conservation efforts. The effect of predation by flathead catfish on robust redhorse has not been evaluated due to practical limitations in conducting such studies. Additionally, the impact and interactions of other large, non-native fishes, such as smallmouth buffalo, blue catfish, and common carp with the various life stages of robust redhorse are also presently not well understood or defined in the river systems where these species coincide.

D. Inadequacy of existing regulatory mechanisms

Many of the environmental factors believed to have reduced populations of robust redhorse to the current levels are historic in nature, including sedimentation from poor land use practices, and chronic, (and severe) water quality degradation. The implementation of the Clean Water Act, the Resource Conservation and Recovery Act, the National Environmental Policy Act, agriculture and soil conservation programs, reforestation, and many other regulatory programs, have improved riverine conditions significantly.

Development of hydropower facilities affects robust redhorse populations by limiting access to probable historic spawning sites and reducing the amount of historic riverine habitat. Site specific flow regimes may be limiting factors below hydropower facilities but can be addressed through the FERC relicensing process for non-federal projects and by NEPA for actions involving federal projects. In many cases, dams also help with sedimentation loading in immediate downstream riverine areas by acting as sediment traps and thus locally improving water quality in tailwater reaches.

While the RRCC has no authority to manage non-point source pollution impacts, participants including the U. S. Fish and Wildlife Service and the state natural resource agencies are pursuing riparian enhancements, watershed protection plans, and similar habitat protection activities through the federal and state regulatory processes. The U. S. Fish and Wildlife Service and state agencies participating in the conservation effort conduct extensive reviews of proposed projects that may impact habitat for robust redhorse. These environmental reviews are major considerations in the issuance of state and federal permits.

E. Other natural or manmade factors affecting its continued existence

The limited geographic range and the presumed low number of wild individuals are considered the most serious threat facing the continued survival of the robust redhorse. The recent discovery of wild populations in the Ocmulgee, Savannah, Pee Dee rivers suggest further exploration of other rivers within the historic range or adjacent rivers close to the historic range (e.g. Cape Fear River) may be productive.

The existing Oconee River population appears to be genetically heterogeneous and actively spawns in the spring (RRCC, 1997). An age and growth investigation indicated over 90% of the population is between 15 and 26 years of age although a few fish as young as 5-6 years have been collected. The absence of juvenile fish from surveys in the Broad River following introduction of 32,000 fingerlings between 1995 and 1998 is consistent with this pattern. The collection of over 40 tagged fish from this introduction in Clarks Hill Reservoir during 1998 through 2002 is also consistent with the observation that collected fish typically have minimum lengths of 40 cm and that a sampling bias may occur.

Lasier et al. (2001) evaluated sediment associated contaminants in the lower Oconee River to determine their sources and evaluate potential for reducing survival and growth of early life stages of robust redhorse. Manganese and zinc were found to be present in potentially deleterious concentrations in sediment pore water, but only zinc was found to inhibit growth in the selected surrogate, a freshwater amphipod, Hyalella azteca. Significant reductions in sediment-metal concentrations occurred between the fall of 1998, when amphipods were tested, and the spring of 1999 when robust redhorse egg and larval stages were evaluated. While manganese concentrations for sediments collected in the spring of 1999 were lower than concentrations in sediments from the fall of 1998, pore water collected downstream of specific creeks discharging into the Oconee River did exhibit toxicity to early robust redhorse life stages. Toxicity is believed to be related to the concentration of manganese and reduction to the Mn^{2+} species.

V. CONSERVATION ACTIONS TO BE IMPLEMENTED

A. Conservation Goals

The following short and long-term goals have been adopted and are implemented though consensus policies approved by the RRCC in October, 2002 (See RRCC, 2002).

1. Short-term goals (2003 – 2008)

   a) Establish refugial populations to reduce the impact of potential catastrophic events on known populations and core ESUs.

   b) Locate wild populations within the historic range

   c) Determine characteristics of populations, including population size, age structure, genetic variability, recruitment rate, and mortality rate.

   d) Implement necessary actions to maintain populations.

   e) Identify and implement habitat restoration and/or protection measures to benefit the species.

2. Long term goals

   Establish or maintain at least six self-sustaining populations distributed throughout the historic range.

B. Conservation Actions

The conservation actions necessary to achieve long and short tem goals are included in specific policies adopted by the RRCC. Specific conservation actions are adopted in management plans for each river system or distinct ESU. These actions address the following:

1. Implement habitat restoration and watershed management practices to protect suitable spawning sites, nursery, and adult holding sites.

2. Assess possible existence of additional spawning sites.

3. Manage artificial propagation from adult broodfish collected from specific ESUs with an identified need for reintroduction of robust redhorse into selected river systems and refugial ponds.

4. Establish a list of candidate sites and a process for prioritization,

5. Determine habitat and life history requirements.

6. Establish river basin management plans or agreements to implement conservation actions for specific sites, including monitoring survival and growth.

The conservation actions necessary to achieve short and long term goals are described in specific policies adopted by the RRCC. These policies provide the operating principles for this conservation effort including: goals; restoration, biology, and conservation; and administration (RRCC, 2002).

C. Monitoring

Monitoring and reporting on the status of the robust redhorse is an important and necessary part of this Conservation Strategy (See RRCC, 2002). Interested organizations, as well as the public at large, are kept informed of the RRCC's efforts on behalf of the robust redhorse and the results of those efforts. In order to monitor the species properly, the RRCC has determined it necessary to take the following steps:

D. Organization and Resources

The continuing coordination issues of the overall effort are the responsibility of the RRCC Excom. The RRCC Excom review research needs, prioritizes projects for proposal and funding, and coordinate use of resources. The RRCC Excom includes representatives from research institutions, US Fish and Wildlife Services, state natural resource agencies, and other participants (See RRCC, 2002).

In addition, each river system is assigned a technical working group (TWG). TWGs represent the members of the RRCC who are actively engaged in research, protection, and restoration of robust redhorse in a specific geographic region. The Conservation Actions developed for the river basin / ESU management plan are coordinated by the TWG and implemented using facilities and resources provided by its members.

The following list examples of research funding and resources provided to this effort.

Georgia Power Company funds research regarding the habitat requirements and recruitment success of the Oconee River population.

The U. S. Fish and Wildlife Service and the Georgia Department of Natural Resources fund brood-fish collection, hatchery operation, reintroduction efforts, and status surveys.

The South Carolina Department of Natural Resources provides additional hatchery production, conducts surveys, and manages projects in South Carolina drainages.

The South Carolina Department of Natural Resources, the North Carolina Wildlife Resources Commission, the U.S. Fish & Wildlife Service, and CP&L conduct population status surveys on the Yadkin-Pee Dee River.

The Electric Power Research Institute funds population genetics research with financial support by Duke Power Company and CP&L.

Georgia Department of Natural Resources and Georgia Power Company fund research on improving culture techniques.

In addition to funding for conservation actions under this Conservation Strategy, specific actions may be agreed upon in Reintroduction Programs (see RRCC, 2002) or through specific Conservation Agreements. Funding for these activities is described in the respective management plans or agreements.

VI. CONSERVATION AGREEMENTS

The Endangered Species Act includes provisions for conservation agreements among private and non-Federal property owners, State and local managing agencies, and the US Fish and Wildlife Service to restore, enhance, or maintain habitats for proposed, candidate and other unlisted species. Conservation agreements may facilitate reintroduction of robust redhorse and related habitat protection through definition of certain goals and commitments by parties cooperating in this restoration effort. The following describes important aspects of these agreements.

A. Conservation Benefits

Implementation of Conservation Agreements for reintroduction of robust redhorse at a number of similar sites may be a necessary step to remove threats to the continued existence of this species as described in section III of this document. It is believed that clearly delineated responsibilities and actions will facilitate conservation of this species.

B. Non-Federal Landowner Assurances

Conservation Agreements may include assurances for property owners that if the robust redhorse is listed as a Federal Endangered Species at a future date, and the agreement has been implemented in good faith by the participating non-federal property owner, the US Fish and Wildlife Service will not require additional conservation measures nor impose additional land, water, or resource restrictions beyond those committed to under the terms of the original agreement. Assurances involving take will be authorized through the issuance of a section 10(a)(1)(A) Enhancement of Survival permit, which will allow the property owner to take individuals of the covered species consistent with those levels agreed upon and identified in the agreement.

C. Adaptive Management Provisions

Adaptive management provisions are necessary to ensure that unforeseen circumstances affecting the conservation of the robust redhorse can be adequately addressed through Conservation Agreements. Adaptive management provisions are especially necessary when, as here, significant biological information is lacking, including information on the life history of the species, possible existence of additional wild populations, and the effectiveness of proposed conservation measures described in specific Conservation Agreements.

If unforeseen circumstances arise through the development of new biological information or result from a catastrophic event that warrant additional conservation measures, such measures would, to the maximum extent possible, be consistent with the original terms of the Conservation Agreement.

D. Additional Provisions in Conservation Agreements

Conservation Agreements created to implement this Conservation Strategy should identify:

- Existing wild populations of the robust redhorse or existing inhabitable river reaches suitable for reintroduction;
- Habitat available for all life stages and habitat protection and enhancement measures that may be necessary to protect wild or introduced robust redhorse;
- Conservation measures participating non-Federal property owners are willing to undertake to conserve the robust redhorse;
- A description of the benefits expected to result from the conservation measures;
- Monitoring provisions including measuring and reporting progress and changes in habitat conditions; and
- Notification provisions to provide state natural resource agencies and the US Fish and Wildlife Service reasonable opportunity to rescue individual robust redhorse before any authorized take occurs.

VII. MEASUREMENT OF SUCCESS

The goal of the RRCC is the restoration of the *Moxostoma robustum* throughout its known range (See RRCC, 2002). In order to implement this effort effectively, the RRCC has adopted short- and long-term goals expressed in this Conservation Strategy and implemented policies to guide future actions (RRCC, 2002).

VIII. FIGURE

A. Historic range of the robust redhorse (*Moxostoma robustum*).

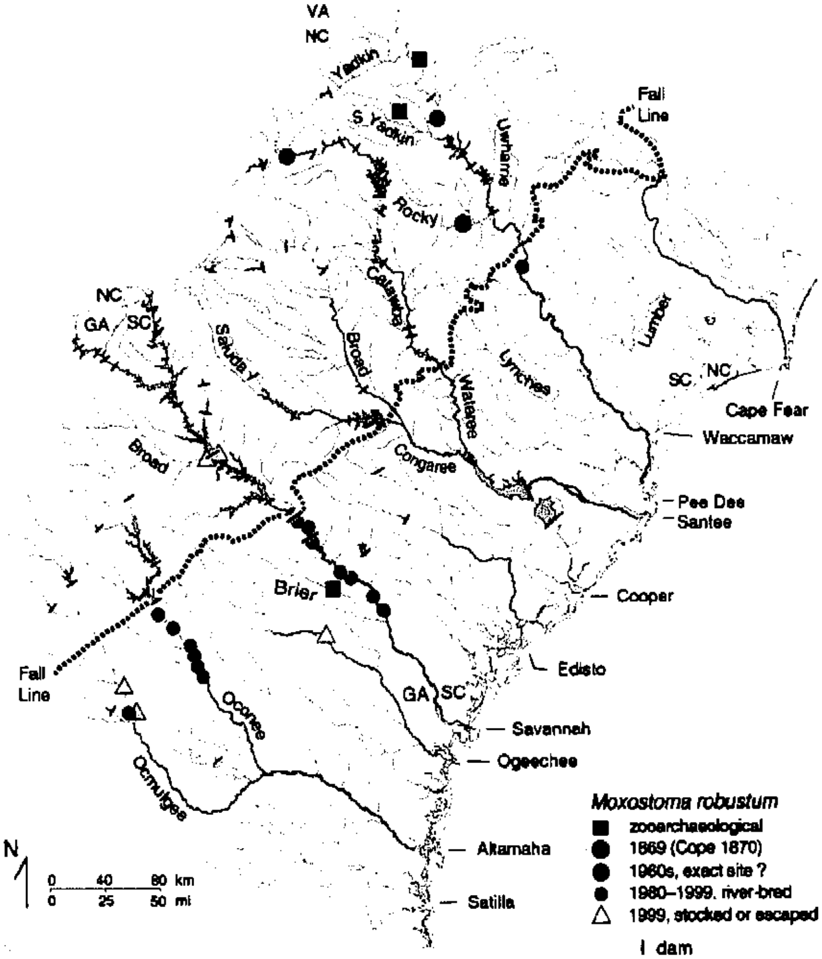


Fig. 1. Records of *Moxostoma robustum*. Number of specimens by drainage or system: Pee Dee 5; Santee 1; Savannah 42 (sites of the 4 record symbols crossed by dam symbols are below the dams); Ogeechee 1; Oconee 870 (detail in Fig. 1); Ocmulgee 3. Triangles represent artificially bred fish captured after stocking or escape from rearing ponds. Fall Line drawn from Anonymous (1963a-c) and Harris and Zullo (1991). Dams shown mainly for larger streams (south of Cape Fear drainage).

Map by R. E. Jenkins, B. J. Freeman, and J. W. Evans (October 1999)

IX. REFERENCES

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Jenkins, R. E. and B. J. Freeman (in prep.). Systematics of the molar-toothed redhorse suckers (*Moxostoma carinatum*) and the rediscovered *M. robustum* of the south Atlantic slope (Pisces, Catostomidae). Unpublished manuscript.

Jenkins, R. E. (in prep.). Systematics of the brassy jumprock (*Scartomyzon brassius*, new species: formerly called *Moxostoma robustum*) of the south Atlantic slope (Pisces, Catostomidae). Unpublished.

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Jennings, C. A., J. L. Shelton, B. J. Freeman, and G. L. Looney. 1998. Annual Report (1996): Culture Techniques and Ecological Studies of the Robust Redhorse, *Moxosotma robustum.* February 1998

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APPENDIX II

Examples of Adaptive Management that May Be Appropriate

A. Stock the Project Site

In the event adequate numbers of fingerlings are not available due to poor harvest, the stocking duration and monitoring period may be extended. Radio-tracking and electrofishing surveys may be rescheduled in the event of such changes.

B. Study the movement of introduced juvenile robust redhorse

Depending on the success of initial radio-tracking studies, the size and number of fish may be altered to provide the most efficient means of defining habitat utilized. Changes in radio transmitters and tracking equipment may also be required. Migration by juvenile robust redhorse is a question to be addressed by this project and will be addressed in the telemetry studies that may include tracking juvenile fish downstream of Juliette, Georgia.

C. Monitor abundance and distribution of introduced robust redhorse

Monitoring may be rescheduled if stocking schedules are altered, but monitoring for juveniles and adults returning to the project site will continue until a determination is made regarding the status of the adult refugial population (i.e., whether a population has been established or not). The primary focus of monitoring is the project site, which is believed to be the most suitable habitat for spawning robust redhorse. Monitoring under this agreement may extend downstream to the city of Macon, Georgia, if necessary.

Flathead catfish and excessive sedimentation have been identified as potential threats to the establishment of a refugial population in the Project Site. Should either of these factors be determined to have a negative effect on the success of this Agreement the Parties may act cooperatively or independently to seek any remedial actions necessary. However, the invasion of the project site by flathead catfish, and the migration of sediments from offsite sources are not under the control of Georgia Power and are outside the scope of this Agreement.

APPENDIX III

Enhancement of Survival Permit

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE

3-201
(1/97)

FEDERAL FISH AND WILDLIFE PERMIT

2. AUTHORITY-STATUTES

16 USC 1539(a)(1)(A)
16 USC 1539(a)(1)(B)

REGULATIONS (Attached)

50 CFR §§ 13 & 17

3. NUMBER

TE038547-0

1. PERMITTEES

GEORGIA POWER COMPANY
241 RALPH MCGILL BOULEVARD
ATLANTA, GEORGIA 30308

TELEPHONE: 404/506-7778

4. RENEWABLE		5. MAY COPY	
[X]	YES	[X]	YES
[ ]	NO	[ ]	NO

6. EFFECTIVE: SEE BLOCK 9

7. EXPIRES: 12/31/2023

8. NAME AND TITLE OF PRINCIPAL OFFICER (if # 1 is a business)

MR. CHRIS M. HOBSON
VICE PRESIDENT, ENVIRONMENTAL AFFAIRS

9. TYPE OF PERMIT

CANDIDATE SPECIES - ENHANCEMENT OF SURVIVAL (EFFECTIVE THE DATE *MOXOSTOMA ROBUSTUM* BECOMES A LISTED SPECIES)

10. LOCATION WHERE AUTHORIZED ACTIVITY MAY BE CONDUCTED

THE OCMULGEE RIVER, GEORGIA, LYING DOWNSTREAM OF LLOYD SHOALS DAM AND UPSTREAM OF A LOW DAM AT JULIETTE, GEORGIA, BETWEEN RIVER MILES 250.2 AND 230.9, AND OTHER AREAS WITHIN THE OCMULGGEE RIVER SUBJECT TO PERMITTEE'S CANDIDATE CONSERVATION AGREEMENT WITH ASSURANCES (CCAA) MONITORING PROVISIONS AND AS CONDITIONED HEREIN.

11. CONDITIONS AND AUTHORIZATIONS:

A. GENERAL CONDITIONS SET OUT IN SUBPART D OF 50 CFR 13, AND SPECIFIC CONDITIONS CONTAINED IN FEDERAL REGULATIONS CITED IN BLOCK #2 ABOVE, ARE HEREBY MADE A PART OF THIS PERMIT. ALL ACTIVITIES AUTHORIZED HEREIN MUST BE CARRIED OUT IN ACCORD WITH AND FOR THE PURPOSES DESCRIBED IN THE APPLICATION SUBMITTED. CONTINUED VALIDITY, OR RENEWAL, OF THIS PERMIT IS SUBJECT TO COMPLETE AND TIMELY COMPLIANCE WITH ALL APPLICABLE CONDITIONS, INCLUDING THE FILING OF ALL REQUIRED INFORMATION AND REPORTS.

B. THE VALIDITY OF THIS PERMIT IS ALSO CONDITIONED UPON STRICT OBSERVANCE OF ALL APPLICABLE FOREIGN, STATE, LOCAL OR OTHER FEDERAL LAW.

C. VALID FOR USE BY PERMITTEE NAMED ABOVE, AND AUTHORIZED AGENTS.

D. ACCEPTANCE OF THIS PERMIT SERVES AS EVIDENCE THAT THE PERMITTEE AND ITS AUTHORIZED AGENTS UNDERSTAND AND AGREE TO ABIDE BY THE TERMS OF THIS PERMIT AND ALL SECTIONS OF TITLE 50 CODE OF FEDERAL REGULATIONS, PARTS 13 AND 17, PERTINENT TO ISSUED PERMITS. SECTION 11 OF THE ENDANGERED SPECIES ACT OF 1973, AS AMENDED, PROVIDES FOR CIVIL AND CRIMINAL PENALTIES FOR FAILURE TO COMPLY WITH PERMIT CONDITIONS.

_XX_ BLOCK 11 OF THIS PERMIT CONSISTS OF ITEMS A -T (7 PAGES TOTAL).

12. REPORTING REQUIREMENTS

REPORTS WILL BE PROVIDED TO THE U.S. FISH AND WILDLIFE SERVICE OFFICES APPEARING IN CONDITIONS 11.S AND 11.T OF THIS PERMIT.

ISSUED BY

TITLE: DEPUTY REGIONAL DIRECTOR, FWS, SOUTHEAST REGION

DATE: 1/9/02

ORIGINAL

E. The Permit Area will consist of those lands identified in Block 10. Within the Permit Area, activities authorized by this Permit include all actions prescribed by and associated with the implementation of the Permittee's CCAA.

F. The authorization granted by this Permit is valid from the date that *Moxostoma robustum* is listed as threatened or endangered under the Endangered Species Act of 1973, as amended, to the expiration date of this Permit and is subject to full and complete compliance with, and implementation of, the Permittee's CCAA executed by the Permittee, the Georgia Department of Natural Resources, and the USFWS.

G. The take of all *Moxostoma robustum* within the Permit Area is authorized when such take is in the form of harassment, harm, and direct mortality that results from electrofishing, sampling, holding or from any other conservation measure or other action specifically identified in the CCAA and/or this Permit.

The following additional conditions are necessary to minimize the take authorized by this Permit:

1. The Permittee shall notify the USFWS office in Condition 11.S in writing at least 30 days in advance, but preferably as far in advance as possible, of any expected incidental take of *Moxostoma robustum* under the Permit and CCAA. Such notification will provide the USFWS with an opportunity to relocate affected individuals, if possible and appropriate, thus potentially minimizing the effect of the take.

2. The Permittee shall not use gill nets, trap nets, or other passive sampling gear as part of the activities authorized by this Permit or the CCAA; active sampling gear, including seines, may be used.

3. No activities authorized or contemplated by the CCAA or this Permit shall occur when water temperatures exceed 26 degrees Centigrade, except for radio telemetry studies which may occur at any time unless capture or handling of *Moxostoma robustum* is necessary as part of those studies. If capture or handling of *Moxostoma robustum* is necessary as part of radio telemetry studies, such capture or handling shall not occur when water temperatures exceed 26 degrees Centigrade.

CONTINUED...

4. *Moxostoma robustum* sampled from the Permit Area for the purposes of implementing the monitoring provision of the CCAA shall be held for no more than 20 minutes.

5. Electrofishing power regulator settings shall not exceed 5 amps at 6 to 120 pulses per second when sampling.

6. All holding tanks (including transport tanks) shall be fitted with an oxygen supply.

H. This Permit does not authorize the incidental take of any other federally listed plant and/or animal species. In the event other federally listed plant and/or animal species are likely to be adversely affected by the Permittee's actions associated with the CCAA and this Permit, the Permittee will meet with the USFWS office in Condition 11.S to develop appropriate management or other measures that will preclude any unauthorized taking. If activities proposed by the Permittee will unavoidably result in taking of species not covered by this Permit, the Permittee has the option of formally amending this Permit by the procedures outlined in Condition 11.I.

I. The Permittee and the USFWS agree that modification and amendments to this Permit may occur. The Permit is based upon the Permittee's expected compliance with the provisions of the CCAA and Permit. Where a conflict occurs between the CCAA and this Permit, the Permit shall control.

The following procedures shall govern the modification and amendment process:

1. Either the Permittee or the USFWS may propose modifications and/or amendments to the Permit by providing written notice. Such notice shall include a statement of the reason for the proposed modification and an evaluation of the effects on the proposed modification on the CCAA, this Permit, and the covered species. This analysis shall be conducted jointly between the Permittee and the USFWS office in Condition 11.S. The Permittee and the USFWS will respond in writing to a proposed modification or amendment within sixty (60) days of the notice.

2. Any amendment or modification shall conform with all applicable legal requirements, including but not limited to the Endangered Species Act, the National Environmental Policy Act, and the USFWS's permit regulations codified at 50 CFR Parts 13 and 17.

CONTINUED...

3. The Permittee can terminate the Permit in accordance with the regulations in effect at the time of Permit issuance, now codified in 50 CFR 13.26 and incorporated herein by reference. In the event the Permittee elects to terminate the Permit before the end of its 22-year duration, the Permittee agrees to provide the USFWS with sixty (60) days advance written notice.

J. The Permittee shall provide adequate funding through the Permit expiration date or other termination. By accepting this Permit, the Permittee warrants that it has and will expend such funds as necessary to fulfill its obligations of this Permit. The Permittee will promptly notify the USFWS offices in Conditions 11.S and 11.T in writing of any material change in its financial ability to fulfill these obligations.

K. Upon locating a dead, injured, or sick *Moxostoma robustum,* or other species that may be covered by the Permit in the future under circumstances not addressed or authorized by the CCAA or this Permit, the Permittee will notify the USFWS Law Enforcement Office, Savannah Coastal Refuge Complex, 1000 Business Center Drive, Suite 10, Savannah, Georgia 31405, or phone number 912/652-4036 by the next working day. Notification must also be made by the next work day to the USFWS office in Condition 11.S. If further authorized by the USFWS Law Enforcement Office identified above, the Permittee may carefully and humanely handle sick, injured, or dead specimens to ensure effective treatment of live individuals or to preserve biological materials of deceased individuals for later analysis. In conjunction with the care of sick or injured endangered species or preservation of biological materials from a dead animal, the Permittee must take responsible steps to ensure that the site where a dead or injured specimen is obtained is not unnecessarily disturbed.

L Any person who is under the direct control of the Permittee, or who is employed by or under contract to the Permittee for purposes authorized by this Permit, may carry out the activities authorized by this Permit. A copy of this Permit must be carried by the Permittee and all person(s) conducting the activities authorized under this Permit.

M. The Permittee shall ensure that all *Moxostoma robustum* that are moved to the Permit Area by the Permittee or its cooperators are tagged with tags that are standard for such activities.

N. The Permittee shall provide monitoring reports to the USFWS as described in Condition 11.O and will meet with the USFWS on an as-needed basis to review the information contained in these monitoring reports. These meetings will provide an opportunity for resolutions of disputes regarding the Permit implementation and to discuss amendments,

CONTINUED...

modifications, or adaptive management strategies related to this Permit and the CCAA. Said meetings will be mutually-agreed upon, as will a list of potential attendees and potential discussion topics.

O. Beginning with the effective date of this Permit and for the duration of this Permit, the Permittee shall submit an annual report by December 31 to the USFWS Offices in Conditions 11.S and 11.T that references Permit TE038547-0 and contains the following:

1. A certification from a responsible official who supervised or directed the preparation of the report:

   "Under penalty of law, I certify that, to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of this report, the information submitted is true, accurate, and complete."

2. An identification of any material non-compliance of the CCAA or this Permit and all measures employed to remediate such non-compliance.

3. An accurate map depicting all portions of the Permit Area where *Moxostoma robustum* are released, reintroduced, and/or captured.

4. A summary of any modifications and/or amendments submitted and approved/denied during the reporting period, including a narrative summary of any changes made to adaptively manage for *Moxostoma robustum* within the Permit Area.

5. A report of all *Moxostoma robustum* management activities conducted within the Permit Area for the reporting period, including the number, age, and sex (if determinable) of *Moxostoma robustum* released within the Permit Area and an accounting of incidental take events which occurred during the reporting period.

6. The names and affiliations of all personnel who conducted management activities with the Permit Area for the reporting period.

P. The Permittee shall notify the USFWS in writing 30 days in advance of any transfer of ownership of Lloyd Shoals Dam (FERC Project 7019).

CONTINUED...

Q. The USFWS agrees to maintain the confidentiality of any information or data submitted by or on behalf of Permittee in the annual report required by Condition 11.N. In addition, the USFWS agrees to maintain the confidentiality of any information or data submitted by or on behalf of the Permittee pursuant to this Permit which the Permittee has designated as proprietary, commercially or financially sensitive, or confidential, to the maximum extent allowed by law. The USFWS shall provide written notice to the Permittee upon receiving a request by any other agency or party for such information or data or a record including such information or data. In the event that the USFWS determines that it may be required to disclose the information or data to the requesting agency or other party, it shall provide to the Permittee written notice thereof a minimum of twenty-one (21) working days prior to the anticipated date of disclosure, to allow the Permittee to object and to take appropriate action to seek to prevent the disclosure or assure that the requesting party will likewise maintain the confidentiality of the information or data with respect to further disclosure.

R. The Permittee and the USFWS acknowledge that changes in circumstances could arise which were not fully anticipated by the CCAA or this Permit and which may result in substantial and adverse change in the status of *Moxostoma robustum*. When determining whether changed and/or unforeseen circumstances have occurred, the determination will be made based on the USFWS's regulations regarding changed and unforeseen circumstances contained at 50 CFR 17.22(d)(5)(i-iii) and 50 CFR 17.32(d)(5)(i-iii), which are incorporated by reference and also contain the regulatory assurances provided to the Permittee by this Permit.

S. For purposes of monitoring compliance and administration of the terms and conditions of this Permit, the contact office of the USFWS is:

Field Supervisor
U.S. Fish and Wildlife Service
247 South Milledge Avenue
Athens, Georgia 30605
Telephone: (706) 613-9493
Facsimile: (706) 613-6059

T. Copies of reports and any other documentation submitted in response to the operation and management of this Permit shall also be provided to:

Endangered and Threatened Species Permits
U.S. Fish and Wildlife Service (AES/TE/P)

CONTINUED...

1875 Century Boulevard, Suite 200
Atlanta, Georgia 30345
Telephone: (404) 679-7110
Facsimile: (404) 679-7081

END

P:\Endangered Species\CCAA Permits\Robust Redhorse\Final Documents\Robust Redhorse CCAA Permit Page 2.final.wpd January 9, 2002 (1:54pm)

CONTINUED...

TABLE 1

Funding Conservation Actions

FILE

United States Department of the Interior

Fish and Wildlife Service

105 West Park Drive, Suite D
Athens, Georgia 30606

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560

Coastal Sub Office
4270 Norwich Street
Brunswick, Georgia 31520

AUG 1 8 2006

Mr. Mike Nichols
Environmental Laboratory Manager
Georgia Power Company
5131 Maner Road
Smyrna, Georgia 30080

Subject: Minor modification to Robust Redhorse Candidate Conservation Agreement with Assurances (CCAA); FWS Log No. NG-06-003-AGPL

Dear Mr. Nichols:

The January 2002 CCAA for the robust redhorse, *Moxostoma robustum*, was developed as a collaborative effort between Georgia Power Company, Georgia Department of Natural Resources, and the U.S. Fish and Wildlife Service (Service) in order to expedite the reintroduction of the robust redhorse into the Ocmulgee River, Georgia. The objectives of the CCAA are to 1) establish a refugial population of robust redhorse in the Ocmulgee River between Lloyd Shoals Dam and a low head dam in Juliette, Georgia, and 2) increase the understanding of habitat requirements and life history of robust redhorse.

Conservation Action 2 of the CCAA is to study the movement of introduced juvenile robust redhorse. In March 2006, ten adult robust redhorse were collected from the Broad River at Anthony Shoals. These older fish provide an opportunity to study movement by radiotelemetry and were readily available. On March 14, 2006, the Robust Redhorse Conservation Committee (RRCC) Executive Committee was contacted to review a proposal to use these fish from the Broad River and any additional fish collected from the Ogeechee River for the telemetry project that was designed to meet the purposes of Conservation Action 2. The Service was contacted March 15, 2006, regarding the need to discuss and document changes to the telemetry project.

Ross Self, current chair of the RRCC, indicated that based on the input of the Executive Committee there was consensus to use the Broad River and Ogeechee River fish for this study (email dated March 20, 2006). Twenty-three additional fish were collected from the Ogeechee River in April 2006 for this telemetry project. Based on the review and input regarding the proposed change, we concur with this modification to the proposed telemetry project, which is part of Conservation Action 2 of the "CCAA for the Robust Redhorse, *Moxostoma robustum*, Ocmulgee River, Georgia". This modification is in accordance with the "Adaptive Management" section of the CCAA, which states the parties to the CCAA may request modifications to the conservation actions.

We appreciate the opportunity to provide comments as this project moves forward. If you have any questions, please contact staff biologist Alice Lawrence at (706) 613-9493 ext. 222.

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

Cc: Ross Self, GDNR, Columbia, SC
Jimmy Evans, GDNR, Fort Valley, GA
Cecil Jennings, USGS Biological Resources Division, Athens, GA
Tim Grabowski, USGS Biological Resources Division, Athens, GA

United States Department of the Interior

Fish and Wildlife Service

105 West Park Drive, Suite D
Athens, Georgia 30606

FILE

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560

Coastal Sub Office
4270 Norwich Street
Brunswick, Georgia 31520

January 3, 2007

Mr. Joe Slaughter
Fisheries Biologist
Georgia Power Company
5131 Maner Road
Smyrna, Georgia 30080

Subject: Modification to Robust Redhorse Candidate Conservation Agreement with Assurances (CCAA); FWS Log No. 41460-2008-FA-0024

Dear Mr. Slaughter:

The January 2002 CCAA for the robust redhorse, *Moxostoma robustum*, was developed as a collaborative effort between Georgia Power Company (GPC), Georgia Department of Natural Resources (GDNR), and the U.S. Fish and Wildlife Service (Service) to expedite the reintroduction of the robust redhorse into the Ocmulgee River, Georgia. The objectives of the CCAA are to 1) establish a refugial population of robust redhorse in the Ocmulgee River between Lloyd Shoals Dam and a low head dam in Juliette, Georgia, and 2) increase the understanding of habitat requirements and life history of robust redhorse.

Conservation Action 1 of the CCAA is to stock the Project Site. The CCAA states that GDNR will stock the Project Site with approximately 4,000 hatchery-reared robust redhorse fingerlings each year for five years, totaling 20,000 fingerlings. At the inception of the CCAA, this number of fingerlings was selected based on population modeling to result in approximately 600 adult fish, which correlated at that time to the population estimate in the adjacent Oconee River. The CCAA has now been enacted for five years, and through 2007, a total of 13,228 fingerling and juvenile robust redhorse have been stocked in the Project Site. At the RRCC Annual Meeting on September 24-25, 2007, the RRCC discussed the need to modify the existing CCAA regarding the stocking requirements contained therein. This discussion was based on several factors: 1) GDNR and the Service will not be propagating robust redhorse from the Oconee River population in spring 2008 because of the low numbers of broodfish that have been captured in recent years, 2) monitoring results from the Ocmulgee River indicating that individuals are surviving and a large percentage are remaining within the CCAA project site, 3) sampling results of the Broad, Ocmulgee, and Ogeechee Rivers indicating that these individuals are surviving and are exhibiting suitable growth, 4) research indicating that robust redhorse stocked from the Broad and Ogeechee rivers, Georgia into the Ocmulgee River, Georgia are behaving similarly to the existing Ocmulgee River stocked population, and 5) recent observations of spawning activities in the Ocmulgee and Broad rivers.

On October 10, 2007, the Service, GDNR, and GPC participated in a conference call to discuss options to address the stocking requirements contained in Conservation Action 1 of the CCAA.

While the parties do not feel that spawning of the Oconee River population in spring 2008 solely for CCAA purposes is justified, they feel that stocking of the Ocmulgee River should continue, when feasible. Stocking a much smaller number of older fish into the Ocmulgee would be appropriate, such as from the Ogeechee and/or Broad rivers, because older fish will have a greater survival rate to adulthood than fingerlings. However, fish that become available in the Broad and Ogeechee Rivers are often needed for other purposes, such as research projects. Therefore, the parties decided that stocking of the Ocmulgee River population from the Ogeechee and/or Broad River populations should continue, dependent on the non-conflicting availability of these individuals. A target number was not established because monitoring results from the Ocmulgee River indicated that the numbers presently stocked may be sufficient to establish a successful refugial population and recent spawning activity suggests that the population may eventually become sustainable. Additional stockings of adult fish from the Ogeechee and/or Broad River would be primarily to increase the probability of success of the stocking program and to increase genetic diversity of the introduced population.

On October 30, 2007, the Robust Redhorse Conservation Committee (RRCC) Executive Committee was contacted to review the proposal to modify the stocking requirements that were designed to meet the purposes of Conservation Action 1. Although a target number will not be set, the proposed stocking modification would be that stocking of the Ocmulgee River should continue, depending on the non-conflicting availability of robust redhorse. Dave Coughlan, current Chair of the RRCC, indicated there was consensus support among the Executive Committee members for this proposed stocking modification (email dated January 2, 2007). Based on the review and input regarding the proposed change, we concur with this modification to the stocking requirements, which is part of Conservation Action 1 of the "CCAA for the Robust Redhorse, *Moxostoma robustum*, Ocmulgee River, Georgia". This modification is in accordance with the "Adaptive Management" section of the CCAA, which states the parties to the CCAA may request modifications to the conservation actions.

We appreciate the opportunity to provide comments as this project moves forward. If you have any questions, please contact staff biologist Alice Lawrence at (706) 613-9493 ext. 222.

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

Cc: Dave Coughlan, Duke Energy, Huntersville, NC
Jimmy Evans, GDNR, Fort Valley, GA

Bin 10151
241 Ralph McGill Boulevard NE
Atlanta, Georgia 30308-3374

404-506-2337

GEORGIA POWER
A SOUTHERN COMPANY

July 16, 2012

Ms. Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Room 1-A – Dockets Room
Washington, DC 20427

Re: Reported fish kill on Georgia Power's Lloyd Shoals Project (# 2336)

Dear Madam Secretary:

Georgia Power received multiple reports of a fish kill in the Southern Shores area of the South River arm of Lake Jackson beginning on July 1, 2012. The Georgia Department of Natural Resources (DNR) had received similar reports as early as June 28 and was in the process of investigating the event when we were notified on July 1. DNR investigated the event and determined that the kill (roughly 2400 fish, predominantly largemouth bass, crappies, gizzard shad, and common carp) was the result of low dissolved oxygen caused by excessive temperatures and low flows (see attachment).

DNR measured dissolved oxygen at 2.5 mg/L during their onsite investigation, a level that can be lethal to some large-bodied individuals but would not cause a total kill of the area. Ambient air temperatures during the preceding week and at the time of the kill had also set record highs for Georgia with highs consistently in the 104-107°F range for several days. DNR has stated that fish kills of this type were happening all over the state due to the combined effects of drought and those record high temperatures. The low dissolved oxygen levels posed no threat to humans, and the DNR concluded that there was no further action required.

The state of Georgia has been and continues to be in a drought. Central Georgia, including Lake Jackson and its drainage basin, has been in an exceptional drought since fall of 2011. The ongoing drought has hampered our ability to raise the lake elevation to its normal summer level; however, recent rains have allowed us to reach full pool as of the date of this report. If you have any questions or require any further information, please contact me at 404-506-2337 or jcharles@southernco.com.

Sincerely,

Joseph Charles

Joseph Charles
Hydro License Coordinator
Georgia Power, Land Department

cc: Keith Weaver, Georgia Department of Natural Resources

attachments

Fisheries Section - Public Waters Fish Kill Basic Investigation Form

Body of Water: Lake Jackson- Hwy 36 South River ______Date: _July 2, 2012___________
Investigators: _Steve L. Schleiger and David Tannehill
Time:1000_______________

1. Date: July 1, 2012 and time morning______________ the fish kill was first observed.
2. Who first observed the fish kill? Blake Tomlin______Phone #: 770-775-4424___
3. Date July 1, 2012_____________________ and time _9:30 pm__the fish kill was first reported.
4. Who first reported the fish kill? __Blake Tomlin______Phone #: _770-775-4424_
5. Exact location and length of kill area: Cove on west side of South River immediately upstream of Hwy 36 Bridge- approximately 8 acres of shallow water
6. Are fish still dying? Yes ______ No ___X__
7. If yes, describe stress symptoms: ____
8. Describe condition of dead fish and estimate time of kill: approximately 2 days old; fish probably died the afternoon of June 30^{th} or the morning of July 1__
9. Are parasitic or fungal infections evident on sick or recently dead fish? Yes ____ No __X_
10. If yes, identify parasites or diseases. (You may need to send specimens to Auburn to confirm diagnosis.) ____
11. What species of fish are dead? Gizzard shad, crappie, catfish, largemouth bass, sunfish___
12. Check the appropriate size range of dead fish:
    fingerlings _____ intermediates _X_____ adults __X_____ all sizes _____
13. Estimate the number of dead fish. _2,471________ What method was used to make this estimate?
    __Physical count________________________________
14. Describe body of water characteristics: (flow, recent changes in water levels, unusual discoloration, residue in water or on bank, abnormal odors) _Cove was cut off due to low flow in South River over the spring, low level in reservoir (4 ft. below normal pool)_
    ____
15. Describe climatic conditions prior to and during kill: _Hot and dry, temperature reached 100+ on both June 30 and July 1__________________________________
    ____
16. Check the water quality in, above, and below kill area and record on water quality form. Remember to do vertical profiles whenever possible..Two separate D.O. readings of 1.15 mg/l and 2.5 mg/l- water only one to two feet deep
17. Are there sources of pollution in the immediate watershed? Yes _____ No __X___
18. If yes, list each source and the results of investigating that source as a possible cause of the kill: ____
    ____
    ____
19. Are there footprints, tire tracks, evidence of dragging a boat, empty rotenone containers, or a single pile of dead fish that may indicate that someone poisoned or dumped the fish? (consider ease or difficulty of access into kill area) Yes _____ No _X____
20. If yes, describe what was found: ____
    ____
21. Is there any evidence from the investigation to indicate the fish died from **other than** natural causes? (low water, low oxygen, parasites, or diseases, etc.) Yes _____ No _X____

22. Are there any indications that municipal, chemical, or any other type of man-influenced pollution or pesticides could have contributed to the fish kill? Yes ______ No _X____

23. If the answers to questions 21 and 22 are no, terminate the investigation at this point and submit this form along with the water quality form to the fish kill coordinator for review within seven days. The EPA pollution-caused fish kill card is not required.

24. If either 21 or 22 is yes, continue the investigation using standard procedures.

25. Use the back of this form or another page to report any additional information or remarks.

Common Carp Fish Kill on Lake Jackson No Cause for Alarm

Social Circle, GA

Thursday, June 7, 2018 - 14:00

A few fish floating in a lake as large as Jackson may not raise interest. However, when that turns into a few hundred dead fish, offices at the Georgia Department of Natural Resources' Wildlife Resources Division: Fisheries Section start to get some calls. Fortunately, the recent die-off of common carp seen currently at Jackson appears to be a natural occurrence. "Common carp have been aggressively spawning at Lake Jackson over the last few weeks, resulting in additional energy consumption and stress, and weakening a fish's immune system allowing bacterial or viral infections to more readily occur, often causing fish death," says Keith Weaver, fisheries biologist at Lake Jackson. "Additionally, these spawning activities ensure that many carp are in constant contact with each other, allowing diseases to spread even more rapidly. Given that this die-off appears to affect this one species and water quality appears normal, we believe that this is a naturally occurring fish kill and of no alarm to anglers or lake visitors."

Biologists observing the kill located dead fish primarily in the South River Arm of Lake Jackson. However, it is still possible that it could continue to spread to other parts of the reservoir.

Common carp are not native to the United States, but were introduced in the late 1800s as a food fish. They are commonly found throughout the southeast. They are slate to gold in color, with a dark spot at the base of the tail and have a sucker-like mouth with a barbel on each corner. They can weigh more than 50 pounds, but 5-25 pounds is more typical.

For more information on fishing in Georgia, visit www.georgiawildlife.com (http://www.georgiawildlife.com).

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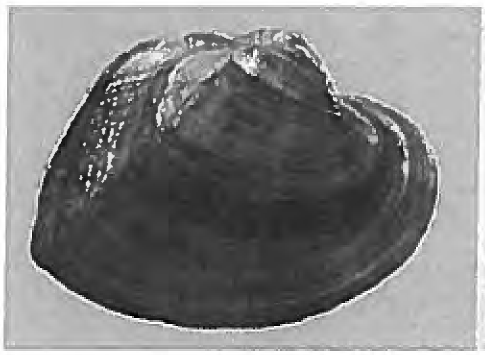
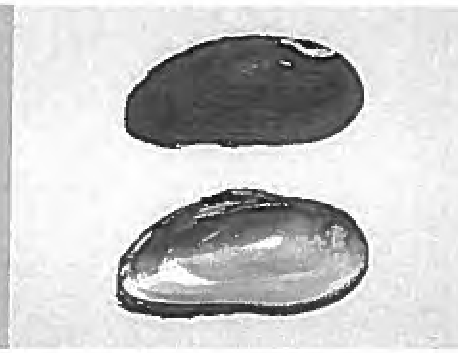
Candidate Conservation Agreement (CCA) for Mollusks of the Altamaha River Basin, Georgia





Georgia Power Company

U.S. Fish and Wildlife Service

Georgia Wildlife Resources Division

August 2017

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LIST OF TABLES

LIST OF APPENDICES

DEFINITIONS

1. **<u>Candidate Conservation Agreement (CCA)</u>** – a voluntary conservation agreement between the U.S. Fish and Wildlife Service (Service) and one or more public or private parties. The Service works with its partners to identify threats to candidate species, plan the measures needed to address the threats and conserve these species, identify willing landowners, develop agreements, and design and implement conservation measures and monitor their effectiveness.

2. **<u>Lloyd Shoals Hydro Project (LSHP), Sinclair Hydro Project (SHP), Wallace Hydro Project (WHP), Hatch Nuclear Project (HNP) and Plant Scherer Project (PSP).</u>** The hydropower facilities and reservoirs are owned by Georgia Power Company (GPC) and are licensed by the U.S. Federal Energy Regulatory Commission (FERC) under the following project numbers:

   - Project No. 2336 (Lloyd Shoals)
   - Project No. 1951 (Sinclair)
   - Project No. 2413 (Wallace)

   GPC owns other properties referred to as "bulk properties" in association with HNP and PSP. Although they may be located at or near the developed portions of these facilities, they are considered as non-project lands owned fee-simple by Georgia Power, and are typically managed for forestry, wildlife, or other purposes. HNP and its associated bulk property, located in the Altamaha River basin near Baxley, Georgia is co-owned by GPC, Oglethorpe Power Corporation, Municipal Electrical Authority of Georgia, and Dalton Utilities. HNP is operated by Southern Nuclear Operating Company (a subsidiary of Southern Company) and licensed by the U.S. Nuclear Regulatory Commission (NRC). A large tract of the PSP, a coal-fired power facility, is managed by the Georgia Department of Natural Resources as the Rum Creek Wildlife Management Area. Other lands associated with PSP are defined here as bulk properties.

3. **<u>Property Covered by this Agreement</u>** – The properties described above are partially owned or owned in full by GPC within the Altamaha River basin.

4. **<u>Parties</u>** – Parties specified in section II of this Agreement are GPC and the Service. Georgia Department of Natural Resources (GDNR) is a Cooperator to the Agreement.

I. INTRODUCTION

This Agreement for the Delicate Spike (*Elliptio arctata*), Altamaha Arcmussel (*Alasmidonta arcula*), Inflated Floater (*Pyganodon gibbosa*), Savannah Lilliput (*Toxolasma pullus*), and Reverse Pebblesnail (*Somatogyrus alcoviensis*) has been developed as a collaborative and cooperative effort between GPC, Service, and GDNR, in order to implement conservation measures for the species. This Agreement allows for modifications to formally involve other State and private parties named in the agreement as cooperators. These conservation measures will be implemented in accordance with the Endangered Species Act (ESA) of 1973, as amended, 16 U.S.C. § 1531 *et. seq.*, and applicable Federal and State regulations. Successful implementation of this Agreement should reduce potential threats to the above species and their habitat.

II. PARTIES AND COOPERATORS TO THE AGREEMENT

A. Parties to the Agreement

Georgia Power Company (Property Owner)

GPC is an electric generation and land management subsidiary of Southern Company. GPC owns and operates the projects described in this Agreement, either partially or in full, located within Georgia's Altamaha River watershed. GPC designates the following individual as the contact for this Agreement:

Joe Ernest Slaughter, IV
Environmental Affairs
Georgia Power Company
2480 Maner Road SE
Atlanta, Georgia 30339

U. S. Department of the Interior (Service)

The Service works to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people. The Southeast Region is committed to expanded partnerships, which offer innovative opportunities to enhance fish and wildlife resources. The Service will assist with technical matters and permit application development.

The Service designates the following individual as the Agreement Administrator for this Agreement:

Don Imm, PhD
Field Supervisor
U.S. Fish and Wildlife Service
Georgia Ecological Services Field Office
106 Westpark Drive, Suite D
Athens, Georgia 30606
706-613-9493

B. Cooperators to the Agreement

Georgia Department of Natural Resources-Wildlife Resources Division (GDNR)

The mission of GDNR is to sustain, enhance, protect and conserve Georgia's natural, historic and cultural resources for present and future generations, while recognizing the importance of promoting the development of commerce and industry that utilize sound environmental practices.

III. AUTHORITY AND PURPOSE

Sections 2, 7, and 10 of the ESA authorize the Service to enter into this Agreement. Section 2 of the ESA states that encouraging interested parties, through Federal financial assistance and a system of incentives, to develop and maintain conservation programs is essential to safeguarding the Nation's heritage in fish, wildlife, and plants. Section 7 of the ESA requires the Service to review the programs it administers and utilize those programs to further the purposes of the ESA. By entering into the Agreement, the Service is utilizing the CCA Programs to further the conservation of the Nation's fish and wildlife. The purpose of this Agreement is to:

A. Implement conservation measures for the Delicate Spike, Altamaha Arcmussel, Inflated Floater, Savannah Lilliput, and Reverse Pebblesnail through cooperative work among the Parties and Cooperators to conserve existing populations of these species within GPC's project areas in the Altamaha River Basin.

B. Increase the understanding of these species' habitat requirements, taxonomy, and life history characteristics so that population expansion and augmentation can be achieved.

The use of a CCA is appropriate because the Delicate Spike is listed as State Endangered, the Altamaha Arcmussel and the Savannah Lilliput are listed as State Threatened, the Inflated Floater is listed as G3 (Vulnerable) across its range, and the Reverse Pebblesnail is listed as G1Q (Critically Imperiled with questionable taxonomy) across its range and S1 (State Imperiled) in Georgia. In 2010, the Service was petitioned by the Center for Biological Diversity (CBD) to federally-list all five of these species and issued a positive 90-day finding stating that a status review was warranted (76 FR 59836). Subsequently, CBD withdrew their petition for several species, including Altamaha Arcmussel, Inflated Floater (Tierra R. Curry's December 17, 2015, letter to the Service) and the Savannah Lilliput (Tierra R. Curry's January 17, 2017 letter to the Service).

In providing for CCAs, the Service did not intend to exclude species that are not officially listed as candidate species, but are nevertheless at risk if populations decline (see the Final Policy, page 32732). Instead, the Service recognizes that taking steps before a species enters into a serious decline is often the most effective way to conserve that species, thereby possibly precluding the need to list the species under the ESA. The conservation measures included in this CCA will help to ensure that these species do not need protection under the ESA in the future.

All Parties to this Agreement recognize that there are specific statutory responsibilities that cannot be delegated by the GDNR or the Service, particularly with respect to the management and conservation of natural resources. Similarly, it is recognized by all Parties that GPC's specific responsibilities with regard to these species are described by and limited to the terms of this Agreement. This Agreement is subject to and is intended to be consistent with all applicable Federal and State laws.

IV. DESCRIPTION OF THE PROJECT SITE

The Project Site is comprised of multiple non-contiguous GPC project areas located across various portions of the upper and middle sections of the Altamaha River Basin, Georgia (Appendix 2). Collectively, those areas include 672 miles of shoreline that offer long-term buffering potential between lands that lay adjacent to lake and riverine habitats. A GPC project area may include:

- a particular GPC–owned FERC hydro facility or other managed facility such as Rum Creek WMA where lacustrine or riverine shorelines exist, or
- a non-project bulk property where shorelines occur.

GPC's Land Department-based Forestry Program manages company-owned bulk properties following four primary objectives. Bulk properties are most often geographically adjacent to GPC infrastructure such as sub-stations, powerline corridors, or power plant facilities. Specifically, GPC's land asset management objectives:

- support GPC's core business, biomass, and sustainability initiatives;
- promote the use of company natural resources for the general public and provide opportunities for outdoor recreation;
- wisely utilize the company's renewable resources for revenue generation; and
- protect and enhance the scenic, environmental, wildlife, recreational and historical values of forestland assets.

For the purpose of scientific investigations of freshwater mollusks listed in this CCA, the term "project area" also may include free-flowing reaches of rivers in the vicinities of any of those types of GPC-owned parcels. Detailed project area maps (Appendix 3; Pages 1-8) delineate GPC-owned lands in the Project Site. The maps depict riparian areas, currently color-coded in red, as GPC-owned but privately-leased properties that implement a 25-foot buffer (the maintenance of a 25-foot buffer on warm water waterbodies complies with OCGA 12-7-1 Georgia Erosion and Sedimentation Control Act). Areas color-coded in yellow and green depict 100 to 300-foot riparian buffers on GPC non-leased, non-developed lands, respectively.

The Project Site includes:

A. Lloyd Shoals Hydro Project (LSHP) (Appendix 3; Page 35) and free-flowing reaches of the Ocmulgee River downstream:

The Lloyd Shoals Hydropower Project (LSHP) was completed in 1911 and is located on the Ocmulgee River in Butts, Henry, Jasper, and Newton counties, Georgia. The facility has a nameplate generation capacity of 18 megawatts (MW). The impoundment, Jackson Lake, has a full- pool surface area of 4,750 acres currently maintained at 529.55 ft. MSL (mean sea level NAVD 1988), a gross storage capacity of 107,000 acre-feet, and 135 miles of shoreline. During normal inflow periods the reservoir level fluctuates, depending on plant operations.

Regarding drawdown on GPC reservoirs, there are many factors that affect GPC's decision and need for drawdown, including, but not limited to drought, dam safety, turbine/generator equipment maintenance requirements, and homeowner maintenance needs. GPC's lake management plan for LSHP changed after 2013 following installation of the Obermeyer gates (reservoir-level control). Currently, LSHP drawdowns are scheduled generally to occur every 3 years with drawdown depth ranging possibly from 5 to 7 feet full pool. Prior to 2013, drawdowns were often conducted annually and as deep as 8 feet below full pool. The next scheduled drawdown for LSHP is in 2018 and is expected to occur sometime in September through November, when inflows are typically lowest.

B. Plant Scherer Project (PSP) (Appendix 3; Page 36):

Plant Scherer is a coal-fired power plant co-owned by GPC, Oglethorpe Power Corporation, Municipal Electrical Authority of Georgia, Gulf Power Company, Jacksonville Electric Authority, and Dalton Utilities. The facility is located in Juliette, Georgia in Monroe County just north of Macon and approximately 70 miles south of Atlanta. The facility's four coal-fired power units have a combined nameplate generation capacity of 3,272 MW. The facility is located next to Lake Juliette on 3,500 acres and began commercial operation in 1982 with Lake Juliette serving as a cooling water source for the facility. Lake Juliette is an impoundment of Rum Creek and receives make-up water pumped from the Ocmulgee River nearby. A 5,739-acre section of facility property is managed by the GDNR as Rum Creek Wildlife Management Area (WMA). For the purposes of this CCA, this project area includes the Rum Creek WMA lands, Lake Juliette, and other GPC bulk properties adjacent to the Ocmulgee River in the vicinity. Surveys may be additionally conducted on free-flowing reaches of the Ocmulgee River in the vicinity of these bulk properties.

C. Wallace Hydro Project (WHP) (Appendix 3; Pages 37-39):

The WHP was completed in 1980 and is located approximately 10 miles upstream of Sinclair Dam in Hancock, Morgan, Putnam, and Greene counties, Georgia on the Oconee River arm of Lake Sinclair. The impoundment has a full-pool surface area of 19,050 acres (FERC 1995) with a 374 mile shoreline. It is operated as a pumped storage facility with SHP serving as the lower storage pool and has a nameplate generation capacity of 321.3 MW (FERC 1996). Reservoir drawdowns are not conducted in the WHP for homeowner shoreline maintenance; however, the lake is drawn down during extreme drought as it supplements the absolute minimum flows required by the downstream Sinclair Hydro Project (SHP). There may be times when a drawdown is necessary for hydro plant maintenance and repair work, but these are infrequent.

D. Sinclair Hydro Project (SHP) (Appendix 3; Pages 40-41) and free-flowing reaches of the Oconee River downstream:

The Sinclair Hydropower Project (SHP) was completed in 1952 and is located on the Oconee River near the town of Milledgeville in Baldwin County, Georgia. The facility has a nameplate generation capacity of 45 MW, a hydraulic capacity of 8,000 cfs, and an average annual generation of approximately 124 gigawatts (GW). The impoundment has a full-pool surface area of 15,330 acres, a gross storage capacity of approximately 333,000 acre- feet, and 417 miles of shoreline. The SHP is operated in conjunction with the Wallace Hydropower Project (WHP). Operation of the WHP results in daily lake level fluctuations of about two feet in Lake Sinclair. GPC's past lake management practices for SHP generally included drawdown every 3-5 years to allow shoreline facility owners to perform maintenance to their facilities. These drawdowns usually occurred in December and January for approximately six weeks, and reduced the wetted perimeter along the shoreline in some areas out to a distance of 40 horizontal feet from the full pool (340 ft. PD) bankside. Drawdown frequency for SHP is designed to occur approximately once every five years. SHP drawdown depth is constrained by water elevation needs at the Wallace pumpback facility. Since 1998, maximum reservoir drawdown elevations in SHP averaged about 5.9 feet below full pool. Future drawdowns will most likely occur during the fall during drier months, when inflows are lowest.

E. Hatch Nuclear Project (HNP) (Appendix 3; Page 42)

Hatch Nuclear Project is co-owned by GPC, Oglethorpe Power Corporation, Municipal Electrical Authority of Georgia, and Dalton Utilities. Located near Baxley, Georgia, it is operated by Southern Nuclear Operating Company, a subsidiary of Southern Company. HNP is licensed by the U.S. Nuclear Regulatory Commission (NRC). Commercial operation at Plant Hatch began in 1975. HNP's two generation units have a combined nameplate capacity of 1,848 MW. This HNP site has no bulk properties associated with it. However, all non-developed HNP property adjacent to the Altamaha River currently receives 300-foot buffer protection. The HNP project area includes adjacent free-flowing reaches of the Altamaha River in the vicinity of the plant.

V. STATUS OF THE SPECIES

A. Delicate Spike

Elliptio arctata (Conrad 1834), the Delicate Spike, was described from the Black Warrior and Alabama Rivers in Alabama. The species attains a maximum length of 90 millimeters and is laterally compressed. The outline is elliptical and elongated, with older individuals often being arcuate in shape. It has a rounded anterior margin, straight to slightly concave ventral margin, and a straight to slightly curved dorsal margin. The posterior margin can be truncate, rounded, or bluntly pointed, with a low and rounded posterior ridge that may be doubled posterioventrally. It has a low posterior slope that is flat to concave. The umbo is low, broad, and does not exhibit sculpturing, except in young individuals. The periostracum can be olive, brown, or black and can occasionally have variable dark green rays. It has small, low, and triangular pseudocardinal teeth and long, thin, and straight to slightly curved lateral teeth. It exhibits a moderately long, narrow interdentum and a shallow, wide umbo cavity. The nacre is often discolored and is typically bluish-white, but is occasionally purplish. Synonyms of the species have included *Unio strigosus, Unio tortivus, Unio perstriatus, Unio gracilentus, Unio viridans, and Unio perlatus*. Several of these synonyms were described from the Savannah River Basin of South Carolina and Georgia and the Catawba and Cape Fear Basins of North Carolina.

a. Habitat

The Delicate Spike primarily occurs in lotic (flowing) systems with moderate current, often in crevices and beneath large cobble or boulders; it can also be found among roots in beds of macrophytes (Williams et al. 2008).

b. Diet

Native unionids feed on phytoplankton, bacteria and particulate organic matter from the water column but diets may change throughout their lives (Vaughn and Hakenkamp 2001).

c. Life History

Little is known regarding the life history of this species. Most native freshwater mussels have an obligate parasitic larval stage (glochidia) in which the larvae must parasitize suitable host fishes. The adult mussels expel glochidia which must attach to an appropriate host. The Delicate Spike is gravid in spring to early summer, but glochidial hosts are currently unknown (Williams et al. 2008; Wisniewski 2008).

d. Range

The Delicate Spike has been found in most eastern Gulf Coast drainages, from the Apalachicola River Basin in Georgia and Florida to a western boundary of the Pearl River Basin in Mississippi. In Alabama, it is rare in the headwaters of the Chipola, Choctawhatchee, and Conecuh drainages, and possibly a few Chattahoochee River tributaries. In the Mobile River Basin populations are widespread, occurring both above and below the Fall Line, but uncommon and highly fragmented. The largest known populations in the Mobile River Basin are in the Alabama River below Claiborne Lock & Dam and the Cahaba River (Williams et al. 2008).

Specimens resembling *E. arctata* have also been collected in Atlantic Slope drainages from the Cape Fear River south to the Altamaha River, Georgia (J. Wisniewski, GDNR, 2014, pers. comm.). *E. arctata* may be the *Elliptio* sp. that is present below LSHP on the Ocmulgee River, known to extend downstream to the Altamaha River near Jesup, Georgia (Appendix 4). Molecular taxonomy research is necessary to definitively determine if this species is in fact the Delicate Spike.

B. Altamaha Arcmussel

Alasmidonta arcula (Lea 1838), the Altamaha Arcmussel, was described from the lower Altamaha River in Liberty (now Long) County, Georgia. The species rarely exceeds 80 millimeters in length and has a delicate, inflated shell, often with distinct concentric sculpturing near the umbo. The umbo is elevated above the hinge line and positioned centrally to slightly anterior of the triangulate shell. Adults of this species typically have brown to yellow periostracum with dark rays and a posterior ridge that is sharp and straight. The right valve has one delicate pseudocardinal tooth and a short, delicate lateral tooth; the left valve has one to two delicate, serrated pseudocardinal teeth with absent or reduced lateral teeth. The beak cavity is shallow and the nacre is typically white or iridescent.

a. Habitat

The Altamaha Arcmussel inhabits both riverine and reservoir habitats of the Coastal Plain and Piedmont physiographic provinces. The species is most frequently found in habitats consisting of low shear stress, depositional areas often associated with edge waters and pools in sand and mud substrates. They were most commonly found in fine sandy substrates and along gently sloping banks with low hanging willows and soft mud in the Altamaha River (Meador et al. 2011). Individuals have been infrequently found in pools that were 2-3 meters deep with coarse sand and gravel substrates (Wisniewski 2008).

b. Diet

Native unionids feed on phytoplankton, bacteria and particulate organic matter

from the water column but diets may change throughout their lives (Vaughn and Hakenkamp 2001).

c. Life History

Little is known regarding the life history of this species. Most native freshwater mussels have glochidia in which the larvae must parasitize suitable host fishes. The adult mussels expel glochidia, which must attach to an appropriate host. The Altamaha Arcmussel is gravid beginning in mid-October, and glochidia have successfully transformed on the Robust Redhorse (*Moxostoma robustum*) and Striped Jumprock (*Moxostoma rupiscartes*); hence this species may be specialized in using Catostomids as its hosts (Johnson et al. 2012).

d. Range

The Altamaha Arcmussel was historically considered endemic to the Altamaha River Basin. However, recent collections of conchologically similar animals have been collected from the Ogeechee and Savannah Rivers (J. Wisniewski, GDNR, pers. comm.). The species is currently present in the Altamaha River, Ocmulgee River, the lower Oconee River, and also recently discovered in Lake Jackson, the impoundment of the LSHP (Appendix 5).

C. Inflated Floater

Pyganondon gibbosa (Say 1824), the Inflated Floater, was presumably described from South Carolina but the type specimen was lost. Johnson (1970) restricted the type locality to the Altamaha River, Hopeton, near Darien, McIntosh County, Georgia. The species has a thin, delicate, and greatly inflated shell. The species is elongate and elliptical in outline, with the anterior margin narrowly rounded, the posterior margin bluntly pointed to slightly truncate, and the ventral margin broadly rounded. The posterior ridge is narrowly rounded to angular. Umbos are inflated and elevated well above the hinge line and positioned anterior to the middle of the shell. A dorsal wing is present posterior to the umbo and very prominent on young individuals. The periostracum of this species is typically glossy green to brown, with or without fine rays. Pseudocardinal and lateral teeth are absent from both valves, the umbo cavity is moderately deep, and the nacre is white.

a. Habitat

The Inflated Floater has been most frequently captured in pools and slackwater areas in rivers and reservoirs with soft substrates of mud, silt, or fine sand, but has been infrequently found in other habitats (Meador et al. 2011).

b. Diet

Native unionids feed on phytoplankton, bacteria and particulate organic matter from the water column but diets may change throughout their lives (Vaughn and Hakenkamp 2001).

c. Life History

Little is known regarding the life history of this species. Most native freshwater mussels have glochidia in which the larvae must parasitize suitable host fishes. The adult mussels expel glochidia, which must attach to an appropriate host. The glochidial hosts for the Inflated Floater are currently unknown.

d. Range

The Inflated Floater is presumably endemic to the Altamaha Basin. However the species was originally described from a lost specimen collected in South Carolina and Johnson (1970) designated a Lectotype (a specimen later selected to serve as the single type specimen) and restricted it to the Altamaha River. This species has been found in the Ocmulgee River (including Lake Jackson in the LSHP), Ohoopee River, Oconee River (including Lake Oconee of the WHP), and the Altamaha River (J. Wisniewski, GDNR, 2015, pers. comm.) (Appendix 6).

D. Savannah Lilliput

Toxolasma pullus (Conrad 1838), the Savannah Lilliput, was described from the Wateree River, South Carolina. The shell is small, typically less than 35 millimeters in length, with valves that are somewhat thick and inflated. In females the anterior margin rounded and the ventral margin is straight to convex. In males the posterior margin is typically broadly pointed while more truncated or broadly rounded in mature females. The umbo typically elevates to the hinge line or slightly above and the periostracum is usually satiny and black or brown. The left valve has two triangular pseudocardinal teeth and short straight lateral teeth; the right valve has one triangular pseudocardinal tooth and one

lateral tooth. The umbo pocket is shallow with nacre that is variable in color, ranging from bluish-white to pink, purple, or iridescent.

a. Habitat

The Savannah Lilliput inhabits shallow waters at the edge of streams, rivers and lakes with mud or silty sand substrate near banks; they also may occur in backwaters. This species is rarely found in deep water (Bogan and Alderman 2008).

b. Diet

Native unionids feed on phytoplankton, bacteria and particulate organic matter from the water column but diets may change throughout their lives (Vaughn and Hakenkamp 2001).

c. Life History

Little is known regarding the life history of this species in the Altamaha River Basin. Most native freshwater mussels have glochidia in which the larvae must parasitize suitable host fishes. The adult mussels expel glochidia, which must attach to an appropriate host. The Savannah Lilliput is a long-term brooder, and has been reported gravid from late April to early August (Hanlon and Levine 2004). Glochidia have successfully transformed on hybrid sunfish (*Lepomis* sp.), thus transformation likely occurs on other species of *Lepomis* (Hanlon and Levine 2004).

d. Range

The range for this species is from the Altamaha River Basin in Georgia to the Neuse River Basin in North Carolina (Bogan and Alderman 2008). In Georgia, it is found within the Savannah, Ogeechee, and Altamaha Basins (Wisniewski 2008). It has most recently been collected from a slough in the lower Altamaha River and Alex Creek, a tributary to the lower Altamaha (J. Wisniewski, GDNR, 2012, pers. comm.; Dinkins 2007) (Appendix 7).

E. Reverse Pebblesnail

Somatogyrus alcoviensis (Krieger 1972), the Reverse Pebblesnail, is a freshwater snail historically known from two locations in Newton County, Georgia. The species is small and globose, often with a shell size of less than 3 mm. The species is distinguished from others similar to it by the shape and structure of the verge of their penis (J. Wisniewski, pers. comm. 2016).

a. Habitat

The Reverse Pebblesnail has been found in shoals with rapidly flowing water, on surfaces of gravel, cobble, boulder, and bedrock, as well as vegetation (*Podostemum ceratophyllum*). The species is absent from silty substrates (Watson 2000).

b. Diet

Little is known about the diet of the Reverse Pebblesnail, though members of the Hydrobiidae family often feed on algae, diatoms, and detritus found in their freshwater habitats (Wikipedia, accessed February 9, 2016).

c. Life History

Little is known regarding the life history of the Reverse Pebblesnail. Snails in Hydrobiidae are small in their juvenile state in spring, reaching maturity by early fall (J. Wisniewski, GDNR, 2016, pers. comm.).

d. Range

The Reverse Pebblesnail is known from two locations in Newton County, Georgia: the Alcovy River at Factory Shoals, and the Yellow River at Cedar Shoals. Observed by Watson (2000) in both of these locations, the species was confirmed at the Factory Shoals location most recently in 2012 by J. Wisniewski (GDNR, 2016, pers. comm.) (Appendix 8).

VI. THREATS TO THE SPECIES

Water demands are expected to increase in the future, posing a threat in the form of decreases in river flows, decreases in reservoir water level management flexibility, and/or increases in domestic wastewater effluent and construction of new impoundments. Dam operations can result in incompatible habitat and water quality for these freshwater mollusk species, as well as fragmentation of populations. Non-native, invasive species, such as the introduced Flathead Catfish (*Pylodictus olivaris)* and Blue Catfish (*Ictalurus furcatus*), may be reducing native mussel populations through direct consumption of mussels or consumption of their host fishes. Hybridization of the Savannah Lilliput with the Lilliput (*Toxolasma parvum*), which is invasive, could also be a possible threat. Land disturbance in riparian zones adjacent to mollusk habitats can negatively affect mollusks and their associated aquatic community. These impacts/threats can result from poorly maintained riparian buffers, direct impacts to riparian vegetation and soil stability such as unregulated use of all-terrain vehicles (ATVs), and erosion from poorly controlled excess point source run-off or soils impacted by cattle use. A variety of land-uses including poorly managed agriculture and silviculture can lead to excess sedimentation as well as introduction of herbicides and pesticides into aquatic systems. Riparian management and protection can help mitigate these threats. In addition, increased bacteria, pathogens, nutrient loads, and other pollutants in water systems can originate from animal waste and domestic wastewater systems. Because of these threats, increasing the understanding of the species' ranges, habitat requirements, taxonomy, and life histories of imperiled mollusk species in the Altamaha Basin is important. Protecting riparian buffer zones on GPC properties, educating landowners regarding the importance of riparian buffer zones, property runoff effects to water quality, and the ecosystem services provided by freshwater mussels, as well as suitably managing GPC reservoir water levels for freshwater mussels, generally, are measures in best management practices (BMP) that can be undertaken to alleviate threats to these imperiled species.

VII. CONSERVATION MEASURES

To accomplish the objectives of this Agreement, the Parties agree to undertake the conservation measures described herein. Actions taken under this Agreement are cooperative and voluntary, and subject to the limitations specified herein, and may help with the understanding of the habitat and life history requirements for these species, as well as alleviating threats to these species within the Altamaha River Basin.

A. Conservation Benefits

This agreement is expected to benefit the Delicate Spike, Altamaha Arcmussel, Inflated Floater, Savannah Lilliput, and Reverse Pebblesnail by implementing the following objectives:

Objective 1 - Increasing the understanding of the species' range, habitat requirements, taxonomy, and/or life histories.

Through this objective, the Parties will ensure that surveys are conducted to determine the extent of these species' distributions in the Altamaha River Basin, especially in the vicinities of the GPC project areas described in this Agreement. Molecular research will be conducted to resolve taxonomic uncertainties and host fish research will be conducted to determine the fish species used in the development and dispersal for all four focal mussel species. Drawdown rate studies will be conducted for the mussel species in this Agreement that inhabit the GPC impoundments.

Objective 2 - Implementing conservation measures to conserve existing populations of these species within GPC's project areas in the Altamaha River Basin.

Through this objective the Parties will ensure that management actions are achieved, including but not limited to conserving lands that will include effective riparian buffers, implementing best management practices for forestry lands, implementing appropriate impoundment drawdown rates and restricting riparian access for ATVs at GPC projects described in this Agreement.

The Parties believe these objectives, specific to this Agreement, are reasonable and that they will help to reduce threats, contributing to the long-term conservation of the species. They will be accomplished through implementation of specific conservation actions, described below.

B. Conservation Actions

There are three primary categories of conservation actions for freshwater mollusks listed in this CCA. Those categories represent tasks to be distributed among field, laboratory, and watershed-based activities. Field-based tasks include conducting intensive searches for species occurrence used ultimately to document geographic distribution and habitat use. Laboratory-based tasks include molecular genetics research and conducting host fish trials and life history studies to result in ecological characterization and taxonomic distinction. Watershed-based tasks include management actions protective of riparian habitat that in turn will be protective of mollusks and associated aquatic organisms as appropriate throughout the Project Site. Those actions are represented by implementation of forestry/riparian zone BMPs including access restriction for ATVs, establishment and protection of expanded riparian buffers, and, potentially, modified GPC reservoir drawdown rates in the long-term depending on results of drawdown studies. In each case, shoreline/riparian zone habitats will be the focus of watershed tasks as guided by adaptive management needs through time.

For each species, and as appropriate through consultation with Service and GDNR, the geographic extent of mollusk surveys and conservation actions is intended as shown in Table 1.

Table 1. Geographic extent of surveys and conservation actions in each Project Area.

Project Areas	Geographic Extent
LSHP	Shoreline segments within FERC project boundary and free flowing reaches of the Ocmulgee River downstream
WHP	Shoreline segments within FERC project boundary
SHP	Shoreline segments within FERC project boundary and free flowing reaches of the Oconee River downstream
HNP	Free flowing reaches of the Altamaha River in the vicinity of the facility
PSP	Rum Creek WMA, shoreline segments of Lake Juliette, and free flowing reaches of the Ocmulgee River in the vicinity

The Project Site encompasses a broad area with specific long-term research objectives designed to aid conservation for the freshwater mollusks listed herein. Unlike some of the research conservation actions that involve a one-time cost that can be achieved during the first few years of implementation, surveys would be conducted throughout the full term of this Agreement. This Agreement's 30-year schedule, shown in Table 2, allows for available funds and personnel resources to be utilized in a manner that results in one annual survey each for all project areas every five years (5-year rotation).

Table 2. Designated years of annual conservation actions for each Project Area.

Project Areas	Survey Years
LSHP	2018, 2023, 2028, 2033, 2038, 2043
PSP	2019. 2024, 2029, 2034, 2039, 2044
HNP	2020, 2025, 2030, 2035, 2040, 2045
SHP	2021, 2026, 2031, 2036, 2041, 2046
WHP	2022, 2027, 2032, 2037, 2042, 2047

Conservation Need by Species

a. Delicate Spike

Updated surveys should be conducted to determine this species' distribution in the Altamaha River Basin. Collections should be made during these surveys so that the taxonomy of the Delicate Spike can be investigated to determine if individuals collected from the Altamaha River Basin (Atlantic Slope drainage) are the same species as those from the Apalachicola River Basin and the Mobile Basin (Gulf Slope drainages). Host fish trials should also be conducted. Conducting species occupancy surveys in the upper Altamaha River Basin and a taxonomic review of this species in the Altamaha River Basin were identified as priority inventory and research needs in the 2015 Georgia State Wildlife Action Plan (SWAP). The conservation of this species will benefit from implementation of riparian best management actions, as described below.

1. Updated surveys in the Altamaha River Basin in riverine locations, especially in vicinity of the Project Site, should be conducted on a repeating five-year study area rotation as described above. Once the 5-year rotation is completed, the cycle will be repeated an additional five times during the 30-year duration of this Agreement. The survey design will follow recently applied intensive survey methods for mollusks as currently accepted by GDNR Nongame and Service.

2. Use tissue material from the individuals collected in the surveys mentioned above to genetically determine if the species in the Mobile, Apalachicola, and Altamaha River Basins is the Delicate Spike in the separate drainages.

3. Conduct laboratory host fish trials to determine the fish species used in development and dispersal.

4. Implement management actions on Project Site riverine shorelines in the Altamaha River Basin, including forestry BMPs on GPC upland bulk properties, restricted access of ATVs, and expanded riparian buffers (≥ 100 feet) on GPC-owned non-privately leased, non-developed lands for at least a minimum of the 30-year duration of this Agreement.

b. Altamaha Arcmussel

Updated surveys should be conducted to determine this species' distribution in the Altamaha River Basin. Collections should be made during these surveys so that the taxonomy of the Altamaha Arcmussel can be investigated to determine if individuals collected from the Altamaha River Basin are the same species as those from the Ogeechee and Savannah River Basins. Host fish trials should also be conducted. Drawdown rates should be studied to determine the effects to this species in GPC's lacustrine Project Sites and the rates adjusted, if warranted. Riparian buffers should be protected to avoid unnecessary bank disturbance and nutrient runoff as this species often is found in shallow areas near the water's edge. This species is in need of riparian BMPs as described below. In developed, lacustrine areas, environmental review for shoreline structure permitting requirements should be further developed.

The 2015 Georgia State Wildlife Action Plan identified several priority actions for the conservation of this species: 1. Conduct an occupancy survey of the Oconee and Ocmulgee

Rivers and those reservoirs located on them; 2. Resurvey the Altamaha River using the occupancy design utilized by Meador (2008) to assess population trends in approximately 2016-2018; 3. Work with reservoir managers to control the rate of reservoir drawdown to allow for mussels to track receding water; 4. Conduct basic life-history studies; and 5. Develop propagation and culture techniques (GDNR 2015).

This CCA will accomplish those actions through the following activities:

1. Updated surveys in both riverine and lacustrine locations within the Altamaha River Basin, especially in vicinity of the Project Site, should be conducted on the repeating five-year study area rotation described above. Once the 5-year rotation is completed, the cycle will be repeated an additional five times during the 30-year duration of this Agreement. The survey design will follow recently applied intensive survey methods for mollusks as currently accepted by GDNR Nongame and Service.

2. Use tissue material from the individuals collected in the surveys mentioned above to genetically determine if the species in the Altamaha, Ogeechee, and Savannah River Basins is the Altamaha Arcmussel in the separate drainages.

3. Conduct laboratory host fish trials to determine the fish species used in development and dispersal.

4. Study the effects of operational and drought-related, reservoir drawdown rates on Altamaha Arcmussel movement. Results from *in-situ* studies will be evaluated by parties of this agreement. As mutually agreed, additional technical expertise may be invited into the studies to assist in determining how and to what level of significance drawdown rate management can benefit Altamaha Arcmussel under normal operational and drought-caused constraints. Since the construction of lake level management enhancements at LSHP in 2013, the facility conducts reservoir drawdown once every 3 years as compared to annually prior to 2013. Implementation of drawdown studies will be made in concert with normal cycles of reservoir operations (i.e., drawdowns) and consistent with terms of the FERC license.

5. As applicable to GPC-owned or GPC-permitted homeowner lake properties, conditions provided in GPC's homeowner permitting program (construction, dredging, etc.) that address protection of protected species and/or their critical habitats will be followed.

6. Implement management actions on Project Site riverine shorelines in the Altamaha River Basin, including forestry BMPs on GPC upland bulk properties, restricted access of ATVs, and expanded riparian buffers ($\geq$ 100 feet) on GPC-owned non-privately leased,

non- developed lands for at least a minimum of the 30-year duration of this Agreement.

c. Inflated Floater

Updated surveys should be conducted to determine this species' distribution in the Altamaha River Basin. Collections should be made during these surveys so that the taxonomy of the Inflated Floater can be investigated. Host fish trials should also be conducted. Drawdown rates should be studied to determine the effects to this species in GPC's lacustrine Project Sites and the rates adjusted, if needed. Riparian buffers should be protected to avoid unnecessary bank disturbance and nutrient runoff as this species often is found in shallow areas near the water's edge. Conservation for this species will benefit from implementation of riparian BMPs as described below. In developed, lacustrine areas, environmental review for shoreline structure permitting requirements should be further developed.

1. Updated surveys in both riverine and lacustrine locations within the Altamaha River Basin, especially in vicinity of the Project Site, should be conducted on the repeating five-year study area rotation described above. Once the 5-year rotation is completed, the cycle will be repeated an additional five times during the 30-year duration of this Agreement. The survey design will follow recently applied intensive survey methods for mollusks as currently accepted by GDNR Nongame and Service.

2. Use tissue material from the individuals collected in the surveys mentioned above to genetically determine if the Inflated Floater is in fact a separate species from the Eastern Floater (*Pyganodon cataracta*).

3. Conduct laboratory host fish trials to determine the fish species used in development and dispersal.

4. Study the effects of drawdown rates on Inflated Floater movement if in GPC lakes subject to drawdown management practices. Results from *in-situ* studies will be evaluated by parties of this agreement. As mutually agreed, additional technical expertise may be invited into the studies to assist in determining how and to what level of significance drawdown rate management can benefit Inflated Floater under normal operational and drought-caused constraints.

5. As applicable to GPC-owned or GPC-permitted homeowner lake properties, conditions provided in GPC's homeowner permitting program (construction, dredging, etc.) that address protection of protected species and/or their critical habitats will be followed.

6. Implement management actions on GPC's Project Sites in the Altamaha River Basin, including the implementation of forestry BMPs on GPC non-developed uplands, restricted access of ATVs, and expanded riparian buffers ($\geq$ 100 feet) on GPC-owned non-privately leased, non-developed lands for at least a minimum of the 30-year duration of this Agreement.

d. Savannah lilliput

Updated surveys should be conducted to determine this species' distribution in the Altamaha River Basin. Host fish trials should also be conducted. Riparian buffers should be protected to avoid unnecessary bank disturbance and nutrient runoff as this species often is found in shallow areas near the water's edge. Conservation of this species will benefit from implementation of riparian BMPs as described below. If the species is located in developed, lacustrine areas, shoreline permitting requirements should be further developed for reservoir structures conditioned for additional environmental review. Drawdown rates should be studied to determine the effects to this species in GPC's lacustrine Project Sites and the rates adjusted, as needed.

Destruction of habitat for the Savannah Lilliput by ATVs during exceptional drought was identified as a contributing reason for the decline of the species in the Ohoopee River (Stringfellow and Gagnon 2001). The 2015 Georgia State Wildlife *Action* Plan identified several priority conservation actions for this species: 1. Sample the lower reaches of the Altamaha and Ocmulgee Rivers with concentrations on backwater slough habitats connected to the rivers; 2. Manage instream flows for the species in the Savannah River and Altamaha River in the vicinity of Plant Hatch; 3. Identify suitable host fishes; and 4. Investigate the status and effects of the invasive Lilliput (*Toxolasma parvum*) on existing populations (i.e. hybridization, competition, etc.; GDNR 2015) along the waterway margins and in floodplain impoundments.

This CCA will accomplish those actions through the following activities:

1. Updated surveys in both riverine and lacustrine locations within the Altamaha River Basin, especially in vicinity of the Project Site, should be conducted on the repeating five-year study area rotation described above. Once the 5-year rotation is completed, the cycle will be repeated an additional five times during the 30-year duration of this Agreement. The survey design will follow recently applied intensive survey methods for mollusks as currently accepted by GDNR Nongame and Service.

2. Use tissue material from the individuals collected in the surveys mentioned above to genetically determine if hybridization is occurring between the Savannah Lilliput and the non-native Lilliput.

3. Conduct laboratory host fish trials to determine the fish species used in development and dispersal.

4. If the Savannah Lilliput is located in a GPC lacustrine Project Site, study the effects of GPC lakes subject to drawdown management practices on its movement. Results from *in-situ* studies will be evaluated by parties of this agreement. As mutually agreed, additional technical expertise may be invited into the studies to assist in determining how and to what level of significance drawdown rate management can benefit Savannah Lilliput under normal operational and drought-caused constraints.

5. If the Savannah Lilliput is located in a GPC lacustrine Project Site, conditions provided in GPC's homeowner permitting program (construction, dredging, etc.) that address protection of protected species and/or their critical habitats will be followed.

6. Implement management actions on GPC's Project Sites in the Altamaha River Basin, including the implementation of forestry BMPs on GPC non-developed uplands, restricted access of ATVs, and expanded riparian buffers (≥ 100 feet) on GPC-owned non-privately leased, non-developed lands for at least a minimum of the 30-year duration of this Agreement.

e. <u>Reverse Pebblesnail</u>

Updated surveys should be conducted to determine this species' distribution in the Altamaha River Basin. Collections should be made during these surveys so that the taxonomy of the Reverse Pebblesnail can be confirmed and distinguished from closely related species in the *Somatogyrus* genus.

1. Updated surveys in riverine locations within the Altamaha River Basin, especially in vicinity of the Project Site, should be conducted on the repeating five-year study area rotation described above. Once the 5-year rotation is completed, the cycle will be repeated an additional five times during the 30-year duration of this Agreement. The survey design will follow recently applied intensive survey methods for mollusks as currently accepted by GDNR Nongame and Service.

2. Use tissue material from the individuals collected in the surveys mentioned above to genetically determine if the species is distinct from *Somatogyrus* spp. found in the separate drainages.

VIII. NOTICES AND REPORTS

The following reporting guidelines will be used by the Parties of this Agreement to evaluate the implemented conservation actions outlined in section VII, "Conservation Measures".

GPC will ensure that the reports for contracted services are provided to the Parties and Cooperators of the Agreement after completion. In addition, GPC will prepare a comprehensive evaluation report after the end of each rotational five-year freshwater mollusk survey cycle and submit the report to the Service and Cooperators to this Agreement before 1 April of the following year; comprehensive evaluation reports will include a summary of field, watershed, and laboratory-based conservation actions. The frequency of submitting evaluation reports can be modified, if conditions warrant and all Parties agree. Any reports will provide the basis for a joint decision by the Parties as to whether the Agreement should be extended for another term.

In the event that any of the Parties to this Agreement determine that there are adverse conditions that may affect the success of the conservation measures of the species defined in this Agreement, such conditions will be reported to all the Parties.

Any notices and reports required by this Agreement shall be delivered to the persons listed in section II, at a minimum and as appropriate.

IX. ADAPTIVE MANAGEMENT

All Parties signing this agreement recognize that implementation of conservation actions must be consistent with the concepts and principles of adaptive management. The effectiveness of the voluntary conservation actions, monitoring methods/results, and new technologies will be reviewed by the Service and GDNR with GPC on an on-going/as-needed basis. Upon evaluation, appropriate modifications to the conservation actions or removal of actions described in this CCA may be necessary to enhance the goals of the effort as appropriate. Nothing in this agreement will limit GPC's ability to pursue modification from a CCA to a CCAA as driven by research discovery toward potential future interest in protecting mollusks in the Altamaha Basin.

GPC, its successors and assigns, expressly reserves the right to install, construct, reconstruct, replace, improve, upgrade, enhance, maintain, operate, use, repair, add on to, demolish, and or otherwise develop the property subject to this Agreement. Nothing contained herein shall be construed as limiting or affecting in any way, except as to wildlife conservation, the authority of the GPC in connection with the property subject to this Agreement.

Applying adaptive management generally follows six steps including:

a. problem assessment

b. design

c. implementation

d. monitoring

e. evaluation, and

f. adjustment.

Application of this process can enable a structured and thoughtful approach to adaptively manage in a manner that effectively deals with unforeseen problems and change.

This agreement may be revised as a result of adaptive management, provided all parties agree to the changes, to continue providing conservation benefits for the freshwater mollusk species described herein. A goal of this CCA is to ensure adequate conservation measures and sufficient adaptive management following the effective date of any decision to list mollusk species subject to this agreement.

X. FUNDING CONSERVATION ACTIONS

Funding for the field-based Conservation Actions, both in the form of monetary and in-kind services, will be provided by GPC in a manner that supports the 5-year repeating rotational cycle for the term of this Agreement, as set forth in the Conservation Actions section.

GPC will annually fund approved field-based conservation actions at level not to exceed $44,500 for the duration of this agreement. Additionally, GPC will fund laboratory-research tasks during the life of the agreement period up to a cumulative total of $150,000. In terms of labor and monetary expense, field-based tasks will comprise the bulk of total conservation effort actions each year.

Field-based work will be planned in coordination with GDNR and Service. To accomplish the field tasks, GPC will annually hire the services of a qualified mussel survey contractor/firm. GDNR, Service and GPC biologists will always be invited to participate in the surveys or in an oversight role. The selected contractor must be recognized as qualified by GDNR and the Service. Field-based tasks will be managed by GPC. Principal surveyors must have appropriate State and Federal permits authorizing collection of species listed in this agreement.

Laboratory-based work will include molecular genetics research, host fish trials and drawdown studies. It is anticipated that laboratory-based research needs will evolve at a pace that chronologically tracks along with progress realized from discovery and genetic sample material collections from field-based studies. Scopes of work desired for laboratory research will be collectively planned as far ahead as practical in coordination among GPC, GDNR and Service. GPC will contract the agreed scopes of lab work with a qualified research laboratory(ies). Qualified labs will be chosen as candidates for the work by GPC as guided by recommendations from GDNR and Service.

GPC will directly bear the cost of watershed-based tasks which include conservation management actions protective of riparian habitat as described above in Section VII "Conservation Actions" throughout the life of this agreement.

Additional resources may be applied to this project from other sources, but these are outside the scope of this Agreement. The Service has provided technical assistance in the Agreement and in providing in-kind services described herein.

Nothing in this Agreement will be construed by the Parties to require the obligation, appropriation, or expenditure of any funds from the U.S. Treasury. The Parties acknowledge that the Service will not be required under this Agreement to expend any Federal agency's appropriated funds unless and until an authorized agency official affirmatively acts to commit such expenditures as evidenced in writing.

XI. DURATION

A. Term

This Agreement will be in effect for the duration of 30 years following its approval and signing by the Parties, subject to the limitations specified herein (see Section XII regarding compliance with existing FERC license obligations). The agreement commencement date will begin the day after receipt of completed authorized signatures.

B. Continuation

After this initial time period, further conservation and management efforts for the species may be addressed through an extension of this Agreement. A continuation of this Agreement must be made in writing and signed by all Parties.

C. Early Termination

If some portion of this Agreement cannot continue to be carried out or if cancellation is desired, GPC will notify the Service within 30 days of the changed circumstances. GPC will remain responsible for any outstanding conservation actions identified in section VI "Conservation Measures" until the early termination date is effective.

The Service may withdraw from this Agreement at any time by submitting a letter with 60 days' notice indicating the desire to terminate the Agreement. The Service will remain responsible for any outstanding conservation actions identified in Section VI, "Conservation Measures" until the early termination date is effective.

XII. COMPLIANCE

A. Federal Energy Regulatory Commission Compliance

Lands owned by GPC contemplated under this Agreement lie within the FERC project boundaries for the LSHP, SHP, and WHP. The current license for the LSHP expires on December 31, 2023, the SHP on April 30, 2036, and the WHP on May 31, 2020 (currently undergoing relicensing at the time of activation of this agreement). GPC operates and manages these hydropower projects in accordance with the terms of its FERC licenses and the applicable rules and regulations of FERC. No terms specified within this Agreement obligates GPC to take actions that may be inconsistent with the terms of their existing FERC licenses. Moreover, the Parties to this Agreement recognize that FERC has authority for the operation of these hydropower projects and may within its authority order GPC to take actions that could at any time affect the existing populations of these five mollusk species and the terms specified in this Agreement. As a Federal agency, FERC actions are subject to consultation requirements under section 7 of the ESA, as well as its own implementing guidance, including designation of a non-federal representative to conduct informal consultation and/or to prepare any biological assessment (50 CFR § 402.02).

B. Nuclear Regulatory Commission Compliance

Lands owned by GPC contemplated under this Agreement lie within the NRC project boundary for Plant Hatch. The current license for Plant Hatch expires in 2022. GPC operates and manages this nuclear project in accordance with the terms of its NRC license and the applicable rules and regulations of NRC. No terms specified within this Agreement obligates GPC to take actions that may be inconsistent with the terms of their existing NRC license. Moreover, the Parties to this Agreement recognize that NRC has authority for the operation of Plant Hatch and may within its authority order GPC to take actions that could at any time affect the existing populations of these mollusk species and the terms specified in this Agreement. As a Federal agency, NRC actions are subject to consultation requirements under section 7 of the ESA, as well as its own implementing guidance, including designation of a non-federal representative to conduct informal consultation and/or to prepare any biological assessment (50 CFR § 402.02).

XIII. SIGNATURES

IN WITNESS WHEREOF, THE PARTIES AND COOPERATOR have, as of the last signature date below, executed this Agreement to be in effect.

8/31/17

Mark Berry, PhD Date
Vice President, Environmental Affairs
Georgia Power Company

8/31/17

Leopoldo Miranda Date
Assistant Regional Director, Ecological Services
Southeast Region
U.S. Fish & Wildlife Service

8/31/17

Rusty Garrison Date
Director, Wildlife Resources Division
Georgia Department of Natural Resources

APPENDIX 1. REFERENCES

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WETLAND PLANT COMMUNITIES
OF THE LLOYD SHOALS HYDROELECTRIC PROJECT

CONTAINS PRIVILEGED INFORMATION-
DO NOT RELEASE

Commerical and
Financial Information —
Privileged and Confidential

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Atlanta, Georgia

February 1989

INTRODUCTION

The following report is a partial requirement for Federal Energy Regulatory Commission's relicensing of Georgia Power Company's Lloyd Shoals Hydroelectric Project. This report presents the findings of a field study of the wetland plant communities of the project area. Field work for this study was carried out from May through September of 1988. Field studies were conducted by boat and on foot.

A master map (in two sheets) of Lake Jackson and its surrounding wetlands and several U. S. Geological Survey quadrangles on which wetlands are mapped accompany this report. The master maps were compiled from black and white infrared aerial photographs taken in December of 1988. Greg Gerlach of the Georgia Power Company Lloyd Shoals land office was especially helpful in acquiring the aerial photographs.

PLANT COMMUNITIES

Six wetland plant community/cover types were identified from the Lloyd Shoals project area: 1) Floodplain Forest; 2) Water Tupelo-Overcup Oak; 3) Willow-Shrub; 4) Alluvial/Deltaic Flat (included in the Shrub-Nonwoody Emergents-Bare Soil type on the wetland map); 5) Non-woody Emergent Communities; and 6) Floating Aquatic. It is estimated that wetland communities occupy about 15 percent of the Lake Jackson shoreline in natural vegetation. (Residential, commercial, and agricultural areas within the project boundary were excluded from consideration here.) The wetland types, with the exception of the Alluvial/Deltaic Flat type and the Water Tupelo-Overcup Oak type are generally found on the upper reaches of the lake along Tussahaw Creek, the Yellow, South, and Alcovy Rivers. A discussion of each community/cover type is given below with the estimated percentage of the total wetland area given.

1. Floodplain Forest (45%). The Floodplain Forest type included all forested stands found on floodplains. Pines were rare in this type and, when present, made up less than 2 percent of the canopy cover. Green ash (*Fraxinus pennsylvanica*), red maple (*Acer rubrum*), and sweet gum (*Liquidambar styraciflua*) were dominant in the canopy. Water oak (*Quercus nigra*), loblolly pine (*Pinus taeda*), tulip poplar (*Liriodendron tulipifera*), and

Florida maple (Acer barbatum) were rarely seen. The understory is dominated by box elder (Acer negundo) and red maple. Along the water's edge, river birch (Betula nigra) and willow (Salix nigra) are usually dominant. Occasionally, water tupelo (Nyssa aquatica) and overcup oak (Quercus lyrata) were found in standing water along the edge of the Willow-Shrub community (discussed below). See Figure 1, Cross-Section of the Wetlands of the Yellow River and master wetlands maps.

The Floodplain Forest type is common along the South, Yellow, and Alcovy Rivers and along Tussahaw Creek. Although this type covers only about 7 percent of the total Lloyd Shoals project area, it is the most widespread wetland type, representing about 45 percent of the total wetland area (see Table 1). [The National Wetlands Inventory designation for this type is Palustrine, Forested, Deciduous, Seasonally Flooded (Cowardin et al., 1979)].

2. Water Tupelo-Overcup Oak (3%). In this community/cover type, water tupelo is the dominant with overcup oak nearly as common. Occasionally, red maple and buttonbush (Cephalanthus occidentalis) are mixed with water tupelo and overcup oak. Both of these latter two species are primarily Coastal Plain species and are uncommon in the Piedmont. This type occurs in standing water along the lake's edge, usually near the Alluvial/Deltaic Flat type (see below). This type occupies less than one-half percent of the total project area and about three percent of the total wetland area. [National Wetlands Inventory designation--

Palustrine, Forested, Deciduous, Intermittently Exposed (Cowardin et al., 1979)]. See Figure 2.

3. Willow-Shrub (12%). This woody community/cover type occurs on recently-deposited sand and mud bars. Willow (*Salix nigra*) is overwhelmingly dominant, but river birch, red maple, green ash, alder (*Alnus serrulata*) (in muddier areas), and buttonbush also occur here. The community is very young; rarely do any of its dominant species reach over 30 feet tall. The Willow-Shrub community usually grades into the Non-Woody Emergent type (see below) or into open sand or mud bars. In Figure 1, this community is called willow-buttonbush and river birch-willow. [National Wetland Inventory designation--Palustrine, Shrub-Scrub, Deciduous, Seasonally Flooded (Cowardin et al., 1979)].

4. Alluvial/Deltaic Flat (12%). This type is found where small creeks flow into Lake Jackson. At the point where the creek empties into the lake, sediment has been deposited over the years, resulting in an alluvial or deltaic wetland. Several of the above communities are usually found here. Figure 2 portrays the "average" community found on this topographic feature. In the figure, one can see that the Floodplain Hardwood, the Water Tupelo-Overcup Oak, the Willow-Shrub, and the Non-Woody Emergent types all are found on the Alluvial/Deltaic flat. However, it is considered a separate type because of its uniqueness and because the communities involved would be impossible to map as separate communities. On the master wetland

maps, this community is mapped under the catch-all designation of Shrub-Nonwoody Emergents-Bare Soil (some areas which are not Alluvial/Deltaic flats but with similar vegetation are included in this type). [National Wetlands Inventory designation--Palustrine, Forested, Deciduous, Seasonally Flooded or Intermittently Exposed (Cowardin et al., 1979)].

5. Non-Woody Emergent Communities (25 %). This type consists of non-woody wetland species and constitutes what is often referred to as "marsh." It is found along the water's edge on mudflats and sandbars and is the first community to invade recently-exposed or -deposited sandbars or mudflats. The largest areas of this community/cover type are found along the South and Yellow Rivers (see master wetland maps and Figure 1). [National Wetlands Inventory designation--Palustrine, Non-Forested, Emergent, Non-Persistent, Seasonally/Intermittently Flooded. (Cowardin et al., 1979).]

In reality, this type is made up of several communities. The wool-grass bulrush community (*Scirpus cyperinus*) is one of the most widespread communities in this type, but there are many more. Stands of pure cattails (*Typha latifolia*) are often found. On the upper South River in drawndown pools, pure stands of knotweed (*Polygonum punctatum*) covering several acres were found. Large colonies of common needlerush (*Juncus effusus*) were encountered on alluvial mudflats, and on wet sandbars, small stands of Virginia cutgrass (*Leersia virginica*) were found. The following species were noted in Lake Jackson Non-Woody Emergent wetlands: rice cutgrass (*Leersia oryzoides*), climbing hempweed (*Mikania* scandens), Walter's cockspur grass (Echinochloa walteri), duck potato (Sagittaria latifolia), alternate-leaved seedbox (Ludwigia alternifolia), blunt spikerush (Eleocharis obtusa), marshmallow (Hibiscus moscheutos), arrow-leaved knotweed (Polygonum sagittatum), false nettle (Boehmeria cylindrica), fringed sedge (Carex crinita), pointed broom sedge (Carex scoparia), sallow sedge (Carex lurida), flat-sedge (Cyperus sp.), and panic grasses (Panicum spp.). Table 2 lists the communities that make up the Non-Woody Emergent type.

6. Floating Aquatic (3%). The Floating Aquatic type consists of communities that are found floating on the surface of the water. The roots of the plants in these communities are not attached to the bottom; therefore, these communities have a tendency to move around from time to time. The Floating Aquatic community is found primarily along the South and Yellow Rivers. This community is dominated by alligator weed (Alternanthera philoxeroides) with duckweeds (Lemna sp. and Spirodela sp.) intermixed in the alligator weed. These floating aquatic vascular plants grow in calm, shallow waters in old river channels, oxbows, and in sheltered coves. [National Wetlands Inventory designation--Lacustrine, Aquatic Bed, Vascular, Permanently Flooded (Cowardin et al., 1979).]

LLOYD SHOALS (LAKE JACKSON) WETLAND MAPS

Master maps of the wetland plant communities of the Lloyd Shoals project are attached to this report. On the master maps, five types are recognized: Forest, Shrub, Mixed Shrub-Forest, Shrub-Nonwoody Emergents-Bare Soil, and Nonwoody Emergents-Bare Soil. The Forest type is equivalent to the Floodplain Forest designation discussed earlier. The Shrub type represents the Willow-Shrub community/cover type, and the Mixed Shrub-Forest type was created for mapping transitional zones between the Forest and Shrub types. The Shrub-Nonwoody Emergents-Bare Soil type encompasses the Alluvial/Deltaic Flat community/cover type, as well as including shrub-marsh-bare soil communities found in other topographic situations (e.g., islands, etc.). Finally, the Nonwoody Emergents-Bare Soil type is equivalent to the Nonwoody Emergent Communities discussed earlier. The Floating Aquatic community/cover type, also mentioned earlier, was not mapped due to its absence on winter aerial photography.

Unfortunately, the December, 1987 black and white infrared photography coverage of the project was not complete. Several sizeable wetlands on the upper South and Yellow Rivers were not photographed; therefore, these wetlands had to be mapped on U. S. Geological Survey topographic maps, which are also attached to this report.

In conclusion, the Lloyd Shoals project has a much greater diversity of wetland plant communities than most Piedmont reservoirs. The wetlands on the upper South and Yellow Rivers are especially diverse and scenic.

Table 1. Plant community/cover types of the Lloyd Shoals project.

COMMUNITY/COVER TYPE[1]	ESTIMATED % OF PROJECT AREA[2]
Mixed Pine	25
Pine-Mixed Hardwood	35
Mixed Hardwood-Pine	15
Mixed Hardwood	10
Floodplain Hardwood	7
Water Tupelo-Overcup Oak	<1
Willow-Shrub	2
Alluvial/Deltaic Flat	2
Non-Woody Emergent Communities	4
Floating Aquatic	<1

[1] Some of these types are composed of several communities which were grouped for mapping purposes. Residential, commercial, and agricultural areas within the project boundary were excluded from consideration here.

[2] These estimates are rough and are for comparison only.

Table 2. Communities of the Non-Woody Emergent type.

COMMUNITY	ASSOCIATED TOPOGRAPHY	SPECIES
Wool-grass bulrush	Depressions on sandbars	*Scirpus cyperinus*
Cattail	Shallow, standing water	*Typha latifolia*
Knotweed	Drawndown pools	*Polygonum punctatum*
Common needlerush	Mudflats	*Juncus effusus*
Virginia cutgrass	Wet sandbars	*Leersia virginica*
Mixed species wetland	Various topography	No dominant plant

FIGURE 1

CROSS-SECTION OF THE WETLANDS OF THE YELLOW RIVER

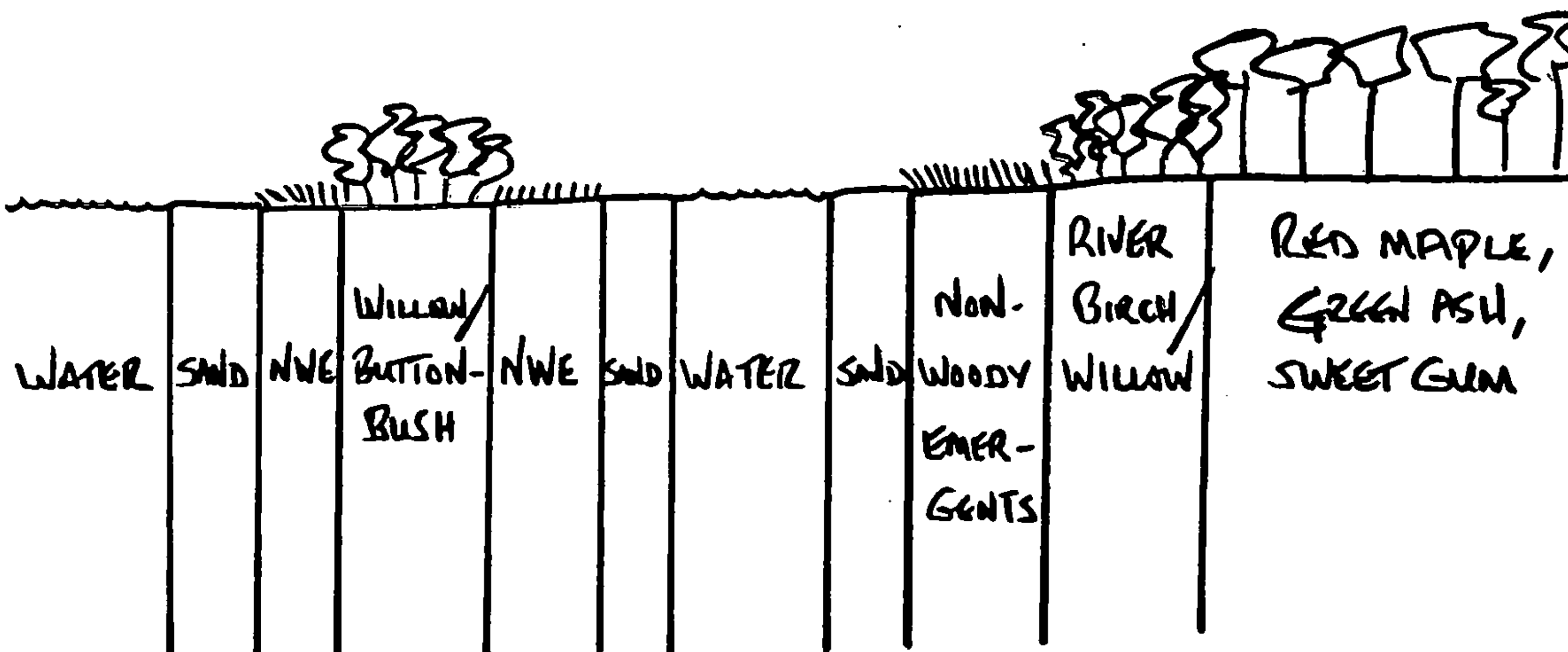
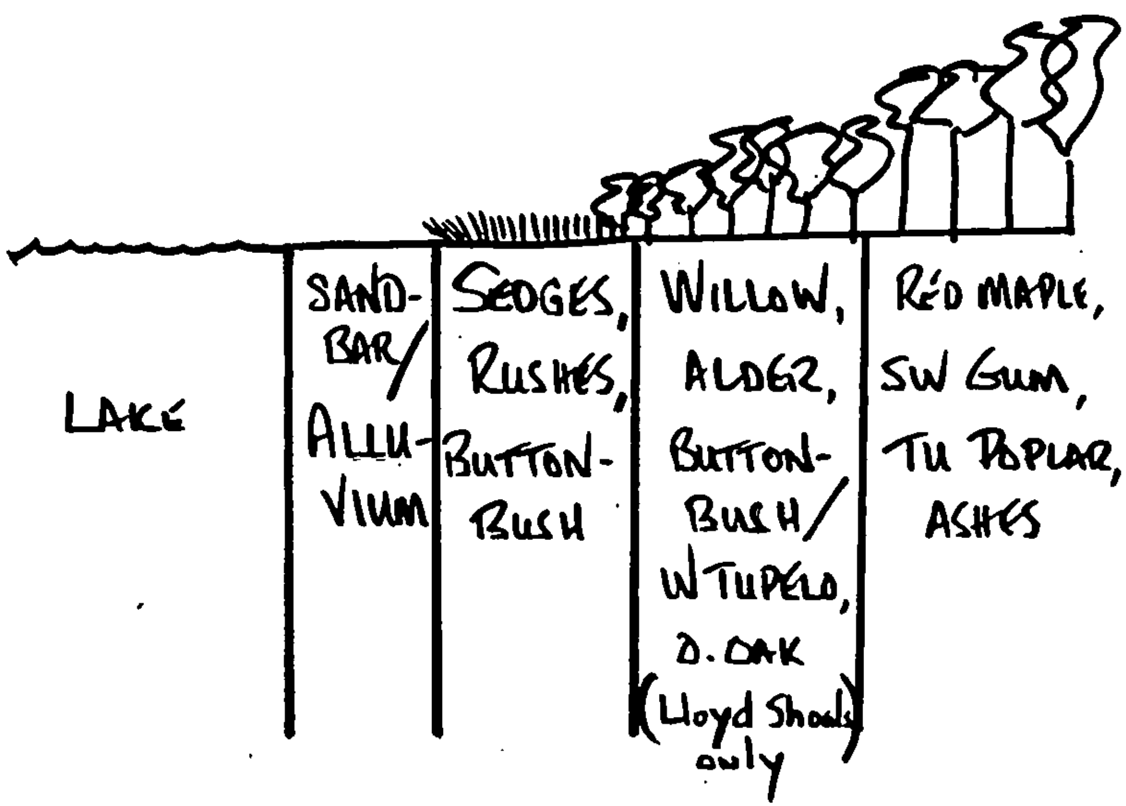


FIGURE 2

CROSS-SECTION OF

ALLUVIAL/DELTAIC WETLANDS



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THE ATLANTA REGION'S PLAN

REGIONAL RESOURCE PLAN

REVISED 10.6.2015

ATLANTA REGIONAL COMMISSION

Contents

Cover Photo: Sope Creek Ruins - Chattahoochee River National Recreation Area/ Credit: ARC

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Regional Resource Plan Executive Summary

The Purpose. Pursuant to Rules of the Department of Community Affairs, Chapter 110-12-4, Regionally Important Resources are defined as *"any natural or cultural resource area identified for protection by a Regional Commission following the minimum requirements established by the Department."* The Regional Resource Plan is designed to

- Enhance the focus on protection and management of important natural and cultural resources in the Atlanta region.
- Provide for careful consideration of, and planning for, impacts of new development on these important resources.
- Improve local, regional, and state level coordination in the protection and management of identified resources.

The Process. The public nomination process in 2009 resulted in over 150 nominations from local governments, non-profit agencies, and private citizens. Many of these nominations included multiple resources, resulting in the consideration of hundreds of individual resources. Beyond the nomination process, numerous opportunities were created for stakeholder input through plan briefings and presentations. After reviewing all nominations, researching the work of other local, state, and federal agencies, and considering input from regional stakeholders, three categories of resources were identified.

- Areas of Conservation and/or Recreational Value
- Historic and Cultural Resources
- Areas of Scenic and/ or Agricultural Value

Using DCA's Rules for Regionally Important Resources, as well as six criteria approved by the ARC Board, resources were evaluated in regard to their *Value and Vulnerability* within the context of the Atlanta Region. Consideration is also given to *Guidance for Appropriate Development Practices* and *General Policies and Protection Measures* to promote the stewardship of these resources. To this end, ARC has identified general *Management Strategies* to guide its involvement in the stewardship of these resources and support the work of local governments in developing their community green infrastructure network.

The Plan. Ultimately, the plan will be used to *"…coordinate activities and planning of local governments, land trusts and conservation or environmental protection groups' activities in the region, and state agencies toward protection and management of the identified Regionally Important Resources.*[1]*"* In addition to the work that ARC has done with mapping the Region's Greenspace Inventory and developing a Green Infrastructure Toolkit, the Regional Resources Plan furthers the work being done on the local, regional, state and federal levels to preserve environmental resources, historic sites, and unique cultural landscapes. With the articulated goal of fostering a continuous green infrastructure network[2], the Regional Resource Plan promotes balanced growth and sustainable development practices to enhance the quality of life in communities throughout the region.

1 Rules of the Department of Community Affairs, Chapter 110-12-4, *Regionally Important Resources*, §110-12-4-.01(2)(d)
2 Ibid., §112-12-4-.02(2)(a)5

Summary of Resources

Areas of Conservation and/ or Recreational Value	
State Vital Areas	Large Water Supply Watersheds
	Small Water Supply Watersheds
	Groundwater Recharge Areas
	Wetlands
	River Corridors
	Mountain Protection
Regional Reservoirs	Lake Allatoona
	Lake Lanier
National Park Service Sites	Chattahoochee River National Recreation Area
	Kennesaw Mountain National Battlefield Park
	Arabia Mountain National Heritage Area
	Panola Mountain National Natural Landmark
State Parks and Other Recreation Areas	Panola Mountain State Park
	Sweetwater Creek State Park
	Stone Mountain
	Allatoona Wildlife Management Area
	Pine Log Wildlife Management Area
	McGraw Ford Wildlife Management Area
	Lake Allatoona USACE Property

ATLANTA BOTANICAL GARDENS / CREDIT: ARC

Summary of Resources

Regional Greenways and Multi-Use Trails	Big Creek Greenway
	Lionel Hampton Greenway
	Johns Creek Greenway
	Suwanee Creek Greenway
	Ivy Creek Greenway
	Camp Creek Greenway
	Western Gwinnett Greenway
	Silver Comet Trail
	Spring Road Trail
	Concord Road Trail
	Bob Callan Connector Trail
	Riverside Trail
	Lower Roswell Trail
	Bell Road Multi Use Trail
	Rogers Bridge Road Multi Use Trail
	State Bridge Road Multi Use Trail
	Atlanta Beltline Eastside Trail
	Atlanta Beltline Westside Trail
	Stone Mountain Trail
	Freedom Park Trail
	Arabia Mountain Trail
	Rockdale River Trail
	Olde Town Conyers Trail
	Woodstock Greenprints Trail
	Peachtree City Path System

Summary of Resources

Historic and Cultural Resources	
National Historic Landmarks	Georgia State Capitol
	MLK National Historic Site and District
	Sweet Auburn Historic District
	Herndon Mansion
	Wren's Nest – the Joel Chandler Harris House
	Fox Theatre
	Dixie Coca Cola Bottling Plant
National Historic Districts (94 Total)	
Olympic Legacy/ Centennial Olympic Park	
Civil War Battlefields and Sites	Ezra Church/ Battle of the Poor House
	Jonesborough
	Kennesaw Mountain
	Lovejoy's Station
	Peachtree Creek
	Utoy Creek
	Nash Farm Battlefield Park
	Shoupades/ Johnston River Line
	Camp McDonald Park
	Fort Walker
	Judge William Wilson House
	Concord Bridge Historic District and Heritage Park
	Jonesboro Confederate Cemetery
	Marietta Confederate Cemetery
Archaeological Sites	Soapstone Ridge
	Fort Daniel
Cemeteries	Oakland Cemetery
	Basket Creek Cemetery
	Marietta National Cemetery
	Decatur City Cemetery
	Westview Cemetery
	Southview Cemetery
	Georgia National Cemetery

Summary of Resources

Cultural Sites	National Archives – Southeast Region
	Georgia State Archives
	The Carter Center and the Jimmy Carter Library and Museum
	Auburn Avenue Research Library
	Monastery of the Holy Spirit
	The Hindu Temple of Atlanta
	Woodruff Arts Center
	Pemberton Place

SOPE CREEK RUINS-CHATTAHOOCHEE RIVER NATIONAL RECREATION AREA / CREDIT: ARC

Summary of Resources

Areas of Agricultural or Scenic Value	
Rural Preserves	North Fulton County
	South Fulton County
	Gwinnett County
	Western Cobb County
	North Cherokee County
	West Douglas County
	South Fayette County/ Clayton County Panhandle
Georgia Centennial Farms	AW Roberts Farm
	Lake Laura Gardens
	Moss Clark Farm
	Fieldstone Farm
	Rolling Acres Farm
	Gresham Galt Farm
	Mabry Farm
	Alfarminda Farm
Georgia Agritourism Sites	Rancho Alegre Farms
	Southern Belle Farms
	Yule Forest/ The Pumpkin Patch
	Adams Farm
	Gibbs Gardens
Designed Landscapes	The Spring at Kennesaw
	Archibald Smith Plantation Garden
	Barrington Hall
	Bulloch Hall
	Goodrum-Abreau House and Grounds
	Iris Garden
	Woodhaven (Georgia State Governor's Mansion)
	The Atlanta History Center Grounds
	Hartsfield Jackson International Airport Floral Clock
	Atlanta Botanical Gardens
	Lewis Vaughn Botanical Garden
	Claude T. Fortson Memorial Garden
	Cator Woolford Gardens
	Callendwolde Park

Summary of Resources

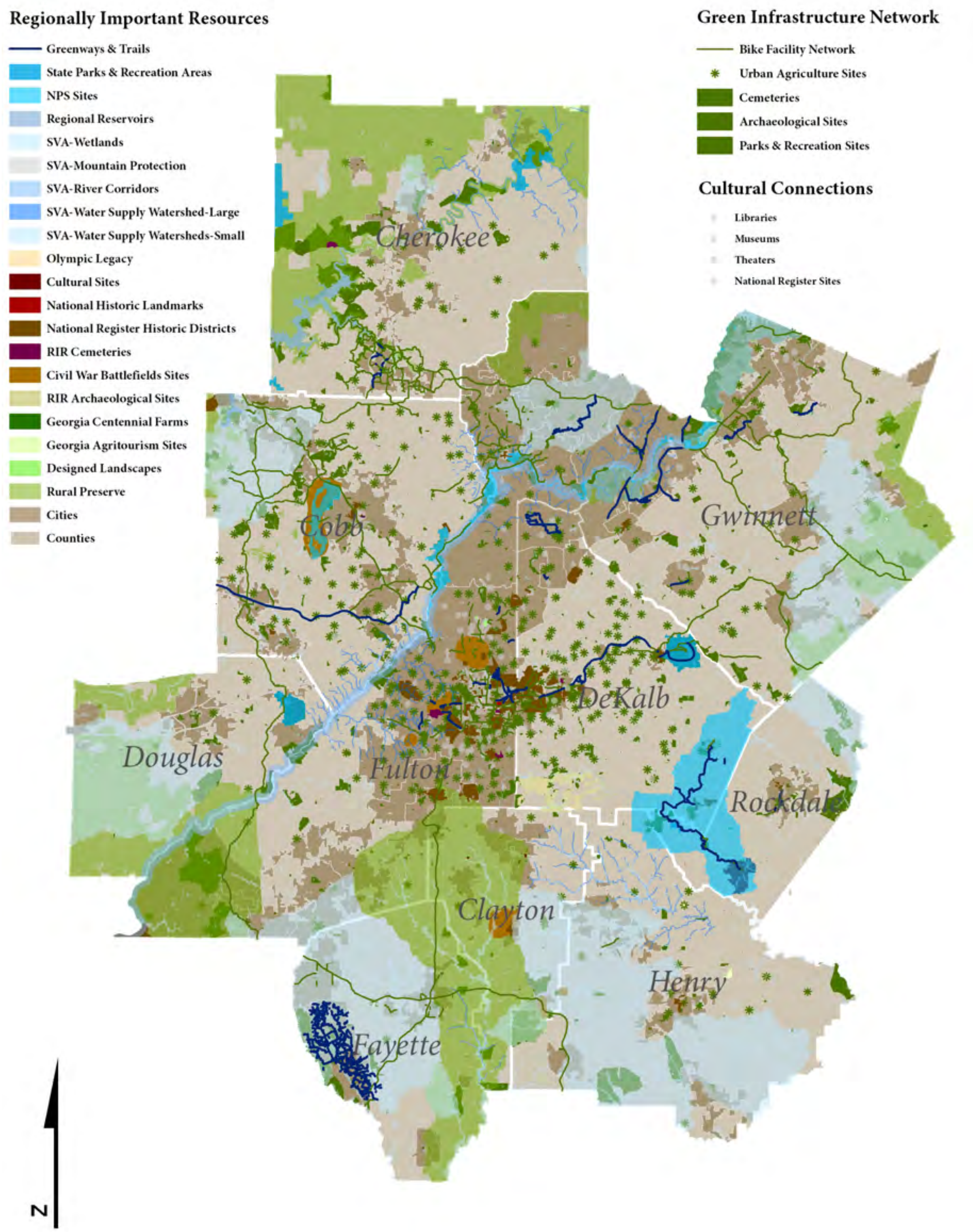
Infrastructure Linkages and Connections*	
Greenspace Linkages	Regional Bicycle Facility Network
	Regional Parks
	Urban Agriculture Sites
	Archaeological Linkages
	Cemeteries
Cultural Connections	Libraries
	Museums
	Theaters

*Infrastructure linkages and connections are not considered Regionally Important Resources for the purposes of this plan.

LOVEJOY CITY GARDEN / CREDIT: ARC

Regionally Important Resources Map

FIGURE 1



Introduction

Background

The Atlanta Regional Commission (ARC) is the regional planning and intergovernmental coordination agency created by the local governments in the Atlanta region pursuant to legislation passed by the Georgia General Assembly. As an area of greater than 1,000,000 in population, ARC has authority under state laws as both a Metropolitan Area Planning and Development Commission (MAPDC) and Regional Commission (RC).

ARC engages in a continuous program of research, study and planning of numerous matters affecting the Atlanta region. As a Regional Commission, ARC must prepare and adopt a Regional Plan to meet both federal transportation planning rules and also minimum standards and procedures for regional planning developed by the Georgia Department of Community Affairs (DCA). In 2008, DCA adopted revisions to Chapter 110-12-6, Standards and Procedures for Regional Planning, "Regional Planning Requirements." ARC's Regional Plan seeks to anticipate and apply comprehensive approaches to accommodate economic and population growth that will occur in the Atlanta region during the next 25 years.

Purpose of Identifying Regionally Important Resources

The Georgia Department of Community Affairs established new rules and procedures for the identification of Regionally Important Resources (RIR). The rules require the development of a plan for protection and management of regional resources and review of activities potentially impacting these resources. ARC is the agency charged with developing a Regional Resource Plan and RIR Map for the 10-county area of the Atlanta region (Cherokee, Clayton, Cobb, DeKalb, Douglas, Fayette, Fulton, Gwinnett, Henry and Rockdale Counties). In support of other agency initiatives ARC is also interested in resources identified in the additional 10 counties within the non-attainment area for air quality (Barrow, Bartow, Carroll, Coweta, Forsyth, Hall, Newton, Paulding, Spalding, and Walton Counties). Generally, the focus of the plan is on the core 10-county area served by the ARC, with the exception of limited multi-jurisdictional resources that overlap the core boundary.

Designation of Regionally Important Resources

Pursuant to Rules of the Department of Community Affairs, Chapter 110-12-4, Regionally Important Resources are defined as *"any natural or cultural resource area identified for protection by a Regional Commission following the minimum requirements established by the Department."* The Regional Resource Plan is designed to

- Enhance the focus on protection and management of important natural and cultural resources in the Atlanta region.
- Provide for careful consideration of, and planning for, impacts of new development on these important resources.
- Improve local, regional, and state level coordination in the protection and management of identified resources.

This plan will identify the methodology and process involved in selecting Regionally Important Resources. It will include a map of Regionally Important Resources, a brief narrative relating the values and vulnerabilities of each resource, as well as guidance for appropriate development practices and general policies, protection measures, and management strategies for identified resources. Ultimately, the plan will be used to *"…coordinate activities and planning of local governments, land trusts and conservation or environmental protection groups' activities in the region, and state agencies toward protection and management of the identified Regionally Important Resources."*

Introduction

Methodology and Process

The process for identifying Regionally Important Resources included a comprehensive approach, described below.

Nomination and Evaluation. ARC held a nomination process for potential resources to be included as Regionally Important Resources beginning in the fall of 2009. ARC made significant efforts to encourage local governments, non-profit organizations, citizens and the State of Georgia to submit nominations for potential inclusion in the Regionally Important Resources (RIR) map.

A nomination form was distributed to local governments and active non-profits engaged with issues related to potential regional resources (e.g. historical societies, land trusts, etc.). Additionally, ARC developed a specific nomination form that was hosted on the ARC web site that was geared toward generating nominations from the general public. This tool also allowed for the submission of photographs in support of nominations.

The public nomination process was opened on August 3, 2009 and remained open through the end of September 2009. **Over 150 nomination forms** were submitted. Many individual nomination forms referred to multiple resources, meaning that several hundred resources had been identified by stakeholders and citizens in the region. Nominations were considered against the criteria established by DCA and ARC as well as other factors. To reinforce the local support within a community, emphasis was placed on including resources that were nominated by a local government or other agency within their community. Certain **types** of resources were nominated throughout different communities, therefore the determination was made to include specific types of resources (i.e. all State and National Parks, all National Register Historic Districts, etc) throughout the region, even if not specifically nominated by a local agency.

There were instances in which it was difficult to classify a resource within a broad typology or rationalize how its inclusion could be equitably justified among the 10-county region. Without diminishing their local significance, ARC determined that rather than designate them as a Regionally Important Resources at this time, they could be included in the regional Greenspace Inventory. Since 2005, ARC has documented publicly accessible greenspace as a part of their overall regional planning efforts. This inventory includes many of the local sites, such as parks and historic features, nominated by local governments through this process. Individually, these resources may not rise to the level of classifying them as regionally important, however collectively, they may play a role in connecting the larger green infrastructure network throughout the region and state.

The Regional Resource Plan was adopted by the ARC Board in October 2010 as part of ARC's Regional Agenda, PLAN 2040. The Resolution to adopt the plan requires that, "*…the Atlanta Regional Commission will use the PLAN 2040 Regional Resource Plan as the basic planning assumptions for these areas and review them annually to make changes to the documents to reflect current planning assumptions.*" During 2011, ARC continued to work with its internal committees and regional stakeholders to revise categories of RIRs to ensure consistency with current planning assumptions. A second call for nominations was distributed in August 2011 and responses informed the inclusion of several new categories of RIRs consistent with criteria set forth by both DCA and the ARC Board. Subsequent updates have added resources that fall within established categories, but have not created new categories of resources.

Introduction

Research and Data Collection. The rules promulgated by the Department of Community Affairs gave general direction in identifying potential resources.

1. Accept nominations by any individual, interested organization, local government/ government agency
2. Consider resources identified by the Georgia Department of Natural Resources as State Vital Areas
3. Consider natural or cultural resources that are already preserved by an existing conservation mechanism
4. Consider natural or cultural resources identified by other state agencies and/or environmental protection organizations

GIS data used for conservation mapping was collected and analyzed as the foundation of the Regionally Important Resources Map. ARC staff also reviewed existing state and federal programs that document and manage significant natural and cultural resources, as well as activities undertaken by a variety of non-profit organizations working to further conservation goals of the natural and built environment.

Criteria for Determining Value of Regionally Important Resources. In addition to guidelines established within the DCA Rules, the ARC Board adopted six criteria to provide guidance in selecting resources that should be considered priorities.

1. Preserves water quality and quantity by protecting drainage, flood control, recharge areas, watersheds, buffers, etc.
2. Creates or preserves active or passive greenspaces including trails, gardens and informal places of natural enjoyment in areas currently underserved by greenspace
3. Protects wildlife habitat by creating, buffering, preserving habitat areas and corridors
4. Preserves areas that have historical or cultural value by virtue of history, place or time period represented
5. Preserves significant working agricultural or forest resources and/or creates opportunities for local food production activities
6. Areas that contribute to region-wide connections between existing and proposed regional resources

A Value Matrix was developed for each area identified as a Regionally Important Resource (Table 1). The Value Matrix measures the criteria proscribed by ARC and DCA against each category of Regionally Important Resource. This matrix will assist in prioritizing conservation activities by identifying which resources meet multiple criteria.

Introduction

Identification of Vulnerability of Regionally Important Resources. The criteria for determining Regionally Important Resources allows for a concise snapshot of the value of each resource to the Atlanta Region. In recognizing the value of these resources, consideration is also given to their potential vulnerabilities. Nominations included descriptions of the resource's vulnerabilities and the degree to which the resource is threatened or endangered. Review of the nominations for each resource provided a similar snapshot in regard to vulnerability. Generally, threats to resources fell within three broad categories.

- *Development Pressures*
    - Threatened by destruction of subsurface resources, such as archaeological sites
    - Fluctuations in land values threatens economic viability of current use
    - Threatened by adjacent development that is incompatible in terms of design, scale or land use
    - Threatened by destruction of significant viewshed
- *Environmental Degradation*
    - Potential adverse impact on wildlife/ loss of biodiversity
    - Subject to damaging pollutants and/ or contaminants
    - Threatened by erosion and/ or stormwater run-off flows
    - Threatened by over-use of resource (i.e. inappropriate recreational use, too much traffic, etc)
- *Resource Management*
    - Lack of protection through adequate regulations or easements
    - Lack of enforcement of existing regulations
    - Lack of financial resources for appropriate stewardship
    - Lack of long-term ownership plan/ transitional ownership

A Vulnerability Matrix was developed to identify the principle threat, or combination of threats, to each resource (Table 2). This matrix will help to organize mitigation measures for resources contending with multiple threats.

Stakeholder Review. Subsequent to determining the final draft plan of Regionally Important Resources in 2010, ARC convened five meetings across the region to discuss nominated resources and to gather additional input as to how resources should be evaluated. All parties that nominated resources were invited to attend the consultation meetings, as well as any local government that was impacted by a nomination.

The Regional Resource Plan was reviewed and approved internally by ARC's Land Use Coordinating Committee and Environment and Land Use Committee prior to being approved by the ARC Board with a Resolution to transmit the Plan to DCA for review.

Introduction

Upon adoption ARC has implemented the promulgation of the Regional Resource Plan through various activities, including

- Informational meetings with regional stakeholders and interested parties
- Presentations to educational groups and other interested parties
- Ongoing data collection and documentation
- Review and comment for plans and projects that may impact RIRs

ARC's *Regional Plan Implementation Program* includes the agency's Short Term Work Program which identifies further activities to promulgate the Regional Resource Plan.

Identification of Regionally Important Resources

After giving consideration to the criteria for Regionally Important Resources identified by DCA and the ARC Board, as well as nominations for individual resources, the following categories were designed to broadly bracket the resources identified as regionally important.

- **Areas of Conservation or Recreational Value**. This broad classification identifies the core natural resources within the Atlanta Region, as well as sites that provide unique opportunities for environmental conservation, heritage preservation and recreation. Consideration was given to areas under management by state or federal agencies, and those that serve populations extending through the region and beyond. In general, this category focuses on large-scale amenities, whose boundaries are often multi-jurisdictional. Local parks and some trails are assumed to be of local significance and best preserved by action at the local level, and not included as a regional resource. However, many of these local resources are maintained on ARC's Greenspace Inventory, which is managed separately from the Regional Resources Plan.
- **Historic and Cultural Resources**. This broad classification focuses primarily on those resources that meet the benchmarks established by the Secretary of the Interior's Standards, as well as other resources identified through State agencies that represent the unique history and heritage of Georgia. In general, individually identified historic or cultural resources are assumed to be of local significance, and best preserved by action at the local level. Individually identified resources that were nominated and supported by a local government or other nominating party have been included in the Plan when it was found they represented unique or transcendent historic or cultural value to the region. Individual resources listed on the National Register of Historic Places are included as Cultural Connections.
- **Areas of Agricultural and Scenic Value**. Though the Atlanta Region primarily includes urban and suburban patterns of development, the fact remains that many areas still reflect the character and aesthetic qualities of Georgia's agrarian roots. Local communities have recognized character areas within their communities that are intended to balance growth pressure with opportunities for rural preservation. Increasing demand for organic and locally grown food production creates new opportunities for agricultural land to remain economically viable without conversion to a more intensive use. These factors, as well as the pace of past development and the potential of future development, have made the recognition of these areas a priority. This category focuses on both site specific resources and broad boundaries of distinctive character within the Atlanta region.

Introduction

The Rules of the Department of Community Affairs also direct Regional Commissions to "include linkages between [mapped] resources to form, to the maximum feasible extent, a continuous regional green infrastructure network." **Greenspace linkages** within the Atlanta region include archaeological sites (mapped generally by Census Block), cemeteries, community parks, the regional bicycle facility network, and urban agriculture sites. Cultural Connections include libraries, museums and theaters. Taken collectively, these resources are not included as Regionally Important Resources and are not subject to any additional Guidance, Policies or Protection Measures. They do function as a backdrop to the Regionally Important Resources Map to form a continuous regional green infrastructure network.

The **Regionally Important Resources Map** (Figure 1) includes all of the resources in the region identified as having regional importance as defined by the criteria established by DCA and ARC. It is a compilation of all resources and identified at the regional scale. In addition to the map, Tables 1 and 2 provide a snapshot of the value and vulnerability of these resources, which are further explored in its supporting narrative. An illustration of the resource within the context of the larger Atlanta Region is provided for easier identification. **Guidance for Appropriate Development Practices** and **General Policies and Protection Measures** for Regionally Important Resources are included within the narrative.

- *Guidance for Appropriate Development Practices* is a listing of best practices to be considered by developers for designing new developments located within one mile of any area included on the Regionally Important Resources Map. The recommendations included within the *Guidance* section reflect broad management practices, but may not be appropriate for every type of development. ARC staff will use professional judgment to determine whether recommendations are applicable to a project under review within one mile of a Regionally Important Resource.

- *General Policies and Protection Measures* are targeted toward local governments that make decisions which affect Regionally Important Resources. Policy recommendations are supported by case studies and model ordinances, as appropriate.

To better qualify the role of ARC in supporting the long range development of the regional green infrastructure network, **Management Strategies** have been defined. ARC will adopt a system of advocacy whereby we either 1) continue to support existing programs and regulations for the management of the resource or 2) continue to support existing programs and regulations for the management of the resource, but will also actively work to facilitate appropriate conservation mechanisms and provide technical assistance for resource management and enhancement.

Regionally Important Resource Value Matrix

TABLE 1

Value Matrix for Regionally Important Resources	DCA Rules for Identification of Regionally Important Resources				Additional Criteria Adopted by ARC Board					
RESOURCE	Resource Nominated by an Individual, Interested Organization, Local Government/ Governmental Agency	Resource Identified by the Georgia Department of Natural Resources as a State Vital Area	A Natural or Cultural Resource that is Already Preserved by an Existing Conservation Mechanism	A Natural or Cultural Resource Identified by Other State Agencies and/ or Environmental Protection Organization	Preserves Water Quality and Quantity by Protecting Drainage, Flood Control, Recharge Areas, Watersheds, Buffers, Etc.	Creates or Preserves Active or Passive Greenspaces, Including Trails, Gardens, and Informal Places of Natural Enjoyment in Areas Currently Underserved by Greenspaces	Preserves Wildlife Habitat by Creating, Buffering, Preserving Habitat Areas and Corridors	Preserves Areas That Have Historical or Cultural Value by Virtue of History, Place or Time Period Represented	Preserves Significant Working Agricultural or Forest Resources and/ or Creates Opportunities for Local Food Production Activities	Areas that Contribute to Region-wide Connections Between Existing and Proposed Regional Resources
AREAS OF CONSERVATION AND/ OR RECREATIONAL VALUE										
Water Supply Watersheds	X	X		X	X		X			X
Groundwater Recharge Areas										
Wetlands		X		X	X					X
River Corridors	X	X		X	X		X			X
Mountain Protection	X	X	X	X			X			X
Regional Reservoirs	X		X	X	X	X	X			X
Regional Greenways and Multi-Use Trails	X		X		X	X	X	X		X
National Park Service Sites	X		X	X		X	X	X	X	
State Parks and Other Recreation Areas	X		X	X		X	X		X	
HISTORIC AND CULTURAL RESOURCES										
National Historic Landmarks	X			X				X		
National Register Historic Districts	X			X				X		X
Olympic Legacy	X							X		
Civil War Battlefields and Sites	X			X				X		X
Archaeological Sites	X		X			X		X		X
Cemeteries	X							X		X
Cultural Sites								X		
AREAS OF AGRICULTURAL AND/ OR SCENIC VALUE										
Rural Preserves	X					X	X		X	X
Georgia Centennial Farms				X		X		X	X	X
Georgia Agritourism Sites			X						X	X
Designed Landscapes	X			X		X	X		X	X

The Resource Narratives of this plan provide a description and additional information on the value and vulnerability of each Regionally Important Resource.

Regionally Important Resources Vulnerability Matrix

TABLE 2

Vulnerability Matrix for Regionally Important Resources	Development Pressures				Environmental Degradation				Resource Management			
RESOURCE	Threatened by destruction of subsurface resources such as archaeological sites	Fluctuations in land values threatens economic viability of current use	Threatened by adjacent development that is incompatible in terms of design, scale or land use	Destruction of significant viewshed	Adverse impact on wildlife/ Loss of biodiversity	Subject to damaging pollutants and/ or contaminants	Threatened by erosion and/ or stormwater run-off flows	Threatened by overuse of resource (i.e. inappropriate recreational use, too much traffic, etc)	Lack of protection through adequate regulations and/ or easements	Lack of enforcement of existing regulations	Lack of financial resources for appropriate stewardship	Lack of long term ownership plan/ transitional ownership
AREAS OF CONSERVATION AND/ OR RECREATIONAL VALUE												
Water Supply Watersheds					X	X	X			X		
Groundwater Recharge Areas												
Wetlands					X	X	X		X	X		
River Corridors					X	X	X		X	X		
Mountain Protection	X	X		X			X		X			
Regional Reservoirs					X	X	X				X	
Regional Greenways and Multi-Use Trails		X			X			X	X		X	X
National Park Service Sites	X		X	X	X		X	X			X	X
State Parks and Other Recreation Areas			X	X	X			X			X	X
HISTORIC AND CULTURAL RESOURCES												
National Historic Landmarks		X	X								X	X
National Register Historic Districts		X	X	X					X			
Olympic Legacy											X	
Civil War Battlefields and Sites	X								X		X	X
Archaeological Sites	X		X						X	X		X
Cemeteries	X		X						X	X		X
Cultural Sites											X	
AREAS OF AGRICULTURAL AND/OR SCENIC VALUE												
Rural Preserves			X	X	X				X			
Georgia Centennial Farms		X	X	X					X			X
Georgia Agritourism Sites		X	X						X			
Designed Landscapes									X			

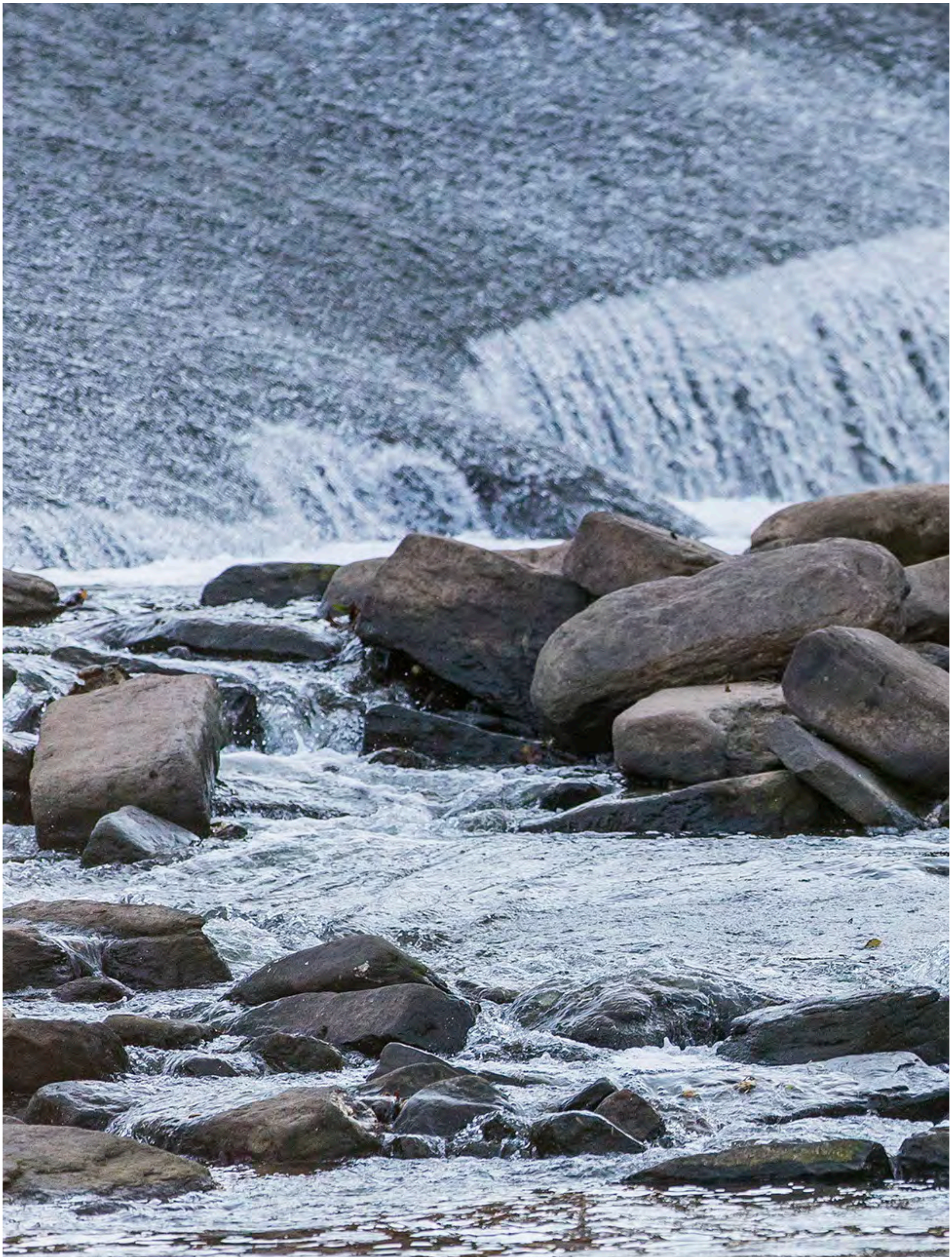
The Resource Narratives of this plan provide a description and additional information on the value and vulnerability of each Regionally Important Resource.

CONSERVATION AND RECREATION

Communities throughout the Atlanta Region place emphasis on the importance of conservation and recreation areas to maintain quality of life, health, and welfare. Within this plan, the foundation of natural resources planning has been the *Environmental Planning Criteria* for State Vital Areas. Defined in compliance with the 1989 Georgia Planning Act, *Minimum Planning Requirements*, these requirements govern water supply watersheds, groundwater recharge areas, wetlands, river corridors and mountains. Development limitations mandated by the State provide a level of protection for these resources; several communities in the Atlanta Region have voluntarily adopted more stringent protections for water features than the minimum required by the state.

Beyond State Vital Areas, other natural resources have been managed in ways that provide conservation and recreation value to the region. Regional river greenways include river corridors that have been enhanced by improvements (such as trails or greenways) and protections (such as easements). Lake Allatoona and Lake Lanier are two regional water reservoirs that are identified for the multiple roles they have for conservation and recreation (smaller water reservoirs are generally encompassed within water supply watersheds). National and State Parks, and other recreational and multi-use trails round out this category.

Local, state and non-profit organizations have invested in parks, trails, and recreational amenities that have begun to lay the foundation of an interconnected green infrastructure system in the region. Given the scale of development throughout the Atlanta Region, the investment in these resources may exceed that of other regions in the state. The need to protect and enhance natural and recreational resources has been bolstered by the connection to economic vitality within a community. Access to parks, trails and greenspace adds value to real property, and conservation of natural resources protects environmental quality and can deter expensive mitigation measures or fines for environmental degradation. Beginning in 2005, ARC undertook an ongoing inventory of publicly accessible greenspace in the Atlanta Region. These include resources such as community parks and trails, as well as larger areas such as state parks and wildlife management areas. Though these resources may not individually meet the criteria for Regionally Important Resources, collectively they are discussed as linkages in regional green infrastructure to support a continuous network.



SOUTH RIVER AT PANOLA MOUNTAIN

Water Supply Watersheds

In compliance with the Georgia Planning Act of 1989, *Minimum Planning Requirements*, the Department of Natural Resources defined *Environmental Planning Criteria* for the protection of water supply watersheds, which fall under the classification of a **State Vital Area.** Water supply watersheds are identified within the context of regional river basins. The *Criteria* for water supply watersheds protect community drinking water sources through the imposition of land use restrictions such as impervious surface limitations and minimum required buffers along stream channels. These development limitations provide a degree of protection for these resources, but several communities within the Atlanta Region have voluntarily adopted more stringent protections for water features within these watersheds than the minimum requirement mandated by the State. Table 3 identifies where water supply watershed protections are in place for water sources in the Atlanta Region.

The protection of water supply watersheds is a multi-jurisdictional responsibility. Developments that affect a water supply watershed may be located in an adjacent city or county from the intake point, thus their stewardship qualifies as a regional issue. The *Criteria* for water supply watersheds distinguish between small watersheds (less than 100 square miles) and large watersheds (greater than 100 square miles), and different rules are imposed for the critical area within a 7 mile upstream radius of the intake point. Within small water supply watersheds, RIR mapping includes the entire impacted land area, however within the large water supply watersheds, only buffer zones along impacted streams are mapped.

Several agencies play diverse roles in water planning and conservation in the Atlanta Region. It is the goal of the Regional Resource Plan to reinforce the recommendations of existing agencies and enhance the guidance set out in other planning documents of these agencies. The recommendations of the Metropolitan North Georgia Water Planning District's (MNGWPD) *Water Supply and Water Conservation Management Plan* were resources for developing *Guidance for Appropriate Development Practices* and *General Policies and Protection Measures* of this Plan. The Georgia Water Stewardship Act (Senate Bill 370) was passed by the Georgia General Assembly in 2010, and it extends many of the provisions of the MNGWPD plans statewide and also directs local governments to work to support existing statewide water conservation campaigns, specifically identifying Conserve Water Georgia, a clearinghouse for information on water conservation. This organization cites additional resources, including *Georgia's Water Conservation Implementation Plan* published by the Georgia Environmental Protection Division, that provide good direction for best management practices for individuals, private sector entities, and local governments. The specific recommendations for *Guidance* and *Policies* in regard to watershed protection in the Regional Resource Plan focus mostly on broad best management practices in deference to specific implementation strategies of other regional water quality plans.

Water Supply Watersheds

Value	Vulnerability
• Nominated by an individual, interested organization, local government/ government agency • Identified by the Georgia Department of Natural Resources as State Vital Areas • Natural or cultural resources identified by other state agencies and/or environmental protection organizations • Preserves water quality and quantity by protecting drainage, flood control, recharge areas, watersheds, buffers, etc. • Protects wildlife habitat by creating, buffering, preserving habitat areas and corridors	• Potential adverse impact on wildlife/ loss of biodiversity • Subject to damaging pollutants and/ or contaminants • Threatened by erosion and/ or stormwater run-off flows • Lack of protection through adequate regulations or easements • Lack of enforcement of existing regulations • Subject to differing regulations over a multi-jurisdictional area

ARC Management Strategies
ARC will continue to support existing programs and regulations for the management of water supply watersheds but will also actively work to facilitate appropriate conservation mechanisms and provide technical assistance for resource management and enhancement. This includes promoting regulations that comply with the Rules for Environmental Planning Criteria and the plan recommendations of the Metropolitan North Georgia Water Planning District, which consider requirements of the Federal Clean Water Act, Federal Safe Drinking Water Act, Federal Flood Protection Programs, and Federal Endangered Species Act, and similar requirements under Georgia law. ARC will also work to promote low-impact development practices; promote infill development and redevelopment; advocate development of a regional Transfer of Development Rights program; protect river greenways; and promote new ordinances for programs such as conservation subdivision guidelines, alternative site design elements, and stormwater utilities that will positively impact water quality. ARC will work proactively to encourage local government plans to comply with regional planning initiatives, including aligning local comprehensive plan elements with regional planning goals to the extent practical.

Groundwater Recharge Areas

In compliance with the Georgia Planning Act of 1989, *Minimum Planning Requirements*, the Department of Natural Resources defined *Environmental Planning Criteria* for the protection of groundwater recharge areas, which fall under the classification of a **State Vital Area.** The *Criteria* for groundwater recharge areas protect those areas that are particularly suitable for the penetration of water into the aquifers that hold the groundwater supply. Using the DRASTIC methodology, a standardized system for evaluating groundwater pollution potential, it has been determined that there are no areas meeting the criteria for high pollution susceptibility groundwater recharge areas in the Atlanta Region. There are areas of soils that are susceptible to the infiltration of pollutants, which are also governed by the *Environmental Planning Criteria*, however these areas do not meet the specifications identified within the Rules for identifying Regionally Important Resources. More information on the DRASTIC methodology can be found in the Rules for Environmental Planning Criteria through the Georgia Department of Community Affairs website at www.dca.state.ga.us/development/planningqualitygrowth/programs/downloads/EPC.pdf

CHATTAHOOCHEE NATURE CENTER / CREDIT: ARC

Wetlands

In compliance with the Georgia Planning Act of 1989, *Minimum Planning Requirements*, the Department of Natural Resources defined *Environmental Planning Criteria* for the protection of wetlands, which fall under the classification of a **State Vital Area.** The *Criteria* for wetlands protect land areas adjacent to surface water bodies that sustain vegetation typically found in areas with saturated soil conditions. These areas support a variety of ecosystems that make dynamic environmental contributions and are important to sustainable planning and practice. Wetlands are generally found along or adjacent to stream corridors in this region. To mitigate their disturbance, communities have incorporated them into trails and greenways, thus still preserving a sensitive habitat while creating a community amenity. Preserving the diversity of wildlife supported by wetlands further lends to creating a recreational and educational amenity on otherwise undevelopable land. In instances where alteration or degradation of wetlands is unavoidable, federal regulations generally require "no net loss of wetlands," therefore the creation of wetlands banks have become more widespread. The disturbance of wetlands is permitted through the US Army Corps of Engineers and governed by Section 404 of the Clean Water Act.

Value	Vulnerability
• Identified by the Georgia Department of Natural Resources as State Vital Areas • Natural or cultural resources identified by other state agencies and/or environmental protection organizations • Preserves water quality and quantity by protecting drainage, flood control, recharge areas, watersheds, buffers, etc. • Protects wildlife habitat by creating, buffering, preserving habitat areas and corridors • Areas that contribute to region-wide connections between existing and proposed regional resources.	• Potential adverse impact on wildlife/ loss of biodiversity • Subject to damaging pollutants and/ or contaminants • Threatened by erosion and/ or stormwater run-off flows • Lack of protection through adequate regulations or easements • Lack of enforcement of existing regulations
ARC Management Strategies	
ARC will continue to support existing programs and regulations for the management of wetlands. This includes regulations complying with the *Rules for Environmental Planning Criteria.* Wetlands are also protected under Section 404 of the Federal Clean Water Act, administered by the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers.	

CHATTAHOOCHEE RIVER / CREDIT: ARC

Protected River Corridors

In compliance with the Georgia Planning Act of 1989, *Minimum Planning Requirements*, the Department of Natural Resources defined *Environmental Planning Criteria* for the protection of rivers, which fall under the classification of a **State Vital Area.** The *Criteria* for protected river corridors focus on preserving the land adjacent to rivers to support a diversity of wildlife, recreational interests, and water quality. Land adjacent to rivers is also subject to periodic inundation due to flooding and other changes in water currents. Limiting development along river corridors enhances the environmental quality within a community and protects investments in real property from damage due to flooding. Within the area served by ARC, several counties have been identified as having protected River Corridors. The **Etowah River** flows through Cherokee County. The **Chattahoochee River** flows through Cobb, Fulton, Douglas and Gwinnett Counties. And the **South River** flows through Henry, Rockdale, DeKalb, and Fulton Counties.

Pursuant to the *Criteria* "river corridor" refers to areas of a protected river and being within 100 feet on both sides of the river as measured from the river banks. A "protected river" is distinguished by exceeding a threshold for average annual flow as determined by the U.S. Geological Service.

In 1973, the Georgia General Assembly passed the Metropolitan River Protection Act. The initial Act, and a later amendment in 1998, establishes a 2,000 foot corridor along the Chattahoochee River through the Atlanta Region, beginning at Buford Dam and extending through Douglas County. Pursuant to the regulations of the Act, ARC oversees the process whereby all land disturbing activity within the corridor is reviewed, approved and certified for consistency with Corridor Standards.

The Endangered Species Act of 1973 allows for the creation of Habitat Conservation Plans to protect endangered wildlife species. The Etowah River Habitat Conservation Plan was initiated by the local governments within the Etowah River Basin, and after several years of planning, a document was submitted to the U.S. Fish and Wildlife Service for review and comment. Once the review is complete, local governments can adopt and implement the provisions of the HCP, furthering the protection of a sensitive natural resource and wildlife that depends upon it.

Value	Vulnerability
• Nominated by an individual, interested organization, local government/ government agency • Identified by the Georgia Department of Natural Resources as State Vital Areas • Natural or cultural resources identified by other state agencies and/or environmental protection organizations • Preserves water quality and quantity by protecting drainage, flood control, recharge areas, watersheds, buffers, etc. • Protects wildlife habitat by creating, buffering, preserving habitat areas and corridors • Areas that contribute to region-wide connections between existing and proposed regional resources.	• Potential adverse impact on wildlife/ loss of biodiversity • Subject to damaging pollutants and/ or contaminants • Threatened by erosion and/ or stormwater run-off flows • Lack of protection through adequate regulations or easements • Lack of enforcement of existing regulations • Subject to differing regulations over a multi-jurisdictional area

Protected River Corridors

ARC Management Strategies
ARC will continue to support existing programs and regulations for the management of protected river corridors. This includes regulations complying with the *Rules for Environmental Planning Criteria* (www.dca.state.ga.us/development/planningqualitygrowth/programs/downloads/EPC.pdf) and the *Metropolitan River Protection Act* (www.atlantaregional.com/environment/water/mrpa-chattahoochee-corridor-protection). When adopted, the provisions of the *Etowah Habitat Conservation Plan* will provide additional recommendations for the stewardship of this resource. River corridors have particular value for water quality protection, preservation of wildlife habitat, and forming connections along regional river greenways.

SOUTH RIVER / CREDIT: ARC

KENNESAW MOUNTAIN NATIONAL BATTLEFIELD PARK / CREDIT: ARC

Mountain Protection

In compliance with the Georgia Planning Act of 1989, *Minimum Planning Requirements*, the Department of Natural Resources defined *Environmental Planning Criteria* for the protection of mountains, which fall under the classification of a **State Vital Area.** The *Criteria* for protected mountains are designed to limit development activities on sensitive mountain slopes to protect the general health, safety and public welfare of a community. Located at the convergence of the Blue Ridge and Piedmont Regions of the state, limited areas of Protected Mountain resources are found within the Atlanta Region.

Mountains contain unique natural and topographic features that support a diversity of wildlife and contribute to the scenic qualities of a community. However, those same features can be fragile and can threaten water quality, real property investments and public welfare. Within the area served by ARC, mountain protection requirements have been established in Cherokee County in proximity to Kennesaw Mountain and Pine Log Mountain. Much of Pine Log Mountain is leased by Georgia DNR as a Wildlife Management Area. Garland Mountain, also in Cherokee County, has not been identified as a Protected Mountain by the State criteria, but Cherokee County does own a large portion of the site.

Value	Vulnerability
• Nominated by an individual, interested organization, local government/ government agency • Identified by the Georgia Department of Natural Resources as State Vital Areas • Natural or cultural resources identified by other state agencies and/or environmental protection organizations • Natural or cultural resources that are already preserved by an existing conservation mechanism • Protects wildlife habitat by creating, buffering, preserving habitat areas and corridors	• Fluctuations in land values threatens economic viability of current use • Threatened by destruction of significant viewshed • Potential adverse impact on wildlife/ loss of biodiversity • Threatened by erosion and/ or stormwater run-off flows • Lack of protection through adequate regulations or easements • Increasing pressure for residential development within scenic mountain areas has resulted in the fragmentation of forest habitats.
ARC Management Strategies	
ARC will continue to support existing programs and regulations for the management of protected mountains. This includes regulations complying with the Rules for Environmental Planning Criteria.	

BUFORD DAM AT LAKE LANIER /

Regional Reservoirs

Major Lakes in the region serve multiple purposes, including preservation of wildlife habitat, recreational amenities and critical drinking water supplies. **Lake Allatoona** is located within Bartow, Cherokee and Cobb Counties and is managed by the U.S. Army Corps of Engineers. It is an integral part of the system of rivers, lakes and reservoirs that provide drinking water to the Atlanta region. The shoreline of the lake includes numerous recreation facilities that are open to the public. The lake is also buffered by greenspace that is not open to the public, but is nonetheless critical to maintaining the lake and providing species habitat. **Lake Lanier**, located mostly within Forsyth and Hall County beyond the 10-county region, is a significant resource for the Atlanta Region. It serves as a source of drinking water, power generation, and flood control, as well as a recreational and economic development amenity for the Atlanta Region. The construction of Buford Dam and the subsequent creation of Lake Lanier was a significant force in shaping the region and marking Atlanta as an emerging major metropolitan area.

Value	Vulnerability
• Nominated by an individual, interested organization, local government/ government agency • Natural or cultural resources identified by other state agencies and/or environmental protection organizations • Natural or cultural resources that are already preserved by an existing conservation mechanism • Preserves water quality and quantity by protecting drainage, flood control, recharge areas, watersheds, buffers, etc. • Creates or preserves active or passive greenspaces including trails, gardens and informal places of natural enjoyment in areas currently underserved by greenspace • Protects wildlife habitat by creating, buffering, preserving habitat areas and corridors	• Potential adverse impact on wildlife/ loss of biodiversity • Subject to damaging pollutants and/ or contaminants • Threatened by erosion and/ or stormwater run-off flows • On-going litigation among Alabama, Florida, and Georgia for the use of the water from Lake Lanier • Severe droughts cause drop in water level • Lack of financial resources for appropriate stewardship, particularly of parks and adjacent resources
ARC Management Strategies	
ARC will continue to support existing programs and regulations for the management of regional reservoirs. Both lakes are located mostly outside of boundaries of the 10-county region, and existing management structures and resources provide stewardship for these sites. Both lake environments are managed by the US Army Corps of Engineers and the *Rules and Regulations Governing Public Use of Water Resource Development Projects Administered by the Chief of Engineers* are found in C.F.R. Title 36 Chapter 3 part 327 and available at http://www.access.gpo.gov/nara/cfr/waisidx_01/36cfr327_01.html	

SILVER COMET TRAIL / CREDIT: RAFTERMAN PHOTOGRAPHY

Regional Greenways and Multi-Use Trails

Both greenways and trails have been identified within the Regional Resource Plan for their conservation value, as well as their function as points of connectivity within larger green infrastructure and transportation networks. As advocacy efforts for greenway and trail building have increased, numerous local governments have begun to identify and develop local greenway and trail systems within their own communities.

Greenways. The area adjacent to all rivers can be considered a greenway, but this plan focuses on those areas that are enhanced by active conservation measures and/ or recreational use of their greenways. Included in this **Big Creek Greenway** (Fulton County); **Lionel Hampton Greenway Trail** (Fulton County); **Johns Creek Greenway (Fulton County); Suwanee Creek Greenway** (Gwinnett County); **Ivy Creek Greenway** (Gwinnett County); **Camp Creek Greenway** (Gwinnett County) and the **Western Gwinnett Greenway** (Gwinnett County).

Multi-Use Trails. Trail systems can be combined with river greenways, but as often can be found utilizing other corridors such as city streets, public utilities, linear parks, or abandoned rail lines. Within the Atlanta Region, several projects exemplify this kind of adaptability. The **Silver Comet Trail** is a non-motorized trail that begins in Cobb County and runs 61 miles to the western state line with Alabama. It is a rails-to-trails project named for the famous engine that formerly ran this route. Investment in a significant stretch of trail infrastructure, such as the Silver Comet, is the mainstay of the emerging regional multi-use path network. It allows for smaller connections to begin to create significant opportunities for greater connectivity. In the case of the Silver Comet Trail, segments such as the Spring Road Trail, Concord Road Trail, and Bob Callan Connector have been built by partners in Cobb County and the Cumberland CID.

A similar example can be seen where significant trail investments have been made in the **Riverside Trail** and **Lower Roswell Trail** in proximity to the Big Creek Greenway Trail. Coupled with improvements made in the city of Johns Creek, including the **Bell Road Multi-Use Trail, Rogers Bridge Road Multi-Use Trail,** and **State Bridge Road Multi-Use Trail** that are in proximity to the Western Gwinnett Greenway, Suwanee Creek Greenway, Ivy Creek Greenway and Johns Creek Greenway, the northwest part of the region has over 35 miles of trails to serve as the foundation of a network.

The Atlanta Beltline is a redevelopment project that includes multiple revitalization elements, but its inclusion as a Regionally Important Resource results primarily from its trail and greenspace concept. The proposed 22-mile loop runs through well-established neighborhoods and commercial centers – many of which include historically and culturally significant resources – and includes 1200 acres of greenway and parkland. Sections of both the **Eastside Trail** and **Westside Trail** have been opened to heavy public use, and they foster connections to existing trail infrastructure, such as the Freedom Park Trail and on road bicycle improvements, including the 10^{th} Street Cycle Track.

Other multi-use trail projects connecting multiple venues include the **Stone Mountain Trail**, a 17 mile trail from the Martin Luther King Center to Stone Mountain Park, which also includes **Freedom Park** with six miles of bike and walking trails through eight intown Atlanta neighborhoods. The **Arabia Mountain Trail** is a 13-mile multi-use trail that runs through DeKalb and Rockdale Counties in proximity to the Arabia Mountain National Heritage Area, connecting to 10 miles of the **Rockdale River Trail.** This trail is planned to eventually connect to the **Olde Town Conyers Trail.**

On the north end of the region, the city of Woodstock has initiated construction of their **Greenprints Trail** network. With over 80 miles of trails planned, and 7 ½ miles already built, Woodstock is on track to mirror on of the region's southside communities with an exceptionally robust multi-use trail network. **Peachtree City's Path System** boasts over 90 miles of trails that can be used by pedestrians, cycles and golf carts have been built in conjunction with the development of the city.

Development of river greenways facilitates conservation and recreational amenities and is closely linked to the protection of river corridors and wetlands, enhancing the protection of water quality and water supply sources. Multi-use trails establish connectivity to parks, historic districts, and other cultural amenities and provide additional opportunities for community and economic development. If strategically planned, greenways and multi-use trails can provide alternate routes for transportation choices for both functional and recreational purposes.

Regional Greenways and Multi-Use Trails

<table>
<tr><th>Value</th><th>Vulnerability</th></tr>
<tr><td>

Nominated by an individual, interested organization, local government/ government agency
Natural or cultural resources that are already preserved by an existing conservation mechanism
Preserves water quality and quantity by protecting drainage, flood control, recharge areas, watersheds, buffers, etc.
Creates or preserves active or passive greenspaces including trails, gardens and informal places of natural enjoyment in areas currently underserved by greenspace
Protects wildlife habitat by creating, buffering, preserving habitat areas and corridors
Preserves areas that have historical or cultural value by virtue of history, place or time period represented
Areas that contribute to region-wide connections between existing and proposed regional resources

</td><td>

Fluctuations in land values threaten economic viability of current or proposed use
Potential adverse impact on wildlife/ loss of biodiversity
Threatened by over-use of resource (i.e. inappropriate recreational use, too much traffic, etc)
Lack of protection through adequate easements for part or all of the greenway
Lack of financial resources for appropriate stewardship
Lack of long-term ownership plan/ transitional ownership for portions of planned greenways

</td></tr>
<tr><th colspan="2">ARC Management Strategies</th></tr>
<tr><td colspan="2">ARC will continue to support existing programs and regulations for the management of regional greenways and multi-use trails, but will also actively work to facilitate appropriate conservation mechanisms and provide technical assistance for resource management and enhancement. Much of the work being done in greenway and trail development results from initiatives of local governments and non-profit agencies. Greenways are typically under the stewardship of the local government in which they are located. The Parks and Recreation Department for Cobb County manages the portion of the Silver Comet Trail within its jurisdiction (www.silvercomet.com). The Atlanta Beltline is managed by Atlanta Beltline Inc. and its development is directed through both comprehensive master plans and zoning overlays (www.beltline.org). Stewardship of the Stone Mountain Trail, Freedom Park, and Arabia Mountain Trail all involve various groups, including the PATH Foundation (www.pathfoundation.org), the Freedom Park Conservancy (www.freedompark.org), and the Arabia Alliance (www.arabiaalliance.org) and are good examples of the strength of developing advocacy groups for a resource. ARC maintains a comprehensive inventory of bicycle lanes and trails, as well as greenspace amenities including local parks. Advocating for a regional effort to coordinate planning activities among local trail, greenway and greenspace amenities will foster greater connectivity throughout the regional and state green infrastructure network.</td></tr>
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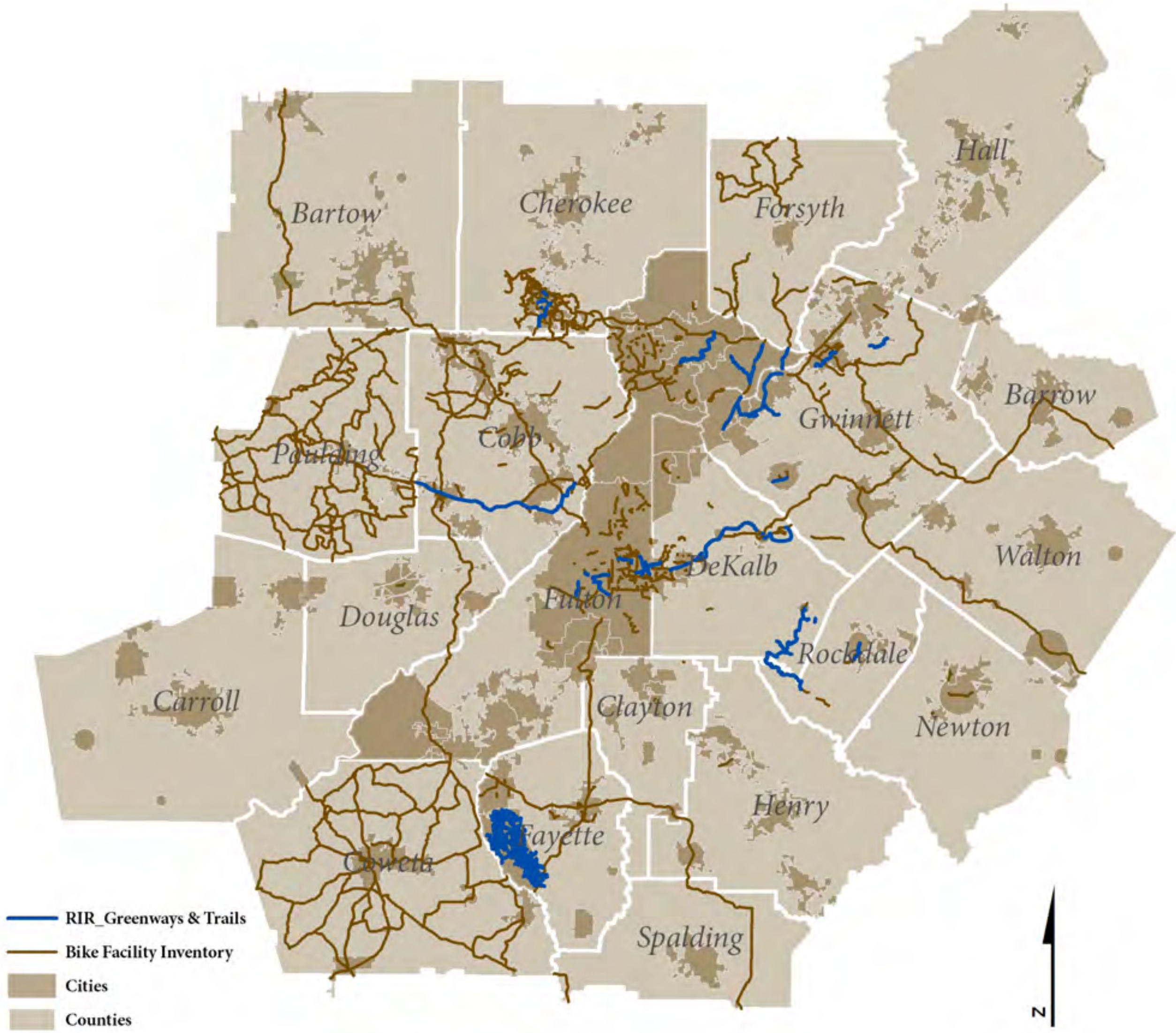
Regional Greenways and Multi-Use Trails

FIGURE 2

Greenspace Linkages: Bicycle Facility Network



Greenways and multi-use trails identified as Regionally Important Resources are part of a larger network of alternative transportation. ARC's Bicycle Facility Network catalogs existing and planned improvements for infrastructure that includes shared travel lanes, side paths, paved shoulders, and conventional bicycle lanes. Regionally Important Resources that are identified greenways and multi-use trails are off-road facilities. Along with existing green infrastructure such as the regional park networks, and path improvements located therein, on- and off-road bicycle infrastructure contributes to connections in the regional green infrastructure network. [Greenspace Linkages are not considered to be Regionally Important Resources for the purposes of this plan].

LYONS FARM AT ARABIA MOUNTAIN NATIONAL HERITAGE AREA / CREDIT: ARC

National Park Service Sites

The National Park Service has created several classifications for park sites, a variety of which are found in the Atlanta Region. Collectively, these sites encompass several thousand acres and offer unique opportunities for environmental conservation, heritage preservation and recreation.

The **Chattahoochee River National Recreation Area** consists of a 48 mile stretch of the Chattahoochee River and 14 land units along its corridor. It begins at Lake Lanier's Buford Dam and continues downstream through Forsyth, Gwinnett, Fulton and Cobb Counties to Peachtree Creek near downtown Atlanta. It is the site of both prehistoric and historic resources and wildlife habitat, and attracts more than 3 million visitors annually. Recreational activities at the site include hiking, fishing, picnicking, rafting, canoeing, kayaking, and evening family programs.

Kennesaw Mountain National Battlefield Park in Cobb County is a site affiliated with the Atlanta Campaign of the Civil War. Encompassing 2,923 acres, it is reflective of cultural elements of Native American, Antebellum, and Civil War history that played itself out on this site. It includes a trail network and several different forms of interpretive media that detail the significance of the site. Other elements of this cultural landscape include historic earthworks, monuments to commemorate fallen soldiers, and historic structures such as Kolb's Farm and family cemetery.

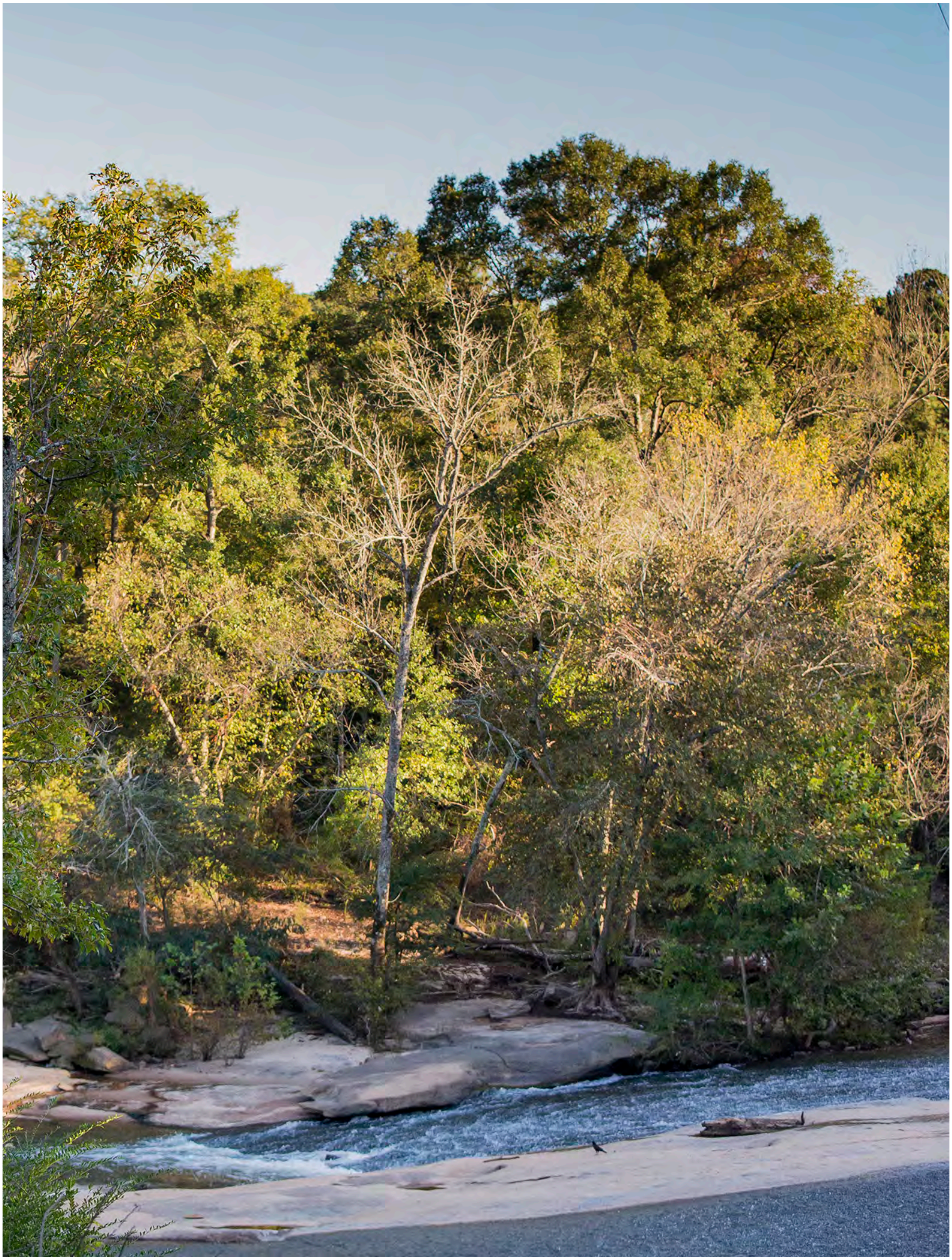
The **Arabia Mountain National Heritage Area** offers a unique showcase of natural, cultural and historic legacies concentrated in portions of DeKalb, Rockdale, and Henry Counties. The land that comprises the Heritage Area includes active quarries, rolling topography, rural landscapes and unique granite outcroppings – a singular habitat feature of the Georgia Piedmont Region. This area has been linked to human settlement and activity for thousands of years and contains unique and diverse ecosystems that encompass spiritual landscapes, mountains, quarries, woodlands, lakes, rivers and farmland. Land acquisition as a part of this project has been identified as an endorsed project by the Georgia Land Conservation Program. Included within the Heritage Area are unique resources, including Panola Mountain State Park, the Davidson-Arabia Mountain Nature Preserve, and the Monastery of the Holy Spirit.

Panola Mountain State Park is registered as a **National Natural Landmark** and its vast granite outcroppings preserve features of the Georgia Piedmont habitat that have been threatened or lost in the vicinity due to residential developments. Located in Rockdale County, it provides passive recreation and learning opportunities while preserving wildlife habitat, watershed protection, floodplain protection and preservation of delicate ecological features including many rare plants of the Piedmont region. It is a key component in both the Arabia Mountain Trail and the Rockdale River Trail, and land acquisition at this site has been targeted as an endorsed project within the Georgia Land Conservation Program.

National Park Service Sites

Value	Vulnerability
• Nominated by an individual, interested organization, local government/ government agency • Natural or cultural resources identified by other state agencies and/or environmental protection organizations • Natural or cultural resources that are already preserved by an existing conservation mechanism • Creates or preserves active or passive greenspaces including trails, gardens and informal places of natural enjoyment in areas currently underserved by greenspace • Protects wildlife habitat by creating, buffering, preserving habitat areas and corridors • Preserves areas that have historical or cultural value by virtue of history place or time period represented • Preserves significant working agricultural or forest resources and/or creates opportunities for local food production activities	• Threatened by Destruction of subsurface resources, such as archaeological sites • Threatened by adjacent development that is incompatible in terms of design, scale or land use • Threatened by destruction of significant viewshed • Potential adverse impact on wildlife/ loss of biodiversity • Threatened by erosion and/ or stormwater run-off flows • Threatened by over-use of resource (i.e. inappropriate recreational use, too much traffic, etc) • Lack of financial resources for appropriate stewardship • Lack of long-term ownership plan/ transitional ownership for some parts of the resources

ARC Management Strategies
ARC will continue to support existing programs and regulations for the management of National Park Service Sites. Existing management structures and resources provide stewardship for these sites. The Chattahoochee River National Recreation Area and the Kennesaw Mountain National Battlefield Park are both managed by onsite personnel of the National Park Service, and management plans for each are available through the National Park Service (www.nps.gov/chat and www.nps.gov/kemo). The Arabia Mountain National Heritage Area was designated through the National Park Service, but its stewardship is largely accomplished through the Management Action Plan of The Arabia Alliance (www.arabiaalliance.org). Within the Heritage Area, separate resources may have individual management plans such the Davidson-Arabia Mountain Nature Preserve, which is a unit of the DeKalb County Parks and Recreation Department (www.co.dekalb.ga.us/parks); Panola Mountain State Park, which is a unit of the Georgia State Parks Division (www.gastateparks.org/ Panola); and Monastery of the Holy Spirit, which is a Roman Catholic Monastery of Trappist Monks (www.trappist.net). The National Natural Landmark designation of Panola Mountain State Park was designated through the National Park Service, but the site's Resource Management falls within the stewardship plans of the Georgia State Park System (www.gastateparks.org) and also benefits from a Friends of Panola volunteer organization.



PANOLA MOUNTAIN STATE PARK

State Parks and Other Recreation Areas

Similar to National Park Sites, State Parks also provide opportunities for environmental conservation, heritage preservation and recreation.

Panola Mountain State Park provides passive recreation and learning opportunities while preserving wildlife habitat, watershed protection, floodplain protection and preservation of delicate ecological features including many rare plants of the Piedmont region. Located in Rockdale County, Panola Mountain State Park is registered as a National Natural Landmark and its vast granite outcroppings preserve features of the Georgia Piedmont habitat that have been threatened or lost in the vicinity due to residential developments. It is a key component in both the Arabia Mountain Trail and the Rockdale River Trail, and land acquisition at this site has been targeted as an endorsed project within the Georgia Land Conservation Program.

Sweetwater Creek State Park, located in Douglas County, includes the ruins of the New Manchester Manufacturing Mill, several miles of hiking trails, and the George Sparks Reservoir. The Visitors Center at the site includes information on recreational opportunities, wildlife habitat and historic resources, and also boasts LEED Platinum certification for its environmentally friendly building design. It is a model structure within the state park system as well as the larger built environment of the region.

Stone Mountain, at 825 feet tall and reaching 1,683 feet above sea level, is the world's largest known free-standing piece of exposed granite. Stone Mountain Park hosts festivals and family-oriented activities, and boasts trails, lakes and opportunities for wildlife viewing. It includes more than 3,000 acres of parkland and attracts over 4 million visitors annually. Located in DeKalb County, the view from the top of the mountain provides a scenic panorama of many parts of the region. The mountain is approximately five miles in circumference at its base, but its subterranean reach is more extensive.

Wildlife Management Areas (WMA) support habitats of diverse wildlife species and provide recreational opportunities for public hunting, fishing and related sports. The Atlanta Region includes the **Allatoona WMA**, the **Pine Log WMA**, and the **McGraw Ford WMA** all in Cherokee County. Fee simple land acquisition within the McGraw Ford WMA was identified as an endorsed project by the Georgia Land Conservation Program. The area in Cherokee County around Lake Allatoona which is under the stewardship of the U.S. Army Corps of Engineers also serves a similar function to that of recreational amenities such as State Parks and WMAs.

State Parks and Other Recreation Areas

Value	Vulnerability
• Nominated by an individual, interested organization, local government/ government agency • Natural or cultural resources identified by other state agencies and/or environmental protection organizations • Natural or cultural resources that are already preserved by an existing conservation mechanism • Creates or preserves active or passive greenspaces including trails, gardens and informal places of natural enjoyment in areas currently underserved by greenspace • Protects wildlife habitat by creating, buffering, preserving habitat areas and corridors • Preserves significant working agricultural or forest resources and/or creates opportunities for local food production activities	• Threatened by adjacent development that is incompatible in terms of design, scale or land use • Threatened by destruction of significant viewshed • Potential adverse impact on wildlife/ loss of biodiversity • Threatened by over-use of resource (i.e. inappropriate recreational use, too much traffic, etc) • Lack of financial resources for appropriate stewardship • Lack of long-term ownership plan/ transitional ownership for some parts of the resources

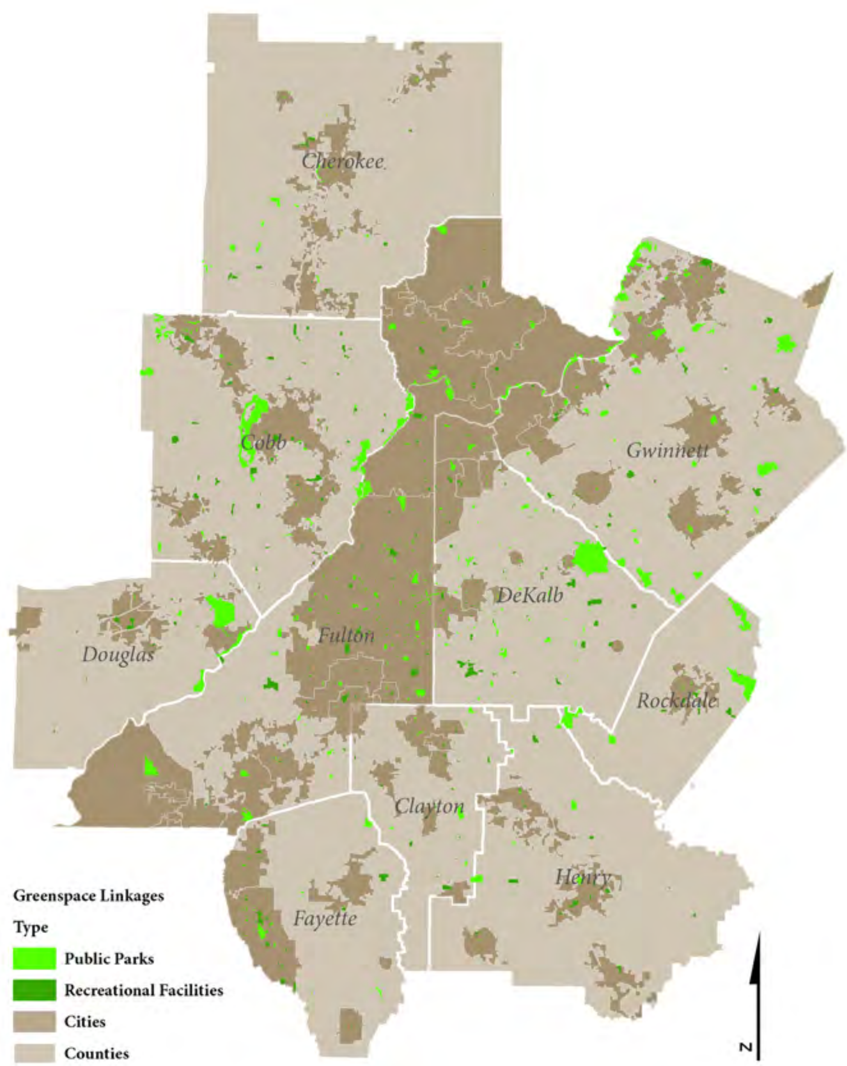
ARC Management Strategies
ARC will continue to support existing programs and regulations for the management of State Parks and Other Recreation Areas. Existing management structures and resources provide stewardship for these sites. Panola Mountain State Park and Sweetwater Creek State Park are both managed as units of the Georgia State Park System (www.gastateparks.org) and both benefit from "Friends of" volunteer organizations. Stone Mountain is owned by the State of Georgia, but is managed through Stone Mountain Memorial Association, a self-supporting Georgia State Authority (www.stonemountainpark.org). The commercial operations of the park are managed through a long-term public/ private partnership with the Herschend Family Entertainment Corporation. The Wildlife Management Areas are all managed through the Georgia Department of Natural Resources, Wildlife Resources Division (www.georgiawildlife.com). The environment around Lake Allatoona is managed by the US Army Corps of Engineers and the *Rules and Regulations Governing Public Use of Water Resource Development Projects Administered by the Chief of Engineers* are found in C.F.R. Title 36 Chapter 3 part 327 and available at http://www.access.gpo.gov/nara/cfr/waisidx_01/36cfr327_01.html

State Parks and Other Recreation Areas

FIGURE 3

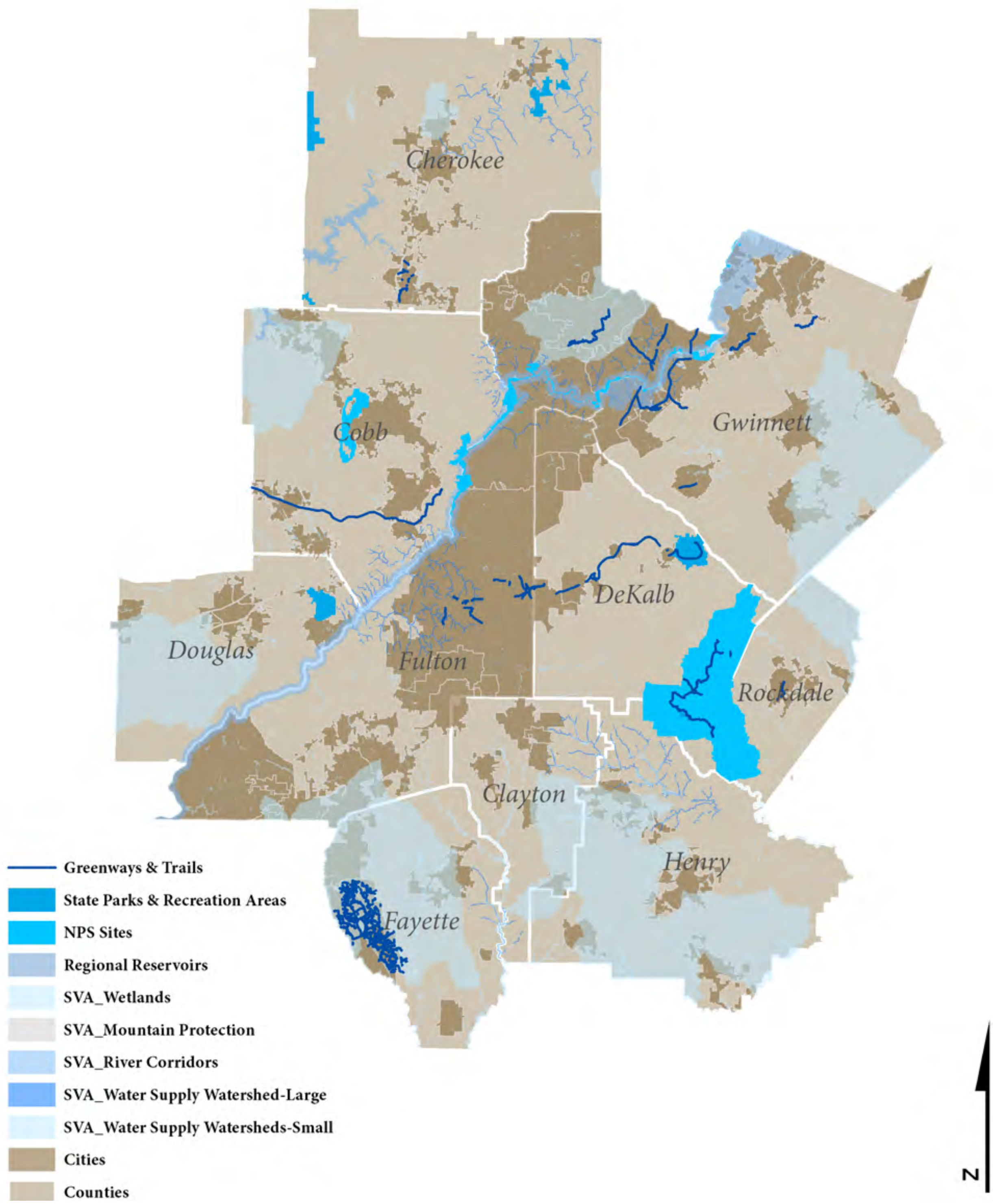
Greenspace Linkages: Regional Parks

The regional park network contributes to the core of a green infrastructure plan. The Atlanta region includes thousands of acres of community parks in all forms and sizes. Many parks are the legacy of historic events such as Piedmont Park, which was the site of the 1895 Cotton States Exposition, or Kennesaw Mountain, site of a key Civil War battle. Others provide environmental protection, such as the Chattahoochee River National Recreation Area. The majority are designed to commemorate key events or important citizens for the local community, or provide recreational areas for neighborhoods. Pursuant to the DCA Rules for Regional Resource Plans, parks in the Atlanta Region are included as Greenspace Linkages as a backdrop to the Regionally Important Resources Map and help to form a continuous green infrastructure network. [Greenspace Linkages are not considered to be Regionally Important Resources for the purposes of this plan.]



CONSERVATION AND RECREATION REGIONALLY IMPORTANT RESOURCES

FIGURE 4



Guidance for Appropriate Development Practices

TABLE 3

Matrix of Guidance for Appropriate Development Practices [1] **Areas of Conservation and/ or Recreational Value**	Water Supply Watersheds	Groundwater Recharge Areas	Wetlands	River Corridors	Mountain Protection	Regional Reservoirs	Regional Greenways and Multi-Use Trails	National Park Service Sites	State Parks and Other Recreation Areas
Regulations and Plans									
Adhere to all local, state and federal regulations for the protection of State Vital Areas	X		X	X	X				
Where practical, exceed minimum required buffers from protected areas	X			X		X	X		
Encourage the voluntary set aside of land in a development that is part of a conceptual greenway connectivity plan							X		
Site Design and Connectivity									
Use alternative designs and materials to minimize the use of impervious surface to the greatest practical extent	X		X	X		X	X		
Where possible, utilize natural features on site for stormwater management	X		X						
Install rain gardens, vegetated swales or other enhanced water filtration design within the landscape of the project to enhance the quality of stormwater run-off	X		X	X	X	X	X		
Where possible, retain existing vegetation and topography	X		X	X	X	X	X		
Locate structures and impervious areas as far away as possible from water resources, including wetlands and flood prone areas on the development site	X		X	X					
Undertake stream restoration or streambank stabilization for any compromised areas of a stream				X			X		
Where possible, link areas along river corridors to existing greenways or establish a conservation mechanism for future greenway development			X	X			X		
Do not disturb land in proximity to the boundary of a potential subsurface resource, such as a cemetery or archaeological site								X	X
Where possible, use multi-use trails to link new developments to public access points for national or state parks and other recreation areas								X	X
Architectural and Design Aesthetics									
Consider impact to viewsheds and take appropriate steps to mitigate impacts					X			X	X
Programs and Protections									
Consider the donation of a conservation easement for land that will be impacted by development in proximity to a historic or cultural resource, and/ or rural or agricultural area								X	X

[1]ARC staff will use professional judgment to determine whether recommendations are applicable to a project under review within one mile of a Regionally Important Resource.

General Policies and Protection Measures

TABLE 4

Matrix of General Policies and Protection Measures **Areas of Conservation and/ or Recreational Value**	**Water Supply Watersheds**	**Groundwater Recharge Areas**	**Wetlands**	**River Corridors**	**Mountain Protection**	**Regional Reservoirs**	**Regional Greenways and Multi-Use Trails**	**National Park Service Sites**	**State Parks and Other Recreation Areas**
Regulations and Plans									
Meet or exceed all state and federal regulations for the protection of State Vital Areas	X		X	X	X				
Adopt model ordinances (or their equivalent) as recommended by the Metropolitan North Georgia Water Planning District	X								
Within the context of a community green infrastructure plan, develop watershed improvement projects that will enhance the health of watersheds in the local community	X		X						
Within the context of a community green infrastructure plan, develop a local greenway management plan that considers both conservation and recreational uses of wetlands, flood prone areas and other water quality resources			X	X			X		
Within the context of a community green infrastructure plan develop local connections among regional parks, trails and other community resources							X	X	X
Site Design and Connectivity									
Promote the redevelopment of existing sites and address any prior water quality impacts at the time of redevelopment	X								
Adopt a conservation subdivision/ cluster subdivision option where appropriate; review and revise existing conservation subdivision/ cluster subdivision ordinances to ensure they accomplish conservation goals	X				X	X			
Ensure local development review process adequately addresses protections for areas that are important to water quality and ensure that local ordinances do not preclude site design standards that improve water quality	X		X	X		X			
Ensure that current development ordinances limit or prohibit the location of structures in flood prone areas			X	X					
Establish incentives for development projects that provide access to a community greenway or trail							X		
Establish criteria to identify potential corridors that possess unique natural, scenic, or cultural value				X			X	X	X
Architectural and Design Aesthetics									
Document significant features that contribute to the scenic viewshed of natural, historic and rural areas and develop design guidelines to mitigate the visual impact of new development in these areas					X				
Programs and Protections									
Work cooperatively to develop a regional TDR program	X		X	X	X	X	X	X	X
Implement a conservation easement donation program for the public holding of easements and/ or explore options for the fee simple ownership of greenspace by local governments	X		X	X	X	X	X	X	X
Examine the feasibility of establishing a PDR program that focuses on land acquisition along stream banks and floodplains			X	X			X		
Establish a wetlands/ streambank mitigation bank along a greenway			X	X			X		
Work proactively to foster partnerships/ "friends of" programs to enhance the effective stewardship of greenways, trails, parks, historic and cultural resources							X	X	X

HISTORY AND CULTURE

Historic and cultural resources create the contextual setting for many of the character defining features of a community. Historic preservation planning is generally governed by the parameters established by the Department of the Interior, National Park Service. The Secretary of the Interior's Standards have come to be accepted as the benchmark by which a property is deemed to have historic significance. A property listed on the National Register of Historic Places has been vetted through an extensive review process and is, by definition, a historic place worthy of preservation.

Communities in the Atlanta Region have recognized projects that demonstrate historic preservation initiatives on multiple scales – from identification of National Landmarks to documentation of subsurface archaeological resources. Included in the Regional Resource Plan are structures that reflect both high-style and vernacular architectural traditions. It includes landscapes by the Olmstead Firm, structures by Heinz, Reed and Adler, and cultural repositories of arts and archives. The diversity of resources within the Atlanta Region is reflected through a multitude of historic districts and individual sites that trace significant cultural events from its prehistoric occupants, through early European settlements, the Civil War, the New South and into the mid-20th century.

In the Atlanta Region, historic preservation has been used as a tool to create benchmarks for community identity beyond just proscriptive architectural requirements. Cultural sites express distinctive beliefs, qualities or ideas of regional importance, and serve as repositories for collections of cultural objects. An increasing awareness of the importance of cultural landscapes – sites and places identified with the unique heritage of a community or region whereby context is created by a combination of historic and natural resources – can overlap with more traditional elements of a green infrastructure network. They can enhance interest and appeal beyond the natural and recreational qualities of a community, and often add an educational component beyond understanding the need to preserve biodiversity and environmental quality.

MARTIN LUTHER KING JR. NATIONAL HISTORIC SITE / CREDIT: RAFTERMAN PHOTOGRAPHY

National Historic Landmarks

There are fewer than 2,500 National Historic Landmarks identified throughout the United States, and the Atlanta Region is fortunate to have seven National Historic Landmarks, all located within the City of Atlanta. National Historic Landmarks are properties identified as having exceptional value or quality in illustrating the history of the United States, therefore they have been identified as Regionally Important Resources.

The Georgia State Capitol: Constructed between 1884 and 1889, the Georgia Capitol is a symbol of the "capitol" of the New South, as Atlanta considered itself to be after Reconstruction. Its design follows the Neoclassical precedent common to government buildings and following the design of the U.S. Capitol. The Capitol grounds are landscaped with native Georgia plants.

Martin Luther King Jr. National Historic Site and District: This district includes the Martin Luther King Jr. birth and childhood home, Ebenezer Baptist Church, Fire Station #6 and the King Center. The work of Martin Luther King Jr. is associated with many events of the Civil Rights movement as well as landmark social reforms passed in the Civil Rights Act and Voting Rights Act of 1964.

Sweet Auburn Historic District: Sweet Auburn is a 1 ½ mile stretch along its namesake Road, Auburn Avenue. This neighborhood, adjacent to the Martin Luther King National Historic Site, is associated with significant events of the Civil Rights Movement, as well as the New South experiences of African Americans.

Herndon Mansion (1910): The Herndon Mansion was the home Alonzo Herndon and wife Adrienne, who was also the designer of the residence. Alonzo was born into slavery and raised in a sharecropping family, but would later become Atlanta's first black millionaire. Beginning his professional career in barbering, his entrepreneurial talents allowed him to operate several barbershops in downtown Atlanta. He invested widely in real estate and founded the Atlanta Life Insurance Company in the Sweet Auburn neighborhood.

Wren's Nest – the Joel Chandler Harris House (c.1880): The Wren's Nest is the home where Harris wrote many of his Uncle Remus/ Br'er Rabbit tales. He spent his early years growing up on a southern plantation where he was exposed to these stories and their storytellers first hand. Harris was not the only author to record these African folk tales brought to the South through the enslaved African population; however, his position with the local newspaper, the *Atlanta Constitution,* provided a forum for widespread dissemination of these tales.

Fox Theatre (1929): The Fox Theatre is a unique example of neo-Mideastern exotic revival architecture and has played a significant role in the cultural heritage of Atlanta. It is also an outstanding example of the classic ornate movie palaces that thrived in the early 20th century.

Dixie Coca Cola Bottling Plant (c.1900): This plant is the first Georgia bottling plant of the Coca-Cola Company, an international beverage icon. In addition to being the oldest surviving building of the early history of the Coca Cola Company, it is also a unique example of Victorian-era commercial architecture.

Stone Hall, Atlanta University (1882): Serving historically as the administration building for Atlanta University between 1882 and 1929, Stone Hall is an icon of the Atlanta University Center (AUC). The AUC is known as a center for the education of black Americans. The building is currently affiliated with Morris Brown College.

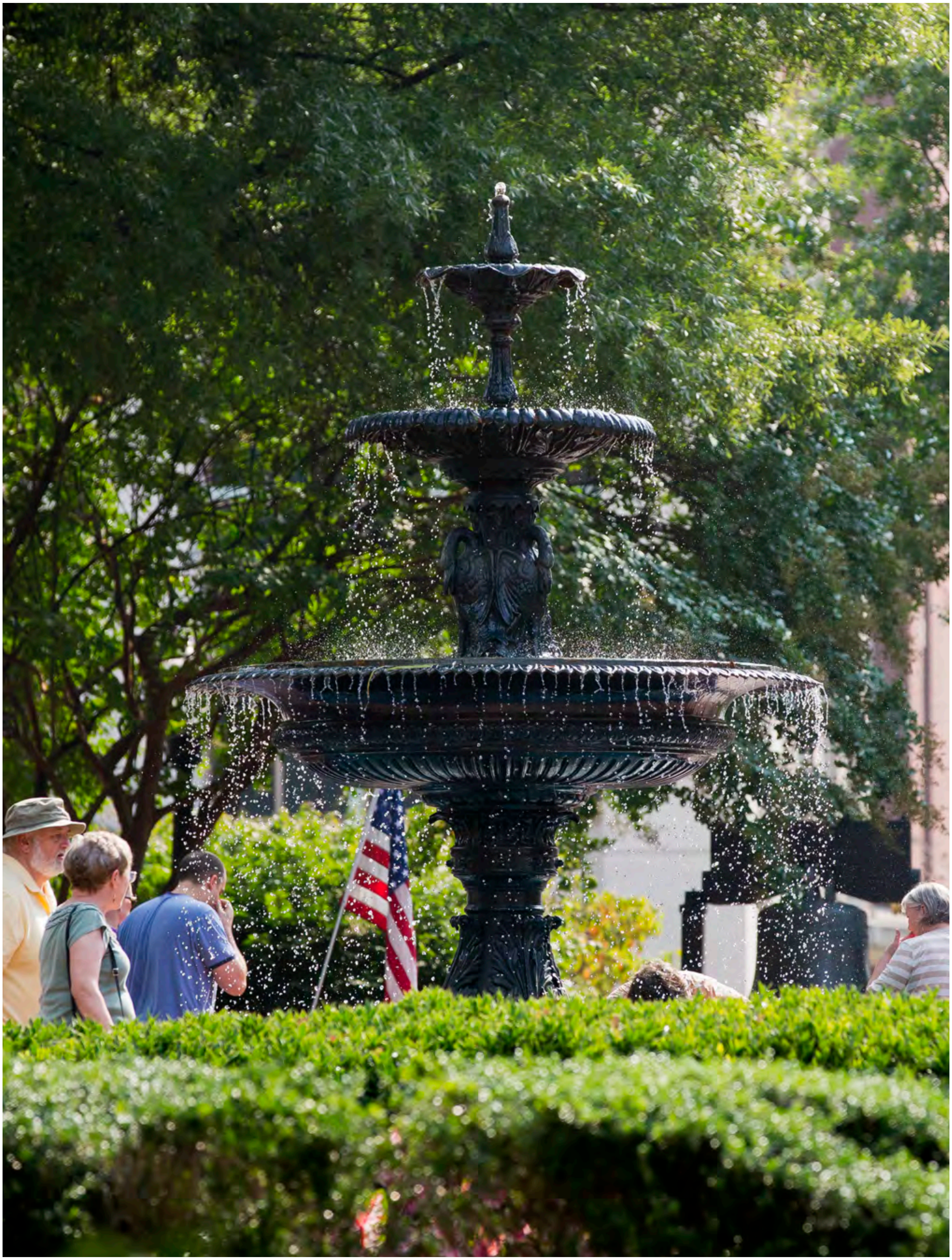
U.S. Post Office and Courthouse (1911): Covering an entire downtown city block, the Second Renaissance Revival structure served as the central post office until services were moved in the early 1930s. Designed to house both postal and court functions, the Eleventh Circuit Court of Appeals occupied the building when it was established in 1981, and was eventually named in honor of Judge Albert P. Tuttle.

National Historic Landmarks

Value	Vulnerability
• Nominated by an individual, interested organization, local government/ government agency • Natural or cultural resources identified by other state agencies and/or environmental protection organizations • Preserves areas that have historical or cultural value by virtue of history, place or time period represented	• Fluctuations in land values threatens economic viability of current use • Threatened by adjacent development that is incompatible in terms of design, scale or land use • Lack of financial resources for appropriate stewardship • Lack of long-term ownership plan/ transitional ownership for some parts of the resources

ARC Management Strategies
ARC will continue to support existing programs and regulations for the management of National Historic Landmarks. The Martin Luther King National Historic Site and District is managed by the National Park Service (www.nps.gov/malu). Other National Historic Landmarks fall under the stewardship of private non-profit organizations. In the Sweet Auburn district, many of the resources are privately owned, but the Historic District Development Corporation – a non-profit community based organization with a professional staff – was formed to foster redevelopment within the area (www.hddc.net). The Herndon Home is operated by the Alonzo F. and Norris B. Herndon Foundation, which was set up by Norris Herndon, the son of Alonzo and Adrienne Herndon. The Wren's Nest is governed by a non-profit Board of Directors and operated by professional staff, the executive director being the great-great-great-grandson of Joel Chandler Harris (www.wrensnestonline.com). The Fox Theatre is governed by a non-profit Board of Directors known as Atlanta Landmarks Inc. and operated by professional staff (www. foxtheatre.org). The Dixie Coca Cola Bottling Plant is part of the Georgia State University Campus and houses the GSU Baptist Student Union.

WRENS NEST NATIONAL HISTORIC LANDMARK / CREDIT: ARC


DOWNTOWN MARIETTA SQUARE / CREDIT: RAFTERMAN PHOTOGRAPHY

National Register Historic District

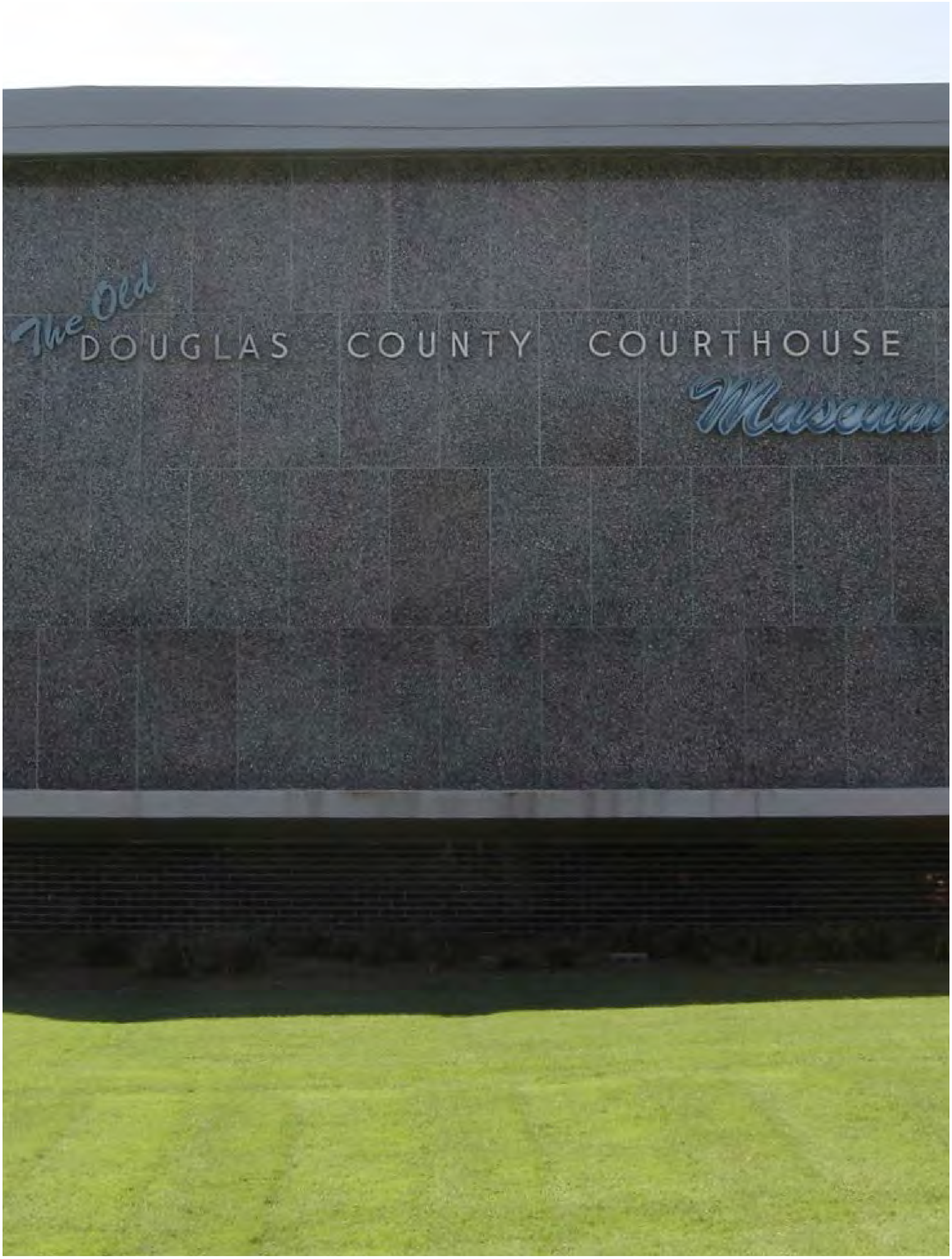
National Register Historic Districts include buildings, structures, sites and objects that are, by definition, worthy of preservation. Districts reflect the core community building blocks of neighborhoods and activity centers that are the character and culture of our region. They encompass a scale and diversity of resources that is appropriate to be considered as regionally significant. Several individual districts were nominated by local jurisdictions for inclusion, and it was deemed equitable to include all National Register districts as equally important. In several instances, National Register Districts also encompassed sites that had been individually nominated as Regionally Important Resources, including Piedmont Park, the Olmstead Parks in the Druid Hills Neighborhood, Grant Park in the city of Atlanta and Woodward Academy, Barrett Park and the City Amphitheatre and Cemetery in the city of College Park. Table 6 identifies all of the National Register Historic Districts in the Atlanta Region that are included as Regionally Important Resources. Individual Resources listed on the National Register of Historic Places are included in Appendix K.

Value	Vulnerability
• Nominated by an individual, interested organization, local government/ government agency • Natural or cultural resources identified by other state agencies and/or environmental protection organizations • Preserves areas that have historical or cultural value by virtue of history, place or time period represented • Areas that contribute to region-wide connections between existing and proposed regional resources	• Fluctuations in land values threatens economic viability of current use • Threatened by adjacent development that is incompatible in terms of design, scale or land use • Threatened by destruction of significant viewshed • Lack of protection through adequate regulations and easements
ARC Management Strategies	
ARC will continue to support existing programs and regulations for the management of National Historic Register Districts. Designation as a National Register Historic District is an honorific title, which confers no additional regulations by the local government. National Register criteria are linked to certain preservation incentives, such as tax credits, and it also triggers a level of review in instances where federally funded, licensed or permitted activities may impact resources within the district. The programs are managed by the State Historic Preservation Office (SHPO) which in Georgia is operated through the Department of Natural Resources, Historic Preservation Division (www.gashpo.org).	

National Register Historic Districts

TABLE 5

National Register of Historic Places Districts by County		
Cherokee County	• Canton Commercial District	• Ball Ground Historic District
Clayton County	• Jonesboro Historic District	
Cobb County	• Acworth Downtown Historic District • Atlanta- Frasier Street Historic District • Big Shanty Village Historic District • Cherokee Street Historic District • Church Street-Cherokee Street Historic District • Clarksdale Historic District • Collins Avenue Historic District	• North Main Street Historic District • Northwest Marietta Street Historic District • Sope Creek Ruins Historic District • Summers Street Historic District • Washington Avenue Historic District • Whitlock Avenue Historic District
DeKalb County	• Avondale Estates Historic District • Briarcliff Historic District • Brookhaven Historic District • Cameron Court District • Candler Park Historic District • Decatur Downtown Historic District • Druid Hills Historic District • Emory Grove Historic District • Emory University District • Kirkwood Historic District • Klondike Historic District	• McDonough-Adams-King Hwy Historic District • Northwoods Historic District • Oglethorpe University Historic District • Ponce de Leon Court Historic District • South Candler Street – Agnes Scott College Historic District • Stone Mountain Historic District • University Park – Emory Highlands – Emory Estates Historic District • Winnona Park Historic District
Douglas County	• Douglasville Commercial Historic District	• Sweetwater Manufacturing Historic District
Fulton County	• Adair Park Historic District • Ansley Park Historic District • Atkins Park District • Atlanta University Center District • Berkley Park Historic District • Brookhaven Historic District • Brookwood Hills Historic District • Cabbagetown Historic District • Capitol View Manor Historic District • Castleberry Hill Historic District • College Park Historic District • Collier Heights Historic District • East Point Industrial District • Fairburn Commercial Historic District • Fairlie-Poplar Historic District • Fox Theatre Historic District • Garden Hills Historic District • Georgia Institute of Technology Historic District • Grant Park Historic District • Grant Park North District • Hapeville Historic District • Home Park School District • Hotel Row Historic District • Howell Interlocking Historic District • Howell Station Historic District • Inman Park Historic District	• Inman Park-Moreland Historic District • Martin Luther King Jr Historic District • Knox Apartments, Cauthorn House and Peachtree Road Apartments Historic District • Lakewood Heights Historic District • Mean Street Historic District • Midtown Historic District • Mozely Park Historic District • Oakland City Historic District • Peachtree Highlands Historic District • Peachtree Highlands – Peachtree Park Historic District • Piedmont Park Historic District • Pittsburgh Historic District • Reynoldstown Historic District • Roswell Historic District • Southern Railway North Avenue Yards Historic District • Sweet Auburn Historic District • Techwood Homes Historic District • Underground Atlanta Historic District • Virginia Highland Historic District • Washington Park Historic District • West End Historic District • Whittier Mills Historic District
Gwinnett County	• Norcross Historic District	• Suwanee Historic District
Henry County	• Lawrenceville Street Historic District	• McDonough Historic District
Rockdale County	• Conyers Commercial Historic District	• Conyers Residential Historic District



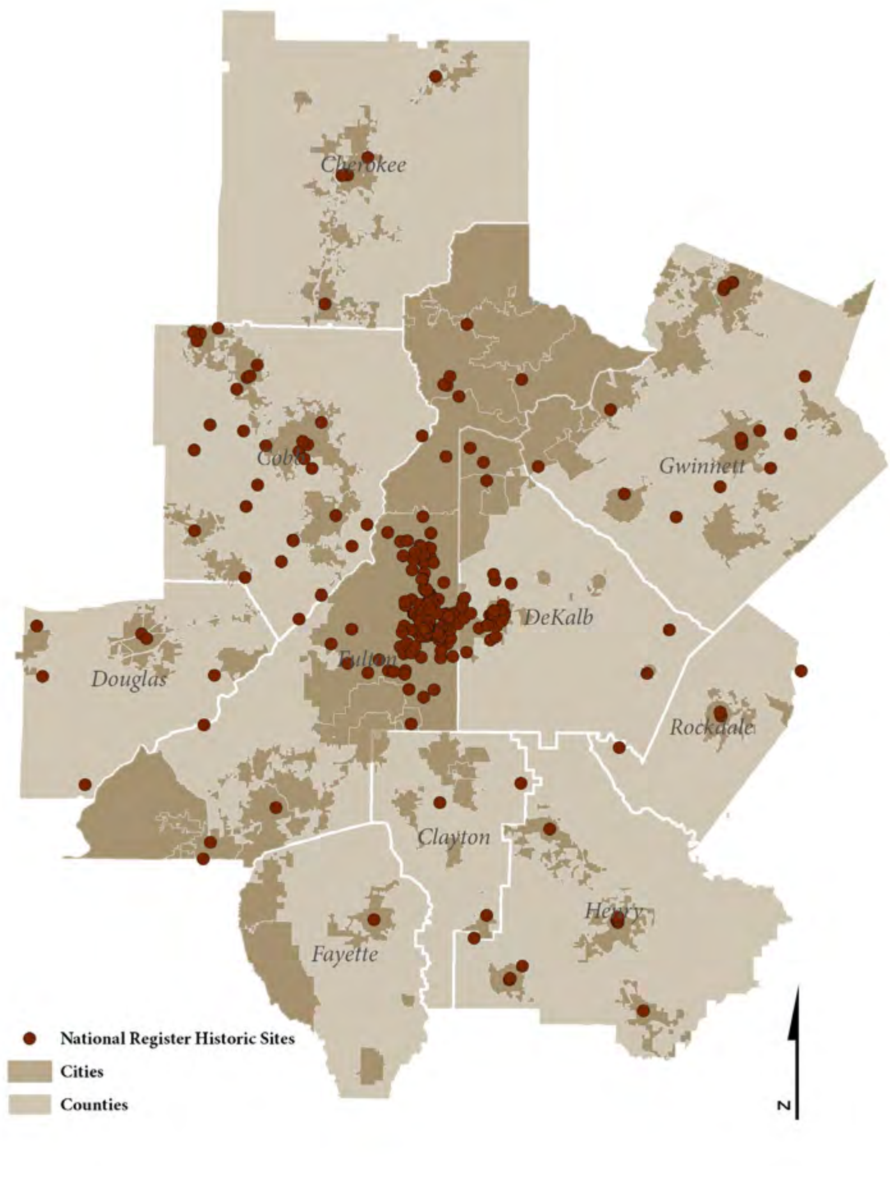
DOUGLAS COUNTY COURTHOUSE MUSEUM / CREDIT: ARC

National Register Historic Sites

FIGURE 5

Cultural Connections

As with districts that are listed on the National Register of Historic Places, individually listed sites bridge the gap among those places in between neighborhoods and commercial centers that laid the foundations of communities. Metro Atlanta claims almost 300 individually listed National Register sites, with countless more eligible sites identified through regular evaluation. These sites are more than just the private homes of important citizens and early civic buildings. They include sites such as the military earthworks at Johnston's Line from the Atlanta Campaign of the Civil War; objects such as the Riverview Carousel and the Memorial to the Six Million. They include commercial and industrial buildings, hotels and schools, churches and train depots. All of these buildings are integral to the history and community development of their cities and towns, and they provide cultural connections in the larger cultural infrastructure network of the Metro Atlanta region. [Cultural Connections are not considered to be Regionally Important Resources for the purposes of this plan.]



National Register Historic Sites

TABLE 6

National Register of Historic Places Individually Listed Resources by County

Resource	County
Canton Cotton Mills No. 2	Cherokee
Canton Wholesale Company Building	Cherokee
Cherokee County Courthouse	Cherokee
Crescent Farm	Cherokee
Roberts, Alfred W., House	Cherokee
Woodstock Depot	Cherokee
Crawford-Dorsey House and Cemetery	Clayton
Orkin Early Quartz Site	Clayton
Rex Mill	Clayton
Stately Oaks	Clayton
Bankston, J. C., Rock House	Cobb
Bethel AME Church	Cobb
Braswell-Carnes House	Cobb
Brumby, Arnoldus, House	Cobb
Butler, Hiram, House	Cobb
Butner--Mctyre General Store	Cobb
Camp McDonald	Cobb
Carmichael, J. H., Farm and General Store	Cobb
Causey, Israel, House	Cobb
Cheney, Andrew J., House	Cobb
Cowen, Stephen D., House	Cobb
Frobel--Knight--Borders House	Cobb
General, The	Cobb
Gibson, John S., Farmhouse	Cobb
Gilgal Church Battle Site	Cobb
Glover--McLeod--Garrison House	Cobb
Johnston's Line	Cobb
Kennesaw Mountain National Battlefield Park	Cobb
Lake Acworth Beach and Bathhouse	Cobb
Mable, Robert, House and Cemetery	Cobb
Marietta National Cemetery	Cobb
McAdoo, William Gibbs, House	Cobb
Midway Presbyterian Church and Cemetery	Cobb
Moore, Tarleton, House	Cobb
Pace, Solomon and Penelopy, House	Cobb
Power, George A., House	Cobb

Resource	County
Rice, John W., Summer Cottage	Cobb
Riverview Carousel at Six Flags Over Georgia	Cobb
Ruff's Mill and Concord Covered Bridge	Cobb
Sope Creek Ruins	Cobb
Taylor--Brawner House and Brawner Sanitarium	Cobb
Zion Baptist Church	Cobb
Alston, Robert A., House	DeKalb
Blair--Rutland Building	DeKalb
Bond Family House	DeKalb
Briarcliff	DeKalb
Briarcliff--Normandy Apartments	DeKalb
Callanwolde	DeKalb
Callanwolde (Boundary Increase)	DeKalb
Cheek--Spruill House	DeKalb
Decatur Cemetery	DeKalb
Decatur Waterworks	DeKalb
Donaldson-Bannister House and Cemetery	DeKalb
Druid Hills Parks and Parkways	DeKalb
Farmer, Neville and Helen, Lustron House	DeKalb
Fischer, Dr. Luther C. and Lucy Hurt, House	DeKalb
Gay, Mary, House	DeKalb
Gentry, William T., House	DeKalb
Hampton, Cora Beck, Schoolhouse and House	DeKalb
Kirkwood School	DeKalb
Lee, Agnes, Chapter House of the United Daughters of the Confederacy	DeKalb
Old DeKalb County Courthouse	DeKalb
Pearce, William and Minnie, House	DeKalb
Pines, Russell and Nelle, Lustron House	DeKalb
Pythagoras Lodge No. 41, Free and Accepted Masons	DeKalb
Scottish Rite Hospital for Crippled Children	DeKalb
Scottish Rite Hospital for Crippled Children (Boundary Decrease)	DeKalb
Seminary, The	DeKalb
Smith-Benning House	DeKalb
Soapstone Ridge	DeKalb

National Register Historic Sites

Resource	County
South Candler Street--Agnes Scott College Historic District	DeKalb
Steele-Cobb House	DeKalb
Swanton House	DeKalb
United States Post Office--Decatur, Georgia	DeKalb
Zuber--Jarrell House	DeKalb
Basket Creek Cemetery	Douglas
Beulah Grove Lodge No. 372, Free and Accepted York Masons--Pleasant Grove School	Douglas
Carnes, John Thomas, Family Log House	Douglas
Douglas County Courthouse	Douglas
Pine Mountain Gold Mine	Douglas
Roberts, Col. William T., House	Douglas
Sweet Water Manufacturing Site	Douglas
Fayette County Courthouse	Fayette
Holliday--Dorsey--Fife House	Fayette
King, Tandy, House	Fayette
61 16th Street Apartment Building	Fulton
63 Magnum Street Industrial Building	Fulton
705 Piedmont Avenue Apartments	Fulton
Academy of Medicine	Fulton
Adams, Charles R., Park	Fulton
Adams, Jack and Helen, Lustron House	Fulton
Alexander, Cecil and Hermione, House	Fulton
Apartments at 2 Collier Road	Fulton
Apartments at 22-24 Collier Road	Fulton
Arnold, Thomas P., House	Fulton
Ashby Street Car Barn	Fulton
Atlanta and West Point Railroad Freight Depot	Fulton
Atlanta Biltmore Hotel and Biltmore Apartments	Fulton
Atlanta Buggy Company and Warehouse--Hatcher Bros. Furniture Company	Fulton
Atlanta City Hall	Fulton
Atlanta Spring and Bed Company--Block Candy Company	Fulton
Atlanta Stockade	Fulton
Atlanta Waterworks Hemphill Avenue Station	Fulton
Atlanta Women's Club	Fulton
Ballard, Levi, House	Fulton

Resource	County
Baltimore Block	Fulton
Barrington Hall	Fulton
Bass Furniture Building	Fulton
Beavers, John F., House	Fulton
Brazeal, Dr. Brailsford R., House	Fulton
Briarcliff Hotel	Fulton
Brittain, Dr. Marion Luther, Sr., House	Fulton
Building at 161 Spring St.	Fulton
Bulloch Hall	Fulton
Burns Cottage	Fulton
Butler Street Colored Methodist Episcopal Church	Fulton
Campbell County Courthouse	Fulton
Candler Building	Fulton
Canton Apartments	Fulton
Capital City Club	Fulton
Carnegie Library of Atlanta	Fulton
Central Presbyterian Church	Fulton
Church of the Sacred Heart of Jesus	Fulton
Citizen's and Southern Bank Building	Fulton
Coca-Cola Building Annex	Fulton
College Street School	Fulton
Cooledge, F. J., and Sons, Company--Hastings' Seed Company	Fulton
Cox--Carlton Hotel	Fulton
Crescent Apartments	Fulton
Crogman, William H., School	Fulton
Cyclorama of the Battle of Atlanta	Fulton
Davis, H.B., Building--Hotel Roxy	Fulton
Degive's Grand Opera House	Fulton
Dixie Coca-Cola Bottling Company Plant	Fulton
Ellis, Rutherford and Martha, House	Fulton
Empire Manufacturing Company Building	Fulton
English-American Building	Fulton
Epting, Thomas and Rae, Lustron House	Fulton
Farlinger	Fulton
Fire Station No. 11	Fulton
First Congregational Church	Fulton
First Methodist Episcopal Church, South	Fulton

National Register Historic Sites

Resource	County
Ford Motor Company Assembly Plant	Fulton
Forscom Command Sergeant Major's Quarters	Fulton
Fox Theatre	Fulton
Freeman Ford Building	Fulton
Fulton County Courthouse	Fulton
Garrison Apartments	Fulton
General Electric Company Repair Shop Warehouse	Fulton
Georgia State Capitol	Fulton
Gilbert, Jeremiah S., House	Fulton
Glenn Building	Fulton
Glenridge Hall	Fulton
Grady Hospital	Fulton
Grant Park North	Fulton
Grant, W. D., Building	Fulton
Great Atlantic & Pacific Tea Company	Fulton
Griffith School of Music	Fulton
Habersham Memorial Hall	Fulton
Harris, Joel Chandler, House	Fulton
Healey Building	Fulton
Herndon Home	Fulton
Highland School	Fulton
Hillyer Trust Building	Fulton
Home Park School	Fulton
Howell, Mrs. George Arthur, Jr., House	Fulton
Hurt Building	Fulton
Imperial Hotel	Fulton
Inman Park	Fulton
King Plow Company	Fulton
Knight, William and Ruth, Lustron House	Fulton
Kriegshaber, Victor H., House	Fulton
Long, Crawford W., Memorial Hospital	Fulton
Memorial to the Six Million	Fulton
National NuGrape Company	Fulton
New Hope African Methodist Episcopal Church and Cemetery	Fulton
Newtown Elementary School	Fulton
Nicolson, William P., House	Fulton
North Avenue Presbyterian Church	Fulton

Resource	County
Oakland Cemetery	Fulton
Odd Fellows Building and Auditorium	Fulton
Omega Chapter of the Chi Phi Fraternity	Fulton
Orr, J. K., Shoe Company	Fulton
Palmer House and Phelan House Apartments	Fulton
Park Street Methodist Episcopal Church, South	Fulton
Peachtree Christian Church	Fulton
Peachtree Heights Park	Fulton
Peachtree Southern Railway Station	Fulton
Peters, Edward C., House	Fulton
Piedmont Park	Fulton
Piedmont Park Apartments	Fulton
Pitts, Thomas H., House and Dairy	Fulton
Raoul, William G., House	Fulton
Retail Credit Company Home Office Building	Fulton
Rhodes Memorial Hall	Fulton
Rhodes-Haverty Building	Fulton
Roberts, Isaac, House	Fulton
Rock Spring Presbyterian Church	Fulton
Rose, Rufus M., House	Fulton
Rucker, Simeon and Jane, Log House	Fulton
Sardis Methodist Church and Cemetery	Fulton
Sciple, Charles E., House	Fulton
Selig Company Building	Fulton
Shrine of the Immaculate Conception	Fulton
Smith, Archibald, House	Fulton
Smith, Tullie, House	Fulton
Southern Bell Telephone Company Building	Fulton
Southern Belting Company Building	Fulton
Southern Dairies	Fulton
Southern Railway North Avenue Yards Historic District	Fulton
Southern Spring Bed Company	Fulton
Spotswood Hall	Fulton
St. Andrews Apartments	Fulton
St. Mark Methodist Church	Fulton
Staff Row and Old Post Area--Fort McPherson	Fulton
Stewart Avenue Methodist Episcopal Church South	Fulton
Stone Hall, Atlanta University	Fulton

National Register Historic Sites

Resource	County
Swan House	Fulton
Temple, The	Fulton
Texas, The	Fulton
Thornton, Albert E., House	Fulton
Thorton Building	Fulton
Tompkins, Henry B., House	Fulton
Trio Steam Laundry	Fulton
Troy Peerless Laundry Building	Fulton
Trygveson	Fulton
Tyler, Mary Elizabeth, House	Fulton
Tyree Building	Fulton
U.S. Post Office and Courthouse	Fulton
United States Post Office, Federal Annex	Fulton
Van Winkle, E., Gin and Machine Works	Fulton
Villa Lamar	Fulton
Wallace, Anne, Branch--Carnegie Library of Atlanta	Fulton
Washington, Booker T., High School	Fulton
Western and Atlantic Railroad Zero Milepost	Fulton
Western Electric Company Building	Fulton
Westinghouse Electric Company Building	Fulton
Wilson, Judge William, House	Fulton
Winecoff Hotel	Fulton
Winship, George, Jr., and Emily, House	Fulton
Witham, Stuart, House	Fulton
Wynne--Claughton Building	Fulton
Yonge Street School	Fulton
Adair, Isaac, House	Gwinnett
Alcovy Road Grist Mill	Gwinnett
Allen, Bona, House	Gwinnett

Resource	County
Allen, John Quincy, House	Gwinnett
Bona Allen Shoe and Horse Collar Factory	Gwinnett
Buford Public School Auditorium	Gwinnett
Craig, Robert, Plantation	Gwinnett
Gwinnett County Courthouse	Gwinnett
Hudson--Nash House and Cemetery	Gwinnett
Mechanicsville School	Gwinnett
Old Seminary Building	Gwinnett
Parks--Strickland Archeological Complex	Gwinnett
Superb, The	Gwinnett
Terrell, William, Homeplace	Gwinnett
Ware, Clarence R., House	Gwinnett
Winn, Elisha, House	Gwinnett
Wynne, Thomas, House	Gwinnett
Brown House	Henry
Crawford-Talmadge House	Henry
Globe Hotel	Henry
Griffin, Smith, House	Henry
Hampton Depot	Henry
Henderson Manufacturing Company	Henry
Henry County Courthouse	Henry
Hooten, James and Bertha, House	Henry
Locust Grove Institute Academic Building	Henry
Walden-Turner House	Henry
Almand--O'Kelley--Walker House	Rockdale
Dial Mill	Rockdale
Parker, Aaron and Margaret, Jr., House	Rockdale
Rockdale County Jail	Rockdale

CENTENNIAL OLYMPIC PARK / CREDIT: RAFTERMAN PHOTOGRAPHY

Olympic Legacy

Atlanta hosted the Summer Olympics in 1996, and the entire region and state had the benefit of the exposure as a world class city, capable of hosting such an event. The modern Olympics began in 1896, and since that time, only two other U.S. cities have had the distinction of serving as host communities. The 1996 games in Atlanta coincided with its centennial celebration, adding another level of significance to the experience. Within the Atlanta Region, Olympic events were held at fifteen different locations, but **Centennial Olympic Park** stands out as Georgia's lasting legacy of the Centennial Olympic Games. Located in downtown Atlanta, the 21-acre park includes commemorative features such as 600,000+ engraved bricks sponsored by private donors; granite from each of the five continents represented in the Olympic Games; and the Fountain of Rings – using the Olympic symbol of five interconnected rings. As a symbol of the Olympic legacy in Georgia, Centennial Olympic Park has been identified as a Regionally Important Resource.

Value	Vulnerability
• Nominated by an individual, interested organization, local government/ government agency • Preserves areas that have historical or cultural value by virtue of history, place or time period represented	• Potential lack of financial resources for appropriate stewardship
ARC Management Strategies	
ARC will continue to support existing programs and regulations for the management of Centennial Olympic Park. The park is owned by the State of Georgia and operated by the Georgia World Congress Center Authority (www.centennialpark.com). It also benefits from a "Friends of" organization that provides additional financial resources.	

CENTENNIAL OLYMPIC PARK

KENNESAW MOUNTAIN NATIONAL BATTLEFIELD PARK / CREDIT: ARC

Civil War Battlefields and Sites

The National Park Service has taken the lead on recognizing the importance of Civil War Battlefields within the context of our local and regional cultural heritage, as well as for their implications for our national history. Working through local partnerships with organizations such as the Georgia Battlefield Association, continued documentation has identified remnants of several significant sites in the Atlanta Region. These are sites of value as both historic resources and cultural landscapes. The Civil War Sites Advisory Commission has identified seven primary Civil War Battles that are associated with the Atlanta Campaign (1864) within the Atlanta Region: **Ezra Church/ Battle of the Poor House** (Fulton County); **Jonesborough** (Clayton County); **Kennesaw Mountain** (Cobb County); **Kolb's Farm** (Cobb County); **Lovejoy's Station** (Clayton County); **Peachtree Creek** (Fulton County) ; **Utoy Creek** (Fulton County). Nominations were also submitted for additional Civil War sites: **Nash Farm Battlefield Park** (Henry County) and the remnants of the earthwork **Shoupades** constructed by Confederate General Joseph E. Johnston (Cobb County).

In addition to battlefields, the Atlanta region has several sites affiliated with events of the Civil War, which are accessible to the public. Located in downtown Kennesaw, **Camp McDonald Park** (Cobb County) was a Confederate Civil War training ground.

The remnants of **Fort Walker** (Fulton County) are located in the city of Atlanta on the edge of National Register listed Grant Park. It includes the remains of earthworks that were formerly a four-gun battery. Also referred to as a *redoubt* (a protected place of refuge or defense), Fort Walker was constructed in 1863 as a part of the defensive line surrounding the city of Atlanta.

The **Judge William Wilson House** (Fulton County), is a two-story Greek Revival House constructed c. 1856. It was used as a temporary headquarters by General William Sherman during the Battle of Atlanta. It is individually listed on the National Register of Historic Places, and a small cemetery on the property includes both family and slave burials.

The **Concord Bridge Historic District and Heritage Park**, including the site of the **Concord Woolen Mill** (Cobb County) was a complete mill community with a school, church and general store. Developed by Martin Ruff and Robert Daniel beginning in the 1830s, the Union Army destroyed the factory on July 4, 1864. Shortly thereafter on July 9, 1864, the Union Army had moved into Douglas County and burned the New Manchester Mills at Sweetwater Creek State Park, also a listed as a Regionally Important Resource. The Concord Woolen Mill was rebuilt in 1869, and Ruff and Daniel are also credited with building the Concord Covered Bridge in 1872.

Finally, cemeteries throughout the region include individual burials or small sections of Confederate soldiers. In addition to the Confederate Cemetery found at Oakland Cemetery (which is individually listed as a Regionally Important Resource), the **Jonesboro Confederate Cemetery** (Clayton County) and **Marietta Confederate Cemetery** (Cobb County) are both under the stewardship of the Georgia Building Authority in addition to four other confederate cemeteries in the State.

Civil War Battlefields and Sites

Value	Vulnerability
• Resource nominated by an individual, interested organization, local government/ governmental agency • Natural or cultural resources identified by other state agencies and/or environmental protection organizations • Preserves areas that have historical or cultural value by virtue of history, place or time period represented • Areas that contribute to region-wide connections between existing and proposed regional resources	• Threatened by destruction of subsurface resources, such as archaeological sites • Lack of protection through adequate regulations and easements • Lack of financial resources for appropriate stewardship • Lack of long-term ownership plan/ transitional ownership for some parts of the resources

ARC Management Strategies
ARC will continue to support existing programs and regulations for the management of Civil War Battlefields and Sites. Many of the resources identified with the Civil War are located on private property. Kennesaw Mountain National Battlefield Park commemorates the battle that took place at Kennesaw Mountain, and includes resources such as Kolb's Farm. Nash Farm Battlefield is a Historic Park managed by Henry County, and one of the eight remaining earthwork Shoupades in Cobb County will be located within a tract of land that has been acquired by the county. "Friends of" groups, including the River Line Historic Area Committee (Mableton Improvement Coalition) and the Friends of Nash Farm, provide additional resources to these sites. The Land for Camp McDonald Park was acquired by Cobb County, and a group of Friends of Camp McDonald Park advocate for the park's preservation and development (http://campmcdonaldpark.org/). Fort Walker falls under the stewardship of the City of Atlanta Department of Parks, Recreation and Cultural Affairs, but as an entity within Grant Park, also has a non-profit advocate in the form of the Grant Park Conservancy (www.gpconservancy.org). The Judge William Wilson house is currently privately owned, though efforts by the city of Atlanta have been initiated to acquire the property, and the Concord Bridge Historic District and Heritage Park is a locally designated historic district by Cobb County with conservation easements held by the Cobb Land Trust (http://www.cobblandtrust.org/html/heritage.html). The Jonesboro and Marietta Confederate Cemeteries are maintained by the Georgia Building Authority (www.gba.georgia.gov).

STONE MOUNTAIN

Archaeological Sites

Soapstone Ridge is a 25-square mile area lying in the southwest corner of DeKalb County, with smaller sections extending into Fulton and Clayton Counties. It is a low ridge, cut by several streams, rising from the south bank of the South River, containing the largest collection of archaic soapstone quarries used by Native Americans in the eastern United States. Archaeological surveys performed in the 1970s identified 65 archaeological sites. Since this time, many sites have been lost to the rapid residential development that took place from the 1980s to the early 2000s. Soapstone Ridge has also been designated as a local historic district governed by the DeKalb County Historic Preservation Ordinance, providing strict archaeological guidelines for areas within the local district. Among other things, these guidelines include a review procedure, requirement for an intensive field survey, and site preservation mechanisms.

The **Fort Daniel Archaeological Project** in Gwinnett County is included as a Regionally Important Resource for its historic value documenting late 18th/ early 19th century frontier settlement patterns in Georgia, and also as an example of the importance of preservation of archaeological sites and the role they plan within a green infrastructure network. The effort to excavate and document Fort Daniel has been lead by professional archaeologists and volunteers, including the efforts of the Gwinnett Archaeological Research Society. Their efforts have resulted in the Friends of Fort Daniel, which has since transformed itself into the non-profit Fort Daniel Foundation, Inc. They have been able to leverage funds to complete a master plan of the site to be developed as the Fort Daniel Historic Site and Archaeological Research Park. Once constructed, the park will serve purposes of both conservation and recreation, and provide a unique educational experience as well.

Within the Atlanta Region, there are numerous other sites that are either listed in the National Register or have been identified as potential National Register eligible archaeological sites. The rapid pace of development within the Atlanta Region has resulted in the alteration or demolition of buildings, sites, objects, landscapes and other traditional historic resources, making the archaeological record even more valuable. Soapstone Ridge and Fort Daniel are illustrative of the unique nature of these types of subsurface resources, and are representative of areas that can benefit from additional research and documentation. The map on the following pages identifies areas that have a high probability of yielding significant archaeological information, and is included herein for purposes of illustration.

Value	Vulnerability
• Resource nominated by an individual, interested organization, local government/ governmental agency • Preserves areas that have historical or cultural value by virtue of history, place or time period represented • Areas that contribute to region-wide connections between existing and proposed regional resources	• Threatened by destruction of subsurface resources, such as archaeological sites • Threatened by adjacent development that is incompatible in terms of design, scale or land use • Lack of protection through adequate regulations and/ or easements • Lack of enforcement of existing regulations • Lack of long-term ownership plan/ transitional ownership for some parts of the resources

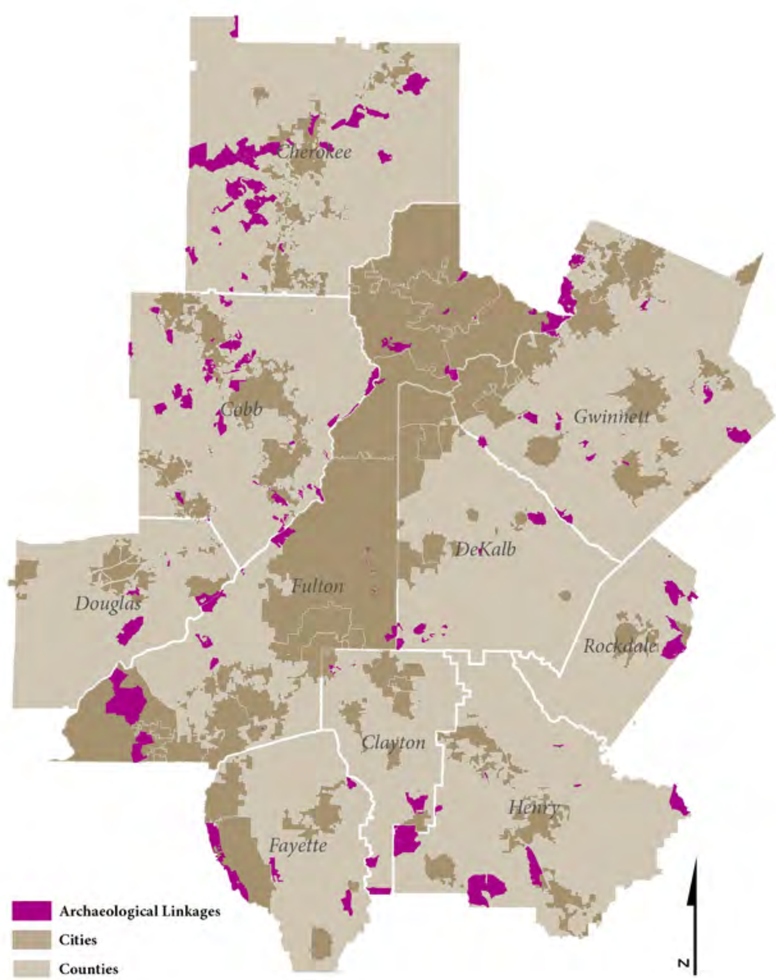
Archaeological Sites

FIGURE 6

ARC Management Strategies
ARC will continue to support existing programs and regulations for the management of archaeological and subsurface resources. Soapstone Ridge has been designated as a site on the National Register of Historic Places. Designation is an honorific title, which confers no additional regulations by the local government. National Register criteria are linked to certain preservation incentives, such as tax credits, and it also triggers a level of review in instances where federally funded, licensed or permitted activities may impact resources within the district. The programs are managed by the State Historic Preservation Office (SHPO) which in Georgia is operated through the Department of Natural Resources, Historic Preservation Division (www.gashpo.org). Soapstone Ridge has also been designed as a local historic district governed by the DeKalb County Historic Preservation Ordinance (www.co.dekalb.ga.us/planning/mainPage). Fort Daniel is eligible for listing on the National Register of Historic Places, but there are currently no local protections for this site.

Greenspace Linkages

The Atlanta Region contains a vast archaeological record of significant events from the past. This includes, but is not limited to, sites associated with prehistoric communities and Civil War battles. Conventional practice dictates that specific knowledge of these sites is limited to credentialed professionals. As sites are better documented and protected, as is the case with Soapstone Ridge and Fort Daniel, they have potential to be classified as Regionally Important Resources. However, the generalized location of archaeological sites informs the Regional Resource Plan. Pursuant to the DCA Rules for Regional Resource Plans, these archaeological sites in the Atlanta Region are included as Greenspace Linkages as a backdrop to the Regionally Important Resources Map and help to form a continuous green infrastructure network. [Greenspace Linkages are not considered to be Regionally Important Resources for the purposes of this plan.]



BASKET CREEK CEMETERY / CREDIT: ARC

Cemeteries

Cemeteries are areas established for, or containing graves, tombs or funeral urns. Common types of cemeteries include municipal cemeteries, religious cemeteries, military cemeteries, family cemeteries, and others established by private burial societies. Many cemeteries function as public greenspace and often include resources of both historic and cultural value as designed landscapes with monuments that reflect distinctive architectural features. Cemeteries also function as placeholders for past development patterns that have long since been lost to encroaching development.

Cemeteries included as Regionally Important Resources include those that are individually listed on the National Register of Historic Places, including **Oakland Cemetery** (Fulton County); **Basket Creek Cemetery** (Douglas County); **Marietta National Cemetery** (Cobb County); and **Decatur City Cemetery** (DeKalb County). Also, cemeteries that reflect distinctive design traditions are included as Regionally Important Resources, including **Westveiw Cemetery** (Fulton County); **Southview Cemetery** (Fulton County); and the **Georgia National Cemetery** (Cherokee County).

<table>
<tr><th>Value</th><th>Vulnerability</th></tr>
<tr><td>

Resource nominated by an individual, interested organization, local government/ governmental agency
Preserves areas that have historical or cultural value by virtue of history, place or time period represented
Areas that contribute to region-wide connections between existing and proposed regional resources

</td><td>

Threatened by destruction of subsurface resources, such as archaeological sites
Threatened by adjacent development that is incompatible in terms of design, scale or land use
Lack of protection through adequate regulations and/ or easements
Lack of enforcement of existing regulations
Lack of long-term ownership plan/ transitional ownership for some parts of the resources

</td></tr>
<tr><th colspan="2">ARC Management Strategies</th></tr>
<tr><td colspan="2">ARC will continue to support existing programs and regulations for the management of regionally important cemeteries. Typical of many older cemeteries, Oakland is managed through a partnership between the City of Atlanta and local non-profit organization (www.oaklandcemetery.com), while individual burial plots are owned by the individuals buried therein, and by extension, their families and descendants. Decatur City Cemetery is similarly managed (http://www.decaturga.com/index.aspx?page=291. Other historic cemeteries are managed by private burial societies, such as Southview (www.southviewcemetery.com) and Westview (http://www.westviewcemetery.com/home.php). Large military cemeteries are typically maintained by the federal government, such as Marietta National Cemetery (http://www.cem.va.gov/cems/nchp/marietta.asp) and the Georgia National Cemetery (http://www.cem.va.gov/cems/nchp/georgia.asp).

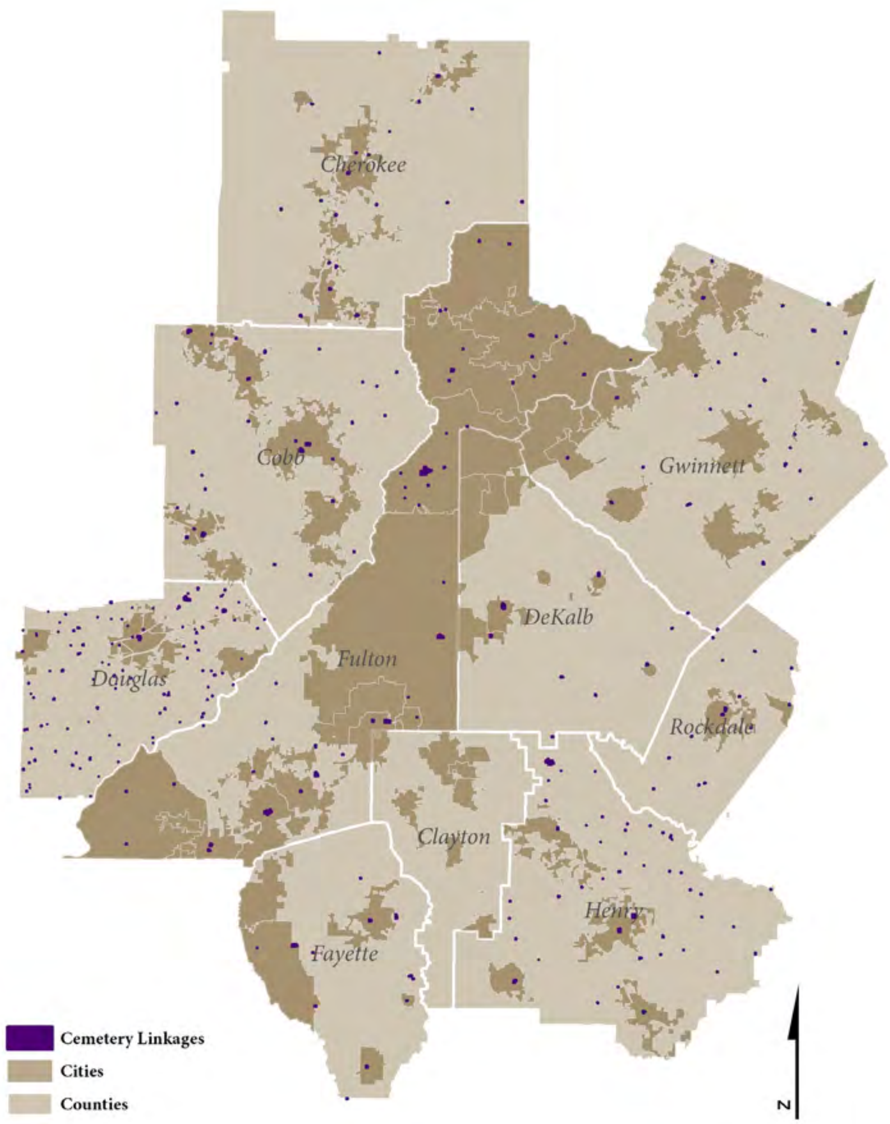
ARC will continue to document existing cemeteries that contribute as regional Greenspace Linkages.</td></tr>
</table>

Cemeteries

FIGURE 7

Greenspace Linkages

Cemeteries also create a larger regional network of unique resources. Over 400 individual cemeteries have been identified in the Atlanta Region. Ongoing research will continue to identify previously undocumented cemetery sites. Cemeteries are significant not only as community greenspace, but also for their value as historic and cultural resources, geneaological records, and their value to foster a local sense of place. Pursuant to the DCA Rules for Regional Resource Plans, cemeteries in the Atlanta Region are included as Greenspace Linkages as a backdrop to the Regionally Important Resources Map and help to form a continuous green infrastructure network. [Greenspace Linkages are not considered to be Regionally Important Resources for the purposes of this plan.]



MONASTERY OF THE HOLY SPIRIT / CREDIT: ARC

Cultural Sites

Cultural Sites include sites or corridors that express distinctive beliefs, qualities or ideas of regional importance. Cultural sites can include, but are not limited to

- Repositories for a collection of natural, scientific, historic, literary, artistic, or other cultural objects;
- Sites with distinctive features that are emblematic of the region; and/ or
- Cultural centers with strong cultural ties.

In the Atlanta Region, the following areas are included as cultural sites:

The National Archives - Southeast Region: The National Archives has 180,000 cubic feet of archival holdings dating from 1716. It is a center for the study of Southern history. Records in the National Archives tell the story of southern families and communities, technological advances that changed lives, and social and economic forces that shaped the makeup of society.

Georgia State Archives: The Georgia Archives identifies and preserves Georgia's most valuable historic documents. The Georgia Archives is the official repository of archival records for the U.S. State of Georgia. Together with the Georgia Capitol Museum, it forms the Georgia Division of Archives and History and is overseen by the office of the Georgia Secretary of State.

The Carter Center and the Jimmy Carter Library and Museum: The Carter Center, in partnership with Emory University, is guided by a fundamental commitment to human rights and the alleviation of human suffering. It seeks to prevent and resolve conflicts, enhance freedom and democracy and improve health. The Carter Center collaborates with other organizations, public or private, in carrying out its mission. The Jimmy Carter Library and Museum is part of the Presidential Library System administered by the National Archives and Records Administration. The Library includes material related to Jimmy and Rosalynn Carter and their family, as well as major figures and significant aspects of the Carter administration. The Museum includes a permanent exhibit of historical memorabilia from the Carter presidency, as well as gallery space for rotating exhibits.

Auburn Avenue Research Library: Anchoring the west end of the Sweet Auburn Historic District, the Auburn Avenue Research Library on African American Culture and History opened in May 1994 in Atlanta. A special library of the Atlanta-Fulton County Public Library System, it is the first public library in the Southeast to offer specialized reference and archival collections dedicated to the study and research of African American culture and history and of other peoples of African descent. In 2001 the Library received a Governor's Award in the Humanities.

Monastery of the Holy Spirit: The Monastery of the Holy Spirit is a Roman Catholic religious community located in Conyers, Georgia, which encompasses approximately 2,000 acres of land; home to a community of monks spanning several generations, who live, work and worship at the Abbey. At the Monastery, monks follow the Cistercian Order, a monastic society wholly ordered to contemplation. For over 60 years, the Monastery has been a place for everyone of all races, creeds, genders or backgrounds.

The Hindu Temple of Atlanta: Conceived of the 1970s, the groundbreaking for the Temple was held in 1986, with construction beginning in earnest in 1989. The various shrines that give the temple is unique architectural presence represent various deities and traditions from the Hindu culture. The temple serves a population greater than Metro Atlanta and Georgia, drawing visitors from the southeast and beyond.

Cultural Sites

Woodruff Arts Center: The Woodruff Arts Center is comprised of the Alliance Theater, the Atlanta Symphony Orchestra and the High Museum of Art. 1.2 million visitors annually come through the Center.

Pemberton Place: Located in downtown Atlanta, this is the location of three attractions that have formed the core of a cultural district on the doorstop of the internationally famous Centennial Olympic Park. The Georgia Aquarium houses more than 100,000 animals in 10 million gallons of water. The World of Coca Cola tells the history of this international brand from its founding in Atlanta in 1886; and the Center for Civil and Human Rights connects Atlanta's historic legacy of Civil Rights with the ongoing struggle for global civil and human rights. It also houses the Morehouse College Martin Luther King, Jr. Collection.

Value	Vulnerability
• Preserves areas that have historical or cultural value by virtue of history, place or time period represented	• Lack of financial resources for appropriate stewardship
ARC Management Strategies	
ARC will continue to support existing programs and regulations for the management of Cultural Sites in the region. ARC is undertaking a survey of arts of cultural institutions that may inform future work in this category. Currently, all identified cultural sites benefit from management and oversight of professional agencies capable of their stewardship.	

HIGH MUSEUM OF ART AT THE WOODRUFF ARTS CENTER / CREDIT: RAFTERMAN PHOTOGRAPHY

Cultural Sites

FIGURE 8

Cultural Connections

Metro Atlanta is home to world class cultural infrastructure. Over half of the cultural non-profit organizations in the State of Georgia are located in the 10-county Atlanta region, with over $1.8 billion in assets. The Atlanta region also ranks at the top of the scale among our national peers in the number of arts related businesses and the employees that work in those industries. Libraries, museums, and theaters provide the front-line opportunities for public access to arts and cultural opportunities in communities across the region. [Cultural Connections are not considered to be Regionally Important Resources for the purposes of this plan.]

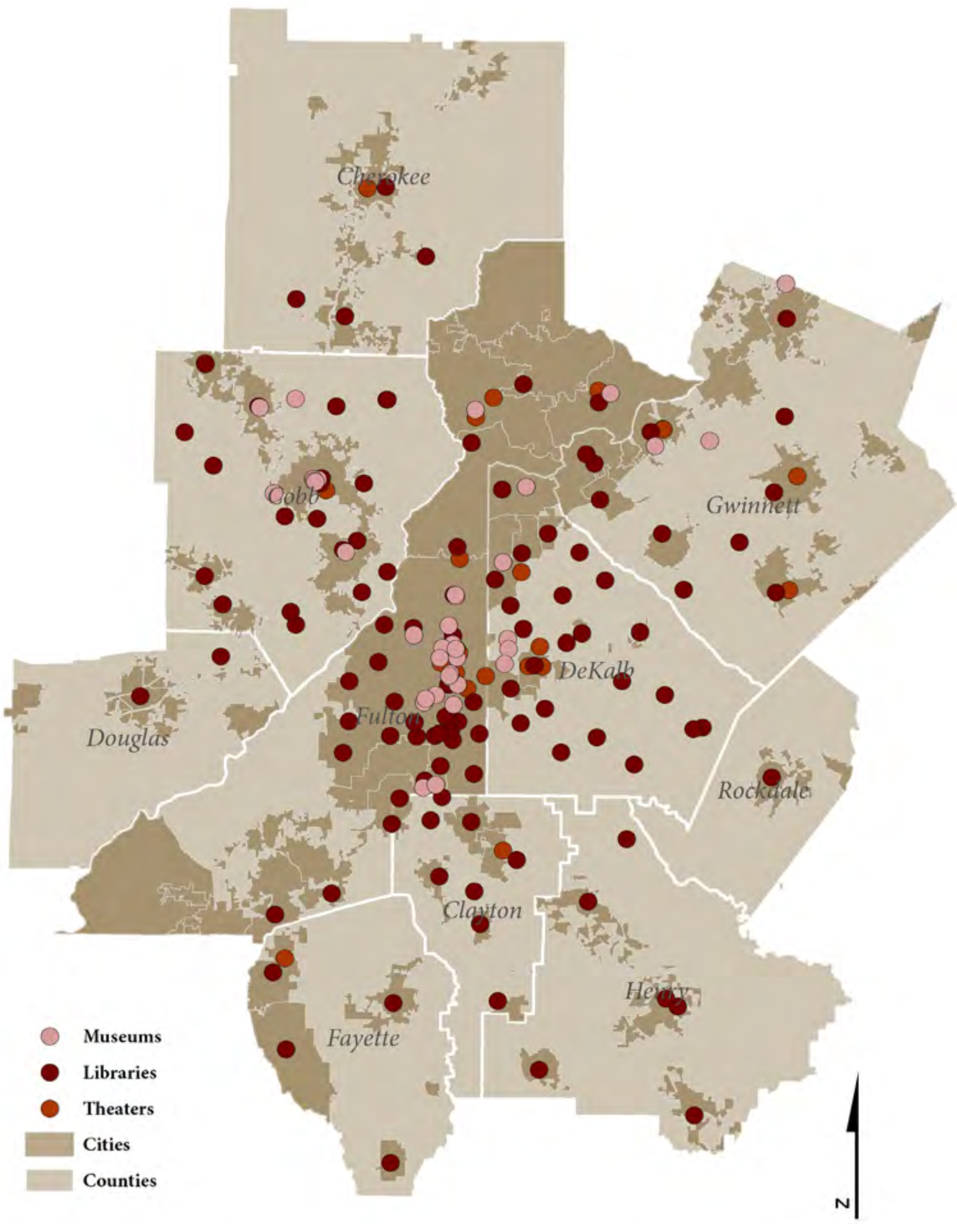
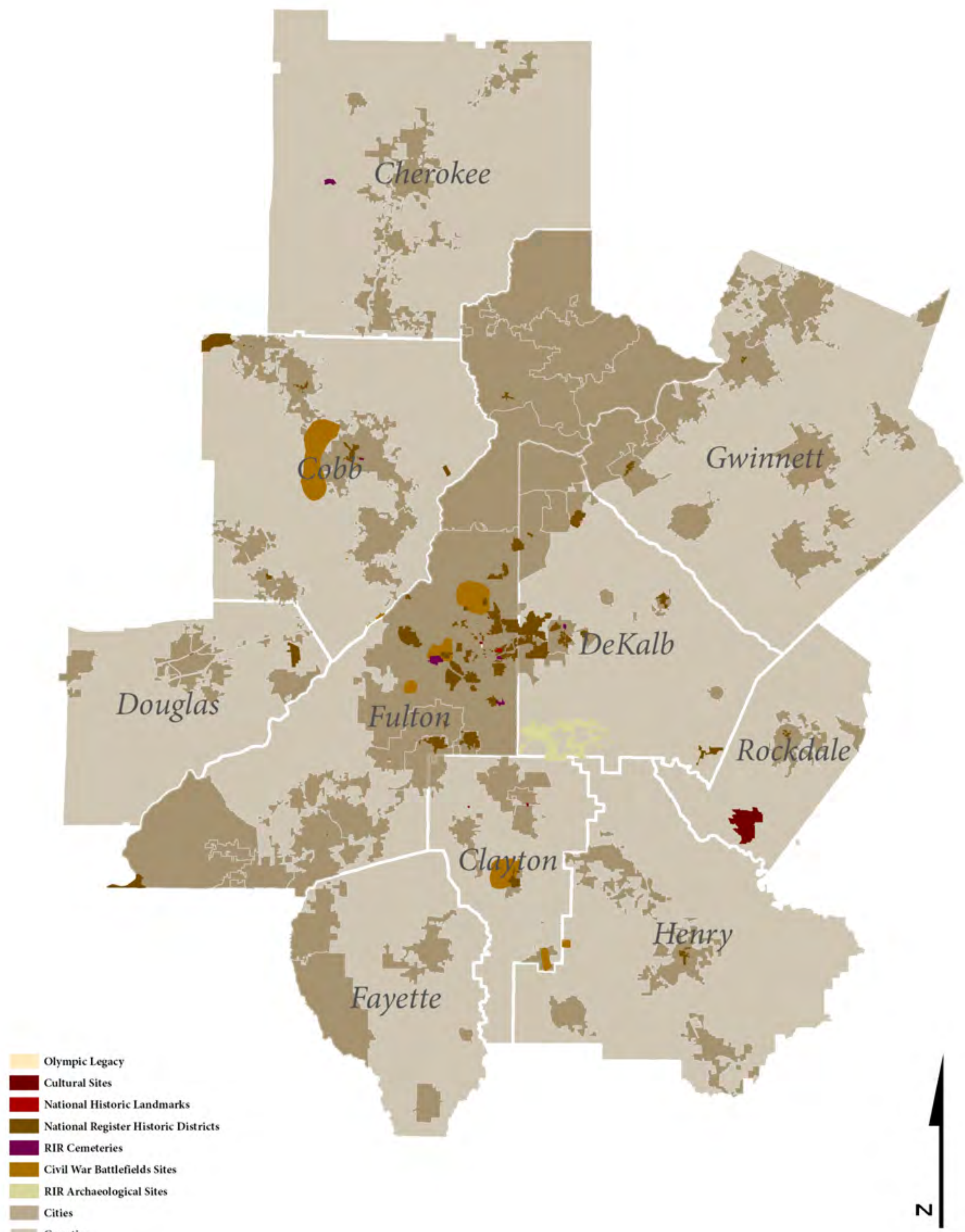


FIGURE 9

HISTORIC AND CULTURAL REGIONALLY IMPORTANT RESOURCES



Guidance for Appropriate Development Practices

TABLE 7

Matrix of Guidance for Appropriate Development Practices[1] **Historic and Cultural Resources**	National Historic Landmarks	National Register Historic Districts	Olympic Legacy	Civil War Battlefields and Sites	Archaeological Sites	Cemeteries	Cultural Sites
Site Design and Connectivity							
Do not disturb land in proximity to the boundary of a potential subsurface resource, such as a cemetery or archaeological site				X	X	X	
Where possible, use multi-use trails to link new developments to public access points for national or state parks and other recreation areas			X				
Architectural and Design Aesthetics							
Consider impact to viewsheds and take appropriate steps to mitigate impacts	X	X		X	X	X	
Design of new development should be compatible in terms of size, scale, and aesthetic appearance near existing resources	X	X	X				X
New developments should complement, but not copy, historic precedents	X	X					
Programs and Protections							
Consider the donation of a conservation easement for land that will be impacted by development in proximity to a historic or cultural resource, or rural or agricultural area	X	X	X	X	X	X	

[1]ARC staff will use professional judgment to determine whether recommendations are applicable to a project under review within one mile of a Regionally Important Resource.

General Policies and Protection Measures

TABLE 8

Matrix of General Policies and Protection Measures **Historic and Cultural Resources**	National Historic Landmarks	National Register Historic Districts	Olympic Legacy	Civil War Battlefields and Sites	Archaeological Sites	Cemeteries	Cultural Sites
Regulations and Plans							
Within the context of a community green infrastructure plan develop local connections among regional parks, trails and other community resources			X	X			
Incorporate a heritage tourism and/ or agritourism component into community economic development plans	X	X		X			X
Site Design and Connectivity							
Establish criteria to identify potential corridors that possess unique natural, scenic, or cultural value		X		X	X		
Architectural and Design Aesthetics							
Document significant features that contribute to the scenic viewshed of natural, historic and rural areas and develop design guidelines to mitigate the visual impact of new development in these areas	X	X					
Understand and advocate the role that historic structures plan in promoting energy conservation and sustainable community design		X					
Programs and Protections							
Work cooperatively to develop a regional TDR program		X	X				
Implement a conservation easement donation program for the public holding of easements and/ or explore options for the fee simple ownership of greenspace by local governments				X	X	X	
Work proactively to foster partnerships/ "friends of" programs to enhance the effective stewardship of greenways, trails, parks, and historic and cultural resources	X	X	X	X	X	X	X
Pursue programs such as Preserve America and/ or Certified Local Government status to increase access to funding opportunities for historic and cultural resource protection	X	X					
Enhance traditional historic preservation efforts by developing an interpretive context through oral history, wayfinding signage, and installation of historic markers	X	X					

SCENIC AND AGRICULTURAL

The pace and scale of the urbanization that has taken place in the Atlanta Region has precluded many of the traditional land uses associated with the rural, agrarian character found throughout Georgia. Nonetheless, the desire of local communities to preserve what is left of their rural character coupled with a recent growth in the interest of locally grown and/ or organic foods calls attention to the unique nature of rural and agricultural uses within the Region. Portions of north and south Fulton County, western Douglas County, eastern Gwinnett County, western Cobb County, northern Cherokee County, and the South Fayette County/ Clayton County Panhandle area still retain much of the feel and character of rural communities. Local Comprehensive Plans for these areas reflect the desire to protect this character against the pressures of continued development. Within these areas, as well as other isolated pockets throughout the Atlanta Region, small-to-medium size farms have been able to engage in agricultural production. Much of this is done on a limited scale, and an informal survey of resources suggests that many of these farming efforts are sustained by access to local farmers markets or Community Supported Agricultural cooperatives. Community gardens are beginning to emerge in places like Decatur (Oakhurst Community Garden), Atlanta (Rose Circle Community Garden) and Suwanee (Harvest Farm at White Street Park).

Overall, each of these areas of agricultural and scenic value identified as Regionally Important Resources encompass a broad range of unique issues and opportunities. Their inclusion in this plan results from the distinctive niche they hold in an otherwise largely urban and suburban region. Within each, there is an array of existing mechanisms to control land use patterns – zoning and development regulations, overlay districts, and future development plans, to name a few. Identifying these areas as Regionally Important Resources reinforces many of the local policies and regulations that govern these areas and enhances the awareness of the value of cultural landscapes within these areas. Of all resources defined within this Plan, areas of agricultural and or scenic value can benefit from holistic land planning efforts that consider their value defined within a larger context and merges the best of natural resource conservation with historic preservation.

SOUTH FULTON SCENIC BYWAY / CREDIT: ARC

Rural Preserves

North Fulton County: The City of Milton comprises the northernmost tip of Fulton County. Incorporated in 2006, the city's vision statement draws a distinction between their goals and others in the urban Atlanta Region: Milton is a distinctive community embracing small-town life and heritage while preserving and enhancing our rural character. Numerous equestrian farms have developed in this region, and the topography reflects a noticeable shift between the Georgia Piedmont and the Blue Ridge environments. The Future Character Areas of their Comprehensive Plan Update rely heavily on descriptors of less intensity: Linear Greenspace, Equestrian Estates, Rural Residential, Agricultural Area, Conservation Area and Greenspace, Rural Village and Scenic Corridors.

Fulton County's Comprehensive Plan also identifies the importance of their rural resources. They identify numerous crossroads communities, or areas that were the "…hub of activities and services in the farming communities." The communities of Crabapple, Birmingham and Arnold Mill are identified as still maintaining a high degree of character, and others including Ocee, Fields Crossroads, Warsaw, Hopewell, Newtown, and Webb retain some level of identity, but have lost most of the buildings that formed the core of the communities. Crabapple, Birmingham, and Arnold Mill fall within zoning overlays in the city of Milton that allow significant opportunities for design review to preserve community character.

South Fulton County: Much of the area of South Fulton that falls within the designation as a Regionally Important Resource lies within the city of Chattahoochee Hills. Numerous nominations for potential resources were received within this area, including cemeteries, scenic views, parks, and watershed protection districts. The collective area identified as a Regionally Important Resource includes many of these areas that were nominated as individual sites. (Appendix C includes a complete list of nominated resources.)

Initiatives aimed at developing this area as a new model for sustainable development in the region have existed for some time. In addition to efforts to preserve and protect water quality and forest resources, Chattahoochee Hills has also developed a plan for a nearly 100-mile system of greenways and trails. Community members advocate for the increasing viability of small farms and preservation of agricultural uses. Enabling mechanisms are in place to use both transfer and purchase of development rights in this area. Also within the South Fulton area, the Georgia Scenic Byways Program has recognized the South Fulton Byway. It is a 29-mile loop that uses Cochran Mill Road, Hutcheson Mill Road and State Highway 70 and allows opportunities to view forest and pastoral landscapes through both motoring and cycling.

Gwinnett County: Two distinct character areas within Gwinnett County have been specifically designed to balance the demand for growth with the need for preservation. The Chattahoochee River Area is comprised primarily of residential development, but the county has determined a need to protect the Chattahoochee River and Lake Lanier through future development that is more environmentally sensitive. Additionally, the local plan found that there is little need or demand for intense development, such as mixed-use, conventional retail centers, industrial uses and multi-family housing. This area includes unincorporated Gwinnett County, as well as portions of Berkeley Lake, Duluth, Suwanee, Sugar Hill and Buford.

Areas of the eastern portion of Gwinnett County have been designated as Rural Estate Areas. This is intended to preserve the county's rural history while anticipating growth pressures that they are likely to see in the future. This area includes several other resources nominated as Regionally Important, including Tribble Mill Park and Harbins-Alcovy River Park.

Western Cobb County: Cobb County has designated areas within their community for limited lower density development. The areas denoted as Rural Residential in the Cobb County Comprehensive Plan and Future Land Use Map likely do not have access to sewer and are not in proximity to major activity centers or public services. These areas are to be developed in a manner that helps protect rural character and environmentally sensitive areas. The area also includes natural and environmentally sensitive resources, particularly those associated with Lake Allatoona and its surrounding environs, that foster open space protection and preserve a sense of rural character.

Rural Preserves

North Cherokee County: Recognizing that large scale farming operations have ceased to be predominant in the county, the intent of the Rural Places Character Area is to provide for an agricultural-residential community that enhances the stewardship of natural and scenic environment. It promotes traditional rural home economies, limits the scale of commercial uses, and discourages suburban patterns of development. Identified elements key to the preservation of this character area include the limitation on sewer expansion and emphasis on greenspace conservation. Much of this area also coincides with land in the Etowah River Basin, which is home to several endangered wildlife species. This Etowah River Corridor will benefit from another level of natural resources management when the Etowah Conservation Habitat Plan is adopted.

West Douglas County: The health of the Dog River Watershed in western Douglas County is a key component of the county's efforts to maintain water quality. As a result the county has initiated efforts to protect land within the drainage basin of the Dog River Reservoir. In addition to water quality monitoring programs, the county developed a zoning classification that results in less impact from impervious surfaces and limited number of septic tanks. The county also imposes buffers and impervious surface limitations adjacent to rivers and streams.

South Fayette County/ Clayton County Panhandle: The significance of these areas as Regionally Important Resources is tied not only to their low density land use patterns and preservation of rural character, but also the importance of the unique ecosystem of the Flint River. The Flint River and surround lands are critical natural features in the southern portion of the Atlanta Region. The headwaters of the Flint River are within the Atlanta region, and it supplies water in the southern portion of the region. It is known for abundant wetlands and is home to several endemic fish species. The Flint River originates near the Hartsfield Jackson International Airport and flows south through Clayton County. All of Fayette County is within the Flint basin as well as portions of Clayton, Fulton and Henry Counties. The headwaters of the Flint River are highly impervious due to the presence of the airport and associated uses.

Much of this area of Clayton County is shown to be appropriate for agricultural or conservation use on its Future Land Use Map. This provides opportunities to preserve a lower density pattern of development that will lend itself to better protection for the health of the river basin. (The importance of River Basins in regional planning is addressed in Appendix A). Also within this area is a large facility operated by the Clayton County Water Authority that uses natural treatment systems to treat reclaimed water, including constructed wetlands. The Authority controls more than 4,000 acres of greenspace within this area.

In Fayette County, the RIR boundary is not only influenced by the geography of the river corridor, but also the county's commitment to protecting its southern portion as an Agricultural/ Residential Zone. Current zoning in the area limits development to one residential unit per five acres, which is the least intensive density in the Atlanta Region. Conservation mapping work by the State of Georgia also supports the need to conserve this area to further overall environmental quality.

LAKE LAURA GARDENS / CREDIT: ARC

Georgia Centennial Farms

The Georgia Centennial Farm Program recognizes the agricultural heritage of the state and the families who have been integral to its history. It focuses on farms that have been in operation for over a century - some held by the same family, and some meeting the criteria to be considered eligible for the National Register of Historic Places. The Centennial Farms in the Atlanta Region have not only been identified as significant historic resources and cultural landscapes by a state agency, but also connect with the ARC criteria of preserving significant working agricultural resources. Nine farms have been recognized in the Atlanta Region through the Centennial Farm Program: **A.W. Roberts Farm** (Cherokee County); **Lake Laura Gardens** (Cobb County); **Moss Clark Farm** (Henry County); **Fieldstone Farm** (Henry County); **Rolling Acres Farm** (Rockdale County); **Gresham Galt Farm** (Cherokee County); **Mabry Farm** (Cobb County); **Alfarminda Farm** (Gwinnett County); **Benefield Farm** (Gwinnett County).

Value	Vulnerability
• Natural or cultural resources identified by other state agencies and/or environmental protection organizations • Preserves water quality and quantity by protecting drainage, flood control, recharge areas, watersheds, buffers, etc. • Creates or preserves active or passive greenspaces including trails, gardens and informal places of natural enjoyment in areas currently underserved by greenspace • Preserves areas that have historical or cultural value by virtue of history, place or time period represented • Preserves significant working agricultural or forest resources and/or creates opportunities for local food production activities • Areas that contribute to region-wide connections between existing an proposed regional resources	• Fluctuations in land values threatens economic viability of current use • Threatened by adjacent development that is incompatible in terms of design, scale or land use • Threatened by destruction of significant viewshed • Lack of protection through adequate regulations and/ or easements • Lack of long-term ownership plan/ transitional ownership for some parts of the resources
ARC Management Strategies	
ARC will continue to support existing programs and regulations for the management of Centennial Farms. The designation as a Centennial Farm is administered through the State Historic Preservation Office (SHPO), which in Georgia is within the Department of Natural Resources, Historic Preservation Division (www.gashpo.org). Each farm is privately owned.	

CHATTAHOOCHEE HILL COUNTRY / CREDIT: ARC

Georgia Agritourism Sites

The Georgia Agritourism Program fosters greater awareness of agritourism destinations by working with local farms to provide signage and other resources to increase visibility. Agritourism programs are a key benefit to maintaining the economic sustainability of regional resources of agricultural importance. Five farms have been recognized in the Atlanta Region through the Georgia Agritourism Program: **Rancho Alegre Farms** (Gwinnett County), **Southern Belle Farms** (Henry County), **Yule Forest/ The Pumpkin Patch** (Henry County), **Adams Farm** (Fayette County) and **Gibbs Gardens** (Cherokee County). Rancho Alegre Farms promotes a variety of opportunities, including field trips, camps, farmers market, and rental space in an environment that includes food gardens, livestock and other elements of agricultural education. Southern Belle Farms includes an operational dairy farm alongside a corn maze and pick your own berry patch. They also offer field trips, seasonal special events and rental space on the farm. Yule Forest/ The Pumpkin Patch has a diversified offering of farm activities that features pick-your-own berries, landscape and holiday trees, and an outdoor classroom experience. Adams Farm shares their produce through a roadside stand, pick-your-own berries, and sale of value added farm products. Gibbs Gardens is a private estate open to the public that features acres of formal gardens, including thousands of daffodils, extensive water lily gardens, and a Japanese garden.

Value	Vulnerability
• A natural or cultural resource identified by other state agencies or environmental protection organizations • Preserves significant working agricultural or forest resources and/or creates opportunities for local food production activities • Areas that contribute to region-wide connections between existing and proposed regional resources	• Fluctuations in land values threatens economic viability of current use • Threatened by adjacent development that is incompatible in terms of design, scale or land use • Lack of protection through adequate regulations and/or easements
ARC Management Strategies	
ARC will continue to support existing programs and regulations for the management of Georgia Agritourism Sites. Both sites are private, family-owned operations. Information on Rancho Alegre Farm can be found at http://ranchoalegrefarm.com/;information on Southern Belle Farms can be found at http://southernbellefarm.com/index.php; information on Yule Forest can be found at http://www.aboutyule.com/; information on Gibbs Gardens can be found at http://www.gibbsgardens.com/; information on Adams Farm can be found at http://www.adamsfarmfayettevillega.com/.	

ATLANTA BOTANICAL GARDENS / CREDIT: ARC

Designed Landscapes

Criteria established by the ARC Board for consideration of Regionally Important Resources includes areas that create or preserve passive greenspaces including gardens. To further refine different types of gardens, the Designed Landscape category includes landscaped areas containing both plant materials and hardscape elements placed in an intentional design – formal or informal – including areas of institutional land uses. However, this category generally excludes areas used for food production or recreation, as the unique treatment of those resources is better defined elsewhere. In many instances, designed landscapes also include both historic and cultural value, by their association with historic sites or the presence of heirloom plan material. The Georgia Historic Landscape Initiative has identified several gardens in the Atlanta Region that have value as both historic resources and greenspace opportunities.

The Spring at Kennesaw: The records of the Georgia Historic Landscape Initiative identify that, "the spring provided water for 150 years to the people of the community. It was the main water source for Camp McDonald prior to and during the Civil War." (Camp McDonald is also identified as a Regionally Important Resource for its value as a Civil War Site.) It speculates that the Standing Peachtree Trail, one of the first transportation routes in the area, was routed to pass by the spring. The Spring was included in the design of Kennesaw's City Hall when their new building was constructed in 1983.

Archibald Smith Plantation Garden: The Archibald Smith Plantation originally sat on 300 acres of farmland in what is now Roswell. Although it now only sits on 8 of those original acres, many of the original ornamental plants still remain. The Roswell Garden Club maintains a Rose Garden on the property, and recreated an antebellum garden at the rear entrance. The house and land stayed in the family for 3 generations, since 1845. Now owned by the city of Roswell, tours are available of the house and grounds. Many features of the original gardens still remain like the stone terraces, and the greenhouse called a "cold frame" house.

Barrington Hall: Built from 1839-1842 on 12 acres at the highest point in Roswell, Connecticut architect Willis Ball designed the home. An unnamed landscape architect from England planned the ornate grounds, though the stone mason, also from England, is credited as Mr. Francis Minhinnett. Many remnants of the original garden design remain. The formal front gates leading to a heart shaped front drive is still lined with some cedars dating to the original planting. Original stone steps lead to boxwood plants that mark the spot where the formal gardens once grew. Remnants of an outbuilding occupy the work yard space at the rear of the large Greek revival home. Some of the hydrangeas planted by the original owner, Barrington King, still survive in the northeast corner of the remaining 6 acre grounds.

Bulloch Hall: Bulloch Hall bears a great resemblance to Barrington Hall. The home, built in 1840 by the same Connecticut architect, Willis Bail, also has a heart shaped front drive. Though little is known about the original design of the grounds, many of the original trees remain. This house was the childhood home of Mittie Bulloch, mother of Theodore Roosevelt, a further claim to fame of the site.

Goodrum – Abreau House and Grounds: The house and gardens are a superb example of Regency design in the Atlanta area. Noted Atlanta architect Phillip Trammell Shutze designed the home and grounds from 1929-1930. Many features of this design remain: serpentine walled garden, the temple, the front gate and walkway, the fish pond, a boxwood theater, and the perimeter wall along West Paces Ferry Road.

Iris Garden: The once clay ravine near Ansley Park, is now a "beautiful showcase of irises." The garden is maintained by the city of Atlanta and the Iris Garden Club. The beautiful plants showcase the natural spring pools, park benches, and mature trees.

Woodhaven (Georgia State Governor's Mansion): Woodhaven was the name of a Tudor-Revival estate house that occupied the grounds of the current Georgia State Governor's Mansion. The estate house was demolished (partially by fire) to make way for the current structure built in 1967, but much of the design of the grounds was left intact from the days of Woodhaven. The records of the Georgia Historic Landscape Initiative describe it as, "the first great estate built in the historic West Paces Ferry Road district in Atlanta, the original site included a grand rambling English Tudor manor surrounded by a large wooded estate. Expressing a close relationship between exterior and interior spaces, the formal and informal gardens, especially the unusual terraced gardens, were perhaps the first of their design, size, and complexity in the Atlanta area." Many of the original landscape design elements remain, including the sunken fountain, the pergola, and the carriage house.

The Atlanta History Center Grounds, including the Swan House Gardens and Grounds: The Atlanta History Center includes several distinct designed landscapes on the 33 acre property.

- *The Mary Howard Gilbert Memorial Quarry Garden* – Located on 3 acres, this site includes a collection of nearly 600 species of plants native to pre-settlement Georgia, many of which could be classified as rare or endangered.
- *Tullie Smith Farm Gardens* – Located adjacent to the 1840s Tullie Smith Farmhouse, the Farm Gardens are a demonstration garden that teaches visitors about mid-nineteenth century plants, including those for grown for consumption, for economic production, and ornamentals.
- *Cherry Sims Asian American Garden* – This garden includes both native plants and exotic imports of Asian origin, many of which were widely used by Southern Gardeners after their introduction to America in the late-eighteenth and nineteenth centuries.
- *Frank A. Smith Rhododendron Garden* – This garden demonstrates a contemporary landscape design populated by shade tolerant plants that thrive throughout the region.
- *Swan House Gardens and Grounds* – The records of the Georgia Historic Landscape Initiative describe the gardens as having a "distinctly Italian flavor." Both the Swan House and its grounds were designed by Phillip Trammel Shutze. Historic design features that still remain include its cloverleaf pools, formal gardens, cascading fountains, and a terraced lawn.
- *Swan Woods Trail* – This area includes 10 acres of wooded landscape. It includes native trees, ferns and wildflowers, as well as the remnants of nineteenth century cotton terracing which predated the suburban development of the Buckhead area.

In addition to sites identified by the Georgia Historic Landscape Initiative, other Designed Landscapes can be seen throughout the region, which include elements of historic value, species diversity, and a unique design aesthetic.

Hartsfield Jackson International Airport Floral Clock: A floral clock recently installed at the entrance to the Hartsfield Jackson International Airport. The floral clock as a design motif is borrowed most recently from the Victorian Era, and there are less than 100 known floral clocks in the world. The airport clock is illuminated with LED lights, irrigated with recycled rainwater and contains a mix of perennials and drought-tolerant annuals.

Atlanta Botanical Gardens: First developed in the late 1970s, the Botanical Gardens have evolved over its 35 year history in its mission to, "develop and maintain plan collections for display, education, research, conservation and enjoyment."

Lewis Vaughn Botanical Garden: Centrally located in downtown Conyers (Rockdale County), the site offers examples of native plants from the Piedmont region, a landscaped water feature, and an open air pavilion.

Claude T. Fortson Memorial Garden: The Claude T. Fortson Memorial Garden, also known as Miss Claude's Garden, is located in downtown Hampton and includes walking trails and shade trees. The garden is open to the public.

Designed Landscapes

Cator Woolford Gardens: The Cator Woolford Gardens, part of the Frazer Center, are part of a 39 acre wooded estate formerly owned by the Woolford family. The garden is open to the public.

Callenwolde Park: The grounds of the Callenwolde Estate include 12 acres of lawns, gardens, nature trails and a rock garden. A restoration effort was undertaken by the DeKalb County Federation of Garden Clubs, and the property is owned and maintained by DeKalb County.

Value	Vulnerability
• Resource nominated by an individual, interested organization, local government/governmental agency • Creates or preserves active or passive greenspaces including trails, gardens and informal places of natural enjoyment in areas currently underserved by greenspace • Preserves significant working agricultural or forest resources and/or creates opportunities for local food production activities • Areas that contribute to region-wide connections between existing and proposed regional resources	• Fluctuations in land values threatens economic viability of current use • Lack of protection through adequate regulations and/ or easements • Lack of long-term ownership plan/ transitional ownership for some parts of the resources

ARC Management Strategies

ARC will continue to support existing programs and regulations for the management of Community Gardens. Most Gardens are operated by a non-profit organization that oversees their management and maintenance, and some community gardens are located on public park land. Many gardens maintain websites, including Truly Living Well (http://www.trulylivingwell.com/); Oakhurst Community Garden (http://oakhurstgarden.org/); Harvest Farm (http://www.suwanee.com/communitygarden.php); Tapesetry WIC Garden (http://www.acfb.org/projects/community_garden/wic.shtml); Mableton Community Garden (http://www.mableton.org/CommunityGarden.html). ARC will continue to work to document community gardens around the region as a part of the larger green infrastructure network.

The Atlanta Regional Commission Community Gardening Manual can be found at http://documents.atlantaregional.com/aging/ascommunitygardensummitmanual2.pdf

COMMUNITY GARDENS OF HENRY COUNTY AT HERITAGE PARK / CREDIT: ARC

Urban Agriculture

The Regional Resource Plan gives consideration to areas that create or preserve passive greenspaces including gardens, as well as opportunities for local food production activities. This plan includes three distinct areas for their contribution to local food production: Community Gardens, Urban Farms and Urban Orchards. These types of Urban Agriculture may be distinct from each other, or found in combination. This plan also recognizes School Gardens and other types of education gardens for their contribution to buildings awareness of the importance of the local food system, the science of agricultural production and the value of good nutrition.

BOULEVARD COMMUNITY GARDEN / CREDIT: ARC

Community Gardens are greenspace areas used for limited production of food and/or ornamental plants that are gardened and managed collectively by a limited group of individuals, and effectively combine both of these goals. The Atlanta Region has seen an increased number of Community Gardens develop to serve diverse populations. They are sponsored by a variety of different organizations for different goals, but in general provide access to fresh healthy foods and ensure greater food security to those who benefit from them. The ARC *Community Garden Manual* identifies a number of benefits of community gardens, including improved quality of life; a catalyst for neighborhood and community development; reduction in family food budgets; preservation of greenspace; and opportunities for intergenerational and cross-cultural connections.

Urban Farms are generally larger in scale than community gardens, and are often cultivated for the commercial sale of products as an agriculturally-oriented business. Some urban farms may be developed in combination with a community garden; some may be operated as a home-based business; some may be operated on agricultural land leased or owned for the purpose. Urban farms in metro Atlanta include the cultivation of wide variety of local fruits, vegetables and flowers; beekeeping for honey; animal husbandry such a goats and cows for meat and dairy; sheep and alpacas for wool; poultry and eggs; and a range of value added products included cheese, condiments and preserves.

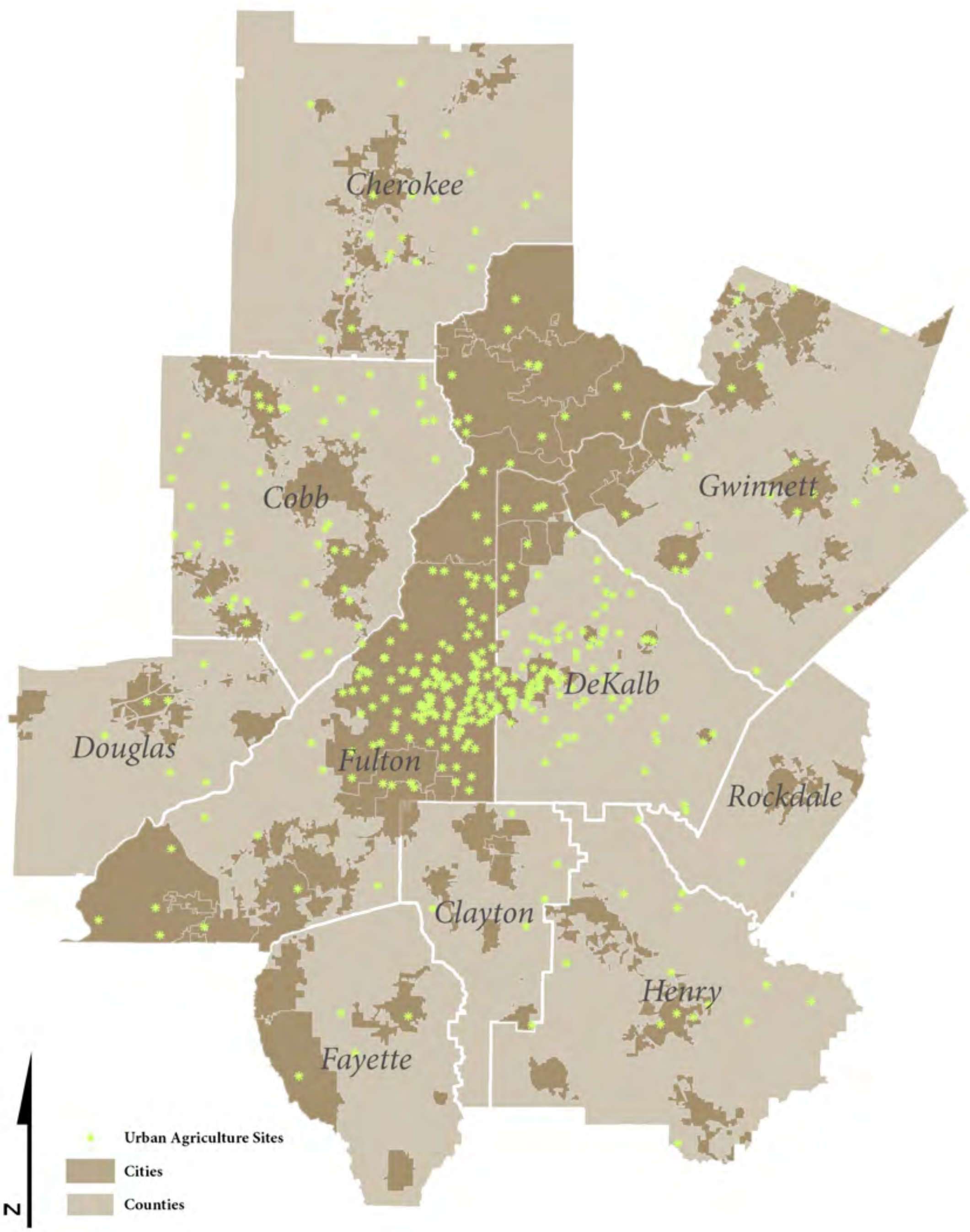
Urban Orchards are found in combination with Community Gardens and Urban Farms, or as their own grove. Urban orchards are increasingly found at public facilities such as fire stations and public schools, as well is in public parks. Orchards typically include fruit and nut trees, and often require less regular maintenance than community gardens or urban farms. Produce from orchards is harvested and donated to a local food bank.

Urban agriculture contributes physically, socially and economically to the health of local communities in metro Atlanta. The metro region will benefit from the continued development of policies and ordinances to promote agricultural activities such as those highlighted in this section. [Urban agricultural sites are not considered Regionally Important Resources for the purposes of this plan.]

Urban Agriculture

FIGURE 10

Greenspace Linkages



Urban Agriculture Case Studies

There is no one-size-fits-all approach to urban agriculture for a community. The following case studies highlight various approaches undertaken throughout the Atlanta region, and underscore the presence of urban agriculture enterprises throughout the 10-County Metro Area. The scalability of agriculture as an economic enterprise – from cottage industry to community supported agriculture – adds a robust element to the economic vitality of the region. Gardens and farms are created, managed and championed through a network of regional partnerships that include local governments, non-profit organizations, for-profit commercial enterprises, community advocates, and the end-product consumer.

City of Atlanta Urban Agriculture Zoning: Through a multi-year process, the city of Atlanta developed a zoning ordinance that allows for either urban gardens or market gardens in every zoning district in the city.

ATLANTA CITY COUNCIL MEMBERS AT TRULY LIVING WELL URBAN FARM / CREDIT: ARC

City of Lovejoy City Garden (Clayton County): Using CDBG funds, the City of Lovejoy developed a 14 acre garden that provides fresh produce year round for free, regardless of income level.

Global Growers Network (DeKalb County): Comprised of multiple distinct gardens, the Global Growers Network is identified with the refugee community of Central DeKalb County that has used this organization to grow culturally specific vegetables from their native countries and connect with others who have relocated to the United States.

Community Gardens of Henry County (Henry County): This network of gardens is managed by a central non-profit organization and is one of the top three contributors to the Plant a Row for the Hungry Program in the region.

Stems and Roots (Douglas County): This backyard garden makes use of raised beds, container gardening and small greenhouses, along with a hive of bees to assist with pollination. The harvest from Stems and Roots has a presence at several community farmers markets.

Sweetwater Growers (Cherokee County): This hydroponic growing operation delivers Georgia Grown herbs and lettuce to commercial markets throughout the southeast.

HARVEST FARM AT WHITE STREET PARK / CREDIT; SUWANEE

Mableton Community Garden (Cobb County): This garden is a part of the Lifelong Mableton Initiative, a partnership among ARC, Cobb County, and the local community in Mableton to create a thriving community for all ages.

Metro Atlanta Urban Farm (Fulton County): This operation grows on five acres in an urban environment with an emphasis on the equitable distribution of healthy foods and focus on community building.

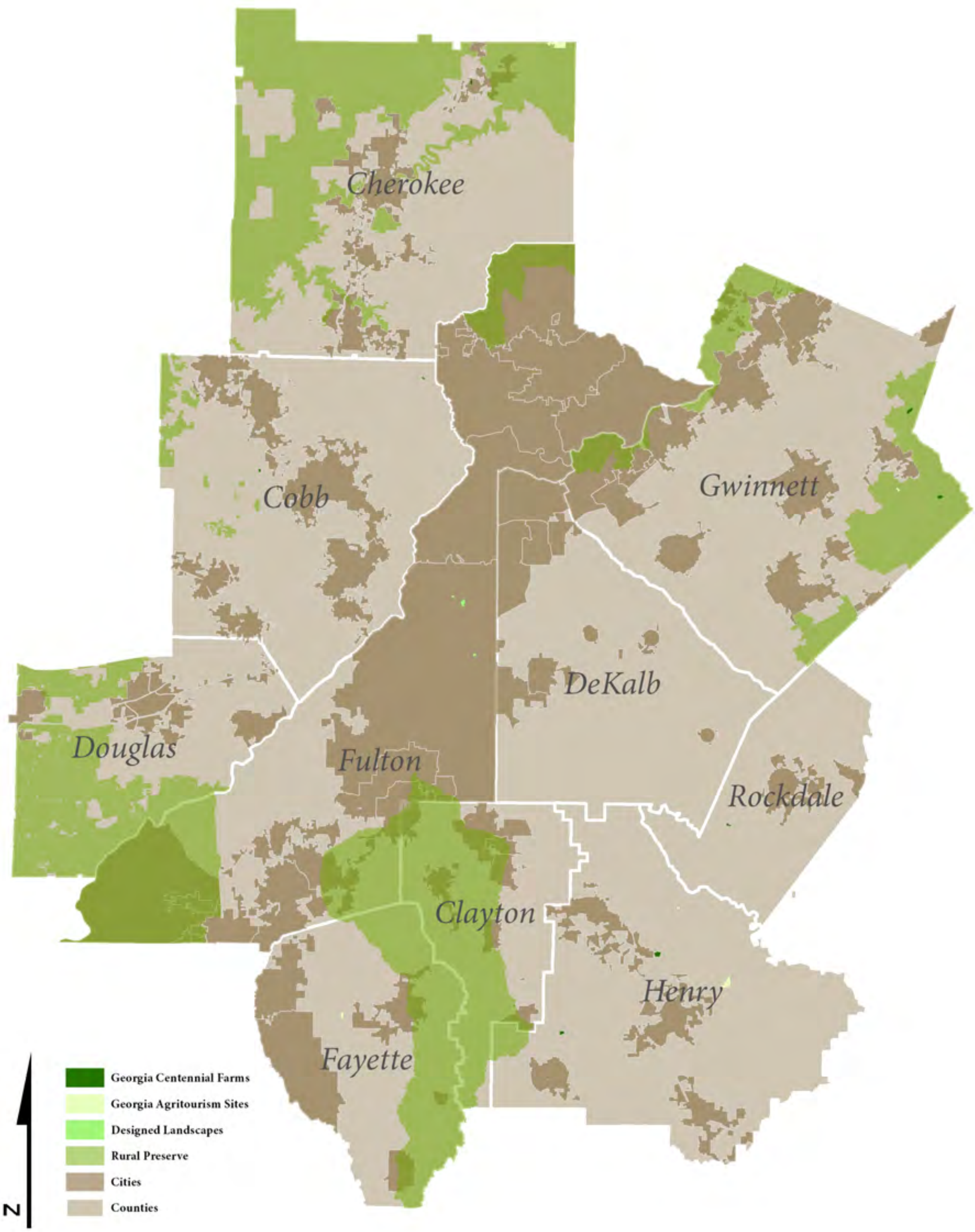
Two Doves Farm (Fayette County): This Certified Organic Farm also focuses on sustainable practices include generating solar energy and hydroponic growing. Pollination is aided by a hive of bees and pest control is assisted by flocks of chickens.

Harvest Farm at White Street Park (Gwinnett County): A community garden that is part of the City of Suwanee municipal park system, this site provides 76 plots to citizens for the organic cultivation of flowers, fruits and vegetables.

Conyers Locally Grown (Rockdale County): This online market provides a forum for local growers in proximity to Conyers and Rockdale County to distribute produce, meat and value added products through a central site. Orders are delivered weekly to a central distribution point in the city of Conyers.

SCENIC AND AGRICULTURAL REGIONALLY IMPORTANT RESOURCES

FIGURE 11



Guidance for Appropriate Development Practices

TABLE 9

Matrix of Guidance for Appropriate Development Practices[1] **Areas of Agricultural and/or Scenic Value**	Rural Preserves	Georgia Centennial Farms	Georgia Agritourism Sites	Designed Landscapes
Regulations and Plans				
Where practical, exceed minimum required buffers from protected areas	X			
Encourage the voluntary set aside of land in a development that is part of a conceptual greenway connectivity plan	X			
Site Design and Connectivity				
Where possible, retain existing vegetation and topography	X		X	
Do not disturb land in proximity to the boundary of a potential subsurface resource, such as a cemetery or archaeological site	X			
Incorporate, as practical, edible landscape options or space for community gardens within community common areas or buffers	X		X	
Where possible, use multi-use trails to link new developments to public access points for national or state parks and other recreation areas				X
Architectural and Design Aesthetics				
Consider impact to viewsheds and take appropriate steps to mitigate impacts	X			X
Design of new development should be compatible in terms of size, scale, and aesthetic appearance near existing resources	X	X		
Programs and Protections				
Consider the donation of a conservation easement for land that will be impacted by development in proximity to a historic or cultural resource or rural or agricultural area	X	X		X
Voluntary covenants should be placed on adjacent developments that acknowledge the right to farm of existing agricultural operations	X	X	X	

[1]ARC staff will use professional judgment to determine whether recommendations are applicable to a project under review within one mile of a Regionally Important Resource.

General Policies and Protection Measures

TABLE 10

Matrix of General Policies and Protection Measures **Areas of Agricultural and/ or Scenic Value**	Rural Preserves	Georgia Centennial Farms	Georgia Agritourism Sites	Designed Landscapes
Regulations and Plans				
Within the context of a community green infrastructure plan develop local connections among regional parks, trails and other community resources	X			X
Ensure that local ordinances do not preclude existing agricultural uses, nor the development of new agriculturally-oriented businesses, such as equestrian uses, home occupations, and local food production, where appropriate	X	X	X	
Clearly define animal units per zoning district that are appropriate to the scale of agricultural operations within the community	X		X	
Incorporate a heritage tourism and/ or agritourism component into community economic development plans	X	X	X	
Site Design and Connectivity				
Adopt a conservation subdivision/ cluster subdivision option where appropriate; review and revise existing conservation subdivision/ cluster subdivision ordinances to ensure they accomplish conservation goals	X			
Establish criteria to identify potential corridors that possess unique natural, scenic or cultural value	X		X	
Architectural and Design Aesthetics				
Document significant features that contribute to the scenic viewshed of natural, rural, and agricultural areas and develop design guidelines to mitigate the visual impact of new development in these areas	X	X	X	
Programs and Protections				
Work cooperatively to develop a regional TDR program	X	X	X	X
Implement a conservation easement donation program for the public holding of easements and/ or explore options for the fee simple ownership of greenspace by local governments	X			X
Work proactively to foster partnerships/ "friends of" programs to enhance the effective stewardship of greenways, trails, parks and historic and cultural resources	X	X		X
Enhance traditional historic preservation efforts by developing an interpretive context through oral history, wayfinding signage, and installation of historic markers	X			

Northeast Georgia Resource Management Plan for Regionally Important Resources

Funding provided by the Georgia Department of Community Affairs

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Introduction

Purpose

This document is intended to serve an advocacy guide to educate and guide citizens, local government, regional, state, and federal agencies, conservation organizations, and land trusts as they work for the protection and management of the many important natural, cultural, and historic resources found throughout the 12-county Northeast Georgia region. The resources, called Regionally Important Resources (RIR), are those determined to be of value to the region and thus the state, and vulnerable to the effects of uncontrolled or incompatible development.

The plan was prepared in accordance with the rules and regulations established by the Georgia Department of Community Affairs (effective July 1, 2009) for the identification of RIRs, the development of a plan for protection and management of the RIRs, and for review of activities potentially impacting the RIRs.

Overview

The plan contains three categories of resources: Conservation, Heritage, and Water. However, many resources may provide benefits to more than one resource category. Each individual resource is identified by its primary resource category and reflects snapshot data, a description of the resource's value to the region, an explanation of its vulnerability to new development, and a list of appropriate development practices. These practices should be used by developers for designing new developments to be located within one mile of an RIR. Additionally, Developments of Regional Impact that will be located within one mile of an RIR will be evaluated against the Practices. Finally, general policies and protection measurers are recommended to provide guidance for local government in its decision-making or planning that affects RIRs.

Methodology

The Regional Commission solicited regionally important resource nominations from local government, land trusts, conservation and environmental organizations, and individuals active throughout the region. Nominations were evaluated by RC staff for their value and vulnerability for possible inclusion in the plan. Evaluation factors focused on the regional importance of the resource (versus the local importance) and the degree to which the resource is threatened or endangered. Additional evaluation factors were as follows:

- Natural Resources
    - Preserves water quality and quantity by protecting drainage, flood control, recharge areas, watershed, buffers, potential reservoirs, etc.
    - Creates or preserves active or passive greenspaces including trails, gardens and informal places of natural enjoyment

especially in areas currently underserved by greenspace.
  - Protects wildlife habitat by creating, buffering, preserving, habitat areas and corridors.
  - Preserves significant working agricultural or forest resources and/or creates opportunities for local food production activities.
  - Contributes to region-wide connections between existing and proposed regional resources.
- Heritage Resources:
  - Recognition of national importance by some entity such as the Georgia or National Register of Historic Places;
  - It is the only such resource in the region;
  - The resource has a shared history or an impact on a shared history;
  - The resource is a part of the region's history;
  - The resource has an economic impact through tourism; and
  - The resource is attached to a figure or event of wider importance that just local.

In addition to nominated resources, RC Planning Division staff examined various planning documents such as the Georgia Land Conservation Partnership Plan, Georgia Wildlife Action Plan, Georgia Statewide Comprehensive Outdoor Recreation Plan, the Northeast Georgia Regional Plan 2004, and affected local governments for consideration of possible resources not nominated but deserving of inclusion of in the Regional Resource Plan.

State Vital Areas, as identified by the Georgia Department of Natural Resources, located within the Northeast Georgia region, were included on the RIR Map. For a list of State Vital Areas, see the Appendix. These areas have preservation/conservation mechanisms in place either through federal, state, or local regulations and help serve to form a regional green infrastructure network as depicted on the RIR Map.

Public Involvement

In an effort to keep the public, elected officials, and RC Council members up-to-date throughout the plan's development, the following was undertaken:

- Summary sheets were developed for each designated resource and State Vital Areas and posted to the agency website at http://negplanning.org/rir/links.
- Periodically, drafts of the Regional Resource Plan were posted to the web site for review and comment.
- Through an e-newsletter and e-mail blasts, the RC Council, elected officials, and interested parties were updated as to the plan's development.

In accordance with the Rules for Regionally Important Resources, as published by the Georgia Department of Community Affairs (DCA), a regional hearing was conducted in order to give the general public the opportunity to comment on the content of the plan.

A copy of the plan was made available for review on the RC's website.

Protection Measures

For the purpose of identifying protection measures, designated resources were divided into three categories: Conservation, Heritage, and Water. Many resources will fit into more than one category and identified protection measures are applicable to multiple resource categories. Protection measures are application to land owners, developers, local government and are so identified to assist with implementation.

Timeline

Development of the RIR plan began in September 2009 with the formation of the Planning Advisory Committee, development of the Regional Plan 2035 web page, and development of the RIR Selection Criteria, which was approved by the RC Council at its December 2009 meeting.

Nominations were accepted December 1, 2009 through January 31, 2010. Thirty-five nominations were received. In February, Planning Division Staff mapped the resources and developed a preliminary evaluation of each nominated resource. During March and April, the Planning Advisory Committee evaluated nominated resources based on the selection criteria, vulnerability of the resource, and potential to facilitate the interconnection of a green network, and recommended resources to the RC Council for designation. Mapping demonstrated that most of the resources were associated with river and stream corridors and the resource's ability to facilitate protection of water quality and quantity as well the interconnection provided by the river corridor was an important factor for recommending resources for designation. Of the thirty-five nominated, twenty-five were recommended for designation. (See Appendix A for the list of nominated resources and reason for denial.) Most of the nominated resources were adjacent to major river corridors or their tributaries and, if vulnerable, were recommended for designation due to their value to help protect water quality and quantity. Linear resources (rail corridors) were recommended for designation because of their long-term potential for recreation, linkage to river corridors, and open space protection. A list of recommended resources and the map were posted on the RC website and RC Council members were notified of their availability.

The RC Council unanimously voted at its April 2010 meeting to designate the recommended resources. Following designation, RC Planning Division staff worked with the Planning Advisory Committee, a subcommittee of the RC Council, to formulate a list of recommended best practices to be used by developers when designing new developments within close proximity to the RIRs, as well as devising general policies and protection measures recommended for appropriate local management of the areas included on the RIR map. A public information meeting was held on September 13, 2010 during the Planning Advisory Committee meeting. A public hearing was held on September 14, 2010. The Resource Management Plan was recommended to the RC Council for transmittal to the Georgia Department of Community Affairs for review and comment its September 2010 meeting. Upon receiving certification of completeness by DCA, the Resource Management Plan was adopted by the RC Council November 18, 2010.

Implementation

The Northeast Georgia Regional Commission will actively promulgate the plan in an effort to coordinate activities and planning of local governments, state agencies, land trust, and conservation or environmental advocacy groups toward protection and management of the identified RIRs. Specifically, the Northeast Georgia Regional Commission will work with and encourage each of these stakeholders to coordinate their activities to foster protection of the RIRs.

Additionally, the Northeast Georgia Regional Commission will encourage local governments in the region to adopt appropriate protection measures, policies, and enhancement activities that will promote protection of the region's important resources. The Regional Commission will also encourage local governmental to include the areas on the RIR Map as conservation areas in the respective local comprehensive plans and will review and evaluate local comprehensive plans for consistency with the Regional Resource Plan.

Finally, the listing of best practices to be considered by developers when designing new developments in close proximity to RIRs, will be used by the Northeast Georgia Regional Commission when reviewing all Developments of Regional Impact (DRI) proposed to be located within one (1) mile of any area included on the RIR map. The DRIs will be reviewed for consistency with the recommended development standards.

CONSERVATION RESOURCES

Overview

The Northeast Georgia region is home to numerous Conservation Resources, including a National Forest, numerous state and county parks, wildlife management areas, heritage farms, greenways, two proposed rails-to-trails, and an Arboretum. Conservation resources provide a number of benefits to the region including recreation, economic development, air and water quality, open space, and history.

Parks, open space, and forestry resources perform essential environmental functions for Northeast Georgia in additional to an improved quality of life. Trees and vegetation provide habitat for wildlife, mitigate the effects of the sun and wind, help to sequester carbon thus reducing atmospheric carbon dioxide, reduce stormwater runoff and soil erosion, and filter pollutants. Additionally, trees and other vegetation enhance the aesthetic value of the region.

The Oconee National Forest and five state parks provide unlimited recreational opportunities for the region's residents and visitors, as well as offering economic opportunities associated with eco-tourism.

Wildife Management Areas, managed by the Georgia Department of Resources, are scattered throughout the region and include the Elbert County WMA, Broad River WMA, Redlands WMA, Clybel WMA, Dove Field WMA, Oconee WMA. Individually, these areas may be less regionally important but, in the aggregate, they provide recreational opportunities for residents of the county in which they are located as well as adjacent counties.

The Piedmont National Wildlife Refuge, nine miles south of Monticello, is partially located in southern Jasper County and provides recreational opportunities not only for Jasper County, but also, adjacent counties, as well as serving as a model for forest ecosystem management for wildlife.

Natural Areas are also found in the region. The primary management objective for these properties is the protection of rare species populations and natural communities of plants and animals.

Northeast Georgia's Conservation Resources are vulnerable to the impact of urbanization. The Oconee National Forest is plagued by fragmentation. Property in WMAs is leased to the State thus making their continued availability uncertain.

The following guiding principles provided the basis for final determination for inclusion as a Regionally Important Conservation Resource:

- Preserves water quality and quantity by protecting drainage, flood control, recharge areas, watershed, buffers, potential reservoirs, etc.

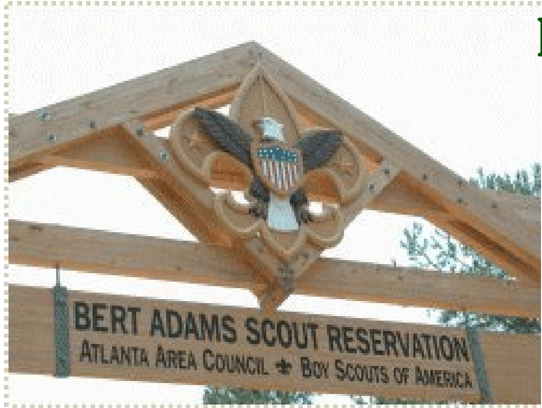
NEGRC
NORTHEAST GEORGIA
REGIONAL COMMISSION

- Creates or preserves active or passive greenspaces including trails, gardens and informal places of natural enjoyment especially in areas currently underserved by greenspace.
- Protects wildlife habitat by creating, buffering, preserving, habitat areas and corridors.
- Preserves significant working agricultural or forest resources and/or creates opportunities for local food production activities.
- Contributes to region-wide connections between existing and proposed regional resources.

Many of the designated Conservation Resources are defined as State Vital Areas[1]. The Resource Management Plan sets out to incorporate these resources, in addition to other designated Conservation Resources, into a green infrastructure network for the region including the cultural and water resources in order to link the region's urban areas to the more rural settings. Proper care and management of this network is critical to the long-term quality of life of the region and the individual communities and citizens.

[1] Chapter 110-1204, Regionally Important Resources, Georgia Department of Community Affairs, July 1, 2009. These areas include Coastal Marshes, Salt Marshes, Tidal Wetlands, Water Supply Watersheds, Groundwater Recharge Areas, and Wetlands.

Bert Adams Boy Scout Reservation



Location: Newton County, GA

Acres: 1,250

Owner/Operator: Atlanta Area Council, Boy Scouts of America

Value

Located near Covington, the Bert Adams Boy Scout Reservation is a 1,250 acre site adjacent to the Yellow River that provides for long-term resident and weekend camping and training events. Thousands of Scouts come to Bert Adams each year to participate in Boy Scout, Webelos and JROTC Summer Camps, Order of the Arrow Events, Venturing and Explorer Outings, Cub Family Camping, Cub World Events, District Camporees, Cub Pack Picnics, ScoutReach Outings, Wood Badge Training, Junior Leader Training, and many other Scouting events. Bert Adams Scout Reservation includes Camp Gorman, Camp Emerson, Cub World and the redeveloped Camp Jamison.

Owned by the Atlanta Area Council of the Boy Scouts of America, it is one of only four Scout camps in the Atlanta area and the only such Scout camp in the northeast Georgia region.

Bert Adams is a unique facility that, in conjunction with the nearby FFA Camp, establishes the area and region as a center for camping, recreation and training opportunities for children. Additionally, the site provides water quality and quantity benefits.

Vulnerability

The Camp is in a rural area in southwest Newton County. It's rural location is deemed by its users as essential for camping and training functions. Long-term, the area is designation for Rural Residential land use. Presently, the area is beginning this transition with the development of two large subdivisions with one-acre zoning density on the Camp's western property line. Presently zoned Agricultural, Little Springs Farm, a 1,977 acre farm immediately adjacent to the Camp's north property line, could be considered for similar one-acre density if sold for non-farm use.

The Newton County Comprehensive Plan Community Agenda identifies the county's current traffic congestion problems. As the southwest portion of Newton County develops, it is reasonable that area roads could be widened to alleviate congestion. However, road widening has the effect of promoting more development which would further jeopardize the Camp's rural setting.

Burge Plantation

Location: Newton County, GA

Acres: 930

Owner: Private

Value

Burge Plantation is an active farm that has been in operation and ownership of a single family for 200 years. The Plantation represents not only European agriculture and settlement in Georgia but rural agricultural aspects of Newton County's history. The area where the Plantation is located was occupied by Native Americans for thousands of years and the farm has an extensive artifact collection of stone knives, tools and projectile points found on the property. The Plantation is listed in the National Register of Historical Places.

The Plantation protects water quality by maintaining vegetated riparian buffers and through responsible agricultural practices. Vegetated riparian buffers also protect and preserve wildlife habitat by creating and buffering habitat areas and corridors. Additionally, the Plantation preserves significant working agricultural or forest resources and/or creates opportunities for local food production activities.

Burge Plantation produces Southern Yellow Pine and organic produce and is a private hunting preserve.

Vulnerability

The Plantation is about 1 mile north of both Mansfield and Newborn and approximately 2/3 mile from the intersection of highways 11 and 142. It is anticipated that, over time, development will extend from this major intersection and the two communities, thus threatening the water and air quality value of the plantation. Area zoning allows 2-acre minimum lot size and prior to the economic downturn, nearby properties were rezoned. Further, increased area development could lead to increased property values thus threatening the long-term survival of the Plantation.

Factory Shoals County Park

Location: Newton County, GA

Acres: 400 (approx.)

Owner: Newton County

Value

Located approximately 10 miles south of the City of Covington, Factory Shoals County Park is situated on the Alcovy River, and boasts granite shoals and a 2-mile stretch of preserved forested river corridor. This park offers picnic areas, primitive campsites (with on-site restroom and shower facilities), and opportunities for a variety of recreational activities from kayaking and canoeing to hiking and fishing. Newton County acquired the property containing Factory Shoals from Georgia Power in 1982, and it was operating as a park by the end of the 1980s.

In addition to providing recreational amenities, Factory Shoals County Park is a historic resource for the local and regional community. The shoals served as a power source for cotton and grist mills dating back to the 19th century. Ruins of these factory buildings and supporting structures are visible today on both river banks as remnants of industrial activity in this area. Mills once operated at Factory Shoals include Newton Factory, White's Factory, and Jones' Mill.

Two cemeteries exist on the property; one on the west bank of the river was closely associated with a nearby church that burned in the early 1900s and contains numerous marked and unmarked graves. Another cemetery with no marked graves is located east of the river, and was once surrounded by a stone wall that has nearly collapsed; the remaining standing portions are roughly 4' in height. It is assumed that a prior logging operation inflicted the most damage to this area.

An aboriginal site is located on a prominent ridge overlooking the Alcovy River. This site has been classified as characteristic of the Middle Archaic period (5500 to 2500 B.C.) due to the particular artifacts found. Archaeologists have opined that the site was likely used intermittently as a camp from which local food resources were exploited, as was common with hunting and gathering patterns.

Vulnerability

Even under County ownership, there remain a handful of threats to the health of the park. Water quality of the Alcovy River is a concern for recreation users. The recent construction of the Alcovy High School nearby has led to an increase in new residential subdivisions; in addition, the future widening of Jackson Highway is likely to increase growth pressures in this still-rural community.

Currently, the several worn foot paths leading to the water's edge present erosion concerns and safety hazards for park visitors. As population in Newton County increases, as projected, due to its proximity to the metropolitan Atlanta region, the increase in the number of visitors will necessitate path improvement of an appropriate scale. Plans exist for establishing a trail system connecting the new high school with the park and other recreational amenities as well as surrounding residential areas.

The primary threat to the archaeological resources at Factory Shoals is vandalism, followed by unauthorized digging and neglect.

Firefly Trail

Location: Athens-Clarke, Greene, and Oglethorpe counties, Arnoldsville, Crawford, Maxeys, Winterville, Woodville, and Union Point

Length: 39 mile corridor

Value

The proposed Firefly Trail protects and reuses a 38-mile historic rail corridor from Union Point to downtown Athens, converting it into a path for walking and bicycling. The Trail features pastoral agricultural lands, quaint small towns, scenic rural highways, historical railroad structures, park space, and a bus transfer center than provides connections to nearly all of Athens and the University of Georgia.

The route, once referred to as the “Athens Branch,” was completed in 1841 as part of the Georgia Railroad and abandoned in 1984 by what is now CSX Transportation, Inc. The Firefly was the name locals gave to the locomotive that operated on this line; it was named for the sparks that flew from its wood-burning engine. Only three of the original depots remain of the original line.

In addition to its potential as a recreation resource, the Trail could provide economic opportunities for the small communities along the corridor.

Vulnerability

Private ownership and resultant encumbrances threaten the integrity of the original rail bed in addition to the potential increased cost of future trail property acquisition.

Development pressures in Athens-Clarke County could threaten the rail bed though, since most of the adjacent development is industrial, the threat is perceived as low. The remainder of the rail bed is in predominantly agricultural land use.

Georgia Wildlife Federation/Alcovy Conservation Center

Location: Newton County, GA

Acres: 115

Owner: Georgia Wildlife Federation

Value

The Georgia Wildlife Federation's beginning can be traced back to late 1935, when U.S. President Franklin D. Roosevelt called for the first North American Wildlife Conference to be held the following year. In late 1936, the first meeting of the Georgia Wildlife Federation (GWF) was held in Macon. Shortly thereafter, the GWF pushed the State to hire professional wildlife biologists for the purpose of managing the many wildlife resources in Georgia. In the 1960s, the GWF led the fight to stop the dredging and channelization of the Alcovy River by the Soil Conservation Service. In subsequent years, numerous other initiatives and campaigns have been carried out by this organization throughout the State for the purpose of "encouraging the intelligent management of the life sustaining resources of the earth…and promot[ing] and encourag[ing] the knowledge and appreciation of these resources." (Georgia Wildlife Federation Mission Statement, 1936)

The Alcovy Conservation Center, located in Covington, GA on the Alcovy River, is the headquarters of the Georgia Wildlife Federation. In addition, the location serves as a community center for environmental education, sportsman's issues, and natural resource conservation. The site itself contains woodland, wetland, and meadow habitats and demonstration gardens for both appreciation and study. A famed tupelo gum river swamp, along the Alcovy River, is accessible via trails on the property.

Vulnerability

This site is threatened by imminent industrial development on three adjacent properties that are zoned for heavy industrial use. Pollution of the Alcovy River through point and non-point sources, either from future industrial developments or upstream locations along the riparian corridor, are also a concern for the health and vitality of the various species and habitats on the property. As of the February 2010, the segment of the Alcovy River from its headwaters in Gwinnett County through Walton County and into Newton County at Big Flat Creek was included on the Section 303(d) (of the Clean Water Act) list of waters as Not Supporting [its] Designated Use (fishing and drinking water) due to the presence of fecal coliform from non-point sources. An assessment is currently pending for the segment from Big Flat Creek to Cornish Creek, situated entirely in Newton County.

Gaither Plantation

Location: Newton County, GA

Acres: 150

Owner: Newton County

Value

The Gaither Plantation is located off of Davis Ford Road along the proposed Bear Creek Reservoir, and was acquired by Newton County 1996 for its proximity to this project and to preserve its historic nature. This site is one of the few remaining former 19th and 20th century cotton plantations in Northeast Georgia, and contains an historic farmhouse called the Gaither Plantation House (c.1855), a log smokehouse c.1830), a pole hay barn c. 1950), agricultural fields, and a number of other historic buildings relocated from elsewhere in Newton County to Gaither Plantation. In addition, two 19th century cemeteries, the Gaither Family Cemetery and the Gaither Slave Cemetery, are located here.

The Gaither Plantation Master Plan includes proposed gardens, natural areas and wildlife habitats, the preservation of an existing on-site pond that would open up into the Bear Creek Reservoir, and hard- and soft-surface trails throughout the property. Through master plan realization, Newton County hopes to preserve this history of this area, maintain and enhance the natural resources on the land, and develop and promote the recreational potential of the plantation. In total, construction costs for this plan are estimated to be just under $3 million.

Vulnerability

Funding for maintenance and restoration is not sufficient; several important structures are in danger of deterioration.

In addition, the development of the proposed Bear Creek Reservoir has the potential to change this mostly rural area. Though the proposed reservoir benefits from a required 150-foot natural buffer there is a risk of sedimentation and pollution as a result of more construction and increased impervious surface. It will be crucial for the Gaither Plantation to be developed in such a way as to contribute to the conservation of the natural resources on and adjacent to the site to avoid negative impacts on water quality.

Georgia FFA-FCCLA Center

Location: Newton County, GA

Acres: 452

Owner: State of Georgia

Value

Located in south-central Newton county, the FFA-FCCLA Center hosts more than 20,000 campers and serves approximately 100,000 meals annually. From its formation in 1929, the Georgia Future Farmers of America Association had envisioned creating a wholesome summer recreational camp for boys. The vision began to materialize in 1937 on a 150-acre hillside overlooking the headwaters of Lake Jackson on the Alcovy River. After the creation of the FHA (Future Homemakers of America, now FCCLA, Future Career and Community Leaders of America), the camp's forward-thinking leaders expanded the programs to become co-educational. Now encompassing approximately 450 acres owned by the State of Georgia, the camp has grown into a nationally-recognized educational center, meeting and exceeding the original vision of its founders (notably, during the 1996 Olympic Games, over 3,200 Germans utilized the facilities).

Initial site work and building began in 1937, conducted by student members of the National Youth Association who utilized granite quarried on the property to construct several of the main buildings. First Lady Eleanor Roosevelt toured the site in 1938, and was able to secure funds for building and infirmary. The value placed on the camp may be recognized by the concerted effort and cooperation of individuals, corporations, and local and state governments in funding the growth and improvement projects that have taken place over many decades.

The Georgia FFA-FCCLA Center is located contiguous to two other designated Regionally Important Resources: Factory Shoals County Park and the Alcovy River Greenway. Together, the FFA-FCCLA Center and Factor Shoals County Park represent 750 acres of preservation space directly adjacent to the Alcovy River; protecting these two sites will bolster the Alcovy River Greenway's water quality efforts.

Vulnerability

Although no imminent threats to the site are known to exist, vulnerabilities could arise from the urbanization of Newton County and development in nearby Jasper County (directly across Jackson Lake/the Alcovy River), and from pollution upstream on the Alcovy River. Newton County land in the vicinity of the Center is zoned in a mix of agricultural and low-density residential; future zoning changes to more intensive uses could compromise the site's natural and pastoral features. Along Jasper County's side of the lake/river across from the Center, zoning is virtually all residential, with existing development at densities among the highest in the county; this could lead to water quality concerns from runoff as well as aesthetic impacts to the less developed Center.

Hurricane Shoals Park

Location: Jackson County, GA

Acres: 81.4

Owner: Jackson County

Value

Located approximately 6.4 miles northeast of the City of Jefferson and approximately 4.5 miles northwest of the City of Commerce, Hurricane Shoals Park is situated on the North Oconee River. Believed to have been occupied at various points in early history by Creek and Cherokee tribes, this park officially opened in Jackson County in 1978 and subsequently began to grown in size through land purchases until 1994. The park contains disc golf and miniature golf facilities, the Pat Bell Conference Center, a horseback riding arena, Heritage Village (where historic structures from throughout Jackson County have been relocated to save them from destruction), and a covered bridge that recently underwent a restoration process after having burned in the 1970s. In addition, a working grist mill is located on site, which grinds corn meal for the annual Art in the Park Festival. This grist mill was built in the 1980s as a tribute to the former cotton gin and grist mill that operated at Hurricane Shoals from 1870 until the mid-1920s. Ruins of the original grist mill can still be seen in the western side of the park.

Vulnerability

The North Oconee River is protected by a 100-foot natural vegetative greenway along both sides, per the Jackson County Code of Ordinances. While this provides some protection from development along the river, the park is adjacent to Interstate 85 to the south. This corridor has the potential to negatively impact the water quality of the North Oconee with road runoff pollution. In addition, proximity to I-85 is attractive to developers of industrial and manufacturing sites, and while the land surrounding Hurricane Shoals Park is currently zoned Agricultural Rural Farm District, the area may feel development pressures in the future.

The Athens Line

Location: Athens-Clarke County, Morgan County, and Oconee County, GA

Length: 32.1 Mi.

Value

"The Athens Line" represents the portion of the Macon-to-Athens rail line that first went into full service in December 1888. Once a holding of the Central of Georgia Railway Company, the line between the City of Madison and the Center community (Jackson County) is now owned by Norfolk Southern and leased by Athens Line, LLC, a short-line operator. The rail bed is inactive from Madison to Bishop, with only intermittent use from Bishop north to Watkinsville, Athens, and Center.

The depot in Farmington (unincorporated, Oconee County) is the only intact original structure of its type remaining on the line. The historic rail bed has the potential to become a significant greenspace corridor connecting communities across Morgan County, Oconee County, and Athens-Clarke County. This is particularly true in the short-term for the inactive section, which could provide a multi-use path and linear park/upland greenway (rails-to-trails) for residents and visitors in Northeast Georgia. The remaining active section could be maintained by rail transport while having a parallel mutli-use path (rails-with-trails). The benefits of these types of facilities include economic development, habitat preservation, increased recreation and exercise opportunities, and, in areas where transportation cycling or walking are feasible, improvements in air quality. The line is located directly across US441 from Oconee County's 364-acre Heritage Park, which features trails, woodlands, and streams, as well as the University of Georgia's Whitehall Forest.

In addition to the inherent environmental and recreational value, such an endeavor would facilitate the preservation of significant historical and cultural features such as the Farmington depot, historic warehouses in Bishop, two river trestles (Apalachee and Oconee rivers), and the general agricultural and transportation history of the region. For example, the brick shells of buildings that once processed cotton for oil are still evident in Farmington along the rail line. When in operation, the oil from these buildings was shipped north to the Hodgson Oil Company in downtown Athens. The Athens Line is ideal for use as part of a regional green infrastructure network (it would connect to Athens-Clarke Coutny's existing greenway) with interpreted narrative of the rail line's impact on the region.

Vulnerability

Since no portion of the Athens Line is officially abandoned, the corridor remains fully intact. However, Norfolk Southern was granted approval to abandon the inactive segment of the line in 1987 but has not initiated the formal process to date. Abandonment could mean disintegration of the corridor in certain parts, depending on the proceedings of various different actors, including state and local governments, interested private-sector parties, and adjacent landowners; breaking up the corridor could make the prospects of rails-to-trails conversion much more difficult. On the other hand, swift action either by local or state government to acquire the corridor directly from the railroad could preserve its historic nature by minimizing threat's to its integrity while likely facilitating an easier trail-building process than would occur if the line were first disassembled and ownership became fragmented.

Thompson Mills Forest Arboretum

Location: Jackson County, GA

Owner: The University of Georgia

Acres: 337.2

Value

Thompson Mills Forest Arboretum is a 337-acre forest deeded to the University of Georgia in 1980 by Lenox Thompson Thornton. The forest, which was designated as the State Arboretum by the Georgia General Assembly in 1991, is two miles southwest of the City of Braselton and includes more than 100 species of native Georgia trees, representing approximately 90% of all the state's native trees. This forest serves as a site for the study of trees and natural plant communities, and was named for the Thompson Mills community, a prominent turn-of-the-century agricultural center. The seven-acre Eva Thompson Thornton Garden features over 100 ornamental trees from around the world. Additionally, the arboretum includes an eight-acre granite outcrop and several miles of pedestrian-only trails.

Thompson Mills Forest Arboretum hosts Future Farmers of America (FFA) and 4-H dendrology teams from many Georgia counties. Other groups, such as forest dendrology classes, Cooperative Extension Service groups, church groups, and school groups, make use of the site for educational purposes.

Vulnerability

Development around the Thompson Mills Forest Arboretum could negatively affect the site if appropriate land use regulations are not put into place and enforced. Potential impacts could be realized in erosion and sedimentation, water quality, habitat, and viewsheds/aesthetics. The University of Georgia appears to have no plans to alter the site's character significantly.

HERITAGE RESOURCES

Overview

Many communities in Northeast Georgia have long recognized the importance of heritage conservation as evidenced by the many historic districts, landmarks, and National Register properties in the region. Heritage conservation not only helps to define a community's unique heritage but, can be a source for economic development, housing, and education.

Heritage resources include historic structures, farms, campgrounds, and rail lines. Thirteen heritage resources were nominated as RIRs and nine were designated. The following guiding principles provided the basis for final determination for inclusion as a Regionally Important Heritage Resource:

- Recognition of national importance by some entity such as the Georgia or National Register of Historic Places;
- It is the only such resource in the region;
- The resource has a shared history or an impact on a shared history;
- The resource is a part of the region's history;
- The resource has an economic impact through tourism; and
- The resource is attached to a figure or event of wider importance that just local.

The Northeast Georgia region has an abundance of heritage resources, in addition to those presented in this plan, that are significant to the history and development of individual communities at the local level. Locally important heritage resources should not be disregarded or neglected as they are equally vulnerable to human intrusion. Communities with such resources are encouraged to continue their conservation and preservation initiatives and to pursue new policies and procedures that support protection.

The identification, documentation, and recognition of heritage resources are all extremely important components of the preservation process; however, the protection of heritage resources from insensitive treatment and outright demolition is essential. Unfortunately, protection provided through existing state and national recognition is minimal. For example, any resource listed in or eligible for listing in the National Register comes under the protective umbrella of the National Historic Preservation Act (Public Law 102-575). The Act mandates, under Section 106, that any federally licensed, permitted, or funded project must be reviewed regarding its impact to the resource. While listing in the National Register does not guarantee protection for these resources, the Section 106 process does allow for alternate projects to be researched in order to minimize potential adverse impacts to these heritage resources.

Designated Heritage Resources, with the exception of Oxford College of Emory University, are located in the unincorporated areas and all in are high-growth corridors and are under pressure from adjacent development and/or anticipated future traffic improvements. While all designated resources have some degree of protection, it is treated largely as a local issue and the degree of protection varies by both resource and community. Many local governments in the Northeast Georgia region have preservation ordinances in place; however, there is no regional protection focus of any cultural resource.

Elder Mill

Location: Oconee County, GA

Owner: Private ownership

Value

Constructed near the turn of the 20th century, Elder Mill was a water-driven turbine grist and wheat mill that operated from 1904 until the 1940s and still contains its century-old milling equipment. The mill was operated by four generations of Elders.

The Mill was purchased by Dr. Charles Morgan in 1969. The milling equipment is still mostly in place as it was in 1941. Dr. Morgan with the help of John Cleveland has made many structural repairs, to the roof, siding, foundation and windows, but has kept the mill just as it was over a hundred years ago.

Vulnerability

The mill is located in the Rural Places Character Area, an area characterized by low-density residential, farms, forests, outdoor recreation, and other open-space activities. Allowable zoning in this character area include AR-3, AR-4, AR-5 or densities of 1 dwelling unit per 3, 4, or 5 acres respectively.

Although the mill is included in the county's Scenic Preservation Designation, an overlay district in the county's zoning ordinance, its long-term protection in uncertain due to its private ownership. While it has been cared for and restored by its current owner, long-term it is at-risk unless acquired by the government or some organization that will permanently protect the structure.

Elder Mill Covered Bridge

Location: Oconee County, GA

Owner: Oconee County

Value

Constructed in 1897 by Nathaniel Richardson, this 99-foot-long bridge originally spanned Calls Creek on the Watkinsville-Athens Road. Due to new bridge construction on what would soon become Hwy 441 and its good condition, in 1924. The bridge was moved by wagon to its present location on Rose Creek by John Chandler of Watkinsville. The c.1900 grist mill ceased operation in 1941.

Constructed in the Town lattice design, the bridge's web of planks crisscrossing at 45- to 60-degree angles are fastened with wooden pegs, or trunnels, at each intersection. It is one of the few covered bridges in Georgia continuing to carry traffic without underlying steel beams.

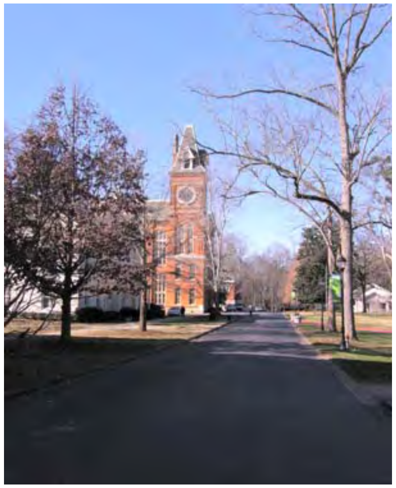
The Bridge was listed in the National Register of Historic Places in 1994.

Vulnerability

Although the bridge is listed in the National Register of Historic Places, and has a Scenic Preservation Designation, an overlay district in the county's zoning ordinance, neither listing offers any real, long-term protection.

The bridge is located in the Rural Places Character Area, an area characterized by low-density residential, farms, forests, outdoor recreation, and other open-space activities. Allowable zoning in this character area include AR-3, AR-4, AR-5 or densities of 1 dwelling unit per 3, 4, or 5 acres respectively. An important consideration in a rezoning to any of these districts is the condition or and level of service provided by road access.

Properties south of the bridge could accommodate a development density and related traffic that the bridge likely could not accommodate thus necessitating rerouting of Elder Mill Road to either bypass the bridge or widening the current road which would necessitate relocation or dismantling of the bridge.



Oxford College of Emory University

Location: Newton County, GA

Acres: Approx. 145

Owner: Emory University

Value

Chartered December 19, 1836, Emory College, now known as Oxford College of Emory University, was established by the Georgia Methodists on 1,452 acres just north of the City of Covington. In conjunction with the school's creation, the intended collegiate community of Oxford, named in honor of the English university where the founders of Methodism (John and Charles Wesley) were educated, was laid out with its main streets converging on the site of the central building of the college campus. Oxford College's first building was started in the spring of 1838, and on December 23, 1839, the Town of Oxford was incorporated.

The historical importance of Oxford College can be viewed from a number of perspectives. Its influence upon Methodism, its formative influence on prominent individuals whose lives impacted all of society, and its connection with significant historical events that have made a lasting impact on the state and nation are all points of reference for study of this institution's importance.

The college contains significant open space, providing active and passive recreation opportunities in abundance. Additionally, great interest in the college and the Town of Oxford has lead to the area becoming a tourist destination, drawing benefits to the local and regional economies.

Vulnerability

Development pressures locally and regionally could threaten Oxford College. As the Town of Oxford, the City of Covington, and Newton County experience growth, communities should take care to minimize potential negative effects. Nearby population growth could conflict with preservation efforts by increasing traffic congestion and threatening aesthetic elements of both the historic campus and the College's more recently acquired natural areas.

Salem Methodist Church and Campground

Location: Newton County, GA

Acres: Approx. 60

Owner: Salem Campground, Inc.

Value

Founded in 1928, Salem Campground is one of the oldest still-existing Protestant camp meeting sites in the nation. Except for during the years of the Civil War, camp meetings have been held every year at Salem since the campground's inception. Adjacent to Salem Campground is the property and site of the Salem United Methodist Church, established in 1824. The current sanctuary was constructed between 1865 and 1870, and replaced the log sanctuary that had been built near the Salem Campground spring. The nearby Town of Oxford and Oxford College of Emory University were formed less than a decade after the church and campground were instituted, and have strong ties to Methodism.

In 1854, the present open-sided tabernacle was constructed, allowing worship to move from an open-air setting to the more formal setting of the substantial and attractive timber-framed edifice. The tabernacle is on the Historic American Buildings Survey of the Library of Congress; the entire campground was placed on the National Register of Historic Places in 1998.

Undeveloped parts of the sixty-acre site could support the goals of local land conservation groups. Over half of the campground (approximately 35 acres) is currently a hardwood forest, which serves as protected wildlife habitat in a community that is rapidly losing such areas. Campground supervisors have no plans to disturb this area. Across Salem Road from the main campground is Salem Spring, a 30-gallon/minute source which is a part of the site. Further, the campground will likely serve as part of a local trail/greenway system envisioned for the Salem Road Overlay, which the County will begin developing this year.

County reports also indicate that the wooden water tower - one of the last entirely wooden structures of its kind in North Georgia - that stores water from Salem Spring houses a family of endangered owls.

Vulnerability

The church and campground site is located on a rapidly developing corridor, surrounded by land that has been rezoned from agricultural and residential to commercial. Current and anticipated future traffic improvements threaten to encroach on the site; Newton County has referenced GDOT plans that appear to call for the widening of Salem Road to six lanes. The site has responsible custodians who recognize and intend to preserve the heritage of their sites as best they can; however, these caregivers are limited in their abilities to stave off potential off-site threats.

Shields-Ethridge Heritage Farm

Location: Jackson County, GA

Acres: 154

Owner: Shields-Ethridge Farm Foundation

Value

The Shields-Ethridge Heritage Farm has been a working agricultural complex since 1799. The main house was built in 1866; its plantation plain facade was changed to represent the neoclassical style in 1914. Over sixty other structures are part of the historic district, including tenant houses, a two-room schoolhouse, barns and storage buildings, a cotton gin complex, a commissary, and a grist mill/hammer mill operation to serve the surrounding farm populations. Bachelors' Academy, located at the Shields-Ethridge Heritage Farm, is a restored two-room building that accommodated one teacher for seven grades.

The Shields-Ethridge Heritage Farm was listed on the National Register of Historic Places on June 25, 1992. The farm was also recognized as a Georgia Centennial Heritage Farm by the Georgia Department of Natural Resources in 1993. The Shields-Ethridge Heritage Farm Foundation, Inc., formed in 1994 to preserve the site's existing buildings.

The County views the farm complex as part of its historic tourism efforts, alongside those of the Chamber of Commerce and historic groups and societies. Additionally, it is used as an educational site for children and as a place for historic festivals, telling the story of Southern heritage and culture over time. The History Channel, the Georgia Department of Natural Resources' Historic Preservation Division, and the National Trust for Historic Preservation have all awarded funding to preserve and promote the farm site due to its historic and natural value.

The heritage farm complex is located 2.5 miles south of downtown Jefferson, the county seat and activity hub of Jackson County. The Farm Foundation holds 154 acres of the overall 500-plus acres.

Vulnerability

Jackson County cites regional and local growth as the main threat to the Shields-Ethridge Heritage Farm, but recognizes that the site could be protected via land use controls, particularly by designating it as an agricultural conservation area and by minimizing development impacts adjacent to it. Another critical threat to the sustainability of the complex as it exists now is the sensitive nature of such aged, historic structures, which, over time, require significant attention and maintenance.

WATER RESOURCES

Overview

The Northeast Georgia region is home to an abundance of water resources. These resources supply the region with drinking water, sewage treatment, power generation, industry, mining, crop irrigation, and recreation. Yet, many of the streams and rivers in the region do not support their designated use of fishing and drinking. Recent droughts have magnified our dependence on these resources.

The Georgia Department of Natural Resources identified water supply watersheds, jurisdictional wetlands, significant groundwater recharge areas, and Protected Rivers as State Vital Areas. However, there are other large significant water resources equally important to the region including Lake Oconee, Lake Jackson, and Lake Roy Varner.

Five rivers in the region have been designated "Protected Rivers" by the Georgia Department of Natural Resources.[2] Protection Plans are required for these rivers (South, Yellow, Ocmulgee, Oconee, and Broad) and include the establishment of natural vegetative buffers adjacent to the protected river to maintain the integrity of the buffer. River corridors are invaluable in the preservation of the qualities that make a river suitable for wildlife, a site for recreation, and a source for clean drinking water.

Groundwater recharge areas are those land areas where soil and geological conditions are favorable for precipitation to infiltrate the soil and the underlying strata to enter and continually replenish the aquifer. These areas, located throughout the region and providing drinking water to the many of the region's residents, are susceptible to contamination when unrestricted development occurs within the significant recharge area.

The region's streams provide a large percentage of the region's total water use. Therefore, the Planning Advisory Committee put great importance on their protection. Because watersheds in Northeast Georgia connect and encompass terrestrial and freshwater ecosystems, they perform a wide variety of valuable services, including the supply and purification of fresh water, the provision of habitat and biological diversity, the sequestration of carbon that helps mitigate climate change, and the support of recreation and tourism.

Wetlands are valuable and important to our region. They offer habitat for wildlife, including migratory birds and other wildlife that depend on wetlands for their survival; improve water quality by removing and sequestering excess nutrients and sediments found in rivers and streams; and, provide valuable open space and create exceptional recreational opportunities, including hiking, fishing, boating and birdwatching; store floodwaters, acting like natural sponges and slowing down the force of flood and storm waters as they travel downstream; and, naturally sequester carbon - a key greenhouse gas.

Many of the region's local governments recognize the value of wetlands and have adopted the State's minimum wetland protection

[2] Chapter 391-31-6, Rules for Environmental Planning, Georgia Department of Natural Resources, Environmental Protection Division.

criteria in addition to planning for the sensitive ecological areas in the development of their comprehensive plans.

Protection of the region's water resources is of vital concern. Non-point source pollution and urban run-off from ever-increasing development make water source protection a vital concern.

Alcovy River Greenway

Location: Northeast Georgia - Walton and Newton counties; Other - Gwinnett County

Total length: 80 miles (approx.); 54.7 miles in Northeast Georgia

Value
The Alcovy River headwaters are located in Gwinnett County, north of Lawrenceville. The river flows into Northeast Georgia to converge with the South River at Lake Jackson in Jasper County.

The floodplain surrounding the Alcovy River is comprised of hardwood swamps which serve as habitat for diverse plant and animal species. Because the Georgia coast was located just south of Macon millions of years ago, many of the species that exist today in the Alcovy River is swamps are usually found in coastal plain areas. One of these species is the tupelo gum tree, and the confluence of the Alcovy River with Cornish Creek is the northernmost pure stand of tupelo gum in the state.

The Alcovy River is a drinking water source for both Walton and Newton counties, and it will be pumped to help feed the proposed Bear Creek Reservoir. The surrounding floodplain and wetlands help to filter stormwater and prevent pollutants from entering into the water supply. The river and floodplain provide a recreational resource to the surrounding area, and serve as a popular destination for sportsmen, hikers, and campers. Because of its unique ecological characteristics, the Alcovy River and surrounding floodplain are also valued as an educational resource and research site.

Vulnerability
As part of the 1999 Alcovy River Watershed Protection Plan, a computer model was run to determine the greatest threats to water quality of the Alcovy River. Of those run through the model, sediment posed the greatest threat to this stream's health. For the year 2020, sediment was projected to increase by over 150% in some areas as a result of urban and suburban development. In the past, the Alcovy experienced increased sedimentation as a result of intense row-crop agriculture.

In addition to sedimentation, portions of the Alcovy River used for drinking and fishing have been listed in the "Not Supporting Designated Use" category of the 303(d) (of the Clean Water Act) list of waters in February 2010 due to the presence of fecal coliform bacteria as a result of non-point source pollution.

The Alcovy River is protected by a 100-foot natural, vegetative buffer in both Newton and Walton counties. However, this does not always cover the entire floodplain, increasing the chances for pollutants to enter this vital source of drinking water with increased residential, commercial, and industrial development in previous agricultural areas.

Apalachee River

Location: Northeast Georgia - Barrow, Greene, Morgan, Oconee, and Walton counties; Other - Gwinnett County

Total length: 67.8 miles

Value

The Apalachee River headwaters are located in Gwinnett County, northwest of Dacula, and it flows into Northeast Georgia forming portions of five county borders to culminate at Lake Oconee.

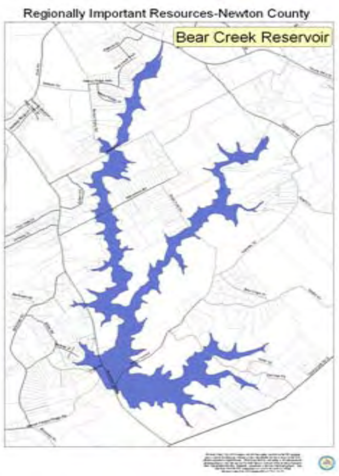
The Apalachee River provides drinking water to Morgan County and the City of Madison, and may be a future drinking water source for Oconee County. In addition, the Apalachee serves as a recreation resource for campers, paddlers, and sportsmen. Two major recreation destinations, Hard Labor Creek State Park and Fort Yargo State Park, are situated on the Apalachee River in Morgan County and Barrow County, respectively. Citizens in Oconee County have come together with the Athens Land Trust to conceptualize the Apalachee River Walk, a proposed 5.5 mile greenway with one trailhead located at the county's Heritage Park, for the purpose of conservation and recreational use. The many intact shoals of various sizes along the corridor serve as important fish habitats.

Vulnerability

Barrow, Morgan, and Walton counties have established a 100-foot natural vegetative buffer along the Apalachee River. The Future Development Map for Barrow County identifies two "emerging suburban" neighborhoods and one industrial area immediately adjacent to the river. These land uses, though separated from the river by a 100-foot buffer, may have negative impacts on water quality due to increased sedimentation from construction and/or runoff. In Walton County, the Apalachee is also covered by the Greenspace Subdivision Overlay District, requiring the preservation of 25% of the gross acreage of a development as greenspace deeded to the county. Oconee County has established a 50-foot conservation buffer along the Apalachee and other perennial streams, increasing in areas where the floodplain extends beyond this zone. In addition, the recently-completed Oconee County Greenways Plan identifies the Apalachee corridor as a potential active greenway and blueway, or paddling trail. Greene County has not established any additional protections for the Apalachee River aside from the required statewide stream buffer of 25 feet, though the Apalachee empties into Lake Oconee near U.S. 278, near the City of Madison's (Morgan County) water intake. For this reason, the Greene County portion of the Apalachee River is the most vulnerable. The addition of this watershed to the county's water supply watershed ordinance would create a 100-foot buffer and prohibit impervious surface and septic tanks within 150 feet of the stream bank, protecting the Apalachee from potentially negative impacts of spillover development from the growing Lake Oconee residential and commercial areas.

The Apalachee River was identified in February 2010 on the Section 303(d) (of the Clean Water Act) list of waters as “Not Supporting [its] Designated Use” for the segment from Williamson Creek in Barrow County to Lake Oconee in Greene County, spanning all five Northeast Georgia counties. The designated use in this instance is fishing, and the violation was cited due to the presence of fecal coliform bacteria as a result of non-point source pollution.

Another potential threat to the Apalachee is the development of the proposed Hard Labor Creek Regional Reservoir, as plans indicate that the Apalachee would be pumped to fill it. These withdrawals would likely have negative consequences for both water quantity and quality.



Bear Creek Reservoir

Location: Newton County, GA

Value

Bear Creek Reservoir is a proposed drinking water reservoir that, once established, will provide drinking water for residents of Newton and Jasper County. (A reservoir with the same name also exists in Jackson County.) A small stream, Bear Creek, will feed the proposed reservoir and will be supplemented by pumping from the nearby Alcovy River. The historic Gaither Plantation, another designated Regionally Important Resource in Northeast Georgia, is located along the edge of the proposed reservoir and will remain intact during and after development. In addition, public walking trails connecting to trail systems in neighboring jurisdictions, as well as picnic areas, are planned for the vicinity.

Vulnerability

Recreational activities and the cost of water treatment in Bear Creek have been negatively affected by increased development in the Alcovy River watershed. Thought predominantly rural at present, the establishment of the Bear Creek Reservoir could dramatically change the surrounding area's landscape; some suburban residential developments have already been constructed in this vicinity. Even with the required 150-foot natural vegetative buffer surrounding the proposed drinking water source, the Bear Creek Reservoir will be at risk of sedimentation and pollution as a result of more construction and increased impervious surface, and state and federal regulations do not provide adequate protection. Newton County has discouraged the development of more residential subdivisions in this area for these reasons; the development of programs encouraging desired development patterns such as agricultural and conservation uses will strengthen this strategy.

Big Haynes Creek/Little Haynes Creek

Location: Northeast Georgia - Walton and Newton counties; Other - Gwinnett and Rockdale counties

Length: Big Haynes Creek (in Northeast Georgia)- 4.9 miles, Little Haynes Creek - 11.4 miles

Value

Situated in the Ocmulgee River Basin, Big Haynes and Little Haynes Creek provide drinking water to nearly 100,000 people in Rockdale County; most of this comes from the 650-acre Big Haynes Creek reservoir, also known as Randy Poynter Lake. From this reservoir, Big Haynes Creek joins with Little Haynes Creek at the Newton County border to flow into the Yellow River.

The two streams also provide important wildlife habitats and contain several wetland areas and groundwater recharge areas.

Vulnerability

In February 2010, a section of Big Haynes Creek in Rockdale County was determined to be in the "Not Supporting Designated Use" category of Section 303(d) (of the Clean Water Act) list of waters. The designated use of Big Haynes Creek in this area is drinking water, and the violation was cited due to the presence of fecal coliform bacteria potentially caused by urban runoff/effects. One intake point along Big Haynes Creek is less than one mile north of the confluence with the Yellow River as it enters Newton County from Rockdale County.

Both Walton and Newton counties have established a required 100-foot natural riparian buffer in the Big Haynes Creek watershed. While this offers some protection, there are numerous reasons to coordinate conservation efforts with the metropolitan Atlanta counties in which the headwaters of the Big Haynes Creek watershed are located.

Development in Rockdale and Newton counties is also causing some stream bank erosion, leading to sediment deposits in the area where Big Haynes Creek meets the Yellow River.

Tributaries of the Broad River: South Fork, Dove Creek, Long Creek which includes Indian, Macks, Dry Fork, Buffalo and Clark creeks

Location: Madison, Oglethorpe, and Elbert counties, GA

Value

The Broad River is among the last free-flowing rivers in Georgia. While its headwaters originate in Banks and Stephens counties, the Broad River is formed by the confluence of the Hudson and Middle Fork rivers at the Franklin/Madison County boundary. The river flows through Elbert, Madison, and Oglethorpe counties to its confluence with the Savannah River at the Strom Thurmond Reservoir.

The Broad River is critical to the health and economic well-being of the citizens of northeast Georgia providing drinking water for the cities of Royston and Franklin Springs, industrial and agricultural water supply for the region, as well as an array of recreational activities including boating and fishing. The river supports a variety of fish including bass, catfish, and as of 2008, the robust redhorse. Currently, public access to the river is quite limited.

The National Park Service recognized 99 miles of the Broad River as being pristine enough to qualify as part of the Federal Wild and Scenic Rivers System. In 1976, The Georgia Department of Natural Resources, recognizing its good environmental condition, proposed that the Broad River be designated an environmental corridor. The Broad River from the Hudson River to its confluence with the Savannah River is designated a Protected River by the Georgia Department of Community Affairs.

The river's 944,000 acre watershed includes parts of thirteen counties. The northern portion of the watershed is confined by steep forested ridges and has very little development. The southern portion is flatter and agriculture extends into the flood plain. Sedimentation is high in this part of the river. Agriculture is the primary land use throughout the valley and includes some managed forest land. Industrial use in the watershed is limited to a few granite quarries.

The watershed remains in a largely natural state. Its position in the Piedmont with the Appalachians to the north and the coastal plain to the south allows for a highly diverse assemblage of plant and animal communities. It provides habitat for deer, turkeys, bobcats, foxes, beavers, otters, muskrats, quail, dove, mallards, wood ducks, turtles, crayfish and many others. Among the rare and endangered species that live in the watershed is the Shoal Lily (Hymenocallis occidentalis) which grows on rocks in and around the river.

Vulnerability

The watershed is in better condition than many Piedmont rivers, but its threats are not taken lightly by its residents. Agricultural non-point source pollution, effluent from septic systems, landfill leachate, litter, construction in the floodplain, riverbank erosion, destruction of the vegetative buffer, lack of tributary protection, and poorly planned development all pose threats to the river. Additionally, lack of public access to the river encourages trespassing which contributes to the degradation of river banks and destruction of vegetation.

Counties within the watershed are taking measures to protect it. Both Elbert and Madison counties require a 100 foot undisturbed vegetative buffer adjacent to the river. Oglethorpe County requires a 150 foot buffer.

The Broad River Watershed Association, a local land trust, was formed with the mission of protecting the Broad River through partnerships with watershed residents and public and private organizations in several conservation projects.

Hard Labor Creek

Location: Walton and Morgan counties, GA

Total length: 31.7 miles

Value

Hard Labor Creek and its watershed, situated within the greater Oconee River Basin, is a contributor to the Apalachee River and Lake Oconee, meeting these two other designated RIRs along the Morgan County/Greene County border. This stream runs through Hard Labor Creek State Park at the Morgan-Walton border, joining the two counties, and is a source of fresh drinking water to Morgan County residents; two intake points are located along Doster Road just northwest of the City of Madison. In Walton County, Hard Labor Creek is planned to feed the proposed 1,634-acre Hard Labor Creek Regional Reservoir that is expected to yield treated water by 2015 to Walton and Oconee counties, as well as other interested jurisdictions.

In addition to its value as a drinking water source, Hard Labor Creek and associated wetlands and floodplain provide habitats to a variety of land-based and aquatic species. The stream and State Park serve as recreational areas offering hiking, horseback riding, camping, swimming, canoeing, and kayaking to Northeast Georgia residents and visitors. This tourist destination is promoted in part by the Friends of Hard Labor Creek State Park.

Vulnerability

The primary threat to water quality in Hard Labor Creek is pollution from nearby roads and agricultural land uses. According to the 2006 Walton County Comprehensive Plan, land use surrounding the stream is mostly agricultural/forestry, with sporadic residential uses. This is also the case for much of the land use surrounding Hard Labor Creek in Morgan County, according to its 2004 Comprehensive Plan, save for the segment traversing the State Park. The Morgan County Zoning Ordinance establishes a 100-foot vegetative buffer along Hard Labor Creek; however, west of the park, the stream runs through a handful of commercial forestry areas before meeting the Apalachee River, opening the door to potential negative impacts as a result of tree harvesting activities. The Georgia Forestry Commission's Best Management Practices for Forestry Manual (2009 version) may help to protect water quality in these areas by providing guidance for operations such as site preparation and pesticide and fertilizer application within the stream management zone (SMZ), or buffer.

The portion of the creek in Walton County is offered some protection by the Cornish Creek, Beaver Dam Creek Watershed & Hard Labor Creek Overlay Protection District, requiring a 100-foot natural greenway buffer along the stream and prohibiting construction of any impervious surface within 150 feet from the stream bank, in addition to the Greenspace Subdivision Overlay District, requiring the preservation of 25% of the gross acreage of a development as greenspace deeded to the county. Even with these protections against development pressures, the stream is threatened by the construction of the proposed Hard Labor Creek Regional Reservoir. This project would have severe impacts on Hard Labor Creek, both in how it functions within Walton County and in Hard Labor Creek State Park, downstream from the site in Morgan County.

Lake Oconee

Location: Morgan and Greene counties, GA (and Putnam County, outside the Northeast Georgia region)

Size: 21,000 acres

Operator: Georgia Power

Value

Lake Oconee was developed by Georgia Power to create electrical power; it is fed primarily by the Oconee River, which flows along the boundaries of and/or through Athens-Clarke County, Greene County, Oconee County, and Oglethorpe County. The lake provides recreation and tourism opportunities through fishing tournaments, boating events, sightseeing, and other means including picnicking, swimming, and camping. Ten official boat ramp access points, three camping locations, and four marinas exist along the lake (http://www.n-georgia.com/lake-oconee-fishing.html).

Georgia Power holds three 85-acre parks along Lake Oconee, each of which offers a picnic pavilion, full-service campgrounds, day-use areas, playgrounds, boat ramps, and a beach with a beach house that includes restroom facilities and a dressing area. The presence of these amenities boosts the regional and local economies by drawing tourists and attracting real estate development, increasing opportunities for collection of both retail sales tax and property tax.

A key component - along with Lake Sinclair - of the "Georgia's Lake Country" marketing alliance (an endeavor of economic and community development groups), Oconee has been and is expected to continue to be a source of interest in Northeast Georgia and beyond.

Lake Oconee and its surrounding areas provide wide-ranging land and water habitat for wildlife, Bald Eagle (Haliaeetus leucocephalus) and the Oglethorpe Oak (Quercus oglethorpensis). Bo0tyh species are threatened and therefore protected by the Georgia DNR and US Fish and Wildlife Service. Used also as a reservoir, the lake provides valuable flood-protection benefits to the surrounding areas; Georgia Power manages its water levels and protects its shorelines.

In addition to its economic and environmental benefits, Lake Oconee, through its Wallace Dam and Hydroelectric Plant, is an important power source. The 120'-high, 2,395'-long dam, completed in 1980, features six units that combine for a capacity of 321,300 killowatts.

Vulnerability

The State of Georgia's listing of the Bald Eagle and the Oglethorpe Oak as "threatened" means that both species are likely to become endangered in the foreseeable future. While the Oglethorpe Oak's habitat exists in several other places in Northeast Georgia, the Bald

Eagle's may be found only near Lake Oconee and potentially near Lake Russell, in Elbert County. The lake environs represent a unique haven for these two sensitive species in the region.

A contributing factor to the lake environs' desirability as a tourism and recreation destination is the scenic nature that characterizes the area. However, as Georgia's Lake Country develops with residential communities and the associated commercial, employment, education, recreation, and other uses, rapid growth may bring adverse consequences. In addition to accompanying loss of aesthetic integrity, inappropriate types and scales of development could impair habitat, water quality, air quality, and other aspects of the natural environment that contribute the lake's ecosystems.

Both Morgan and Greene counties have water intakes at different locations near US278/SR12 as it crosses Lake Oconee, Morgan's being approximately three miles north of Buckhead and Greene's five miles west of Greensboro. Water quality throughout Lake Oconee - and upstream along the Oconee River, North Oconee River, and Middle Oconee River - must be protected to ensure that these sources remain viable to support nearby populations.

Georgia DNR is updating designated uses of waters including adding recreation uses to some reservoirs. Updated designated uses should be approved by U.S. EPA in spring 2011. If a recreation designated use is added to this lake, an assessment is recommended to evaluate the impact of activities on and around the lake as they pertain to recreation.

Lake Roy Varner

Location: Newton and Walton counties, GA

Size: 1.3 mi^2 (approx. 850 Ac.)

Operator: Newton Co. Water Resources Dept.

Value

Lake Varner is a 1.3 square-mile drinking-water reservoir that supplies water to approximately 150,000 people in Newton, Walton, and Jasper counties (as well as the municipalities of Covington, Oxford, Porterdale, Newborn, and Mansfield). It is a well-known and well-used fishing lake, and features shoreline walking trails and picnic areas for public use. Lake Varner opened to public fishing in 1992, and despite regulations put in place to safeguard the lake and its banks, it continues to be a popular destination for anglers and recreational boaters such as canoeists.

Walton and Newton counties are currently partners in the lake and associated water treatment facilities. County and municipal jurisdictions meet regularly to discuss the lake and the water it provides, with Newton County providing financial assistance to some of the smaller communities to help them expand their distribution systems.

In addition to providing multiple passive recreational activities available to residents of several nearby counties, Newton County's management of the reservoir protects adjacent wetlands and controls development within the watershed. Approximately 1,400 acres are preserved and protected as part of the reservoir's site, including buffers, mitigation space, and recreation areas. The lake's dam provides downstream flood control for Cornish Creek.

The Lake Varner area is part of the known habitat for Altamaha Shiner (Cyprinella xaenura). This species is threatened and therefore protected by the Georgia DNR and U.S. Fish and Wildlife Service.

Vulnerability

Development in the Cornish Creek and Alcovy River watersheds that feed Lake Varner contribute sediment and other pollutants, resulting in increased costs of water treatment, impacts to fishing and canoeing, and higher management costs. Pollution could bring negative impacts for fishing-based tourism and economic development in the area. Droughts and floods can severely impact water quality; impervious area restrictions would ameliorate flood-condition impacts.

The only intake point on the lake is at its southern end, approximately 0.7-miles north of the intersection of Alcovy Road and Gregory Road. The water quality of the lake, Cornish Creek, and Little Cornish Creek must be protected to ensure that this drinking-water source remains viable to support local populations.

The State of Georgia's listing of the Altamaha Shiner as "threatened" means that the species is likely to become endangered in the foreseeable future. No other habitat for this species is thought to exist within eight miles of Lake Varner.

Georgia DNR is updating designated uses of waters including adding recreation uses to some reservoirs. Updated designated uses should be approved by U.S. EPA in spring 2011. If a recreation designated use is added to this lake, an assessment is recommended to evaluate the impact of activities on and around the lake as they pertain to recreation.

South River

Location: Newton County, GA (and DeKalb, Rockdale, Henry, and Butts counties, outside the Northeast Georgia region)

Length: 22.3 mi

Value

From its headwaters in DeKalb County to its discharge into Lake Jackson, the South River traverses DeKalb County, Rockdale County, Henry County, Butts County, and Newton County (the river forms Newton's boundary with Henry and Butts). It is an important recreational resource, providing fishing, boating, space for trails, and associated greenspace.

DeKalb, Rockdale, and Newton counties all have greenway projects or activities along the South River, involving governments, landowners, the Georgia Wildlife Federation, and groups such as the PATH Foundation and Newton Trails. Historic and cultural resources along the river are, and will continue to be, designated, preserved, and managed by public and/or private groups.

Georgia Power, the Lake Jackson Homeowners Association, and environmental groups are working to improve the quality of the river's discharge into Lake Jackson. Although a Riverkeeper organization does not currently exist specifically to oversee the South River, Riverkeeper groups below Lake Jackson (on the Ocmulgee and Atamaha rivers) have an abiding interest in the South River's water quality. Keep Covington/Newton Beautiful supports the river's health through its participation in the Rivers Alive program, which focuses on stream and riparian cleanup.

The South River provides natural wildlife habitat in a developed area. Most significantly, habitat for the Piedmont Blue Burrower (Cambarus harti), an endangered crayfish, is found along or near the South River where it flows through Newton County. As an endangered species, this crayfish is protected by the Georgia DNR and U.S. Fish and Wildlife Service.

Native American settlements dating back to 5,000 B.C.E. have been found and documented in the area of the confluence of the South River with the Yellow River, at the entry of Lake Jackson.

Vulnerability

The State of Georgia's listing of the Piedmont Blue Burrower as "endangered" means that the species is in danger of extinction throughout all or part of its range. The South River is the only location in Northeast Georgia where the Burrower's habitat may be found, and thus, this resource is critical to the region.

While Newton County maintains a River Corridor Protection Overlay District (including the South River) as part of its zoning ordinance, single-family dwellings are allowed throughout this district, provided they adhere to certain standards. These include a 100-foot local buffer (with an additional 50' buffer for septic tanks and impervious surfaces) and situation on at least two acres of land, in addition to the statewide 25-foot stream buffer. Septic tanks serving single-family dwellings are permitted here, although drain fields are not. Other uses, such as road and utility crossings, timber production and harvesting, wastewater treatment, agricultural production, and recreational facilities, are permitted but must also meet specified conditions. The County has expressed a desire to preserve more of the riparian area through means including conservation easements, increased development regulations, and fee-simple acquisition of flood zones, buffers, and wetlands along the corridor.

Polychlorinated biphenyls (PCBs) have been found in fish tissues in the section of the South River in Newton County. PCB testing on experimental animals has revealed toxicity to the liver, gastrointestinal system, blood, skin, endocrine system, immune system, nervous system, and reproductive system, according to the Georgia Environmental Protection Division (EPD), and effects of PCB ingestion can be especially severe in fetal development. While the source of PCB contamination is unknown, it is attributed to contamination from urban runoff from Metropolitan Atlanta and combine sewer overflows. Other possible sources could include movement of contaminated bedload sediment, soil erosion, air deposition, and other nonpoint source discharges. Continued presence of these contaminants could adversely affect the fishing-related uses along the river, including the economic benefits they bring.

As the South River is one of the three major sources for Lake Jackson (along with the Alcovy River and the Yellow River), water quality preservation activities for the river, its tributaries, and surrounding lands are critical.

Yellow River

Location: Newton County, GA (and Gwinnett, DeKalb, and Rockdale counties, outside the Northeast Georgia region)

Length: 26.7 mi

Value

From its headwaters north of Lawrenceville to its discharge into Lake Jackson, the Yellow River traverses Gwinnett, DeKalb, Rockdale, and Newton counties. It is an important recreational resource, providing fishing, boating, space for trails, white-water rapids, and associated greenspace.

DeKalb, Rockdale, and Newton counties all have greenway projects or activities along the Yellow River, involving governments, landowners, the Georgia Wildlife Federation, and groups such as the PATH Foundation and Newton Trails. Historic and cultural resources along the river are, and will continue to be, designated, preserved, and managed by public and/or private groups. The realization of a master plan for mutli-use trails connecting Conyers to Covington via the Yellow River could provide significant economic and transportation benefits to the area.

The Newton County Water and Sewer Authority and the City of Covington are involved in protecting the river under the terms of their wastewater discharge permits. Georgia Power, the Lake Jackson Homeowners Association, and environmental groups are working to improve the quality of the river's discharge into the lake. Although a Riverkeeper organization does not currently exist specifically to oversee the Yellow River, Riverkeeper groups below Lake Jackson (on the Ocmulgee and Altamaha rivers) have an abiding interest in the Yellow River's water quality.

The Yellow River provides natural wildlife habitat in a developed area. Most significantly, habitat for two state- and federally-listed species is found in or around the Yellow River: the Black-Spored Quillwort (endangered) and the Pool Sprite (threatened).

Native American settlements dating back to 5,000 B.C. have been found and documented in the area of the confluence of the South River with the Yellow River, at the entry of Lake Jackson. The Hightower Trail, the boundary between the Creek and Cherokee nations, crosses the Yellow River in Gwinnett County.

Vulnerability

The Black-spored Quillwort (Isoetes melanospora) is an endangered perennial whose only known location is six Georgia counties; the Quillwort's "endangered" status means that it is in danger of extinction throughout all or part of its range. The Pool Sprite (Amphianthus pusillus) is listed by the federal and state governments as "threatened," meaning that it is likely to become endangered in the foreseeable future throughout all or parts of its range. Along the Newton County section of the Yellow River, habitat for both species is found only around the upper reaches of the river, near the border with Rockdale County.

After sampling in 1999, the section of the Yellow River in Newton County was listed as "not supporting" its designated use for fishing and drinking water due to the presence of fecal coliform, carried to the river by urban runoff (nonpoint). If conditions do not improve, potential detrimental impacts to the health of humans and wildlife, as well as to fishing-related tourism and economic development, could occur.

Newton County maintains a Watershed Protection Overlay District (including the Yellow River) as part of its zoning ordinance. The district requires a 100 foot natural and undisturbed buffer adjacent to perennial streams and an additional 50 foot setback for septic tanks and their drain fields and structures. Other uses, such as road and utility crossings, timber production and harvesting, wastewater treatment, agricultural production, and recreational facilities, are permitted but must also meet specified conditions. The County has expressed a desire to preserve more of the riparian area through means including conservation easements, increased development regulations, and fee-simple acquisition of flood zones, buffers, and wetlands along the corridor.

As the Yellow River is one of the three major sources for Lake Jackson (along with the Alcovy River and the South River), water quality preservation activities for the river, its tributaries, and surrounding lands are critical.

REGIONALLY IMPORTANT RESOURCES MAPS

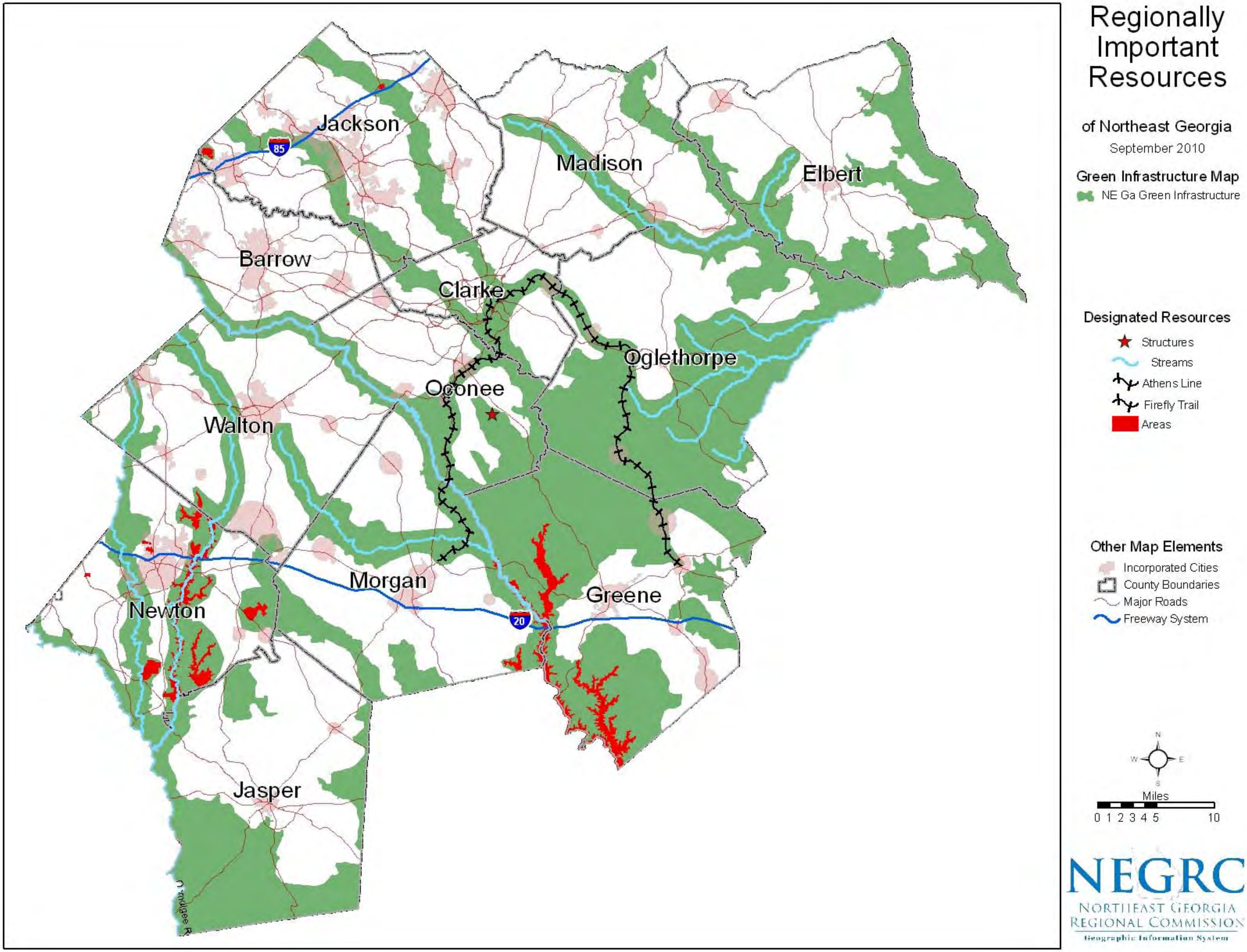
The RIR Map is a detailed illustration of all designated RIRs within the Northeast Georgia RC region as well as the State Vital areas as required by the Department of Community Affairs (DCA) Rules for Regionally Important Resources. The map is presented in two formats, the Green Infrastructure Map and the individual county RIR maps.

The Green Infrastructure Map is a generalized map meant to serve as an advocacy map to educate and guide interested parties on the location of areas recommended to be set aside for greenspace. The RIR Rules require that the designated resources be connected, to the maximum extent feasible, in a continuous regional green infrastructure network. One of the networks DCA suggested using to create the interconnection is the Southeast Ecological Framework.

The Southeastern Ecological Framework Project was a GIS-based analysis to identify ecologically significant areas and connectivity in the southeast region of the US, including Georgia. This network is a strategically planned and managed network of wilderness, parks, greenways, conservation easements, and working lands with conservation value that benefits wildlife and people, supports native species, maintains natural ecological processes, sustains air and water resources, links urban settings to rural ones, and contributes to the health and quality of life for the communities and citizens sharing this network. The network encompasses a wide range of elements, including: natural areas such as wetlands, woodlands, waterways, and wildlife habitat; public and private conservation lands such as nature preserves, wildlife corridors, greenways, and parks; and public and private working lands of conservation value such as forests and farms, as well as, outdoor recreation and trail networks. The Southeast Ecological Framework best connected the RIR resources in the Northeast Georgia region, leaving only two sites not linked to the green infrastructure network.

Individual county RIR maps were developed to provide the detail not possible with the Green Infrastructure Map and depicts designated RIRs and State Vital Areas in their relation to the Green Infrastructure linkage.

The RIR Map is presented in a layered form on the RC's map server http://maps.negplanning.org and allows user to turn the various layers on and off as needed for viewing ease. Additionally, the map displays city and county boundaries, major roads, and the Georgia Department of Transportation designated Bicycle Trails located in the region. While these State Bicycle Trails are not designated RIRs, these components of transportation infrastructure serve as important linkages between resources, particularly east to west, where no other linkages exist.


Regionally Important Resources
of Northeast Georgia
September 2010
Green Infrastructure Map
NE Ga Green Infrastructure
Designated Resources
Structures
Streams
Athens Line
Firefly Trail
Areas
Other Map Elements
Incorporated Cities
County Boundaries
Major Roads
Freeway System
Miles
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Jackson
Madison
Elbert
Barrow
Clarke
Oglethorpe
Oconee
Walton
Morgan
Greene
Newton
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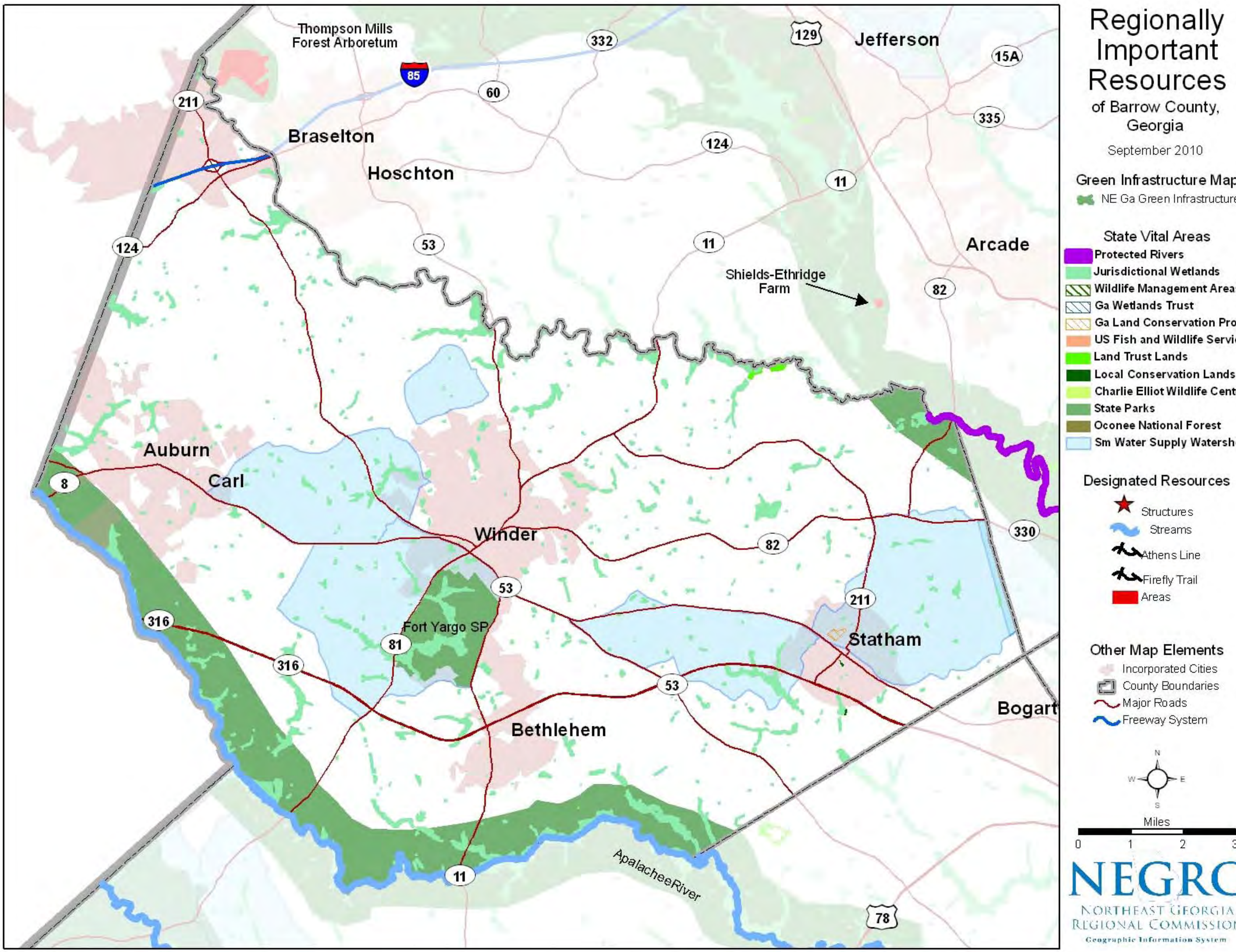
NEGRC
NORTHEAST GEORGIA
REGIONAL COMMISSION
Geographic Information System



Regionally Important Resources
of Barrow County, Georgia
September 2010
Green Infrastructure Map
NE Ga Green Infrastructure
State Vital Areas
Protected Rivers
Jurisdictional Wetlands
Wildlife Management Areas
Ga Wetlands Trust
Ga Land Conservation Prog.
US Fish and Wildlife Service
Land Trust Lands
Local Conservation Lands
Charlie Elliot Wildlife Center
State Parks
Oconee National Forest
Sm Water Supply Watershed
Designated Resources
Structures
Streams
Athens Line
Firefly Trail
Areas
Other Map Elements
Incorporated Cities
County Boundaries
Major Roads
Freeway System
Miles
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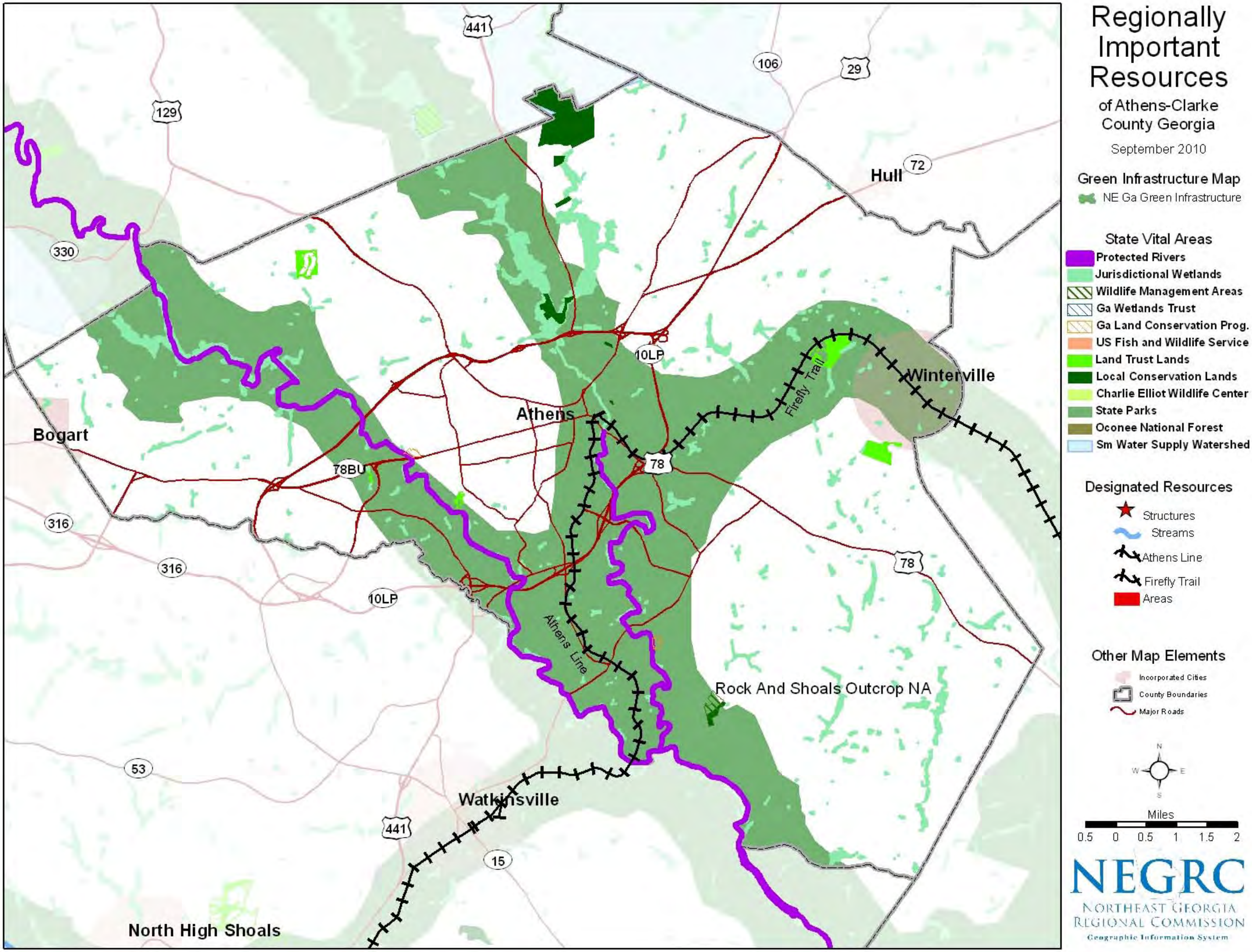
NEGRC
Northeast Georgia Regional Commission
Geographic Information System
Thompson Mills Forest Arboretum
Jefferson
Braselton
Hoschton
Arcade
Shields-Ethridge Farm
Auburn
Carl
Winder
Fort Yargo SP
Statham
Bethlehem
Bogart
Apalachee River


Regionally Important Resources
of Athens-Clarke County Georgia
September 2010
Green Infrastructure Map
NE Ga Green Infrastructure
State Vital Areas
Protected Rivers
Jurisdictional Wetlands
Wildlife Management Areas
Ga Wetlands Trust
Ga Land Conservation Prog.
US Fish and Wildlife Service
Land Trust Lands
Local Conservation Lands
Charlie Elliot Wildlife Center
State Parks
Oconee National Forest
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Other Map Elements
Incorporated Cities
County Boundaries
Major Roads
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NEGRC
NORTHEAST GEORGIA REGIONAL COMMISSION
Geographic Information System
Athens
Bogart
Hull
Winterville
Watkinsville
North High Shoals
Rock And Shoals Outcrop NA
Athens Line
Firefly Trail
441
129
106
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72
330
10LP
78
78BU
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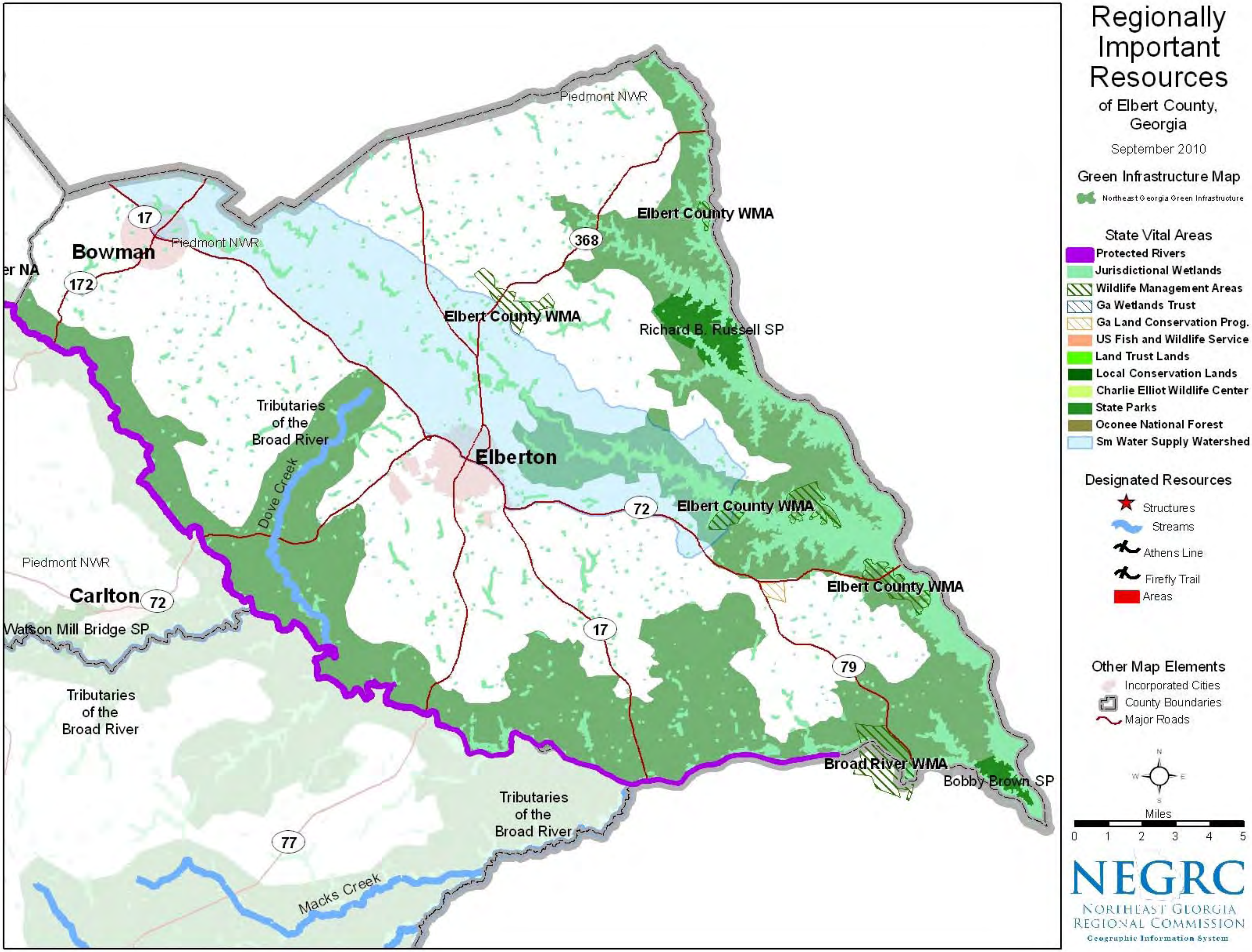
53
15

Regionally Important Resources

of Elbert County, Georgia

September 2010



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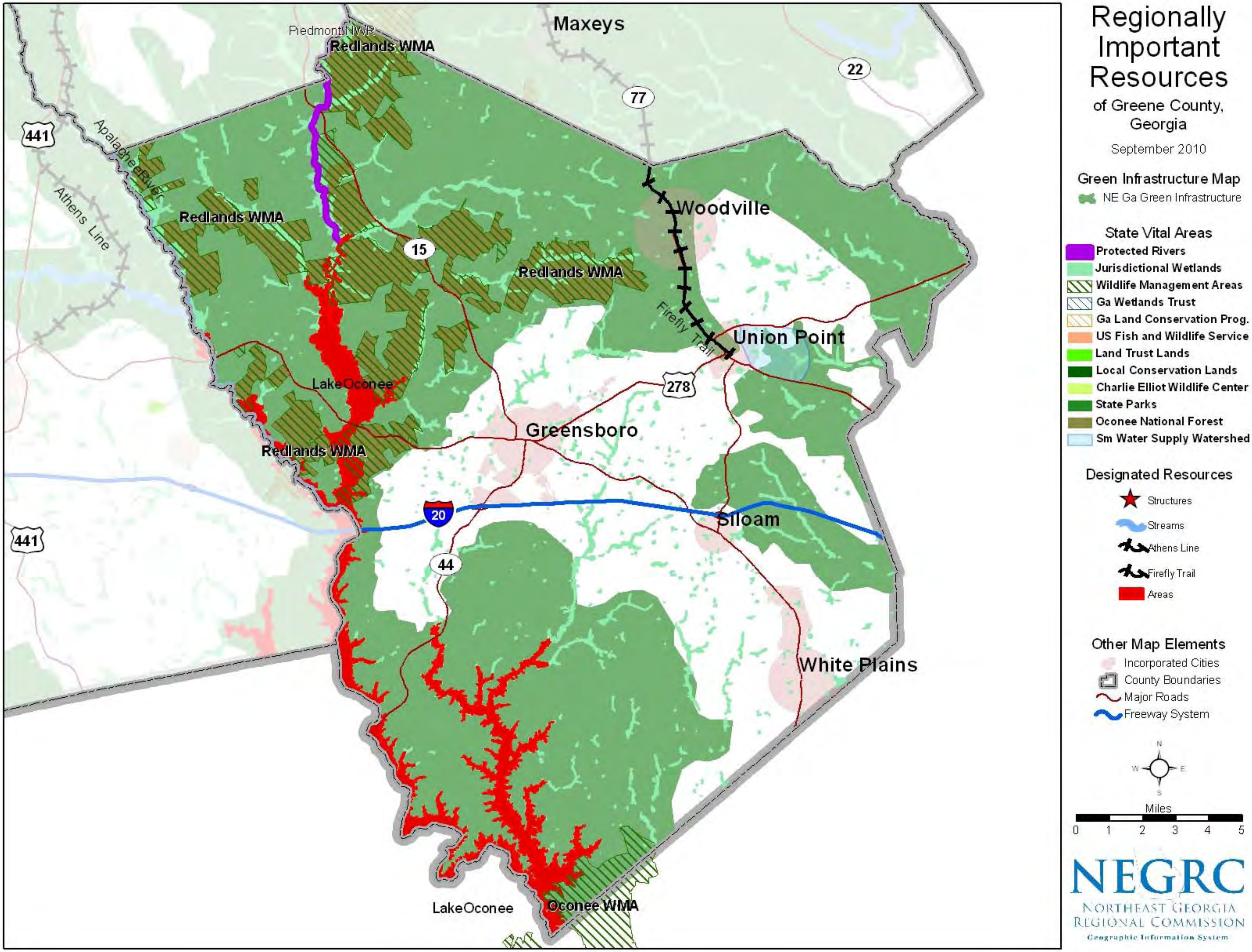
NORTHEAST GEORGIA REGIONAL COMMISSION
Geographic Information System

Regionally Important Resources

of Greene County, Georgia

September 2010



NEGRC

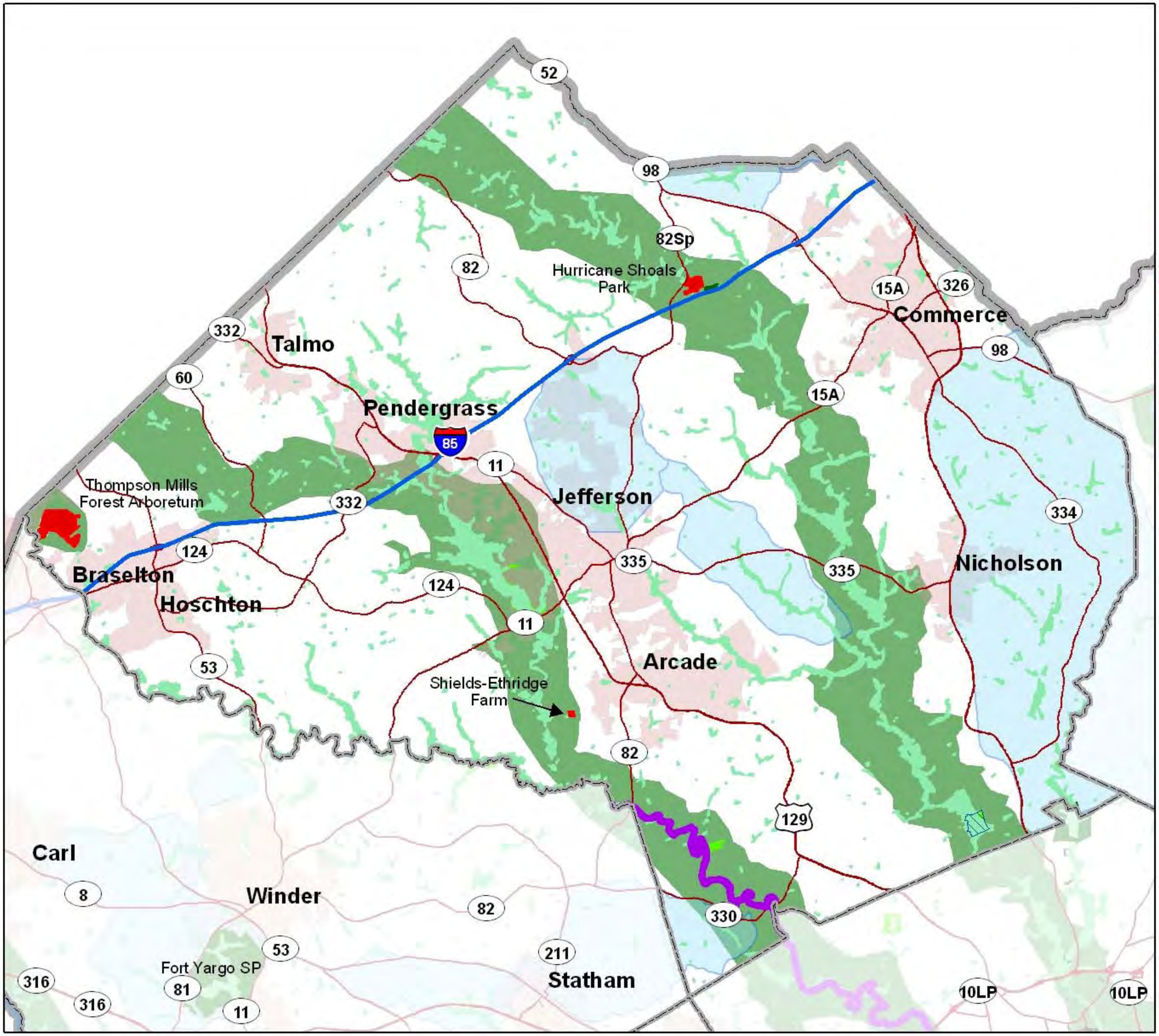
Northeast Georgia Regional Commission

Geographic Information System

Regionally Important Resources

of Jackson County, Georgia

September 2010



Green Infrastructure Map

- NE Ga Green Infrastructure

State Vital Areas

- Protected Rivers
- Jurisdictional Wetlands
- Wildlife Management Areas
- Ga Wetlands Trust
- Ga Land Conservation Prog.
- US Fish and Wildlife Service
- Land Trust Lands
- Local Conservation Lands
- Charlie Elliot Wildlife Center
- State Parks
- Oconee National Forest
- Sm Water Supply Watershed

Designated Resources

- Structures
- Streams
- Athens Line
- Firefly Trail
- Areas

Other Map Elements

- Incorporated Cities
- County Boundaries
- Major Roads
- Freeway System

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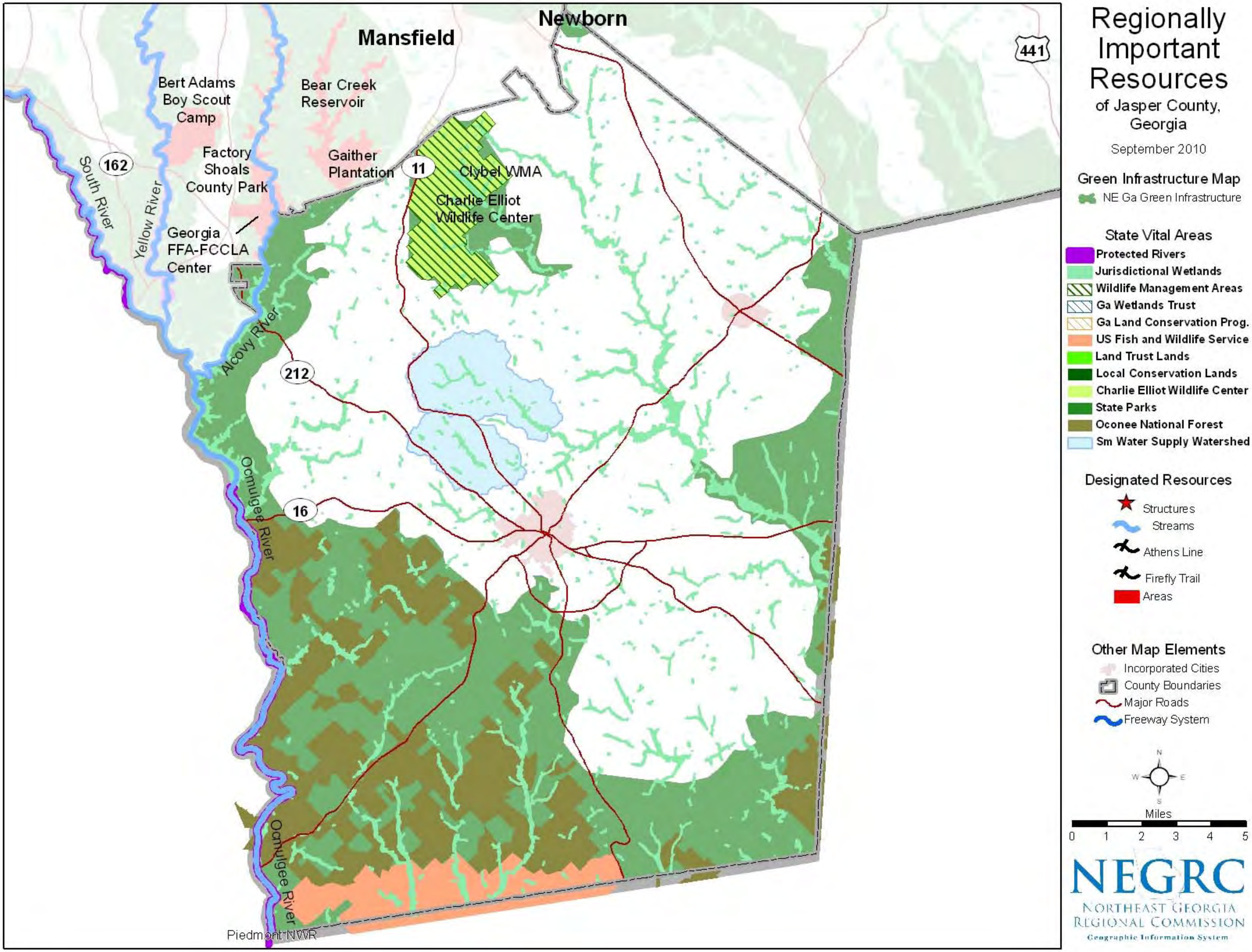
NEGRC
NORTHEAST GEORGIA REGIONAL COMMISSION
Geographic Information System



Regionally Important Resources
of Jasper County, Georgia
September 2010
Green Infrastructure Map
NE Ga Green Infrastructure
State Vital Areas
Protected Rivers
Jurisdictional Wetlands
Wildlife Management Areas
Ga Wetlands Trust
Ga Land Conservation Prog.
US Fish and Wildlife Service
Land Trust Lands
Local Conservation Lands
Charlie Elliot Wildlife Center
State Parks
Oconee National Forest
Sm Water Supply Watershed
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Firefly Trail
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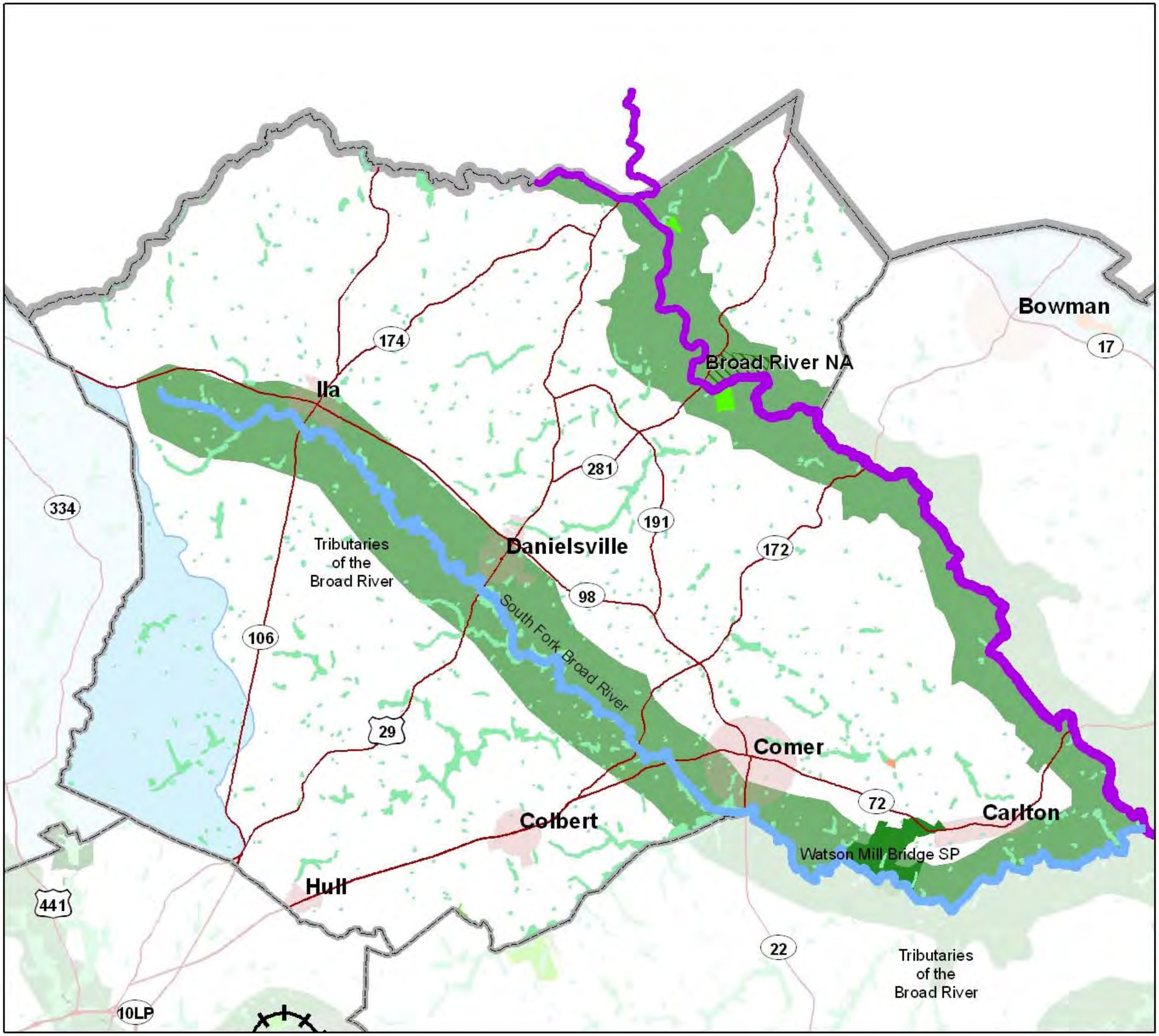
Other Map Elements
Incorporated Cities
County Boundaries
Major Roads
Freeway System
Miles
0 1 2 3 4 5
NEGRC
Northeast Georgia Regional Commission
Geographic Information System
Newborn
Mansfield
441
Bert Adams Boy Scout Camp
Bear Creek Reservoir
Factory Shoals County Park
Gaither Plantation
11
Clybel WMA
Charlie Elliot Wildlife Center
162
South River
Yellow River
Georgia FFA-FCCLA Center
Alcovy River
212
Ocmulgee River
16
Ocmulgee River
Piedmont NWR



Regionally Important Resources

of Madison County, Georgia

September 2010

Green Infrastructure Map

NE Ga Green Infrastructure

State Vital Areas

Protected Rivers
Jurisdictional Wetlands
Wildlife Management Areas
Ga Wetlands Trust
Ga Land Conservation Prog.
US Fish and Wildlife Service
Land Trust Lands
Local Conservation Lands
Charlie Elliot Wildlife Center
State Parks
Oconee National Forest
Sm Water Supply Watershed

Designated Resources

Structures
Streams
Athens Line
Firefly Trail
Areas

Other Map Elements

Incorporated Cities
County Boundaries
Major Roads

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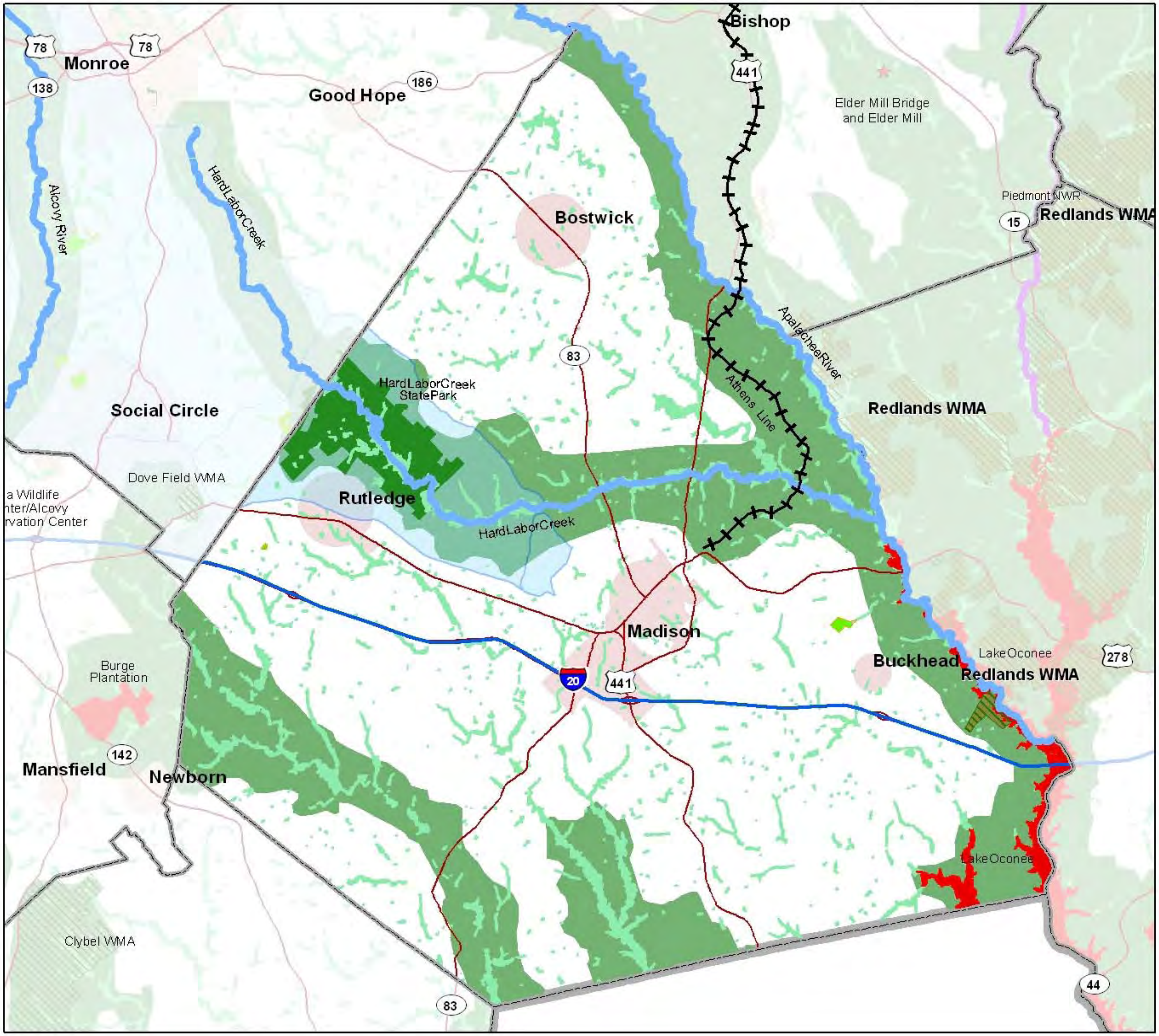
NEGRC
NORTHEAST GEORGIA REGIONAL COMMISSION
Geographic Information System



Regionally Important Resources

of Morgan County, Georgia

September 2010

Green Infrastructure Map

NE Ga Green Infrastructure

State Vital Areas

- Protected Rivers
- Jurisdictional Wetlands
- Wildlife Management Areas
- Ga Wetlands Trust
- Ga Land Conservation Prog.
- US Fish and Wildlife Service
- Land Trust Lands
- Local Conservation Lands
- Charlie Elliot Wildlife Center
- State Parks
- Oconee National Forest
- Sm Water Supply Watershed

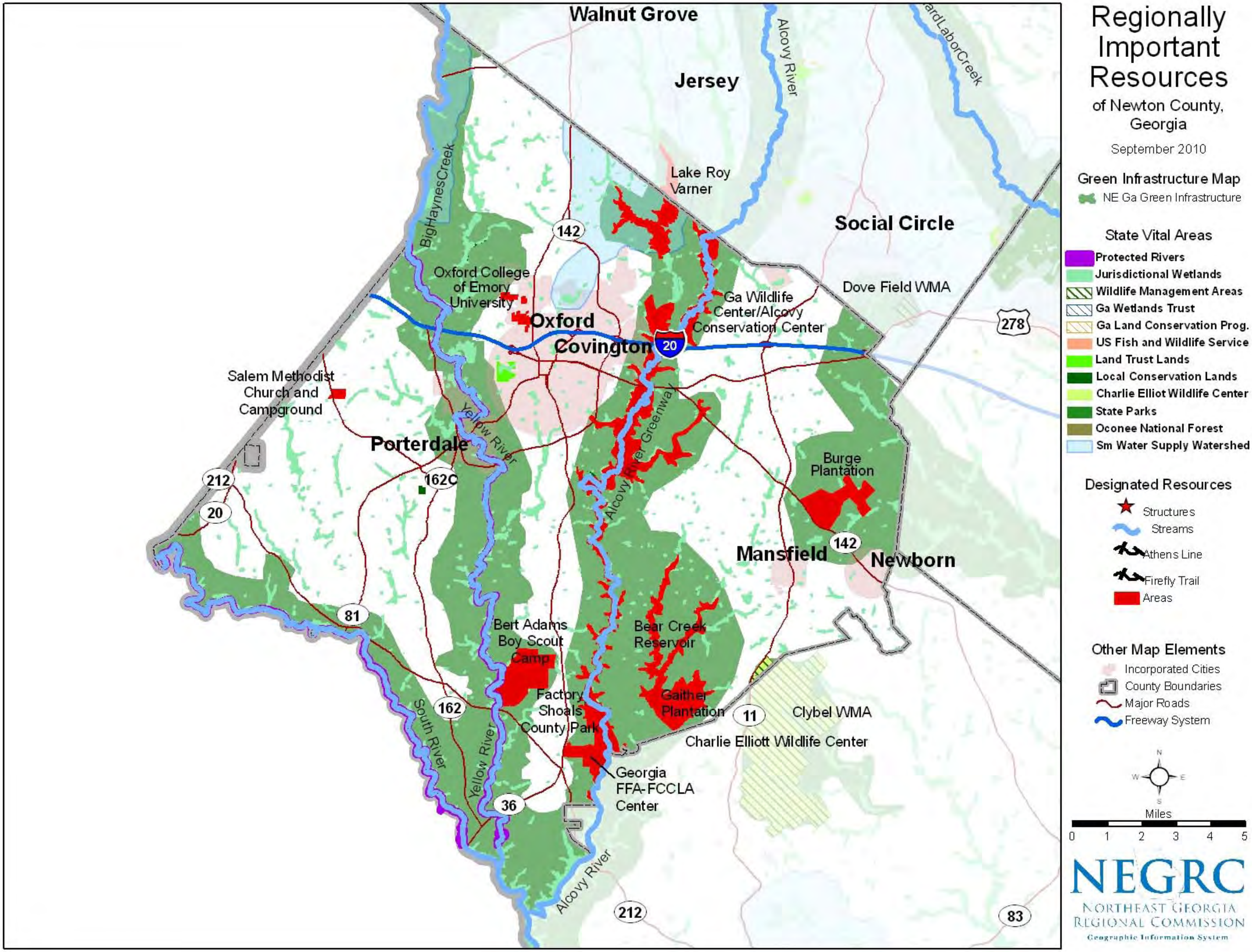
Designated Resources

- Structures
- Streams
- Athens Line
- Firefly Trail
- Areas

Other Map Elements

- Incorporated Cities
- County Boundaries
- Major Roads
- Freeway System

NEGRC
NORTHEAST GEORGIA REGIONAL COMMISSION
Geographic Information System



Regionally Important Resources
of Newton County, Georgia
September 2010
Green Infrastructure Map
NE Ga Green Infrastructure
State Vital Areas
Protected Rivers
Jurisdictional Wetlands
Wildlife Management Areas
Ga Wetlands Trust
Ga Land Conservation Prog.
US Fish and Wildlife Service
Land Trust Lands
Local Conservation Lands
Charlie Elliot Wildlife Center
State Parks
Oconee National Forest
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Incorporated Cities
County Boundaries
Major Roads
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Miles
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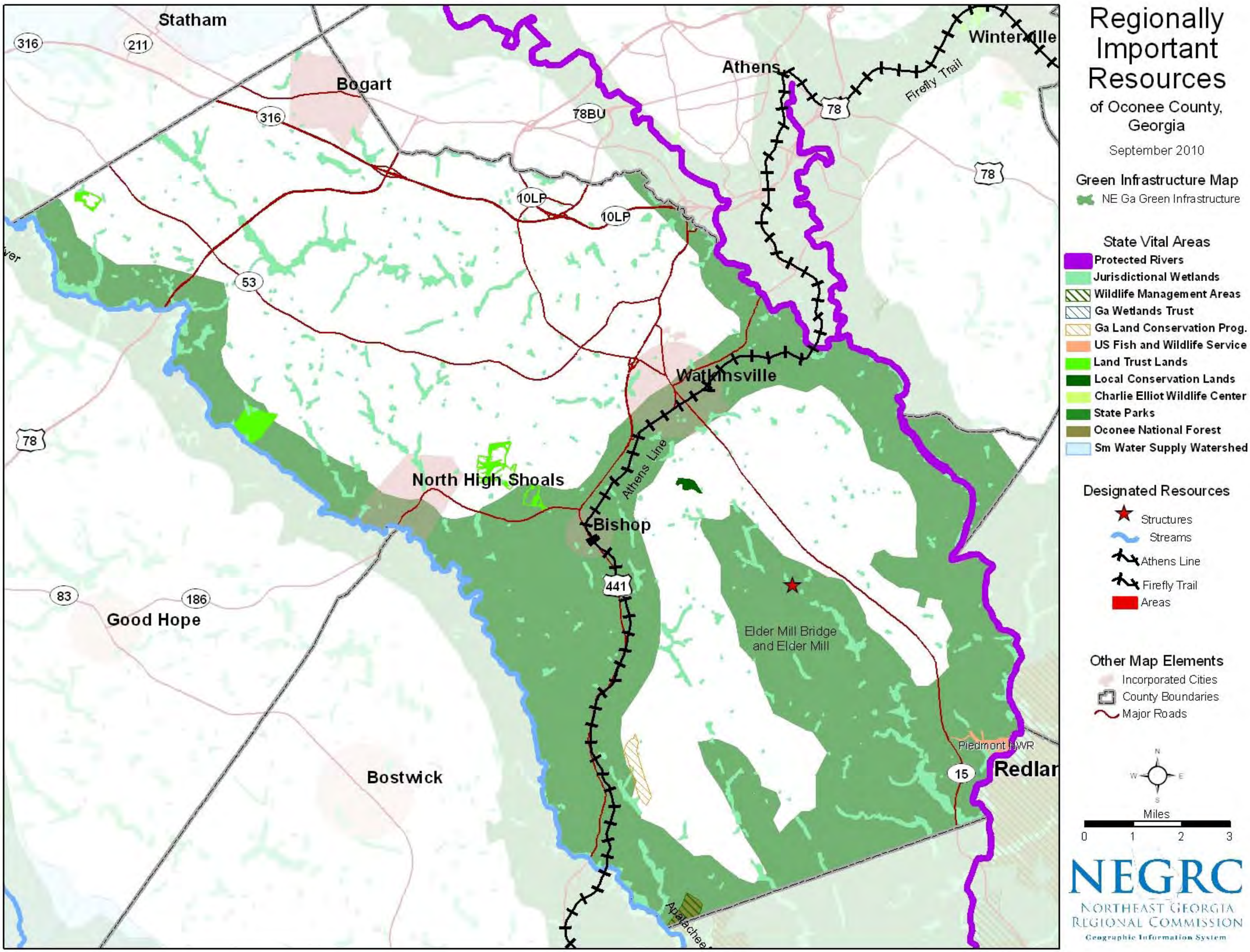
NEGRC
Northeast Georgia Regional Commission
Geographic Information System
Walnut Grove
Jersey
Alcovy River
HardLaborCreek
Lake Roy Varner
Social Circle
Dove Field WMA
BigHaynesCreek
Oxford College of Emory University
Oxford
Covington
Ga Wildlife Center/Alcovy Conservation Center
20
278
142
Salem Methodist Church and Campground
Porterdale
Yellow River
Alcovy River Greenway
162C
212
20
Burge Plantation
Mansfield
Newborn
81
Bert Adams Boy Scout Camp
Bear Creek Reservoir
Factory Shoals County Park
Gaither Plantation
11
Clybel WMA
Charlie Elliott Wildlife Center
162
South River
Georgia FFA-FCCLA Center
36
Alcovy River
212
83


Regionally Important Resources
of Oconee County, Georgia
September 2010
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Wildlife Management Areas
Ga Wetlands Trust
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NEGRC
Northeast Georgia Regional Commission
Geographic Information System
Statham
Bogart
Athens
Winterville
Watkinsville
North High Shoals
Bishop
Good Hope
Bostwick
Redlan
Elder Mill Bridge and Elder Mill
Piedmont NWR
Firefly Trail
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83
186
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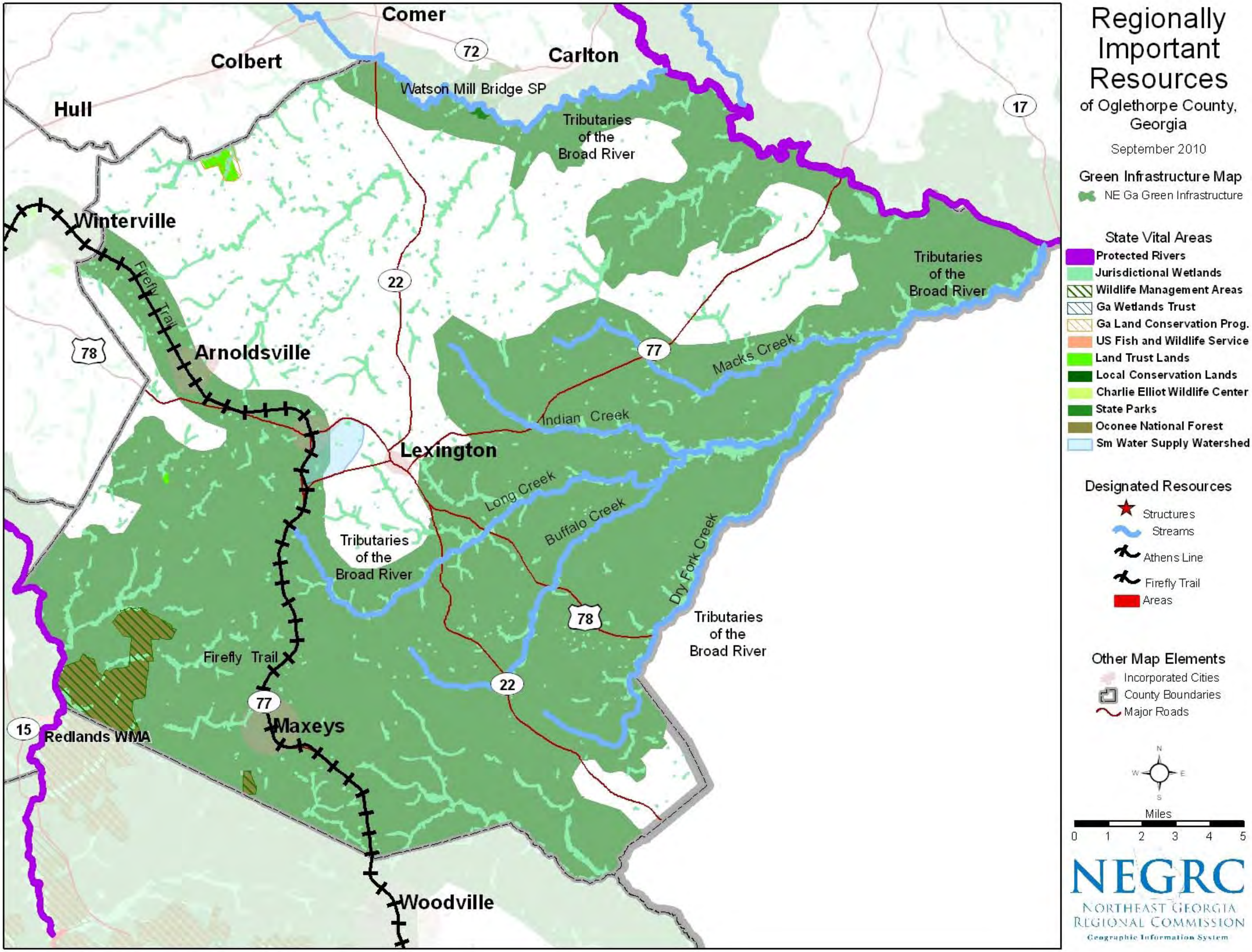

Regionally Important Resources
of Oglethorpe County, Georgia
September 2010
Green Infrastructure Map
NE Ga Green Infrastructure
State Vital Areas
Protected Rivers
Jurisdictional Wetlands
Wildlife Management Areas
Ga Wetlands Trust
Ga Land Conservation Prog.
US Fish and Wildlife Service
Land Trust Lands
Local Conservation Lands
Charlie Elliot Wildlife Center
State Parks
Oconee National Forest
Sm Water Supply Watershed
Designated Resources
Structures
Streams
Athens Line
Firefly Trail
Areas
Other Map Elements
Incorporated Cities
County Boundaries
Major Roads
Miles
0 1 2 3 4 5
NEGRC
Northeast Georgia Regional Commission
Geographic Information System
Comer
Colbert
Carlton
Hull
72
17
Watson Mill Bridge SP
Tributaries of the Broad River
Winterville
Firefly Trail
78
Arnoldsville
22
77
Macks Creek
Indian Creek
Lexington
Long Creek
Buffalo Creek
Dry Fork Creek
Tributaries of the Broad River
Tributaries of the Broad River
Tributaries of the Broad River
78
Firefly Trail
22
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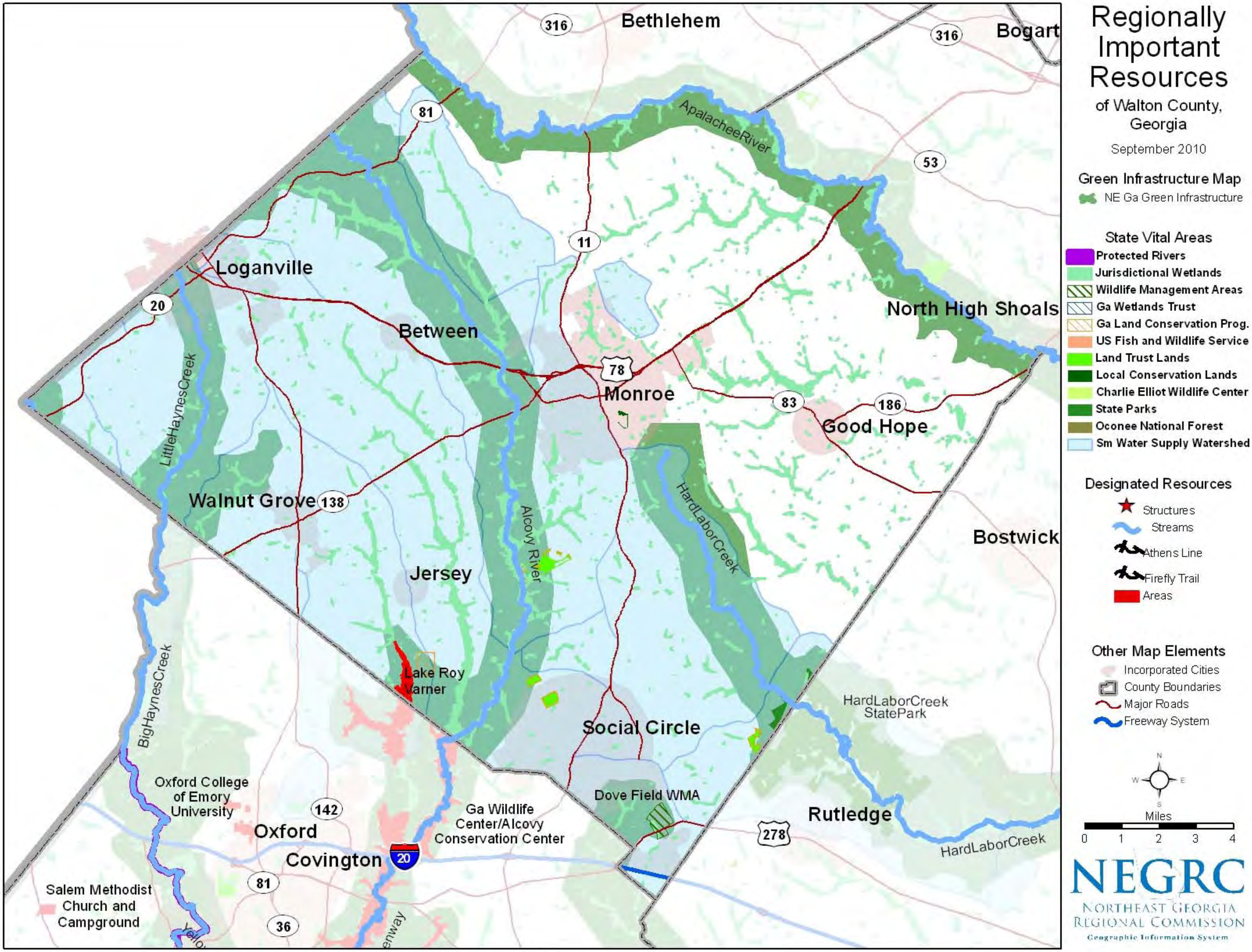
15
Redlands WMA
Maxeys
Woodville


Regionally Important Resources
of Walton County, Georgia
September 2010
Green Infrastructure Map
NE Ga Green Infrastructure
State Vital Areas
Protected Rivers
Jurisdictional Wetlands
Wildlife Management Areas
Ga Wetlands Trust
Ga Land Conservation Prog.
US Fish and Wildlife Service
Land Trust Lands
Local Conservation Lands
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State Parks
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Incorporated Cities
County Boundaries
Major Roads
Freeway System
Miles
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NEGRC
Northeast Georgia Regional Commission
Geographic Information System
Bethlehem
Bogart
North High Shoals
Loganville
Between
Monroe
Good Hope
Walnut Grove
Bostwick
Jersey
Lake Roy Varner
Social Circle
HardLaborCreek StatePark
Dove Field WMA
Rutledge
Oxford College of Emory University
Oxford
Covington
Ga Wildlife Center/Alcovy Conservation Center
Salem Methodist Church and Campground
ApalacheeRiver
LittleHaynesCreek
BigHaynesCreek
Alcovy River
HardLaborCreek
316
81
11
53
20
78
83
186
138
142
278
36

APPROPRIATE DEVELOPMENT PRACTICES

Appropriate Development Practices

The integrity of a designated resource is not only the resource itself, but also the viewsheds, adjacent sites and structures, and development and land-use practices that can contribute to, or detract from, a resource's value. Conservation and Heritage resources are most threatened by development. Water Resources are threatened by the potential point and non-point source pollution entering the waters and negatively impacting water quality as well as the destruction of wetlands and wildlife habitat from development activities. Therefore, it is important to discuss appropriate development practices to protect these resources and the areas around them. Examining the potential affects of development and implementing suitable protection mechanisms can reduce, if not completely negate, development impacts.

The following are recommended appropriate development practices that should be used by developers for designing new developments to be located within one mile of an RIR. The practices will be used by the Northeast Georgia Regional Commission for reviewing and evaluating Developments of Regional Impact located within one mile of a resource.

- Establish a complementary mix of land uses (residential, commercial, civic, etc.), both vertically and horizontally, within convenient walking distance of one another (a quarter-mile, or 5-10 minutes) via direct and safe connections. By creating projects with multiple land uses, automobile trips become less necessary and pavement may be used more sparingly, reducing impacts to traffic, air quality, and water quality. The National Association of Homebuilders maintains a Mixed-Use & Compact Development resource online (http://www.nahb.org/reference_list.aspx?sectionID=628).
- Use infrastructure availability to steer development away from areas of natural, cultural, historic, and environmentally sensitive resources.
- Link to adjacent developments and neighborhoods via a trail and/or greenspace system.
- Utilize shared parking opportunities (http://www.vtpi.org/tdm/tdm89.htm) and seek reduced parking requirements (http://www.vtpi.org/tdm/tdm72.htm#_Reduce_Parking_Supply) in areas to decrease the total impervious surface area and protect water quality.
- Encourage the redevelopment or adaptive reuse of existing buildings, sites, and districts, including brownfields and greyfields. Cleaning up and reinvesting in these properties protects the environment, reduces blight, and takes development pressures off greenspaces and sensitive lands.
- Coordinate new development patterns with those of existing neighborhoods by use of compatible scale and design. Examples include appropriate housing size and style, lot size and setbacks, street design (especially width), landscaping, tree preservation, and grading.
- Site plans and building design should be sensitive to the natural features of the site, including woodlands, steep slopes, wetlands, and floodplains.
- Enlist significant site features including view shed corridors, trees, and existing heritage resources, as amenities that shape the identity and character of new and infill development, and redevelopment.
- Preserve historic and cultural resources located on or adjacent to the site.

- Buffer the periphery of the development site with natural landscaping that maintains the vegetative and aesthetic character of surrounding roadways.
- Create linkages to and between existing or planned green infrastructure corridors (riparian areas, utility easements, etc.) within and adjacent to the site through the use of conservation easements or other tools. This reduces direct water pollution and can also serve as a tool for natural stormwater management (http://www.epa.gov/greeninfrastructure/).
- Cluster development on designated portions of the site to permanently protect the balance of the total acreage, avoid disturbances to environmentally-sensitive areas, incorporate natural features as amenities, and promote shared water/sewer infrastructure, where possible. This is also known as conservation development (http://urbanext.illinois.edu/lcr/cluster.cfm).
- Establish aquatic buffers, beyond the minimum required by state law, that serve as natural boundaries between waterways and new development to provide greater filtering and better protect wetlands and water quality.
- Utilize Low-Impact Development (LID) practices to employ a range of economical devices to control runoff at the source instead of relying solely on complex and costly collection, conveyance, storage and treatment systems to protect water quality.
    - Limit the proportion of the site that can be covered in impervious roofs and pavement to protect water quality through the use of green roofs and porous pavement materials, where possible, to allow underlying soil to absorb rainfall and treat pollutants, shared parking, shared driveways, or landscaped detention islands within cul-de-sacs.
    - Address stormwater management through site design modification and BMPs to reduce runoff volume and decentralize flows to allow natural infiltration to occur as close as possible to pre-development conditions through the use of bioretention areas or rain gardens, vegetated swales, filter strips, cistern collection systems, preservation of existing wooded areas, mature trees, and natural terrain, and clustering homes on smaller lots. This will create a more hydrologically functional landscape and offer developers a more cost-effective alternative to address storm water management in lieu of costly conveyance systems.
- Limit clearing, grading, and disturbance to those areas that construction actually requires to preserve existing trees and soils that attenuate, treat, and infiltrate rainfall and runoff.
- Survey and analyze the environmental features of the site (topography, soils, wildlife habitat, hydrology, trees and vegetation, and historical and cultural sites) to minimize the potential for negative impacts; to avoid sensitive areas, land physically unsuitable for development, and prime agricultural land; and, to identify areas that may be suitable for parks, trails, or greenbelts.
- Utilize drought-tolerant species in landscape design to promote water conservation. A species list is found in Appendix C.
- Utilize WaterSense® products in new construction and renovation projects to promote water efficiency. Products include showerheads, toilets, bathroom sink faucets and accessories, and urinals.

GENERAL POLICIES AND PROTECTION MEASURES

General Policies and Protection Measures

General policies and protection measurers are intended as guidance for local governments in planning and decision-making that affects Regionally Important Resources. In addition, the Northeast Georgia Regional Commission will use these policies and protection measurers when reviewing local comprehensive plans for consistency with *Plan 2035*, the Northeast Georgia regional plan, and to encourage local government to adopt the policies and implementation measures most appropriate for the protection of the resources in their community. Each policy is followed by identified applicable implementation measures that can be utilized by local government, developers, and property owners for resource protection. A description of each implementation measure follows the list of Policy and Protection Measures.

- Incorporate Regionally Important Resource protection into local planning efforts,
- Reach out to and encourage involvement by local and regional stakeholders in planning and development processes.
- Offer educational opportunities related to Regionally Important Resources through increased public involvement.
- Work with adjacent communities to ensure uniformity in regulations affecting resources that cross or are situated near jurisdictional boundaries.
    - Applicable Implementation Measures:
        - Buffers
        - Connectivity Corridors
        - Focused Growth Areas
        - Increased Public Involvement
        - Habitat Conservation Plans
        - Transportation and Recreation
- Protect water quality by ensuring that development allows for the greatest amount possible of direct infiltration of rainwater (rather than relying on detention/retention ponds).
    - Applicable Implementation Measures:
        - Buffers
        - Cluster Development
        - Connectivity Corridors
        - Conservation Easements
        - Low-Impact Development (LID)
        - Restrictive Covenants
- Reduce contamination of the natural environment by pollutants.
    - Applicable Implementation Measures:
        - Chemical Application Reduction
        - Low-Impact Development (LID)
- Avoid disturbances of pre-development conditions whenever possible to prevent unnecessary harm to the environment.

  - Applicable Implementation Measures:
    - Buffers
    - Cluster Development
    - Connectivity Corridors
    - Conservation Easements
    - Environmental Management
    - Focused Growth Areas
    - Low-Impact Development (LID)
    - Restrictive Covenants
    - Species and Habitat
- Designate and preserve natural corridors for habitat and water quality protection.
  - Applicable Implementation Measures:
    - Buffers
    - Cluster Development
    - Connectivity Corridors
    - Conservation Easements
    - Overlay Zoning
    - Restrictive Covenants
    - Species and Habitat
    - Transferable Development Rights (TDRs)
- Create buffers between developments and sensitive water, conservation, and heritage resources.
  - Applicable Implementation Measures:
    - Buffers
    - Cluster Development
    - Connectivity Corridors
    - Conservation Easements
    - Restrictive Covenants
- Situate development in appropriate areas of the community or site, conserving open space and protecting sensitive environments, including wildlife habitat.
  - Applicable Implementation Measures:
    - Buffers
    - Cluster Development
    - Connectivity Corridors
    - Conservation Easements
    - Focused Growth Areas
    - Overlay Zoning

- Restrictive Covenants
- Species and Habitat
- Transferable Development Rights (TDRs)

- Design new projects that complement existing communities and resources such as historic structures and sensitive ecosystems
  - Applicable Implementation Measures:
    - Buffers
    - Cluster Development
    - Connectivity Corridors
    - Conservation Easements
    - Design Guidelines
    - Form-Based Zoning
    - Historic Preservation
    - Performance Zoning
    - Restrictive Covenants
- Concentrate community development efforts on existing, underused sites and structures (infill development, adaptive reuse of existing structures)
  - Applicable Implementation Measures:
    - Focused Growth Areas
    - Historic Preservation
    - Overlay Zoning
    - Transferable Development Rights (TDRs)
- Encourage concentrations of complementary activities and land uses.
  - Applicable Implementation Measures:
    - Cluster Development
    - Focused Growth Areas
    - Mixed-Use Development
    - Transferable Development Rights (TDRs)
- Link to adjacent developments and neighborhoods via a trail and/or greenspace system.
  - Applicable Implementation Measures:
    - Connectivity Corridors
    - Focused Growth Areas
    - Form-Based Zoning
    - Mixed-Use Development
    - Transferable Development Rights (TDRs)
    - Transportation and Recreation
- Connect to and create recreational opportunities within and between residential areas and activity centers.

- Applicable Implementation Measures:
  - Cluster Development
  - Connectivity Corridors
  - Focused Growth Areas
  - Mixed-Use Development
  - Transportation and Recreation
- Plan for new projects with regard for the significant linkages between Regionally Important Resources protection and local economies.
  - Applicable Implementation Measures:
    - Historic Preservation
    - Low-Impact Development (LID)
    - Mixed-Use Development
    - Overlay Zoning
    - Species and Habitat
    - Transferable Development Rights (TDRs)
    - Transportation and Recreation
- Promote and incentivize best development practices.
  - Applicable Implementation Measures:
    - Cluster Development
    - Conservation Easements
    - Historic Preservation
    - Low-Impact Development (LID)
    - Mixed-Use Development
    - Transferable Development Rights (TDRs)

Description of Implementation Measures

Below is a description of the implementation measures presented in the General Policies and Protection Measures. Each implementation measure is followed by a key to indicate the entity that could undertake the protection implementation.

LG - local government; **D** - developer; **LO** - landowner

Buffers

Buffers offer protection through the physical separation of development and the resource to be safeguarded. Water body buffers may surround rivers, lakes, ponds, and reservoirs. Buffers filter rainwater runoff from adjacent land uses, ensuring better water quality. Many communities set a minimum development buffer width for water bodies, especially those used as drinking water sources. This minimum width should depend on the type and permeability of the soil, the steepness of slopes, existing plant life, and the kinds of pollutants likely to be found in runoff from adjacent land uses. Because water bodies often cross jurisdictional boundaries, intergovernmental cooperation is necessary to improve water quality; of special importance is the coordination of strategies with upstream communities within which headwaters are situated.

A natural or planted buffer may be constructed or maintained along the property line to separate incompatible development from Conservation or Heritage resources. (LG, D, LO)

Chemical Application Reduction

Before, during, and after development, utilize best management practices for fertilization and controlling pests and invasive vegetation. Where feasible, use environmentally benign products. (D, LO)

Connectivity Corridors

A connected system of green infrastructure presents a host of benefits. Preserving sensitive habitat in a linear nature, whether aligned with a stream or an upland passageway, will provide a transportation corridor for wildlife thus increasing the range for area wildlife. When located along riparian areas, these corridors can have important water quality benefits beyond those derived simply from development buffers (communities often choose to extend riparian conservation beyond the bounds of enforced buffers).

Apart from natural corridors such as rivers and ridgelines, some communities use existing easements or other utility corridors to plan and implement greenway systems and habitat corridors. Examples include transmission lines, pipelines, and, on a smaller scale, sewer easements. Greenways often provide significant benefits to community residents in areas such as transportation, recreation, education, and economic development, in addition to their inherent natural advantages. (LG, D)

Conservation Subdivision

Conservation subdivisions are a popular device for encouraging flexibility and strategically concentrating home construction on the development site in order to protect sensitive and valuable open space, habitat, and other environmental resources. Familiar examples of this principle as used by local governments include planned unit developments (PUDs) or planned developments (PDs). Benefits of these subdivisions include: protected water quality, wildlife habitat, reduced infrastructure construction costs, reduced demand for publically funded greenspace, and a means for expanding public trails and greenways. (LG, D)

Conservation Easements

To preserve natural attributes of their property, landowners may sometimes opt into conservation easements, agreements to forfeit development rights while retaining land ownership. This can be beneficial in situations where reducing the property's tax burden on the owner is necessary, or when an area has been identified as critical to conservation efforts. (D, LO)

Design Guidelines

Building design guidelines may be used to ensure new developments complement the nearby Resources, rather than compete with or detract from them. (LG)

Focused Growth Areas

One method for preventing low-density sprawl is to identify and implement focused growth areas within the community. Within these areas higher-density development would be encouraged through zoning tools; outside of these areas, restrictions would be placed on lot size and uses to preserve agricultural, forested, or designated open space lands. Tools to consider are infill development districts and adaptive-reuse ordinances. (LG)

Form-Based Zoning

Instead of regulating by land use, transect or form-based zoning codes regulate development by building type, location, transect, or a combination of these. These codes focus on the relationship between buildings and the street. Graphics are often used to depict building scale, proportion, location within the site, and location of parking. A similar approach, Performance Zoning, allows for flexibility in use as long as a project meets established criteria pertaining to intensity of development and impacts on the environment and adjacent areas. (LG)

Historic Preservation

Once historic resources have been identified and inventoried, communities have a variety of options available for protecting them in the future. A popular protection mechanism is the designation of an historic property or district. Designation may happen at the federal, state, or local level; local designations offer the most flexibility on the part of the local government, and often have a more direct impact on development. Another tool for protecting existing resources is a demolition delay ordinance, which prohibits the total or partial destruction of structures that meet certain criteria outlined by the community (age, architectural type, etc.) An historic preservation easement is a voluntary legal agreement, initiated by the landowner, to protect the historic or cultural resource through subsequent ownership.

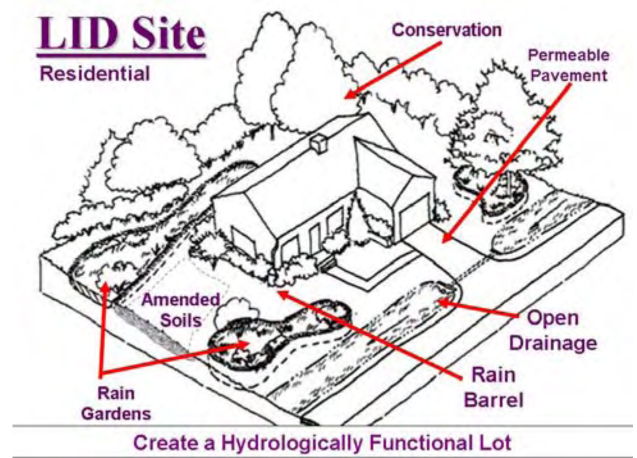
To enhance existing historic resources, developers and landowners may take advantage of existing state and federal historic rehabilitation and restoration tax incentives. Some individual jurisdictions also develop local property tax credit programs to encourage this type of activity in designated historic districts. (LG, D, LO)

Increased Public Involvement

Increased public involvement during the development process will allow for concerns about impacts on nearby resources to be brought to the attention of local governments and developers before potentially detrimental actions are taken. (LG, D, LO)

Low-Impact Development (LID)

LID is the practice of mimicking pre-development site conditions to the greatest degree possible so as to prevent negative impacts to the surrounding environment. While LID is primarily associated with conscientious stormwater management, there are many additional benefits to be realized through the use of these and other related techniques. Prior to property acquisition, a recommended first step would be to conduct a land suitability analysis, utilizing a Geographic Information System (GIS) to determine whether the site would support its intended use.



LID goals may be realized in part by passing a tree protection ordinance for mature trees, utilizing native species and natural landscapes, and encouraging the planting of green roofs, or vegetated roof covers.

Impervious surface usually refers to pavement such as roads and parking lots; soil compacted during construction is also somewhat impervious. These areas prevent rainwater from infiltrating the ground; instead, they produce runoff that may carry materials from fertilizers, gasoline and motor oil, metals, sediment, and waste to water resources. LID methods of reducing runoff, especially near Regionally Important Resources, may involve encouraging the use of porous or permeable paving materials and reducing impervious surfaces by establishing parking maximums, enabling shared parking for adjacent property owners, limiting street width and curbing, limiting pavement in turnarounds, and reclaiming pavement where possible. Additionally, stormwater regulations favoring vegetated swales over more conventional drainage systems can lessen runoff. These may be used as components of a local green streets or green infrastructure program.

Other water quality problems may be prevented through the development of a local erosion and sedimentation ordinance (per the Erosion and Sedimentation Act of 1975), grading restrictions, and limiting and phasing clearing as part of project development. These tools are especially important in areas where growth, and therefore construction activity, is expected. (LG, D, LO)

Mitigation Banks

Mitigation banks help restore, establish, enhance, or preserve wetlands, streams, or other resources by offering compensation opportunities when development carries unavoidable impacts to these features. Establishing a system that positions mitigation bank sites at certain designated RIRs could provide permanent protection status while encouraging appropriate development elsewhere.

Mixed-Use Development

Mixed-use zoning in areas accessible by foot or bicycle is a tool used, in part, to reduce dependency on automobiles for transportation. Mixed-use development may refer to a mix of uses within one building, or a mixture of uses on a site. Residents and visitors are able to move between residential, commercial, and even light industrial areas with greater ease. This, in turn, reduces the need for increasing impervious surface within the community through the construction of new roads and parking areas. (LG, D)

Overlay Zoning

Overlay zoning is a technique in which additional restrictions are laid over existing zoning; the area covered by the additional restrictions is referred to as an overlay district, and its purpose is to supplement the underlying zoning regulations. Examples of overlay districts include those intended to protect historic areas, floodplains, watersheds, conservation areas, and downtowns. (LG)

Performance Zoning

Performance zoning regulates land uses based on their actual physical characteristics and functions as compared to specific standards identified by the community. (LG)

Restrictive Covenants

In areas where there is no qualified organization available to hold a property easement, a group of landowners with common goals may impose restrictive covenants to limit the future use of their land. An agreement of this sort would be binding on future titleholders. (LO)

Habitat Conservation Plan

The U.S. Fish and Wildlife Service is available to work with individuals and local government to develop Habitat Conservation Plans, the primary tool for balancing development and nature preservation to manage endangered species on property. Potential benefits of Habitat Conservation Plans are: they shift the conservation focus from single-species management to multi-species and habitat management; engage private landowners and local governments in conservation planning; protect unlisted species, thereby reducing the likelihood that listing will be needed; and, promote long-term conservation of species and habitats through protection and management. (LG, D, LO)

Transferable Development Rights (TDRs)

TDR is a technique that restricts development on one property while compensating for said restrictions by allowing a greater intensity of development on another tract. Communities utilizing TDRs identify "sending zones," or areas in which restrictions on development are desirable, and "receiving zones," or areas in which development is encouraged. (LG, D)

Transportation and Recreation

Street connectivity regulations focus on creating a transportation system in which multiple routes serve the same origins and destinations for maximum efficiency. In a related way, non-motorized connectivity ensures that bike lanes, sidewalks, and multi-use paths allow people to get from place to place safely without driving. Appropriate recreation enhancements, such as the conversion of an unused rail corridor to a multi-use trail, also enable residents and visitors to experience and appreciate those Resources accessible to the public. (LG, D)

APPENDICES

Appendix A

Regionally Important Resource Nominations Not Designated

Resource	Reason Not Designated
Auburn Ball Park	Local importance only, small site, does not provide significant water quality protection
Brick Store	Local importance only
Covington Historic Districts: and Campground Covington Mills & Mill Village, Covington Historic District, Floyd Street, North Covington	Local importance only, protected through local designation, not vulnerable
James Shackleford Memorial Park	Local importance only, small site, does not provide significant water quality protection
Mansfield	Local importance only
McGuirt's Bridge Road	Local importance only
Newborn Historic District	Local importance only, protected through local designation, not vulnerable
Oconee County Farmland	Local importance only, area not well defined
Old Social Circle Road	Local importance only
Porterdale Historic District	Local importance only, protected through local designation, not vulnerable

Appendix B

State Vital Areas

State Vital Areas include coastal marshes, salt marshes, tidal wetlands, water supply watershed for municipal drinking water, jurisdictional wetlands (wetlands connected to waters of the United States), groundwater recharge areas (high pollution susceptibility areas only), 100' buffer zone adjacent to protected rivers, state parks, wildlife management areas, conservation easements, and national forests.

State Vital Areas within Northeast Georgia include:

- Protected Rivers
  - Broad River from Hudson River to confluence with the Savannah River
  - Middle Oconee River from Apalachee River to Lake Oconee
  - North Oconee River from its confluence with East Fork Trail Creek to its confluence with the Middle Oconee River.
  - Ocmulgee River
  - South River
  - Yellow River
- State Parks/State Recreation Areas
  - Ft. Yargo
  - Hard Labor Creek
  - Bobby Brown State Recreation Area
  - Watson Mill Bridge
  - Richard B. Russell
- National Forest
  - Oconee National Forest
- Wildlife Management Areas and Heritage Sites
  - Broad River Natural Area
  - Elbert Co WMA
  - Broad River WMA
  - Rock & Shoals State Heritage Site
  - Redlands WMA
  - Oconee WMA
  - Clybel WMA (includes the Charlie Elliot Wildlife Center)
  - Walton Public Dover Field (includes Walton State Fish Hatchery)
- National Wildlife Refuge (NWR)
  - Piedmont NWR

Appendix C

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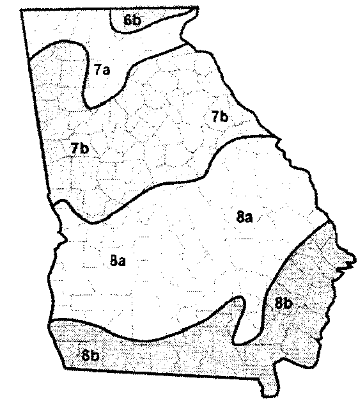
Cold Hardiness Zones in Georgia	
Zone	Ave. Min. Temp.
6b	-5 to 0 °F
7a	0 to 5 °F
7b	5 to 10 °F
8a	10 to 15 °F
8b	15 to 20 °F



Drought-tolerant Plants

The following plants are known to have good drought-tolerance, good pest resistance and adaptability to a wide range of soils and environmental conditions in Georgia. When selecting trees and shrubs, consider their mature size and provide sufficient growing space.

*** Indicates plant is native to the U.S.**

Common Name	Botanical Name	Georgia Hardiness Zones	Mature Size Ht./Width (Ft.)	Evergreen or Deciduous	Comments
Trees					
American Holly*	*Ilex opaca*	6b to 8b	50/40	E	Male and female trees. Only the female bears fruit.
Bald Cypress*	*Taxodium distichum*	6b to 8b	70/30	D	Adapts to wet or dry sites
Bouganvilla Goldenraintree	*Koelreuteria bipnnata*	6b to 8b	40/30	D	Showy pink capsules in summer
Chestnut Oak	*Quercus prinus*	6b to 8b	70/60	D	Very adaptable
Chinese Pistache	*Pistacia chinensis*	6b to 8b	35/35	D	Brilliant orange fall color
Crape Myrtle	*Lagerstroemia indica*	6b to 8b	Variable	D	Many flower colors and plant sizes
Deodar Cedar	*Cedrus deodara*	7a to 8b	70/60	E	Gets large so needs lots of space
European Hornbeam	*Carpinus betulus*	6b to 8b	60/40	D	Use as single specimen or in groups for screening

Common Name	Botanical Name	Georgia Hardiness Zones	Mature Size Ht./Width (Ft.)	Evergreen or Deciduous	Comments
Trees (continued)					
Foster Holly	*Ilex* x *attenuate*	6b to 8b	40/20	E	Red fruit persist all winter. Pyramidal growth habit.
Ginkgo	*Ginkgo biloba*	6b to 8b	80/80	D	Male and female trees. Female has smelly fruit so plant a male
Hedge Maple	*Acer campestre*	6b to 8b	45/45	D	Specimen tree or hedge for screeing
Japanese Zelkova	*Zelkova serrata*	6b to 8b	80/50	D	Elm-like foliage. Nice shade tree
Lacebark Elm	*Ulmus parvifolia*	6b to 8b	50/50	D	Tough tree. Several cultivars
Laurel Oak*	*Quercus hemisphaerica*	6b to 8b	60/40	D	Nice shade tree
Needle Palm*	*Rhapidopyllum hystrix*	6b to 8b	12/12	E	Tough plant. Sharp needles near main trunk
Nellie R. Stevens Holly	*Ilex* 'Nellie R. Stevens'	6b to 8b	25/15	E	Great for specimen or screening
Overcup Oak*	*Quercus lyrata*	6b to 8b	50/50	D	GA Gold Medal Winner
Pin Oak*	*Quercus palustris*	6b to 8b	70/40	D	Pyramidal growth habit
Sawtooth Oak	*Quercus acutissima*	6b to 8b	60/70	D	Tough large shade tree
Shumard Oak*	*Quercus shumardii*	6b to 8b	80/60	D	Large pyramidal shade tree
Southern Magnolia*	*Magnolia grandiflora*	6b to 8b	80/80	E	Little Gem cultivar (30ft. x 15ft.) is recommended for small spaces
Trident Maple	*Acer buergerianum*	6b to 8b	30/30	D	GA Gold Medal Winner
Willow Oak*	*Quercus phellos*	6b to 8b	60/40	D	Nice pyramidal form
Windmill Palm	*Trachycarpus fortunei*	6b to 8b	40/10	E	Cold-hardy trunk-forming palm
Yaupon Holly*	*Ilex vomitoria*	7a to 8b	30/20	E	Female produces translucent red fruit
Shrubs					
Adam's Needle*	*Yucca filamentosa*	6b to 8b	6	E	Bold texture, sharp spines, yellow-white spring flowers
American Beautyberry*	*Callicarpa americana*	6b to 8b	8/6	D	Clusters of magenta fruit in summer
Beautybush	*Kolkwitzia amabilis*	6b to 8b	10/15	D	Pink bell-shaped flowers in spring
Bumald Spirea	*Spiraea* x *bumalda*	6b to 8b	5/5	D	Several cultivars, flower colors and plant sizes
Burkwood Viburnum	*Viburnum* x *burkwoodii*	6b to 8b	10/8	E	Cultivar Mohawk is a GA Gold Medal Winner
Butterfly-bush	*Buddleia davidii*	6b to 8b	15/10	D	Many flower colors. Butterfly magnet
Chastetree	*Vitex agnus-castus*	6b to 8b	20/20	D	Purple, lavender or white cultivars

Common Name	Botanical Name	Georgia Hardiness Zones	Mature Size Ht./Width (Ft.)	Evergreen or Deciduous	Comments
Shrubs (continued)					
Chinese Photinia	*Photinia serrulata*	6b to 8b	25/30	E	Large shrub, hedge, or screen plant
Cutleaf Lilac	*Syringa laciniata*	7a to 8b	8/4	D	Pale lilac, fragrant flowers in spring
Dwarf Yaupon Holly	*Ilex vomitoria* 'Nana'	6b to 8b	5/5	E	A common foundation shrub
Firethorn (Pyracantha)	*Pyracantha coccinea*	6b to 8b	20/20	E	Red summer berries
Flowering Quince	*Chaenomeles speciosa*	6b to 8b	10/10	D	Many flower colors
Fortune's Tea-olive	*Osmanthus* x *fortunei*	6b to 8b	30/30	E	More cold-hardy than fragrant tea-olive
Forysythia (Yellow Bells)	*Forsythia x intermedia*	6b to 8b	10/10	D	Yellow spring flowers
Fragrant Tea-olive	*Osmanthus fragrans*	7b to 8b	30/30	E	Fragrant fall flowers
Glossy Abelia	*Abelia grandiflora*	6b to 8b	6/6	E	Many improved cultivars. Rose Creek is a GA Gold Medal Winner
Japanese Aucuba	*Aucuba japonica*	7a to 8b	10/15	E	Bold tropical-like foliage
Japanese Cleyera	*Ternstroemia gymnanthera*	6b to 8b	10/6	E	Accent plant, hedge or screen
Japanese Spirea	*Spiraea japonica*	6b to 8b	Variable	D	Several cultivars, flower colors and plant sizes
Juniper	*Juniper* spp.	6b to 8b	Variable	E	Many forms and sizes
Leatherleaf Viburnum	*Viburnum rhytidophylum*	6b to 7b	10/10	E	Large shrub or screen plant
Prague Viburnum	*Viburnum* x *pragense*	6b to 8b	10/10	E	White spring flowers. Good screen plant
Rose-of-Sharon	*Hibiscus syriacus*	6b to 8b	12/10	D	Many cultivars and flower colors
Southern Waxmyrtle	*Myrica cerifera*	7a to 8b	15/15	E	Tough plant. Dwarf cultivars available
Thunberg Spirea	*Spiraea thunbergii*	6b to 8b	5/5	D	White spring flowers, fine texture
Vanhoutte Spirea	*Spiraea* x *vanhouttei*	6b to 8b	10/12	D	Arching branches. White spring flowers
Winter Jasmine	*Jasminum nudiflorum*	6b to 8b	4/7	E	Yellow flowers in late winter. Often used on banks or to cascade over walls
Vines/Groundcovers					
Carolina Yellow Jessamine*	*Gelsemium sempervirens*	6b to 8b	20	E	Yellow spring flowers
Confederate Jasmine	*Trachelospermum jasminoides*	7a to 8b	20	E	White spring flowers. Madison is a cold-hardy cultivar.
Creeping Juniper	*Juniperus horizonatalis*	6b to 8b	0.5 to 1/6	E	Blue Rug and Bar Harbour are popular cultivars
Creeping Phlox	*Phlox subulata*	6b to 8b	0.5/2	E	Often used on banks
Lady Banks Rose	*Rosa banksia* 'Alba Plena'	6b to 8b	30	D	Yellow double flowers in spring

Common Name	Botanical Name	Georgia Hardiness Zones	Mature Size Ht./Width (Ft.)	Evergreen or Deciduous	Comments
Vines/Groundcovers (continued)					
Mondograss	*Ophiopogon japonicus*	6b to 8b	0.5/0.5	E	Good turfgrass substitute in shade
Shore Juniper	*Juniperus conferta*	6b to 8b	1/6	E	Blue Pacific and Emerald Sea are popular cultivars
Trumpet Honeysuckle*	*Lonicera sempervirens*	6b to 8b	20	E	Many cultivars and flower colors
Trumpetcreeper*	*Campsis radicans*	6b to 8b	40	D	Orange-scarlet spring flowers
Virginia Creeper*	*Parthenocissus quinquefolia*	6b to 8b	50	D	Tough vine for walls, or arbors
Herbaceous Perennials					
Black-eyed Susan*	*Rudbeckia* spp.	6b to 8b	Variable		Many species and cultivars
Blue Anise Sage	*Salvia guaranitica*	7a to 8b	4/4		Deep blue flowers from spring to frost
Butterfly Weed*	*Asclepias tuberosa*	6b to 8b	3/2		Orange spring flowers
Coronation Gold Yarrow	*Achillea x* 'Coronation Gold'	6b to 8b	2/2		A very popular hybrid
Daylily	*Hemerocallis* spp.	6b to 8b	Variable		Hundreds of cultivars, flower forms and flower colors
False Blue Indigo*	*Baptisia australis*	6b to 8b	3/4		Violet-blue lipine-like flowers
Gaura*	*Guara lindheimeri*	6b to 8b	4/3		White and pink-flowering cultivars
Globe Thistle	*Echinops ritro*	6b to 8b	4/3		Blue summer flowers
Golden Rod Hybrids	*Solidago hybrida*	6b to 8b	Variable		Many nice cultivars
Lamb's-Ears	*Stachys byzantina*	6b to 8b	1/1		Woolly foliage. Purple summer flowers
Mexican Sage	*Salvia leucantha*	7b to 8a	4/4		Blue and white flowers all summer
Purple Coneflower*	*Echinacea purpurea*	6b to 8b	3/2		Several cultivars. Purple, rose or white flowers
Red Hot Poker	*Kniphofia uvaria*	6b to 8b	3/3		Red torch-like flowers in late spring
Rosemary	*Rosmarinus officinalis*	6b to 8b	Variable		Light blue flowers. Many cultivars
Russian Sage	*Perovskia atriplicifolia*	6b to 8b	4/4		Light blue late-summer flowers
Sedum (Stonecrop)	*Sedum* spp.	6b to 8b	Variable		Popular roof garden plant. Tough
Speedwell	*Veronica* spp.	6b to 8b	Variable		Many species and cultivars. Pink, purple, blue, or white flowers
Statice	*Limonium latifolium*	6b to 8b	2/2		Prefers partial shade
Texas Sage*	*Salvia greggii*	7a to 8b	3/3		Scarlet flowers all summer
Wormwood	*Artemisia* spp.	6b to 8b	Variable		Silver King and Powis Castle are popular cultivars

Common Name	Botanical Name	Georgia Hardiness Zones	Mature Size Ht./Width (Ft.)	Evergreen or Deciduous	Comments
Annuals					
Annual Periwinkle	*Catharanthus roseus*		1/1		Pink, red, or white flowers
Blanket Flower*	*Gaillardia pulchella*		1 to 2/2		Flowers spring to frost
Dusty Miller	*Senacio cineraria*		1/1		Gray fuzzy foliage. Small daisy-like yellow flowers
Globe Amaranth	*Gomphrena globosa*		1 to 3/1		Likes heat. Several cultivars
Mealycup Sage	*Salvia farinaceae*		½		Purple or lavender flowers
Moss Rose (Purslane)	*Portulaca grandiflora*		0.5/1		Many colors. Single or double flowers
Musk Mallow	*Abelmoschus moschatus*		2 to 3/2		Yellow flowers, 3 inches across. Pacific Light Pink is a popular cultivar
Narrow-leaf Zinnia	*Zinnia angustifolia*		1/1		Tough plant. Flowers yellow, orange, or white
Purple Heart	*Setcreasea purpurea*		1/3		Magenta foliage. Small lavender flowers
Strawflower (Paper Daisy)	*Helichrysum bracteatum*		1 to 3/2		Many colors
Sulphur Cosmos	*Cosmos sulphurens*		1 to 3/2		Yellow, orange or white flowers
Treasure Flower (Gazania)	*Gazania rigens*		1.5/1.5		Daisy-like flowers. Many colors

Prepared by Gary L. Wade, Ph.D., Department of Horticulture, The University of Georgia, July, 2007.

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ThreeRivers
REGIONAL COMMISSION

REGIONALLY IMPORTANT RESOURCES PLAN

FEBRUARY 2012

Regionally Important Resources Plan

FEBRUARY 2012

Prepared by:

ThreeRivers
REGIONAL COMMISSION

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EXECUTIVE SUMMARY

Executive Summary

PURPOSE

The purpose of this plan is to serve as a guide that identifies regionally important resources within the ten-county Three Rivers Region. The plan also provides implementation strategies for the protection and management of these resources. Regionally Important Resources (RIR) are those determined to be of value to the region and thus the state, and vulnerable to the effects of uncontrolled or incompatible development. Hence, this plan seeks to lay a foundation for the enhancement of local, regional, and state coordination efforts to preserve our most precious natural, cultural and heritage resources. Further, this plan examines best management practices and the impacts of new development on regionally important resources.

The plan has been prepared in accordance with the rules and procedures established by the Georgia Department of Community Affairs (effective July 1, 2009) for the identification of RIRs, the development of a plan for protection and management of the RIRs, and for review of activities potentially impacting the RIRs.

The Regionally Important Resources Plan is utilized in subsequent development of the Regional Plan and is actively promulgated by the Regional Commission in an effort to coordinate activities and planning of local governments, land trusts and conservation or environmental protection groups, and state agencies towards protection and management of the identified Regionally Important Resources.

OVERVIEW

A RIR is defined as a natural or historic resource that is of sufficient size or importance to warrant special consideration by the local governments having jurisdiction over that resource. The Georgia Planning Act of 1989 authorizes the Department of Community Affairs (DCA) to establish procedures for identifying Regionally Important Resources statewide.

The Three Rivers Regional Commission is a regional planning agency serving 10 counties which include Butts, Carroll, Coweta, Heard, Lamar, Meriwether, Pike, Spalding, Troup, and Upson and 45 municipalities in West Central Georgia. The Three Rivers Regional Commission Regionally Important Resources Plan consists of three primary categories: Water, Conservation and Cultural/Heritage Resources. Water resources are the total range of natural waters present on earth and that are of potential use to human beings. These resources include the waters of the oceans, rivers, lakes, and groundwater recharge areas.

Executive Summary

Conservation resources include the management of the human use of natural resources to provide the maximum benefit to current generations, while maintaining the capacity to meet the needs of future generations. Cultural and/or Heritage resources encompass archaeological, traditional, and built environment resources, including but not necessarily limited to buildings, structures, objects, districts, and sites.

Each resource category provides specific data about individual resources and includes a description of the resource's value to the region along with an explanation of its vulnerability to new development. Each resource category also provides a listing of best practices to be considered by developers for designing new developments to locate in or around any regionally important resources. This plan describes general policies and protection measures recommended for appropriate management of regionally important resources.

Finally, this plan includes a Regionally Important Resource Map for the ten-county Three Rivers Region that identifies all important natural, cultural, and heritage resources. A green infrastructure map displays a linkage of natural resources that attempts to form a contiguous regional green infrastructure network.

METHODOLOGY

The Three Rivers Regional Commission solicited regionally important resource nominations from local governments, conservation and environmental organizations, and individuals active throughout the Region. Nominations were evaluated by Regional Commission staff and the members of the Regionally Important Resources Planning Advisory Council. The evaluation of resources examined the value and vulnerability for possible inclusion in the plan. Evaluation factors focused on the regional importance of the resource (versus the local importance), and the degree to which the resource is threatened or endangered.

State vital areas identified by the Georgia Department of Natural Resources are included on the Regionally Important Resources Map. In addition, existing natural resources that are protected through state and federal regulations have been identified as regionally important resources.

Representatives from local governments and the Planning Advisory Council established a list of recommendations that identifies best practices to be used by developers when designing new developments within close proximity to these RIRs, as well as devising general policies and protection measures recommended for appropriate local management of the areas included on the RIR Map.

Executive Summary

PLANNING ADVISORY COUNCIL

The purpose of the ***Planning Advisory Council*** was to coordinate regional planning efforts and provide guidance to the Three Rivers Regional Commission in the task of updating its Regionally Important Resources Plan. The Planning Advisory Council played an advisory role in providing information and recommendations related to Regionally Important Resources. This Council provided a wealth of knowledge and feedback about local resources in the community that serve a regional significance. The members of the Planning Advisory Council are listed below:

Regionally Important Resources
Planning Advisory Council

BUTTS COUNTY
Christy Lawson
Michael Brewer

CARROLL COUNTY
Amy Goolsby

COWETA COUNTY
Sandra Parker

HEARD COUNTY
Jimmy Knight
Sandi Allen

HEARD COUNTY
Timothy Turner
James E. Parker

MERIWETHER COUNTY
Sabra McCullar
Mr. Robin Glass

PIKE COUNTY
David Allen
Ken Gran

SPALDING COUNTY
Toussaint Kirk
Chris Edelstein

TROUP COUNTY
Nancy Seegar
Alton West

UPSON COUNTY
Steve Hudson
Frank King

Executive Summary

TIMELINE

The implementation of planning activities for the Regionally Important Resources Plan began in February 2011 with the identification of regional stakeholders to serve on the Planning Advisory Committee and the solicitation of nominations for regionally important resources.

Nomination forms for the resources were sent to each county and municipality within the region, as well as local and state environmental organizations in March 2011. The Three Rivers Regional Commission accepted nominations from April 1, 2011 to April 30, 2011.   Eight nominations were received. Three Rivers Regional Commission (TRRC) staff recommended water and conservation resources which preserve water quality, wildlife habitat, and working agricultural or forest resources. In addition, staff identified cultural and heritage resources that were recognized as a national historic landmark or listed on the Georgia or National Register of Historic Places. Staff also evaluated cultural and heritage resources that impact our vibrant history and preserve the historic character of our region.

The next step in the regional resource planning process was the creation of a map. A Regionally Important Resources Map was created to identify recommended water, conservation and cultural/heritage resources. The TRRC Council unanimously voted at its June 2011 meeting to designate the recommended resources as regionally significant on the regional resources map.

In June 2011, the Three Rivers Regional Commission Council appointed an eighteen-member Planning Advisory Council to assist in providing related data and recommendations for the plan. The first planning advisory council meeting was held on July 12, 2011. The Planning Advisory Council convened three (3) times during the months of July and August 2011 to evaluate nominated resources and discuss best management practices for the protection of water, conservation and cultural/heritage resources. The planning advisory council also evaluated various environmental and historic preservation policies and protection measures for recommended resources.

A public notice was posted in several local newspapers within the Three Rivers Region to inform area citizens about the Regional Resource Plan. In addition, staff sent out email blasts to regional stakeholders. A draft of the RIR Plan was also made available for review on the Three Rivers Regional Commission website at www.threeriversrc.com. A public meeting was held on October 25, 2011 to solicit input and feedback from the citizens of our region. The Regional Resource Plan was recommended to the TRRC Council for transmittal to the Georgia Department of Community Affairs for review and comment at its October 2011 meeting. The final plan was adopted by the TRRC Council on February 23, 2012.

Environmental Criteria

PART V ENVIRONMENTAL CRITERIA AND RESOURCES

The Rules for Environmental Planning Criteria were developed by the Georgia Department of Natural Resources (DNR) and are part of the local government planning standards. The rules direct local governments to establish local protection efforts to conserve critical environmental resources. They are divided into the following five sections:

- Water Supply Watersheds;
- Groundwater Recharge Areas;
- Wetlands;
- Protected Rivers; and
- Protected Mountains.

The intent of the Part V DNR Protection measures is to: 1) preserve the environmental sensitive areas within the delineated boundaries of each measure in perpetuity; 2) preserve aquifers, topographical or soil features; and 3) preserve water intake zones and wetlands in order to provide a natural filtering for water supply resources.

STATE VITAL AREAS

Specific resources have been identified by the Georgia DNR as State Vital Areas and are depicted on the RIR Map. The Three Rivers Region includes water supply watersheds, groundwater recharge areas, wetlands, protective rivers, 100' buffer zones adjacent to protected rivers, state parks, wildlife management areas, conservation easements, and national forests. These resources are defined in the Environmental Planning Criteria which establishes Georgia's Minimum Planning Standards.

State vital areas within the Three Rivers Region include:

* **Protected Rivers**
- Chattahoochee River
- Flint River
- Ocmulgee River

* **State Parks**
- Chattahoochee Bend State Park
- Indian Springs State Park
- John Tanner State Park
- Sprewell Buff State Park

* **Wildlife Management Areas (WMA)**
- Big Lazar WMA
- Joe Kurz WMA
- West Point WMA

* **Groundwater Recharge Areas**

* **Wetlands**

* **Water Supply Watersheds**

National Historic Landmarks

National Historic Landmarks

National Historic Landmarks *(NHL)* are nationally significant historic places designated by the Secretary of the Interior that possess exceptional value or quality in illustrating or interpreting the heritage of the United States. All NHLs are included in the National Register of Historic Places; however, not all entities listed in the Register are considered NHLs. NHL designation is an official recognition by the federal government of the national significance of historic properties, which:

- Recognizes that properties are important to the entire nation;
- Affords designated NHLs the same benefits of properties listed in the National Register;
- Allows owners of landmarks to manage their property as they choose, provided no Federal license, permit, or funding is involved;
- Affords the Advisory Council on Historic Preservation (ACHP) an opportunity to comment on Federal projects with the potential to affect a landmark, and the proposed project's effects on the property;
- Offers opportunities for owners to obtain Federal and State tax incentives for historic preservation (when applicable); and
- Provides a bronze plaque bearing the name of the landmark and attesting to its national significance to the owner, if requested.

National Register of Historic Places

NATIONAL REGISTER OF HISTORIC PLACES

The National Register of Historic Places is the official list of the Nation's historic places worthy of preservation. Authorized by the National Historic Preservation Act of 1966, the National Park Service's National Register of Historic Places is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect America's historic and archeological resources.

Listing in the National Register provides formal recognition of a property's historical, architectural, or archaeological significance based on national standards. Properties can be nominated to the National Register individually, as a historic district, or as Multiple Property Submission (MPS), which is a thematic nomination that simultaneously nominates groups of related significant properties.

Eligibility Requirements

To be eligible for listing in the National Register, historic resources (districts, sites, buildings, structures, and objects) generally must be at least 50 years old; must possess integrity of location, design, setting, materials, workmanship, feeling, and association; and must be considered significant in American history, architecture, archaeology, engineering, and culture. The National Register includes:

- All historic areas in the National Park System;
- National Historic Landmarks that have been designated by the Secretary of the Interior for their significance to all Americans; and
- Properties significant to the Nation, State, or community that have been nominated by State historic preservation offices, Federal agencies, and Tribal preservation offices, and have been approved by the National Park Service.

Regionally Important Resources

WATER RESOURCES

- ***Water Supply Watersheds***
- ***Groundwater Recharge Areas***
- ***Wetlands***
- ***Chattahoochee River***
- ***Flint River***
- ***Ocmulgee River***
- ***Lake Jackson***
- ***High Falls Lake***
- ***Lake Meriwether***
- ***West Point Lake***
- ***Still Branch Reservoir***

NATURAL OR CONSERVATON RESOURCES

- ***Big Lazar WMA***
- ***Joe Kurz WMA***
- ***West Point WMA***
- ***Chattahoochee Bend State Park***
- ***Bush Head Shoals***
- ***John Tanner State Park***
- ***Indian Springs State Park***
- ***Sprewell Bluff State Park***
- ***High Falls State Park***
- ***Chattahoochee Greenway***
- ***Camp Meeting Rock Reserve***
- ***Blackjack Mountain***
- ***McIntosh Reserve***
- ***Warm Springs Regional Fisheries Center***

Regionally Important Resources

HERITAGE RESOURCES

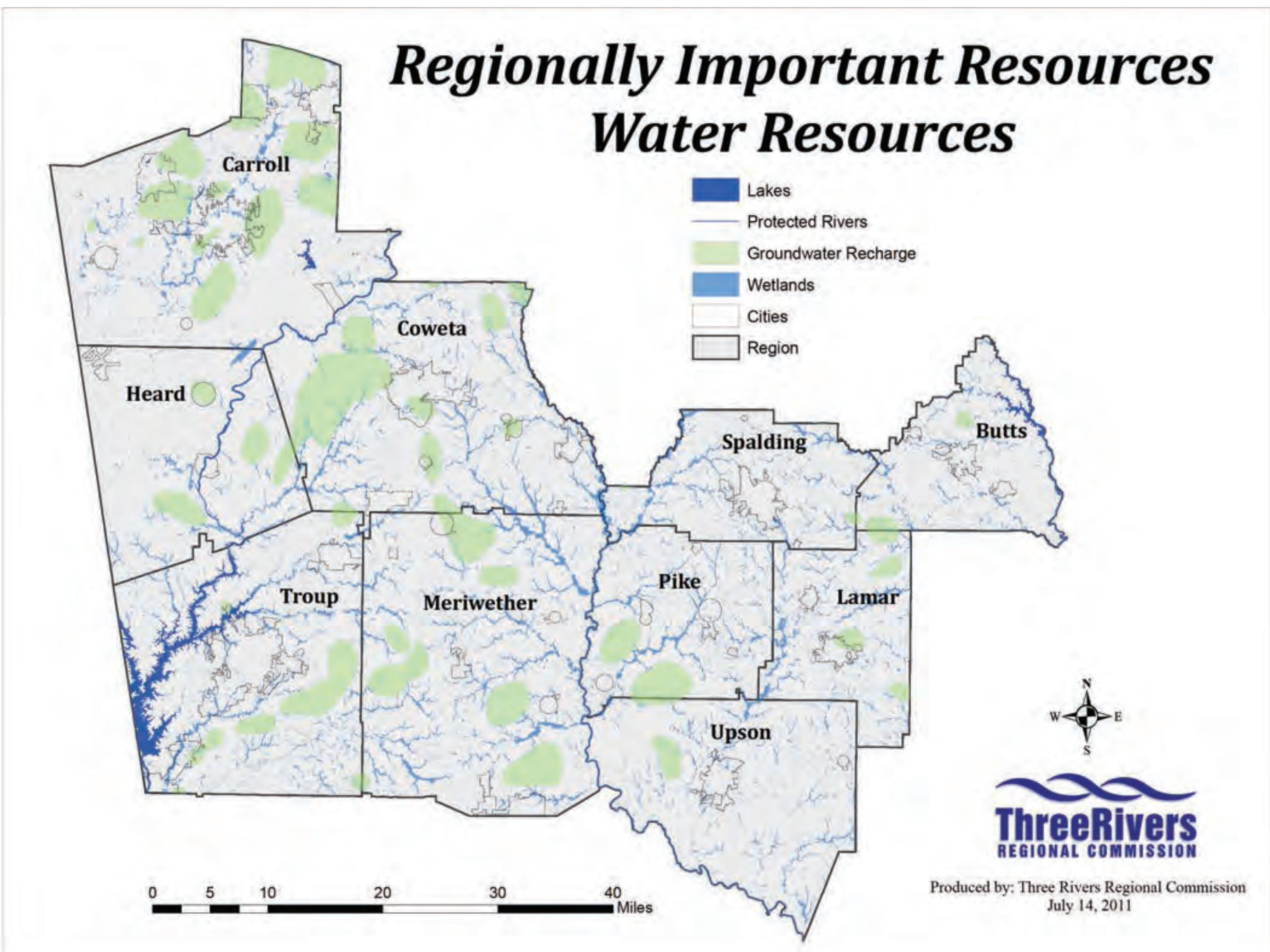
- ***Centennial Farms***
- ***Historic Courthouses***
- ***Bellevue Mansion***
- ***Warm Springs Historic District***
- ***R. M. Jones Crossroads Store***
- ***Potts Brothers Gabbettville Crossroads Store***
- ***Heard County Old Jail & Museum***
- ***Lamar County Old Jail & Museum***
- ***Auchumpkee Creek Covered Bridge***
- ***Red Oak Creek Covered Bridge***
- ***Austin Dabney Gravesite***
- ***LaGrange Stonewall Cemetery & Horace King Gravesite***
- ***Oakhill Cemetery***
- ***Griffin Stonewall Cemetery***
- ***The Royal Theatre***
- ***Ritz Theatre***
- ***The President Theatre***
- ***Chestnut Oak Center***
- ***Fort Tyler Battlefield & Cemetery***
- ***Hogansville Amphitheatre***
- ***Eleanor Roosevelt School***
- ***Hills and Dales Estate***
- ***Indian Springs Hotel***
- ***Moore's Bridge Park***
- ***R. F. Strickland Building***
- ***William Barker Whiskey Bonding Barn***

Water Resources

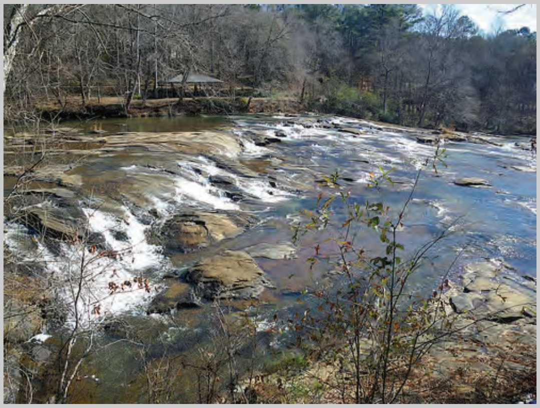
Water Resources Overview

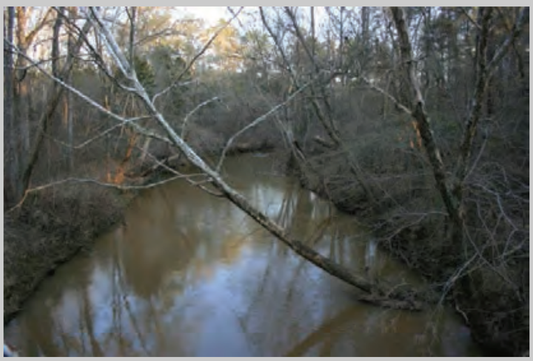
The Three Rivers Region's water resources include rivers, water supply watersheds, significant groundwater recharge areas, wetlands, and stream corridors. These specific resources have been identified by the Georgia Department of Natural Resources (DNR) as State Vital Areas and are portrayed on the RIR Map. These same resources are addressed in DNR's Environmental Planning Criteria. The Environmental Planning Criteria is the portion of the state's Minimum Planning Standards that deals specifically with the protection of these above named water resources.

Water sources in the region are important for the necessary day-to-day living activities of the inhabitants of the region. Water sources are important for drinking, cooking, bathing, sewage treatment, industry, electrical plants, recreation, and irrigation of crops. These sources are vulnerable to human intrusion and drought. Therefore, it is important to have guidelines in place to protect these significant resources. The map below displays the location of water resources throughout the region.



Water Resources

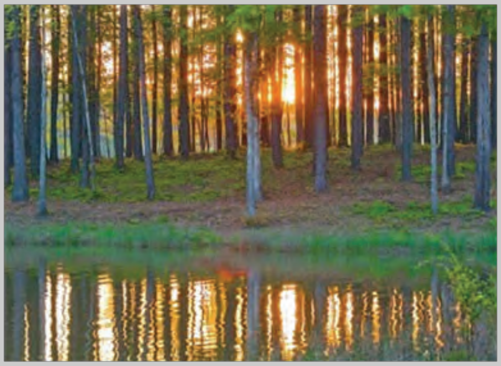




WATER SUPPLY WATERSHEDS

VALUE: A water supply watershed is the area where rainfall runoff drains into a river, stream or reservoir used downstream as a source of public drinking water supply. By limiting the amount of pollution that gets into the water supply, local governments can reduce the costs of purification and help safeguard public health. The protection criteria for water supply watersheds vary depending on size. Water supply watersheds are one of the most vital natural resources necessary to maintain an acceptable quality of life for the residents of the Three Rivers Region. The water supply watersheds provide drinking water, sewage treatment, electrical generation, industry and mining, recreation, and irrigation of crops. The Three Rivers Region includes three major watersheds: Chattahoochee, Flint and Ocmulgee. Some of the watersheds in the Three Rivers Region require additional protection or management activities. These include watersheds that serve as public drinking water sources, and those that do not meet their designated use due to water quality issues. Communities with water supply source watersheds within their jurisdictions will need to implement additional measures to help protect public drinking water supplies.

Water Resources



WATER SUPPLY WATERSHEDS

VULNERABILITIES:

- The land uses in a watershed can have a major impact on the amount and types of pollution that ends up in a lake, river, or creek. Water Supply Watersheds are most vulnerable to non-point source pollutants which may enter a lake or creek from runoff that occurs after a rainfall.

- Urbanized or residential areas located near a watershed may also contribute pollutants in the watershed. This increases the vulnerability of a watershed from rainfall that hits impervious surfaces and carries the pollutants to the lake and creeks via local storm drains. Pet wastes, car oil, and road salts are all transported into the watersheds because of the runoff from urban or residential areas.

- Another source of pollution to watersheds from urban and residential land use is construction. Construction activities may cause huge losses of soil from the construction site to a local waterway.

- Agricultural land uses may also contribute pollutants to a watershed. Agricultural practices can impact the vulnerability of water supply watersheds. These agricultural practices include exposing soil through the application of fertilizers and pesticides. In addition, farms that own livestock have a potential to transport animal waste into local streams.

Water Resources

GROUNDWATER RECHARGE AREAS

VALUE: Groundwater recharge is a hydrologic process by which aquifers are replenished by the downward movement of water. The amount of groundwater recharge that occurs in a particular area depends on the climate, topography, and surgical geology of that area. Significant groundwater recharge areas are locations where these conditions favor groundwater recharge. Groundwater recharge areas are those land areas where soil and geological conditions are favorable to the process whereby precipitation infiltrates the soil and the underlying strata to enter and continually replenish the aquifer. In the Three Rivers Region, almost all water-supply needs are met by groundwater, and recharge is critical to maintaining the abundance and quality of groundwater. Groundwater contributes to wells and flow to various streams, springs, and wetlands year-round, sustaining them during droughts and dry summer months.

VULNERABILITIES:

- Groundwater recharge areas are most vulnerable to contamination from harmful pollutants that are discharged into vital water sources.

- Significant changes in groundwater recharge areas increase vulnerability due to the impacts of climate change.

- Increased population often results in the over-use of groundwater recharge areas. These areas are vulnerable to decreasing capacity levels that force the construction of deeper wells to reach available groundwater.

Water Resources

WETLANDS

VALUE: Wetlands are a fundamental part of the natural water system. Federal law defines freshwater wetlands as those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include swamps, marshes, bogs, and similar areas. The area's wetlands are valuable and important for a number of reasons including protecting shoreline from erosion, serving as water storage areas during storms and floods, acting as groundwater recharge areas, and helping to filter contaminants and sediments. Additionally, wetlands support a diversity of plant and animal species and offer exceptional recreational opportunities. Several local governments have established the state's planning criteria, for each of these environmentally sensitive areas that exist within their jurisdictions.

VULNERABILITIES:

- Potential adverse impact on wildlife/ loss of biodiversity;
- Subject to damaging pollutants and/ or contaminants;
- Threatened by erosion and/ or stormwater runoff;
- Lack of protection through adequate regulations or easements;
- Lack of enforcement of existing regulations; and
- Subject to differing regulations over a multi-jurisdictional area.

Water Resources

PROFILE

Location: Troup, Heard, Carroll and Coweta Counties

Length: 430 miles

SOURCES:

1. ***Brown's Guide to Georgia.*** 10 October 2011. www.brownsguide.com/v/chattahoochee-river/.

CHATTAHOOCHEE RIVER

VALUE: The Chattahoochee River is one of the most geographically and culturally significant waterways in Georgia. Originating in the north Georgia mountains, it then flows through metro Atlanta and through four of the Three Rivers Region counties. It becomes the border of Georgia and Alabama at West Point, Georgia. The Chattahoochee, Flint, and Apalachicola Rivers together make up the Apalachicola-Chattahoochee-Flint (ACF) River Basin. The Chattahoochee is approximately 430 miles long and makes up the largest part of the ACF's drainage basin.[1] In addition to providing drinking water and power in Georgia, the Chattahoochee River is a major resource for recreation. Fishing, tubing, canoeing, boating, hiking and camping are all popular activities. Important parks along the River include McIntosh Reserve, the new Chattahoochee Bend State Park, and the future Moore's Bridge Park. The portion of the river in Troup County is part of the proposed Chattahoochee Trace National Heritage Area which is currently undergoing a feasibility study by the National Park Service.

VULNERABILITIES: The Chattahoochee River is ranked among the top ten percent of the most polluted watersheds in Georgia and in the top twenty percent in the nation. Pollution from metropolitan Atlanta is the greatest threat to the river with urban and storm water runoff. Agricultural practices also place a strain on the aquatic life in the river, as farmland erosion enters the river and degrades the aquatic habitat. Development and growth, although slowing in recent years, continues to remain a threat to the purity of the river. The Chattahoochee River is also at the center of the ongoing "water wars" between Alabama, Georgia, and Florida. These states remain in disagreement as to who should claim the water rights to the Apalachicola, Chattahoochee, and Flint Rivers.

Water Resources

PROFILE

Location: Upson, Pike, Spalding, Coweta and Meriwether Counties

Length: 344 miles

SOURCES:

2. ***Brown's Guide to Georgia.*** 10 October 2011. www.brownsguide.com/v/chattahoochee-river/.

FLINT RIVER

VALUE: The Flint River is a 344-mile-long river in the U.S. state of Georgia.[2] The river drains 8,460 square miles of western Georgia, flowing south from the upper Piedmont region south of Atlanta to the wetlands of the Gulf Coastal Plain in the southwestern corner of the state. Along with the Apalachicola and the Chattahoochee rivers, it forms part of the ACF basin. In its upper course through the red hills of the Piedmont, it is considered especially scenic, flowing unimpeded for over 200 miles. Though the Flint begins in metropolitan Atlanta, self-purification occurs from the river's unimpeded flow and its abundant wetlands, which filter pollutants. The river is thus home to an abundance of unusual animals and plants. Unique to the Apalachicola-Chattahoochee-Flint system are the shoal bass, which is highly prized among fishermen, and the Halloween darter. The Flint River is also home to more than twenty species of freshwater mussels.

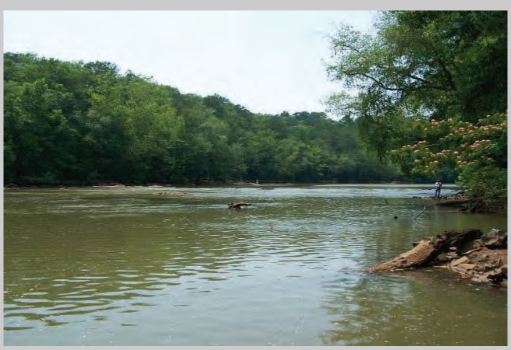
VULNERABILITIES: The Flint River is susceptible to development pressures, which may bring pollution with storm water runoff to the river. As previously mentioned, the Flint River remains embroiled in the "water wars" struggle between Alabama, Florida, and Georgia. The Flint River is also very susceptible to flooding. The most recent major flood happened in the summer of 1994. Conversely, the Flint River can be prone to drought effects. In 2000, the General Assembly passed the controversial Flint River Drought Protection Act, which aims to preserve a minimum flow in the river by paying farmers in southwest Georgia not to irrigate their land from area streams during severe drought years. The Flint River remains one of most un-impeded waterways in the country. Recent droughts have resurfaced the threat of dam construction along the river to the dismay of environmental groups and former president Jimmy Carter.

Water Resources

PROFILE

Location: Butts County

Length: 255 miles



SOURCES:

3. ***Brown's Guide to Georgia.*** 10 October 2011. www.brownsguide.com/v/chattahoochee-river/.

OCMULGEE RIVER

VALUE: The Ocmulgee River is a tributary of the Altamaha River, approximately 255 miles long.[3] It is known for its relatively unspoiled and gentle current. It provides the principal drainage for a large section of the Piedmont and coastal plain of central Georgia. It is formed in north central Georgia, southeast of Atlanta, by the confluence of the Yellow, South, and Alcovy rivers, which join as arms of the Lake Jackson reservoir. It flows southeast past Macon, founded on the fall line, and joins the Oconee from the northwest to form the Altamaha near Lumber City. Downstream from Lake Jackson, the river flows freely and is considered relatively unspoiled among the rivers of the region. The Ocmulgee River is a popular destination for canoeing, bass fishing, and catfish fishing. In 1995, there were fifty-two public water supply facilities providing an estimated 234 million gallons per day to 1,360,000 people in communities throughout the Ocmulgee River basin. The majority of water supplies in the Upper Ocmulgee watershed (the region draining into the river basin from Macon northward) were surface-water withdrawals. The Ocmulgee River is highly valued for its fish and wildlife.

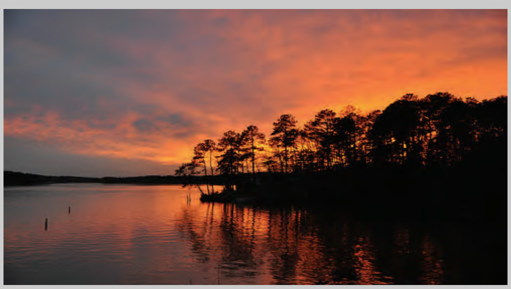
VULNERABILITIES: Because of the Ocmulgee River's highly valued fish and wildlife, it is important to maintain and protect the river. Increased growth and use of the river can lead to increased pollution and reduced stream flow. Swampland and wetlands should be protected from development, so that the natural wildlife habitat remains intact.

Water Resources

PROFILE

Location: Butts County

Size: 4,750 acres



SOURCES:

4. ***Anglerweb.*** 10 October 2011.www.anglerweb.com/fishingreports/

LAKE JACKSON

VALUE: Lake Jackson is one of the oldest reservoirs in Georgia, 44 miles (71 km) southeast of Atlanta in a rural area situated within parts of three counties (Jasper, Newton and Butts).[4] The Lloyd Shoals Dam was built in 1910 by Central Georgia Power Company, and electricity was originally generated for the city of Macon. Relative to others in the state, it is a smaller lake (about 4,750 acres (19.2 km^2) with 135 miles (217 km) of shoreline) which still generates electricity and provides a location for water sports, boating, skiing, wakeboarding, and fishing. Lake Jackson is formed by the joining of the Yellow, Alcovy, and South rivers. The Tussahaw Creek is also a significant tributary to the Lake. Lake Jackson also features lakefront homes and is a popular choice for a second home getaway.

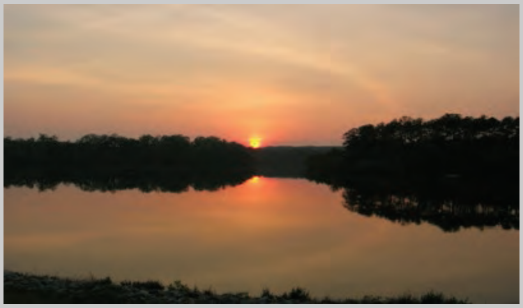
VULNERABILITIES: Development along the lakeshore could impact the natural beauty and wildlife habitat at Lake Jackson. Also, pollution from the streams and rivers that feed into the lake could harm the health of the lake and its inhabitants.

Water Resources

PROFILE

Location: Butts. And Lamar Counties

Size: 650 Acres



PROFILE

Location: Meriwether County

Size: 150 Acres

SOURCES:

5. ***Anglerweb.*** 10 October 2011.www.anglerweb.com/ fishingreports/

HIGH FALLS LAKE

VALUE: High Falls Lake is a 650-acre water resource located in Butts, Lamar, and Monroe Counties.[5] The Lake ties into the river basin and watershed areas of the Towaliga River, which serves as the main source of water for this part of the Region. The Georgia Department of Natural Resources operates the Lake for recreational purposes that include boating and sport fishing.

VULNERABILITIES: High Falls Lake is potentially vulnerable to flooding, drought and man-made occurrences. The development of residential subdivisions surrounding the lake increases its vulnerability to non-point source pollutants. The Georgia Department of Natural Resources currently monitors the Lake for any signs of contamination.

LAKE MERIWETHER

VALUE: Lake Meriwether is an important water source in the region and is entirely located in Meriwether County. The City of Woodbury draws its public water supply from the lake. It is known for its natural beauty and is often photographed by nature photographers. The lake also serves as host to the annual Meriwether County 4th of July celebration, drawing visitors from adjacent counties. It also allows for camping and fishing. Cane Creek is a small stream that feeds into Lake Meriwether.

VULNERABILITIES: Because it is a source for drinking water, the impact would be great if the lake should become contaminated with pollutants from the creeks that feed into the lake. Wildlife could also be harmed by pollution and any development around the lake.

Water Resources

PROFILE

Location: Troup County

Size: 25,900 Acres

SOURCES:

6. ***Anglerweb.*** 10 October 2011.www.anglerweb.com/fishingreports/

WEST POINT LAKE

VALUE: West Point Lake is a man-made reservoir formed by the damming of the Chattahoochee River by the U.S. Army Corps of Engineers.[6] A number of water supply reservoirs are located along the Chattahoochee River in Georgia and West Point Lake is one of the largest. Located in Heard and Troup Counties, this reservoir extends for about 35 miles along the Chattahoochee River near the Alabama-Georgia state border. West Point Dam controls seasonal flooding and provides hydroelectric power. This reservoir also stores water during rainy periods, to be released later during dry periods, and hence helping to maintain the water level in the Chattahoochee River from Columbus, Georgia, southwards to the Gulf of Mexico at Apalachicola, Florida. Recreational facilities include camping, fishing, boating, playgrounds, hiking, and an amphitheater.

VULNERABILITIES: Development pressures along West Point Lake's waterfront detracts from the beauty of the shoreline, causes an increase of siltation in the water body from disturbed soils and impervious surfaces, and an increase in the amount of potentially harmful fecal bacteria entering the lake because of septic tanks and drain fields. Droughts have a significantly harmful effect on West Point Lake, affecting both drinking water and recreation at the lake.

Water Resources

PROFILE

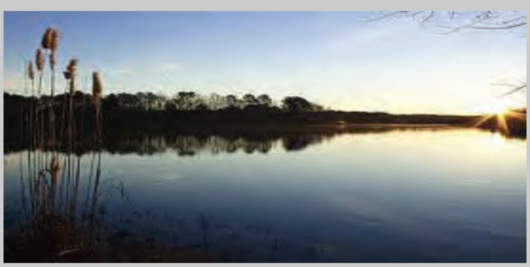
Location: Pike County

Size: 875 Acres

PROFILE

Location: Spalding County

Size: 314 Acres



SOURCE:

7. ***City of Griffin.*** 10 October 2011. www.cityofgriffin.com.

STILL BRANCH RESERVOIR

VALUE: The Still Branch Reservoir was opened in 2008. It is located in Pike County off Georgia Highway 18 just five miles south of Concord. The reservoir consists of 875 acres of property and the reservoir itself is 475 acres.[7] The reservoir serves Pike County, Spalding County, East Coweta County, North Meriwether County, and the Cities of Williamson, Zebulon, and Griffin. Still Branch Regional Reservoir is stocked with bass, bream, and channel catfish. While fishing in this wildlife area, one can experience the home of three sets of bald eagles, Canadian geese, loons, numerous duck species, wild turkeys, deer and a host of other wildlife animals. Still Branch has 39 wood duck boxes, hosting one of the largest wood duck populations in the area. These boxes are managed in conjunction with Ducks Unlimited and Troop 123 of the Boy Scouts of America.

HEADS CREEK RESERVOIR

VALUE: Heads Creek Reservoir is part of a regional system which provides drinking water to 100,000 people. This reservoir is located in Spalding County and was constructed in 1964. It is comprised of 314 acres. The reservoir holds 510 million gallons of water and works in tandem with the Still Branch Regional Reservoir to supply the region with water. It supplies drinking water to Spalding County, and the Cities of Griffin, Concord, Williamson, and portions of Coweta, Lamar, and Butts Counties.

VULNERABILITIES: Because these reservoirs are a source for drinking water, the impact would be great if the water resources should become contaminated with pollutants from the creeks that feed into the lakes. Wildlife could also be harmed by pollution and any development around the lakes.

Appropriate Development Practices

WATER RESOURCES

Listed below are recommended best management practices for use by developers and landowners to protect our vital water resources. These practices, when applicable, are to be used when designing and developing sites located within one mile of a Regionally Important Water Resource. These recommendations will also be used when conducting Developments of Regional Impact (DRI) reviews for projects located within one mile of a listed water resource. Water resources are especially sensitive to expanding development. These resources are habitat for wildlife, recreational amenities, and often a community's water supply.

- Limit full scale clearing, grading, and land disturbing activities to avoid the loss of mature trees, runoff and sedimentation, and soil depletion.
- Assess and maintain environmental features including topography, soils, hydrology, trees, vegetation, wildlife habitat, historic and cultural sites. Seek to preserve the environmentally sensitive areas identified in the assessment by utilizing them for parks, trails, and greenbelt connectivity.
- Establish and utilize riparian buffers which go beyond state requirements to protect streams, wetlands, and other waterways from development.
- Sensitivity of natural features which include forested areas, steep slopes, wetlands and floodplains should be considered within site plans and building design.
- Work with the Georgia Forestry Commission, Natural Resource Conservation Service, Resource Conservation and Development Council, and the UGA Cooperative Extension Service to promote and protect resources.
- Utilize agricultural and forestry best management practices to reduce the amount of pollutants into waterways.
- Encourage conservation subdivisions and cluster development to retain as much open space as possible.
- Reduce parking requirements and the percentage of impervious surface footprint within the development site.
- Utilize porous pavement materials when possible to reduce stormwater runoff and groundwater depletion.
- Utilize rain gardens and bio-retention areas in place of traditional stormwater controls to collect water and reduce run-off.
- Construct vegetative swales in place of traditional curbs and drainage pipes.
- Utilize programs and grants such as the Georgia EPD 319(h) grant to improve and restore streams and watersheds.

Policies & Protection Measures

WATER RESOURCES

Listed below are general policies and protection measures intended to guide local governments in planning and decision making which affect Regionally Important Water Resources. The protection and conservation of regionally important water resources is important to the health and well being of all citizens. Local governments play an active and vital role in the protection of water resources through the comprehensive planning process, policy decisions, and code enforcement.

- The establishment of green infrastructure projects and other techniques should be designed to protect water quality and environmentally sensitive settings.
- Local governments are encouraged to adopt, revise and enforce Part V Environmental Planning Criteria ordinances specific to their jurisdictions.
- Local government should revise and update existing zoning, development and other environmental ordinances to require more permeable surface paving options, therefore reducing the percentage of impervious surface within new development.
- Local governments should establish development standards that go beyond the state buffer width requirements for the protection of water resources.
- Establish overlay districts to local zoning ordinances to add an additional layer of protection for water supply watersheds and other environmentally sensitive areas.
- Create passive recreation opportunities which protects greenspace and establishes green linkages.
- Encourage environmental stewardship and educate the public on environmental awareness.
- Consider the establishment of a farmland protection program.
- Establish Adopt-a-Stream groups to monitor streams and rivers.
- Establish partnerships with local governments, agencies and citizens to protect important natural resources.
- Establish working relationships with agencies such as the Georgia Department of Natural Resources, Trust for Public Land, the Nature Conservancy, the Georgia Conservancy, the Army Corps of Engineers.
- Implement the Total Maximum Daily Load Implementation Plans for streams listed on the EPD 303(d) list.

Conservation Resources

Conservation Resources Overview

Conservation areas are designed to conserve, protect, and enhance natural lands for the benefits of enjoyment of present and future generations. Trees and vegetation provide a habitat for wildlife, mitigate the effects of the sun and wind, help to restore carbon thus reducing atmospheric carbon dioxide, reduce stormwater runoff and soil erosion, and filter pollutants. Additionally, trees and other vegetation enhance the aesthetic value of the region. One of the indicators of a healthy community and a high quality of life is an environment that is conserved and enjoyed by its residents. The Three Rivers Region has identified several conservation resources including four (4) state parks, three (3) wildlife management areas, one (1) greenway trail, three (3) local passive recreational parks and one (1) federally-owned and operated fish hatchery.

Conservation resources provide unique opportunities for recreation and eco-tourism activities. These areas also protect wildlife habitats by creating, buffering, and preserving, habitat areas and corridors. Conservation areas also reserve significant working agricultural or forest resources and/or creates opportunities for local food production activities. The map below highlights conservation or natural resources within the Three Rivers Region.

Wildlife Management Areas (WMA)

PROFILE

Location: Upson County

Size: 3,900 acres

PROFILE

Location: Meriwether County

Size: 3,700 acres

SOURCE:

8. ***Georgia Department of Natural Resources.*** *Public Fishing Guides.* 10 October 2011. http://www.georgiawildlife.org/node/297.

BIG LAZAR WILDLIFE MANAGEMENT AREA

VALUE: Big Lazar Wildlife Management Area is located in Upson County. A portion of this WMA is located on Gum Creek in Talbot County, Georgia and is used for recreational purposes. Construction was completed in 1987.[8] It has a normal surface area of 193 acres. It is owned by the Georgia Department of Natural Resources Fisheries Management Division. Big Lazar Wildlife Management Area Lake Dam is of earthen construction. Its height is 48.8 feet with a length of 960 feet. Its capacity is 5,432 acres. Normal storage is 3,088 acres.

JOE KURZ WILDLIFE MANAGEMENT AREA

VALUE: Joe Kurz Wildlife Management Area is located in Meriwether County. It is owned by the Georgia's Wildlife Resources Division and Wildlife Management Areas. It spans approximately 3,700 acres.[8] The area is popular for seasonal hunting of deer, dove, squirrels and rabbits. There are also areas available within the WMA for primitive camping. Boat access is available to the Flint River from the Joe Kurz Wildlife Management Area.

Wildlife Management Areas (WMA)

PROFILE

Location: Troup County

Size: 10,000 Acres

SOURCE:

9. ***Georgia Department of Natural Resources.*** Waterfowl Hunting and Management. 10 October 2011. http://www.georgiawildlife.org/node/1403.

WEST POINT WILDLIFE MANAGEMENT AREA

VALUE: West Point Wildlife Management Area is lies within Troup and Heard Counties. Located five miles north of LaGrange, this wildlife area is popular for hunting and bird watching. It contains three managed impoundments that are hunted on a quota basis.[9] Also, there are over 40 acres of goose grazing pastures that attract geese and are open for hunting. This 10,000 acre Wildlife Management Area is open to hunting deer, turkey, small game, and waterfowl with archery, firearms, and primitive weapons.

Included with the West Point WMA is Glovers Creek Wetland Restoration Project which is managed by the Georgia Department of Natural Resources. This particular section is made up of 90 acres of moist-soil habitat enhanced through the replacement of an old water control structure. The wetland is managed for production of moist-soil vegetation that provides food for wintering waterfowl. Wildlife benefiting the wetland area includes, kingfishers, wood ducks, mallards, and other puddle ducks.

The historical settlement of Owensbyville was once located in the Heard County portion of the WMA. Home foundations and abandoned wells can still be found today.

VULNERABILITIES: The Wildlife Management Areas are threatened by the encroachment of development in the region. In addition, water resources within the WMAs are susceptible to pollutants from runoff and animal waste. The land within the management areas is leased to the State of Georgia and funding to maintain the leases have been threatened recently due to budget issues.

State Parks

PROFILE

Location: Coweta County

Size: 2,910 acres

SOURCE:

9. ***Georgia Department of Natural Resources.*** State Parks and Historic Sites. 10 October 2011. http://www.gastateparks.org/ChattahoocheeBend.

CHATTAHOOCHEE BEND STATE PARK

VALUE: Chattahoochee Bend State Park is Georgia's newest state park. It opened in July 2011. This state park showcases a spectacular tract of wilderness in northwest Coweta County. Located in a graceful bend of the Chattahoochee River, the park is a haven for paddlers, campers and anglers. At 2,910 acres, Chattahoochee Bend is one of Georgia's largest state parks, protecting seven miles of river frontage.[9] An observation platform provides nice views of the river and forest. Although most of the park has been left in its natural state, the new park offers amenities that include 25 RV campsites, 12 tent walk-in campsites, 10 tent pop-up campsites, 16 riverside platform campsites, four screened Adirondack campsites, two picnic shelters, and a visitors center. Other amenities include a boat ramp that provides easy access to the river, a playground and more than six miles of wooded trails for hiking and nature photography. A half-mile hike from the day-use area leads to an observation platform with views of the river and forest.

VULNERABILITIES: State Parks depend on visitors for revenue. With its relatively isolated location (approximately 11 miles from SR-16 and approximately 10 miles from SR-34), it will be interesting to track the number of visitors to the park during its first year. Budget cuts from the State have greatly impacted the Georgia State Park System. Since 2007, state parks and historic sites have seen budget cuts from the legislature. In addition, Chattahoochee Bend State Park is located along the banks of the Chattahoochee River. Because of this, the park could be vulnerable to flooding.

State Parks

PROFILE

Location: Carroll County

Size: 138 Acres

PROFILE

Location: Butts and Monroe Counties

Size: 1,050 Acres

SOURCE:

10. ***Georgia Department of Natural Resources.*** State Parks and Historic Sites. 10 October 2011. http://www.gastateparks.org.

JOHN TANNER STATE PARK

VALUE: This West Georgia park, located in Carroll County, is best known for having the largest sand swimming beach of any Georgia state park. The park is operated by Carroll County. It is a recreational haven for water lovers looking for boating and fishing opportunities as well. Visitors can enjoy camping, picnicking, miniature golf, volleyball and horseshoes. Six motel type units are located near the beach, each with a fully equipped kitchen, dining area, living area and bedroom. The park is named after a local businessman who operated the property as a private park from 1954 until 1971.

VULNERABILITIES: Once supported by the state, this park may lose some visibility and the number of visitors may decline as it is no longer a state park and is a county run facility. The park is also subject to litter from park visitors. The lakes in the park are susceptible to pollution from the creeks and stream that feed into the lake.

HIGH FALLS STATE PARK

VALUE: The High Falls State Park is a 1,050 acre park located near Jackson, Georgia.[10] The majority of the State Park is situated in Monroe County. A portion of this beautiful resource is also located in Butts County. The major attractions of the park include High Falls Lake and a 35-foot waterfall. The park also features a pedestrian bridge and trails that provide scenic views of the falls and creek.

VULNERABILITIES: High Falls Park is threaten by increased growth from residential and commercial development in the surrounding areas. To reduce this risk, all surrounding jurisdictions must maintain the water quality of the Towalgia River and its tributaries within federal water quality standards .

INDIAN SPRINGS STATE PARK

PROFILE

Location: Butts County

Size: 528 Acres

Year Established: 1931

VALUE: Indian Springs State Park is a 528 acre Georgia state park located near Jackson and Flovilla. The park is named for its several springs, which the Creek Indians used for centuries to heal the sick. Indian Springs is thought to be the oldest state park in the nation. It was acquired from the Creek Indians by the state through the Treaty of Indian Springs (1825) and the Treaty of Washington (1826).[11] Thereafter, Indian Springs has been operated continuously by the state as a public park, although it did not gain the title "State Park" until 1931. The area became a resort town in the 19th century. It became an official "State Forest Park" in 1927. In 1931, along with Vogel State Park, it became a founding unit of Georgia's state park system. Visitors are still allowed to sample the park's spring water, in addition to enjoying swimming, fishing, and boating. Several structures within the park were built during the Great Depression by members of the Civilian Conservation Corps (CCC). The park also contains a 105 acre lake, Chief McIntosh Lake, which is consistently stocked with fish, as well as a 3/4 mile nature trail. The park features a small museum that is open seasonally. Exhibits include the park's natural history, the resort era, activities of the CCC, and the history and culture of the Creek Indians. The park offers 10 cottages; 88 tent, trailer, or RV Campsites; a pioneer campground; 7 picnic shelters; a large group shelter; and a group camp for scouts.

VULNERABILITIES: Like all Georgia State Parks, Indian Springs State Park is vulnerable to budget cuts by the State of Georgia. In the past few years, the parks have been at the forefront of budget reductions. The state has cut back on staff and operations at all of the state parks and historic sites. Another vulnerability to the state park is that the water quality of Chief McIntosh Lake could be affected if streams that flow into it become polluted.

SOURCE:

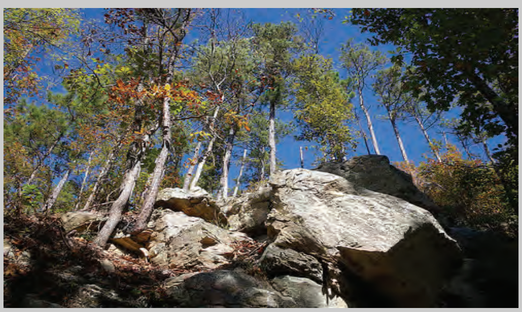
11. ***Georgia Department of Natural Resources.*** State Parks and Historic Sites. 10 October 2011. http://www.gastateparks.org.

State Parks

PROFILE

Location: Upson County

Acres: 1,372 Acres



SOURCE:

12. ***Georgia Department of Natural Resources.*** State Parks and Historic Sites. 10 October 2011. http://www.gastateparks.org.

SPREWELL BLUFF STATE PARK AND WILDLIFE MANAGEMENT AREA

VALUE: This little-known treasure on the Flint River is the perfect location for a daytime getaway. Visitors can cool off in the gently flowing river, skip rocks across the water, picnic on the river's edge or toss horseshoes in a grassy field. A three-mile trail winds along the bank and up rocky bluffs, offering excellent views from high above the river.[12] Hikers can look for abundant wildflowers and butterflies. Birding enthusiasts might spot tanagers, warblers, osprey and eagles. A boat ramp is available for canoeists, kayakers, rafters and anglers, and canoes may be rented from nearby outfitters. The park consists of 1,372 acres and includes a boat ramp, a picnic area with grills, and a playground. However, no camping facilities are available.

VULNERABILITIES: Because the park is located along the Flint River, the health of the park is entangled with that of the river. There is concern that the water resources provided by the river may be over-utilized in times of prolonged drought to the harm of the river. There could be future needs for reservoirs upstream and the growing metropolitan areas north could impact the overall health of the river. The potential impacts on fish and aquatic habitats, as well as birds and other wildlife and vegetation are also of concern.

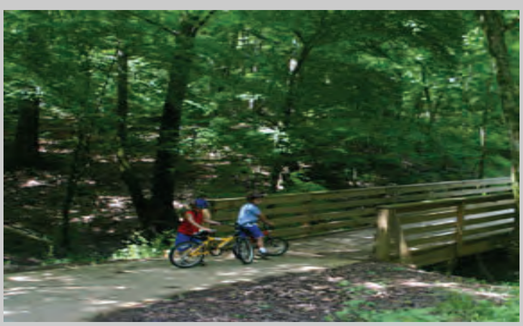
Other Conservation Resources

PROFILE

Location: Heard County

Length– Proposed master plan 40 miles

Completed Portion: 2 Miles



SOURCE:

13. ***Heard County Historical Society.*** Greenway Trail. 11 October 2011. http://www.hh.thehandcoders.com/

CHATTAHOOCHEE GREENWAY

VALUE: This pedestrian, bicycling, and equestrian system is currently in various stages of design and construction. The Chattahoochee Greenway Master Plan is expected to span the entire 48 mile section of the Chattahoochee River. The City of Franklin initiated this project, constructing the initial two-mile, hard-surface Old Town Chattahoochee Trail, named after the original Creek Indian village located close to the city's eventual settlement.[13] The greenway also connects with the city's Old Town Chattahoochee Trail at the downtown square with sidewalk, lighting, Veteran's Park rehabilitation and landscape enhancements. The well-designed greenway fits into the natural character of the area, especially along the Chattahoochee River. Additional tourism

VULNERABILITIES: The trail must be maintained from intrusive plant growth along the trail surface. There is also a potential for litter to accumulate along the trail. The trail has been a source for mischief by the local youth as well. The greenway may potentially face development pressures from both residential and commercial uses. The greenway is also vulnerable to flooding of the Chattahoochee River.

Other Conservation Resources

PROFILE

Location: Heard County

Size: 110 acres

Owner: Nature Conservancy

PROFILE

Location: Carroll County

Size: 312 Acres

SOURCE:

14. ***THe Nature Conservancy.*** Camp Meeting Rock Preserve. 11 October 2011. http://www.nature.org/ ourinitiatives/regions.

SOURCE:

15. ***Mountain Zone.*** Black Jack Mountain. 11 October 2011. http:// www.mountainzone.com/ mountains.

CAMP MEETING ROCK PRESERVE

VALUE: Camp Meeting Rock, also known as Flat Rock, includes 110 acres of granite flat rock in Heard County, near Franklin in western Georgia.[14] While such outcrops occur from Virginia to Alabama, 90% of them are in Georgia, and this site is one of the largest in the southeast, although the preserve covers only a small portion of the overall rock surface.

VULNERABILITEIS: Conservation of the habitat is a priority because similar areas have been damaged by quarrying, dumping, and vehicular traffic.

BLACKJACK MOUNTAIN

VALUE: Blackjack Mountain is a scenic landmark, located in the very southwest corner of Carroll County, Georgia on the Georgia-Alabama border and Heard County line. The nearest city is Ephesus, Georgia, 2.2 miles to the south. The mountain is one of the higher points in Georgia, south of Interstate 20. Blackjack Mountain is a long north-south trending ridge. The Native Americans used this promontory as a reference point on their East-West trading path and are believed to have used the summit for sacred ceremonies.[15]

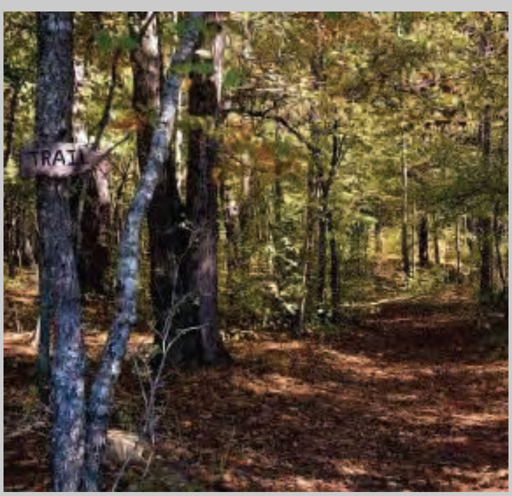
VULNERABLITIES: Blackjack Mountain was a high land conservation priority. In early 2005, the Trust for Public Land assisted Carroll County in protecting Blackjack Mountain. The acquisition of Blackjack Mountain will protect a very scenic view shed and preserve over 312 acres of pines and mixed hardwoods, two small lakes, several small tributaries, a federally designated wetland and a valuable wildlife habitat.

Other Conservation Resources

PROFILE

Location: Whitesburg—Carroll County

Size: 527 Acres



MCINTOSH RESERVE

VALUE: The park is located along the banks of the Chattahoochee River just outside the city limits of Whitesburg in Carroll County. The park is called "reserve" because when Chief McIntosh and eight other Creek Indian chiefs signed the Treaty of Indian Springs exchanging Creek lands in Georgia for Western lands, Chief McIntosh reserved this land for himself.[16] The park, located on land given to Carroll County by the Georgia Power Company, lies just outside Whitesburg, Georgia. In 1978, Carroll County acquired 527 acres of land adjacent to the Chattahoochee River. Included in this parkland is the site of McIntosh's plantation, known as Lochau Talofau or Acorn Bluff. It features hiking and horseback trails, picnic tables and related facilities, a children's water park, a boat ramp, ball field, and camping areas.

VULNERABILITIES: The park is subject to flooding of the adjacent Chattahoochee River. The flood of September 2009 flooded much of the park and it was closed for several months as a result. The park is subject to future flooding and litter from park guests.

SOURCE:

16. ***Carroll County.*** McIntosh Reserve. 11 October 2011. http://www.carrollcountyga.com/pages/mcintosh_reserve_park/.

Other Conservation Resources

PROFILE

Location: Meriwether County

Established: 1898

Size: 18.23 Acres

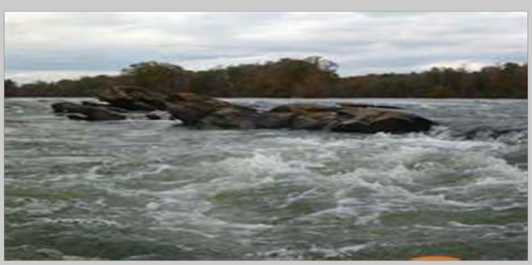
SOURCES:

17. **US Fish & Wildlife Service.** *Warm Springs National Fish Hatchery*. 11 October 2011. http://www.fws.gov/warmsprings/FishHatchery/index.html

PROFILE

Location: Heard County

Size: 604 Acres



SOURCES:

18. ***Brown's Guide to Georgia.*** 10 October 2011. www.brownsguide.com/v/bushheadshoals.

WARM SPRINGS REGIONAL FISHERIES CENTER

VALUE: The Warm Springs National Fish Hatchery (NFH) was established in 1899. The facility was authorized by Congress in 1898 to serve as warmwater hatchery under the United States Fish and Fisheries Commission, which later became the United States Fish and Wildlife Service.[17] The Warm Springs NFH consists of 56 acres with 40 ponds totaling 18.23 acres of water. The species of fish includes such water creatures as striped bass, sturgeon, robust redhorse and paddlefish which are vital to the fishery resources of the Southeastern United States and the Atlantic Coast. The various species of fish are raised at the hatchery and stocked in cooperation with the various state game and fish agencies.

VULNERABILITIES: As a federally owned fish hatchery, the Warm Springs Regional Fisheries Center is protected under federal regulations. The various species of fish are most vulnerable to disease and parasitism. The United States Fish and Wildlife has designed an innovative defense system which reduces the risk of diseased or infected water creatures.

BUSH HEAD SHOALS

VALUE: Bush Head Shoals is located along the Chattahoochee River in the northeast part of Heard County. It is popular with kayakers who wish to paddle the river. It contains five islands along the river.[18] This beautiful conservation resource has been identified for designation as a state park in the near future.

VULNERABIITIES: The islands at Bush Head Shoals are vulnerable to litter and debris thrown out into the Chattahoochee River. In addition, the water is susceptible to impurities from runoff and pollutants discharged from septic systems.

Appropriate Development Practices

CONSERVATION RESOURCES

Listed below are recommended best management practices for use by developers and landowners to protect our vital natural resources. These practices, when applicable, are to be used when designing and developing sites located within one mile of a Regionally Important Resource. These recommendations will also be used when conducting Developments of Regional Impact (DRI) reviews for projects located within one mile of a natural resource.

- Link new developments to existing residential areas via a trail and/or greenspace system.
- Establish extensive natural landscape buffers along the periphery of the development site which give visual separation.
- Sensitivity of natural features which include forested areas, steep slopes, wetlands and floodplains should be considered within site plans and building design.
- Limit full scale clearing, grading, and land disturbing activities to avoid the loss of mature trees, runoff and sedimentation, and soil depletion.
- Assess and maintain environmental features including topography, soils, hydrology, trees, vegetation, wildlife habitat, historic and cultural sites. Seek to preserve the environmentally sensitive areas identified in the assessment by utilizing them for parks, trails, and greenbelt connectivity.
- Encourage development to be setback from roadways to protect the natural viewshed.
- Work with the Georgia Forestry Commission, Natural Resource Conservation Service, Resource Conservation and Development Council, and the UGA Cooperative Extension Service to promote and protect resources.
- Utilize agricultural and forestry best management practices to reduce the amount of pollutants into waterways.
- Encourage conservation subdivisions and cluster development to retain as much open space as possible.
- Utilize porous pavement materials when possible to reduce stormwater runoff and groundwater depletion.
- Utilize rain gardens and bio-retention areas in place of traditional stormwater controls to collect water and reduce run-off.
- Construct vegetative swales in place of traditional curbs and drainage pipes.

Policies & Protection Measures

CONSERVATION RESOURCES

The protection and conservation of regionally important natural resources is important to the health and well being of all citizens. Listed below are general policies and protection measures intended to guide local governments in planning and decision making which affect Regionally Important Natural Resources. Local governments play an active and vital role in the protection of natural resources through the comprehensive planning process, policy decisions, and code enforcement.

- Local governments are encouraged to create more compact urban development in order to preserve conservation resources of regional significance.
- Local governments are encouraged to preserve the rural character of specific areas and provide opportunities for parks and other conservation activities.
- Local governments are encouraged to adopt, revise and enforce Part V Environmental Planning Criteria ordinances.
- Local governments are encouraged to revise and update local zoning, development and other environmental ordinances to require more permeable surface paving options, therefore reducing the percentage of impervious surface and pollution within new development.
- Encourage developments to go beyond the state buffer width requirements for the protection of natural resources.
- Explore the adoption of Transfer of Development Rights, conservation easements, fee simple acquisitions, and conservation tax credits to allow for the preservation of natural areas and open space.
- Establish overlay districts to local zoning ordinances to add an additional layer of protection for water supply watersheds and other environmentally sensitive areas.
- Establish development standards for the development of cluster subdivisions that feature walking/bicycle trails, passive parks, and greenbelts.
- Create passive recreation opportunities which protects greenspace and establishes green linkages. Consider the establishment of a farmland protection program.
- Encourage environmental stewardship and educate the public on environmental awareness.
- Establish partnerships with local governments, agencies and citizens to protect important natural resources.
- Establish working relationships with agencies such as the Georgia Department of Natural Resources, Trust for Public Land, the Nature Conservancy, the Georgia Conservancy, the Army Corps of Engineers.

Cultural and Heritage Resources

Heritage Resources Overview

Cultural and historic resources distinguish one place from another and make it unique. The Three Rivers Region is made up of many of these resources which give it a specific and special identity. These resources not only give each community and the region a sense of place but also play a major role in quality of life, education, economic development, housing, and government.

The purpose of this section of the Regionally Important Resource Plan is to assist with preservation of these vital cultural and heritage resources which future growth and development could impact. The resources listed in this section include historic structures, districts, sites, cemeteries, centennial farms, courthouses, crossroads stores, covered bridges, homes, and theatres. Some of these resources depict unique local significance and others are of national significance.

The nominated resources listed in this section were selected because it either:

- Embodies unique characteristic s or significance on a local and national level;
- Represents the only example of that type of resource in the entire Region;
- Is related to a special person or event in history; or
- Contains a shared history or has an impact on the entire Region.

A number of our listed cultural and heritage resources are recognized on a national level by way of the National Register of Historic Places or as a National Historic Landmark. Others have been recognized on the state level by being placed on the Georgia Trust for Historic Preservation's *Places in Peril* list.

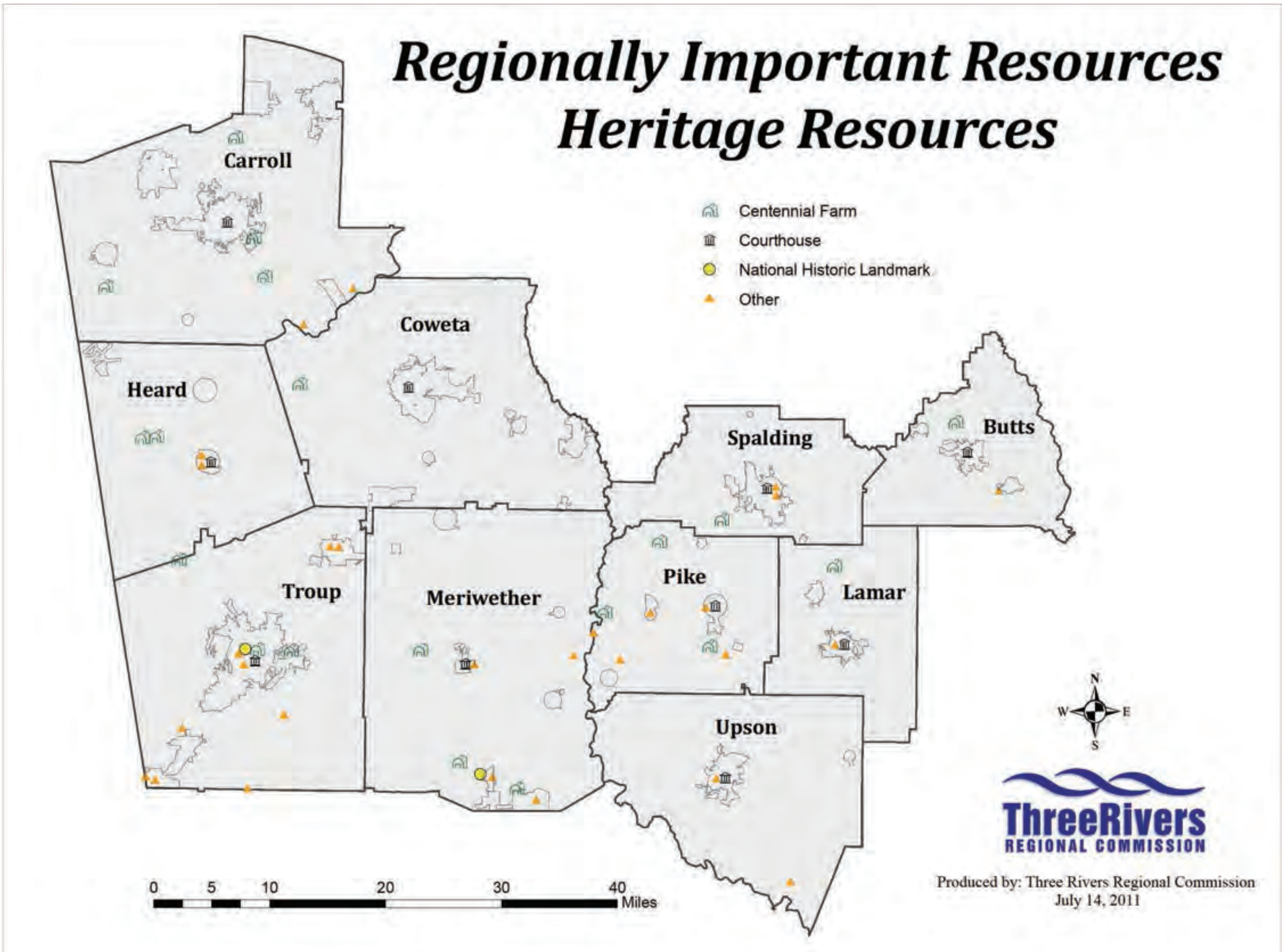
The identification, documentation, and recognition of cultural and heritage resources are extremely important components of the preservation process; however, the protection of these resources from insensitive treatment and demolition is essential. Historic resource programs such as the National Register of Historic Places, National Historic Landmarks, National and State *Places in Peril* lists, and local preservation ordinances only provide minimal protections.

Any resource listed in or eligible for listing in the National Register of Historic Places comes under the protective umbrella of the National Historic Preservation Act of 1966. The Act mandates, under Section 106, that any federally licensed, permitted, or funded project must be reviewed regarding its impact on the historic resource.

Examples of preservation efforts are seen throughout the Three Rivers Region. These include established local government preservation commissions, active adaptive reuse projects, Main Street and Better Hometown designated communities, and individual citizen preservation efforts to name a few.

Heritage Resources Overview

The Heritage Resources Map below displays significant cultural and heritage resources with the Three Rivers Region.



Centennial Farms

PROFILE

Number of Farms: 19

Locations: Butts, Carroll, Coweta, Heard, Lamar, Meriwether, Pike, Spalding, Troup

Centennial Family Farms: 15

Centennial Farms: 1

Centennial Heritage Farms: 3

The identification of Centennial Farms provides an additional unique and interesting resource to the region. The Georgia Centennial Farm Program is focused on the preservation of agricultural heritage within the state. These heritage resources, found within the natural landscape, have shaped what our communities have become today. The Three Rivers region is extremely fortunate to have 19 farmsteads that have been awarded some form of centennial farm recognition. This program recognizes and honors qualifying farms that fall within one of the three defined categories. The categories and their requirements are as follows:

<u>Centennial Family Farm Award</u>

- Owned by members of the same family for 100 years or more; and
- Not listed in the National Register of Historic Places.

<u>Centennial Farm Award</u>

- Does not require continual family ownership
- Farm must be at least 100 years old; and
- Listed in the National Register of Historic Places.

<u>Centennial Heritage Farm Award</u>

- Owned by members of the same family for 100 years or more.
- Listed in the National Register of Historic Places.

VALUE:

- Protects areas that hold a historic value and represent a time and place in history;
- Preserves existing green space both active and passive; and
- Preserves the act of working farmsteads. within the region.

VULNERABILITIES:

- Incompatible development that overtakes, or resides next to the farmstead;
- Lack of existing protection via regulations, ordinances and development agreements; and
- Loss of cultural value through the destruction of surrounding uses.

Centennial Farms

Name	County	Type	Year
O'Neal Farm	Butts	Centennial Family Farm	1996
Reaves Family Farm	Carroll	Centennial Family Farm	1995
Crowley and Reynolds Farm	Carroll	Centennial Family Farm	1999
Ogletree Farm	Carroll	Centennial Family Farm	2002
The Levans Farm	Carroll	Centennial Family Farm	2009
W.L. Crowder Place	Coweta	Centennial Heritage Farm	1993
Oak Grove	Heard	Centennial Family Farm	2003
Hillaba Hatchee Acres	Heard	Centennial Family Farm	2004
Weldon Lake Farm	Lamar	Centennial Family Farm	1993
Sea Horse Farm	Meriwether	Centennial Family Farm	1993
Bulloch Farms, Inc.	Meriwether	Centennial Family Farm	1994
Perkerson Place	Meriwether	Centennial Family Farm	2002
Anderson Farm	Pike	Centennial Family Farm	2000
The Farm	Pike	Centennial Family Farm	2008
The Cochran-Caldwell Farms	Pike	Centennial Family Farm	2010
Orr-Williamson-Gaissert	Spalding	Centennial Heritage Farm	2002
Liberty Hill Tree Farm	Troup	Centennial Heritage Farm	1993
Cloverland Farm	Troup	Centennial Farm	1993
Dallis Farm	Troup	Centennial Family Farm	1994

Historic Courthouses

PROFILE

Historic Courthouses: 9

Oldest Structure: 1859 (Spalding)

For years, courthouses have been not only the symbol of justice within the county, but also as the central focus point of many downtowns. It was the one structure that provided an image to the community, and subsequently sparked the surrounding development. Seven of the ten courthouses in the Three Rivers region are considered historic and still in use. The Spalding County Courthouse and the Troup County Courthouse still exists but are not occupied as the main courthouse, but as extensions of the court. Heard County is the only county where the original historic courthouse does not exist.

VALUE:

- Protects areas that hold a historic value and represent a time and place in history;
- Preserves structures from an era that have little representation in current development; and
- Provides a unique image to the community.

VULNERABILITIES:

- Lack of existing protection via regulations, ordinance and development agreements;
- Loss of cultural value through the destruction of surrounding uses; and
- Lack of adequate maintenance due to funds and accessibly.

Historic Courthouses

County	Location	Year Built	Architectural Style	Current Use	Recognition
Butts	Jackson	1898	High Victorian Eclec-tic	Courthouse	National Register of Historic Places
Carroll	Carrollton	1928	Italian Renaissance	Courthouse	National Register of Historic Places
Coweta	Newnan	1904	Neoclassical Revival	Courthouse	National Register of Historic Places
Heard	Franklin	1964	Modern	Courthouse	None
Lamar	Barnesville	1930	Neoclassical Revival	Courthouse	National Register of Historic Places
Meriwether	Greenville	1904	Neoclassical Revival	Courthouse	National Register of Historic Places
Pike	Zebulon	1895	Romanesque Revival	Courthouse	National Register of Historic Places
Spalding	Griffin	1859	Vernacular Italianate	Court Offices	National Register of Historic Places
Troup	LaGrange	1939	Stripped Classical	Juvenile Court	National Register of Historic Places
Upson	Thomaston	1908	Neoclassical Revival	Courthouse	National Register of Historic Places

National Historic Landmarks

PROFILE

Location: LaGrange, GA

Added to NHRP: Nov 7, 1972

Designated NHL: Nov 7, 1973

PROFILE

Location: Warm Springs, GA

Added to NHRP: June 30, 1974

Added to NHLD: January 16, 1980

BELLEVUE MANSION

The Bellevue Mansion was the historic home of Senator Benjamin Harvey Hill. The structure was originally built in the early 1850's, and was situated on a 1200 acre plantation. The excellent example of Greek revival architecture is still located at its original address and is a few blocks from the Lafayette Square.

WARM SPRINGS HISTORIC DISTRICT

The Warm Springs Historic District includes the Roosevelt Warm Springs Institute and the Little White House. The Warm Springs Institute was founded by Franklin Delano Roosevelt in 1927. He often visited the property, which included springs that are at a constant 88 degree Fahrenheit, to combat his symptoms of polio. While the springs did exist and serve many prior to FDR, it was he who made the greatest impact. Disgusted with the conditions of the center, he purchased the facility and land, and turned it into the establishment it is today. The tranquility of the site inspired him to construct what is known today as the Little White House. Today, the springs have provided hydrotherapy to thousands of patients.

VALUE:

- Protects areas that hold a historic value and represent a time and place in history; and
- Preserves cultural aspects that are not commonly found in today's society.

VULNERABILITIES:

- Lack of existing protection via regulations, ordinances and development agreements;
- Loss of cultural value through the destruction of surrounding uses; and
- Distraction from the surrounding development.

Crossroads Stores

PROFILE

Location: Troup County

Year Built: 1903

Recognition: National Register of Historic Places — 2009

PROFILE

Location: Troup County

Year Built: 1894

Recognition: National Register of Historic Places —1983

R. M. JONES CROSSROADS STORE

VALUE: Troup and Harris County residents first settled at the crossroads of the LaGrange-Whitesville-Columbus Stagecoach route and the West Point to King's Gap Road in the late 1820's. Named for local landowner, Christopher Columbus Jones (1831-1904) and his son Monroe, Jones Crossroads once had several flourishing businesses, including a cotton gin, a racehorse track, a tavern, and a U.S. post office called Paulina. Monroe Jones established the rock store in 1903 which members of the Avery Family have owned and operated since the 1920's.

POTTS BROTHERS GABBETTVILLE CROSSROADS STORE

VALUE: This corner store is the only one of a few remaining historic crossroad stores in the State of Georgia. Country stores, located at rural crossroads, provided food, clothes, farm supplies and medicine to area farms. It was common for stores to also serve as the area post office.

VULNERABILITIES: Most crossroad stores within the State of Georgia have been demolished. The R. M. Jones Crossroads Store currently operates as an antique store. However, future commercial development pressures may increase the vulnerability of the store's operation. The Potts Brothers Gabbettville Crossroads store is currently for sale. Therefore, it is vital that the community market the rich heritage of the crossroads stores in its tourism efforts to enhance economic development opportunities.

PROFILE

Location: Franklin—Heard County

Year Built: 1921

Recognition: National Register of Historic Places - 1981

HEARD COUNTY JAIL AND MUSEUM

VALUE: The Heard County Jail built in 1921, serves as the Heard County Historical Center and houses a museum. The Museum offers a look into the past of this rural community and highlights include the jail cells. This Museum has exhibits dedicated to notable residents of the county. One major exhibit is dedicated to local personality, Mahayley Lancaster, a fortune-teller, lawyer, political activist, schoolteacher, and self-proclaimed "oracle of the ages," who became a West Georgia legend in the first half of the twentieth century. The county jail and sheriff's residence was in operation from 1912 to 1964. The Heard County Jail was added to the National Register of Historical Places in 1981. [19]

VULNERABILITIES: The Heard County Historical Center has made some major restorations to this building over the past few years. However, funds are limited for ongoing structural maintenance. The structure is vulnerable to incompatible additions and surrounding developments.

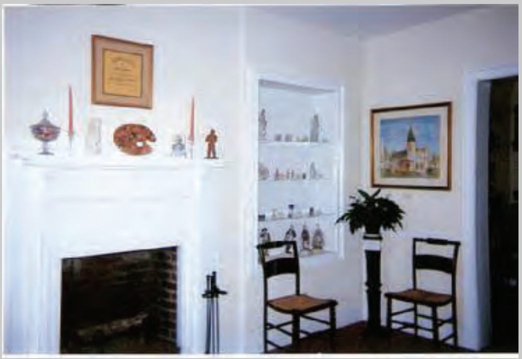
SOURCE:

19. ***Heard County Historical Society.*** *History* 10 October 2011. http://www.heardhistory.org/

PROFILE

Location: Barnesville—Lamar County

Year Built: 1938



LAMAR COUNTY OLD JAIL AND MUSEUM

VALUE: The Old Jail Museum & Archives is housed in the old Lamar County Jail building. This building, completed in 1938, was a Works Progress Administration (WPA) structure.[20] The sheriff and his family lived downstairs and the inmates were housed upstairs in cells. This building was used for inmates until 1992 when a new Detention Center was completed on Roberta Drive. In September 1995, the building became a dual purpose facility that includes a museum and genealogical research. The archives process dozens of requests for research each month. The museum houses artifacts that have been collected from Barnesville, Milner and the surrounding districts within Lamar County.

VULNERABILITIES: The "Old" Lamar County Jail has suffered greatly over the years from deferred maintenance due to the lack of funds to restore the exterior and interior features of the building.

SOURCE:

20. ***Lamar County.*** *Old Jail Museum and Archives.* 10 October 2011. http://www.lamarcountyga.com/oldjail.html

Historic County Jails

PROFILE

Location: Greenville—Meriwether County

Year Built: 1896

Recognition: National Register of Historic Places— 1973

Georgia Trust for Historic Preservation's *Places in Peril* List - 2008

SOURCE:

21. **Meriwether County History.** *Historic 'Old' Jail.* 10 October 2011. http://meriwetherquest.com/history/jail.html

MERIWETHER COUNTY HISTORIC 'OLD' JAIL

VALUE: The 1896 Meriwether County Jail features an unusual modified Italianate villa style with asymmetrical towers and Romanesque arches.[21] Its three-story hanging tower provides a reminder of an earlier form of capital punishment. Located just off the courthouse square, it is one of Greenville's earliest structures. The jail was listed in the Georgia Trust for Historic Preservation's Places in Peril List in 2008. The building is now privately owned and has received major structural restoration over the past few years.

VULNERABILITIES: The Meriwether County Old Jail is currently vacant. Major structural restorations have been made to this historic building over the past few years. The building is now privately owned and is currently up for sale. The County does not have control over the structure. The building is most vulnerable to incompatible additions and alterations. In addition, funding to restore the building is limited. The County must work with the owner to seek opportunities to preserve this valuable heritage resource.

Historic Covered Bridges

PROFILE

Location: Thomaston—Upson County

Year Built: 1892

Length: 96 feet

Architect: Dr. J.W. Herring

Recognition: National Register of Historic Places —1975

AUCHUMPKEE CREEK COVERED BRIDGE

VALUE: The Auchumpkee Creek Covered Bridge sits just off of US 19 in West Central Georgia. The bridge, built in 1892, is 96 feet long with a town lattice truss.[21] The Auchumpkee Creek Bridge is also known as either the Zorn's Mill Bridge or Hootenville Bridge. The bridge was built by local bridge builder Dr. J. W. Herring and his company, Herring and Alford. The bridge has been rebuilt or restored twice. The first restoration of the bridge occurred in 1985. In the summer of 1994, not long after its 100th birthday, the bridge was washed out by local flooding. In 1997, Georgia Department of Transportation (GDOT) rebuilt the bridge from the ground up.

VULNERABILITIES: The Auchumpkee Creek Covered Bridge is most vulnerable to environmental factors from potential erosion and flooding. The bridge is in excellent condition since being rebuilt in 1997. The structure is not utilized for the transport of vehicles.

SOURCE:

21. ***Georgia Covered Bridges.*** *Auchumpkee Covered Bridge.* 12 October 2011. http://www.gribblenation.com/gapics/covdbrdg/auchumpkee.html

Historic Covered Bridges

PROFILE

Location: Meriwether County

Year Built: 1840s

Length: 391 feet

Architect: Horace King

Recognition: National Register of Historic Places—1973

RED OAK CREEK COVERED BRIDGE

VALUE: The Red Oak Creek Covered Bridge is sometimes called the Imlac Covered Bridge, which spans Red Oak Creek in the small community of Imlac not far from Woodbury, Georgia. Only 12 miles north of Warm Springs, this bridge is a rare surviving example of the ingenuity of famed bridge builder Horace King. Including approaches, it stretches for 391 feet, making it the longest wooden bridge in Georgia.[22] The main span is 253 feet long and is the state's oldest covered bridge. Designed and built by King and possibly his sons during the 1840s using the Town Lattice Truss design, the covered bridge has spanned Red Oak Creek for more than 170 years. It was repaired during the 1980s and still remains in use today. The bridge currently has the capacity to carry cars and small trucks over the Red Oak Creek.

VULNERABLITIES: The Red Oak Creek Covered Bridge is located in the eastern part of Meriwether County near Flint River. The bridge is vulnerable to the affects of environmental factors from erosion and flooding. The bridge is also threatened by the possibility of destructive activities. Long-term preservation of historic covered bridges must be an ongoing effort to ensure its use for future generations.

SOURCE:

22. ***Explore Southern History.*** *Red Oak Covered Bridge.* 12 October 2011. http://www.exploresouthernhistory.com/

Historic Cemeteries & Gravesites

PROFILE

Location: Pike County

SOURCE:

23. R. W. Rogers. ***History of Pike County from 1822 to 1922*** (n.d.);

PROFILE

Location: LaGrange—Troup County

AUSTIN DABNEY GRAVESITE

VALUE: Austin Dabney, a Georgia slave, earned freedom in exchange for his service in the Patriot Army. On August 14, 1786, Dabney became the only African American to be granted land, fifty acres, by the state of Georgia in recognition of his military service during the Revolution.[23] The legislature also provided seventy pounds to emancipate Dabney from his owner, Richard Aycock. At his death in Zebulon in 1830, Dabney left all his land and property to Giles Harris and was buried in the Harris family plot in Pike County. His name appears on a historical marker in Griffin, Georgia.

LAGRANGE STONEWALL CEMETERY & HORACE KING GRAVESITE

VALUE: The LaGrange Stonewall Cemetery is the burial site for Civil War Confederate soldiers and includes the gravesite of covered bridge builder, Horace King. He built a number of covered bridges and other structures throughout the southeast. In the Three Rivers region this includes the Red Oak Covered Bridge in Meriwether County and the eastern block of buildings on LaFayette Square in LaGrange, Georgia. King moved to LaGrange where he and his sons prospered through the work of their construction firm. King died in 1887 and is buried on the grounds of LaGrange's Stonewall Cemetery. In 1978, Horace King's gravesite was discovered and marked by Ocfuskee Historical Society.

VULNERABILITIES: Both the Austin Dabney Gravesite and LaGrange Stonewall Cemetery which features Horace King's gravesite site are subject to potential vandalism and litter. Ongoing maintenance operations are in place to protect these heritage resources.

PROFILE

Location: Griffin, —Spalding County

PROFILE

Location: Griffin—Spalding County

OAK HILL CEMETERY

VALUE: Oak Hill Cemetery was a part of Lewis Lawrence Griffin's original plan for the city. Many persons responsible for the establishment of the City of Griffin and Spalding County are buried in this cemetery. Nationally known figures buried in Oak Hill include James S. Boyton, governor of Georgia, a hero of the Confederate navy, John McIntosh Kell and Martha Eleanora Holliday.[24] The cemetery is one place to walk through Griffin's history.

STONEWALL CEMETERY (GRIFFIN)

VALUE: Stonewall Cemetery is located on part of a plot given as a burial site by General Lawrence Griffin, who founded the City of Griffin in 1840.[24] Several hundred confederate and one (1) union solider, causalities of the Battle of Atlanta and Jonesboro are buried at this cemetery. A principal monument, located at the center of the cemetery, was among the first dedicated to the Confederate dead. The first recorded Confederate Memorial Day in Griffin and the State of Georgia was held on October 26, 1866 at the Stonewall Cemetery.

VULNERABLITIES: The Oak Hill and Stonewall Cemeteries are surrounded by commercial and residential development. The cemeteries are threaten by development pressures from the surrounding areas. In addition, theses cemeteries are vulnerable to looting and vandalism.

SOURCE:

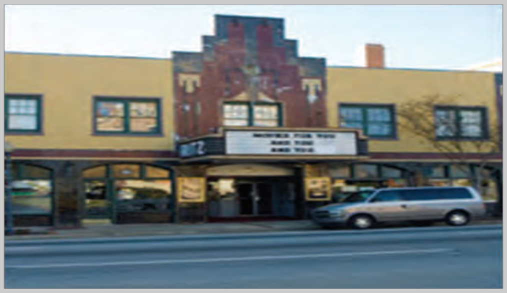
24. ***City of Griffin.*** *Places of Interest.* 12 October 2011. http://www.cityofgriffin.com/Visitors/PlacesofInterest.

Performance Theatres

PROFILE

Location: Thomaston—Upson County

Year Built: 1927



SOURCE:

25. **The Georgia Trust.** *2010 Places in Peril: Ritz Theatre* 12 October 2011. http://www.georgiatrust.org/news/2010pip/.ritz_theatre.

PROFILE

Location: Manchester—Meriwether County

Year Built: 1935

SOURCE:

26. **The President Theatre.** http:www.thepresidenttheatre.com/

RITZ THEATRE

VALUE: Prominently located on the courthouse square in Thomaston, the Ritz Theatre was originally built in the Mission Revival style in 1927, during the height of Thomaston's economic growth.[25] It was sold a year later, and the new owners altered the building, giving it an Art Deco façade. Throughout its history, the Ritz Theatre has served Thomaston and surrounding towns as a home for the arts as well as an anchor on the downtown square. The Ritz Theatre continues to show first run movies and serves more than 24,000 patrons annually. It also provides space for performances and special events to schools, churches, clubs, charitable organizations and private citizens.

THE PRESIDENT THEATRE

VALUE: The President Theatre, a 1935 historic building is of art deco/ art modern design located in Manchester, Georgia.[26] The President was one of over 100 theatres Roy E. Martin Sr. of Columbus, Georgia, owned. Opened during President Franklin Delano Roosevelt's term in Washington, Mr. Martin named the theatre to honor President Roosevelt's presence in Warm Springs, Georgia. The facility was recently restored to its original mid-century beauty and will serve as a community center for Meriwether County.

VULNERABILITIES: Both theatres are located in small downtown communities that have struggled financially due to a declining economy. The structures are most vulnerable to deferred maintenance and incompatible additions. The communities must strive to establish historic preservation regulations that retain the historic integrity and promote its use as community gathering places for special events.

Performance Theatres

PROFILE

Location: Hogansville—Troup County

Year Built: 1937

Architect: O. C. Lam

Recognition: National Register of Historic Places: 2001

THE ROYAL THEATRE

VALUE: The period after World War II and through the Korean War brought great prosperity to the town of Hogansville. It was the commercial center for northern Troup, Heard, and Meriwether Counties and southern Coweta County. Main Street was abuzz with activity, and the sidewalks were choked with shoppers every Saturday. In 1937, the Royal Theatre was built by Mr. O. C. Lam. His brother, Mr. O. C. Lam was superintendent of schools at the time.[27] This theatre, an excellent example of Art Deco style, was the center of social life in Hogansville for decades.

VULNERABLITIES: The Royal Theatre has undergone major renovations over the past decade. However, a leak in the front parapet wall has contributed to water penetrating the Art Deco facade. This water damage is causing tiles to deteriorate, posing a threat to the structure. The theatre is also vulnerable to ongoing operational, maintenance, and restoration costs. With the popularity of home entertainment and multiplex theaters, smaller historic theatres are at risk of becoming obsolete.

SOURCE:

27. **National Trust for Historic Preservation.** 12 October 11. http://www.preservationnation.org/travel-and-sites/sites/southern-region/royal-theater-ga-hogansville.html.

Other Heritage Resources

CHESTNUT OAK CENTER

PROFILE

Location: Pike County

Size: 25 Acres

VALUE: The Chestnut Oak Center offers a unique recreational experience for families in Pike County and surrounding areas. This 25-acre facility is located just south of Zebulon, Georgia. The Center offers a multi-use community center which includes a community conference center, a covered multi-purpose arena, renovated historic buildings, and an outdoor amphitheatre set in natural green spaces with trails that wander through native chestnut oaks.

VULNERABILITIES: Although the Chestnut Oak Center is located in a predominately rural community, the facility may be threaten by future residential or commercial development.

FORT TYLER AND PINEWOOD CEMETERY

PROFILE

Location: West Point, Georgia — Troup County

VALUE: Brigadier General R. C. Tyler, the last general to be killed during the Civil War, died while making a heroic last stand at the Battle of West Point, a little known fight on the border between Alabama and Georgia.[28] Fort Tyler was a square earthwork built atop a high hill in West Point, Georgia. Its primary purpose was to defend the vital bridge over the Chattahoochee River at West Point; a city uniquely located on the west side of the river on a point of land formed by the Alabama border and the Chattahoochee. Fort Tyler has been beautifully reconstructed on its original site, which was reclaimed after years of use as a city reservoir. Located adjacent to Pinewood Cemetery is the Fort Tyler Cemetery Section which is the burial place of General Tyler, the last general killed in the Civil War. The cemetery also contains the graves of 76 Civil War soldiers.

VULNERABILITIES: Fort Tyler maybe at risk to future development and Pinewood Cemetery to road construction projects.

SOURCE:

28. ***Explore Southern History.*** *Fort Tyler Historic Site.* 12 October 2011. http://www.exploresouthernhistory.com/forttyler.html

Other Heritage Resources

PROFILE

Location: Hogansville — Troup County

Year Built: 1939

SOURCE:

29. ***City of Hogansville.*** *History.* 12 October 2011. http://www.cityofhogansville.org/history/

HOGANSVILLE HISTORIC AMPHITHEATRE

VALUE: The Hogansville Amphitheatre was built as a National Youth Administration project in 1939 using stone from a nearby rock quarry. According to historians, local youth and textile workers, idled from a strike, helped build the amphitheatre during the great depression on the school property.[29] The amphitheatre was recently restored for use as a local venue for social gathering events. The amphitheatre is the sight of many local events including a series of concerts given during the Hummingbird Festival and West Georgia Idol.

VULNERABILITIES: The Historic Amphitheatre is most vulnerable to incompatible additions and alterations. Historic preservation design guidelines should be established within this area to protect the structure's unique features.

PROFILE

Location: Meriwether County

Year Built: 1937

Recognition: National Register of Historic Places — 2010

ELEANOR ROOSEVELT SCHOOL

VALUE: The Eleanor Roosevelt School, a one story, large brick building, was constructed in 1937. It was the last Rosenwald School built. Philanthropist, Julius Rosenwald was disheartened by the state of education among African Americans in the rural South. He built over 5,300 schools between 1910s and 1930s to increase educational opportunities for African American youth. The building served as a school until 1972. It was later used as an adult education center, day care center, and carpet cutting and storage facility.

VULNERABILITIES: This vacant building is vulnerable to vandalism, demolition pressures and possible changes to the building's character. Local advocates are currently seeking funds to purchase and rehabilitate the building. The school is structurally sound, but would require over $400,000 in funds for rehabilitation.

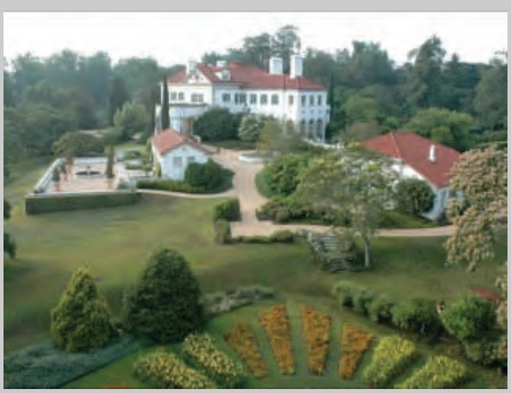
Other Heritage Resources

PROFILE

Location: Troup County

Year Built: 1916

Size: 35 Acres



HILLS & DALES ESTATE

VALUE: This historic estate was the home of textile magnate Fuller E. Callaway, Sr. and his family. The property features the historic Ferrell Gardens which are one of the best preserved 19th century gardens in America. The gardens were created by Sarah Ferrell between 1841 and 1903 and include extensive boxwood plantings, fountains, an herb garden, and a greenhouse. The centerpiece of the 35-acre estate is a beautiful Italian villa designed by the noted architects Neel Reid and Hal Hentz, which was completed in 1916.[30] The Visitor's Center features museum exhibits, a 14 minute orientation film and a gift shop. A major restoration of the house was completed in April of 2010, and all three floors of the home are open for guided tours.

VULNERABILITIES: The Hills and Dales Estate is privately owned and has been fortunate to be afforded a high degree of protection. As with many house museums, however, obtaining and sustaining the necessary funding to cover operating and maintenance expenses is an ongoing effort. Other concerns regarding the Estates' setting and viewsheds include threats from incompatible additions and development to surrounding properties that are not in keeping with the historic character of the property.

SOURCE:

30. ***Hills and Dales Estate. .*** *History.* 12 October 2011. http://www.hillsanddales.org/

Other Heritage Resources

PROFILE

Location: Butts County

Year Built: 1823

Recognition: National Register of Historic Places — May 7, 1973

SOURCE:

31. **Butts County Historical Society.** *Historic Properties* 12 October 2011. http://www.buttscountyhistoricalsociety.org/

PROFILE

Location: Whitesburg—Carroll County

Year Constructed: Moore's House built in 1857

INDIAN SPRINGS HOTEL

VALUE: The Indian Springs Hotel, a circa 1823 hotel, is located in Butts County, Georgia.[31] It was owned by the Creek Indian Chief William McIntosh, who was murdered for his part in signing over the Indian lands to the government. Today, it is a museum rich with heritage and displays a unique history of the Butts County area.

MOORE'S BRIDGE PARK

VALUE: The Moore's Bridge Park is located near Whitesburg, Georgia in Southeast Carroll County and buffers 1.4 miles of the Chattahoochee River. The park is layered with history, including Civil War, Native American, African American, and transportation history. This site once served as the gateway to Southern Carroll County. Priority has been placed on conserving and interpreting the property's rich history and notable features. A key feature of Moore's Bridge Park is the Historic James Moore House. James D. Moore was originally the land owner of this property, and his house is the most historically significant feature still standing on the site. The James Moore house is centrally located within the park just above the former Horace King Covered Bridge site, and provides opportunities for many types of functions including educational and historical events.

***VULNERABILITIES*:** Both the Indian Springs Hotel and Moore's Bridge Park are highly protected heritage resources in the Region. However, local guidelines have not been established to help safe guard these significant resources against incompatible development in areas adjacent to the hotel and park. These resources also remain vulnerable to the challenges of costs associated with ongoing operations, maintenance, and restoration.

Other Heritage Resources

PROFILE

Location: Concord—Pike County

Year Built: 1907

Recognition: National Register of Historic Places - 1982

PROFILE

Location: Pike County

Year Built: 1870

Recognition: National Register of Historic Places - 2008

SOURCE:

32. ***The Whiskey Bonding Barn.*** *History.* 10 October 2011. http://whiskeybondingbarn.com/history.php

R. F. STRICKLAND BUILDING

VALUE: This 1907 two-story brick building, located on Main Street in Concord, Georgia, housed the first business in the area. Strickland's Company began in 1840, and shaped the development of the town of Concord. This building is an important landmark in Pike County and is currently used as a Community Center for the City of Concord and the surrounding regional area.

WILLIAM BARKER WHISKEY BONDING BARN

VALUE: William Thomas Barker (1839-1902), a farmer in Pike County, Georgia, built the whiskey bonding barn circa 1870.[32] Constructed in the late 1800's, soon after the War Between the States, this building most likely served as the local bonding warehouse for local distilleries. Pike Historic Preservation, Inc. purchased and renovated the Barn with an eye toward retaining its architectural integrity and significance as a symbol of the area's agricultural past. On May 12, 2008, the Whiskey Bonding Barn was listed in the National Register of Historic Places.

VULNERABILITIES: The R. F. Strickland Building and William Barker Whiskey Bonding Barn have both undergone major renovations over the past decade. However, these structures are most at risk to incompatible additions and alternations that may develop in the future. The buildings are vulnerable to high costs to maintain the historic integrity and serve as community gathering places.

Appropriate Development Practices

CULTURAL AND HERITAGE RESOURCES

Cultural and heritage resources are especially important to a community, as they make up its unique identity and give a sense of place. These resources are especially sensitive in that development can affect a heritage site in two ways; both directly and indirectly. Development can have an adverse affect to a resource through structural changes and even demolition but also through changes in its historic setting. The site of a cultural or heritage resource can be integral to the historical context in which it embodies. Therefore, potential effects of new development which can involve infrastructure such as roads, demolition or rehabilitation of adjacent structures, infill or redevelopment, should be examined. The examination of these potential effects may lessen or completely rule out any impact to cultural and heritage resources.

Listed below are recommended best management practices for use by developers and landowners to protect our unique cultural and heritage resources. These practices, when applicable, are to be used when designing and developing sites or involve a historic structure located within one mile of a Regionally Important Cultural and Heritage Resource. These recommendations will also be used when conducting Developments of Regional Impact (DRI) reviews for projects located within one mile of a heritage or cultural resource.

- Infill development should be designed to remain compatible with the historic landscape and setting by utilizing existing structures for appropriate adaptive reuse where possible while maintaining architectural integrity.
- Significant site features should be maintained. This includes trees, viewsheds, and existing historic structures. Natural buffers should be established or maintained to protect viewsheds and between incompatible uses.
- New construction and additions should be compatible in mass and scale to historic structures in the area.
- Site plans, building design and landscaping should be sensitive to cultural and historic features of the site.
- New design involving historic interpretations of surrounding structures, which are similar in scale and character, is encouraged to maintain architectural integrity.
- Existing street grid patterns and uniform alignment of facades should be maintained in new construction by orienting new structures at similar setbacks and lot alignment as existing structures.
- Locate any needed parking behind existing structures as to not impede the view to the historic structure.

Policies & Protection Measures

CULTURAL AND HERITAGE RESOURCES

Listed below are general policies and protection measures intended to guide local governments in planning and decision making which affect Regionally Important Cultural and Heritage Resources. Local governments play an active and vital role in the protection of cultural and heritage resources through the comprehensive planning process, policy decisions, and code enforcement.

- Local governments should seek to protect, preserve, promote, the cultural and heritage resources of the Three River's region that contribute to its unique character.
- Seek to list significant historic structures to the National Register of Historic Places.
- Projects involving historic resources listed on the National Register should adhere to the *Secretary of the Interior's Standards for the Treatment of Historic Properties.* Structures not listed on the National Register are encouraged to follow the same standards.
- Support, cooperate with and take advantage of programs offered by various agencies which support historic resources such as the Georgia Historic Preservation Division, the Georgia Trust for Historic Preservation, the National Trust for Historic Preservation, Advisory Council on Historic Preservation, Main Street and Better Hometown organizations, and any other non-profit organizations.
- Encourage the maintenance and adaptive reuse of all historic buildings, sites, structures, districts, and objects when possible.
- Consider adopting a tree ordinance to allow for the preservation of mature trees which are significant to the resources setting.
- Consider adopting a historic preservation ordinance, designating a local historic district and becoming a Certified Local Government.
- Encourage and support the sensitive use of cultural and historic sites as tourist attractions and modes of economic development when appropriate.
- Support and strengthen any existing historic preservation commissions, regulations, and incentives within a project area. Establish regulations and incentives where none exist.
- Consider the adoption of form-based codes as an alternative to traditional zoning regulations.
- Regulations regarding signage at a particular historic site should encourage the sensitivity of the resources.
- Cultural and heritage resources are to be protected from destruction, inappropriate infill development, and/or incompatible alterations that would negatively affect and historic structure or site.
- Historic resources are to be considered valuable and integral parts of a community which make up its identity and sense of place.

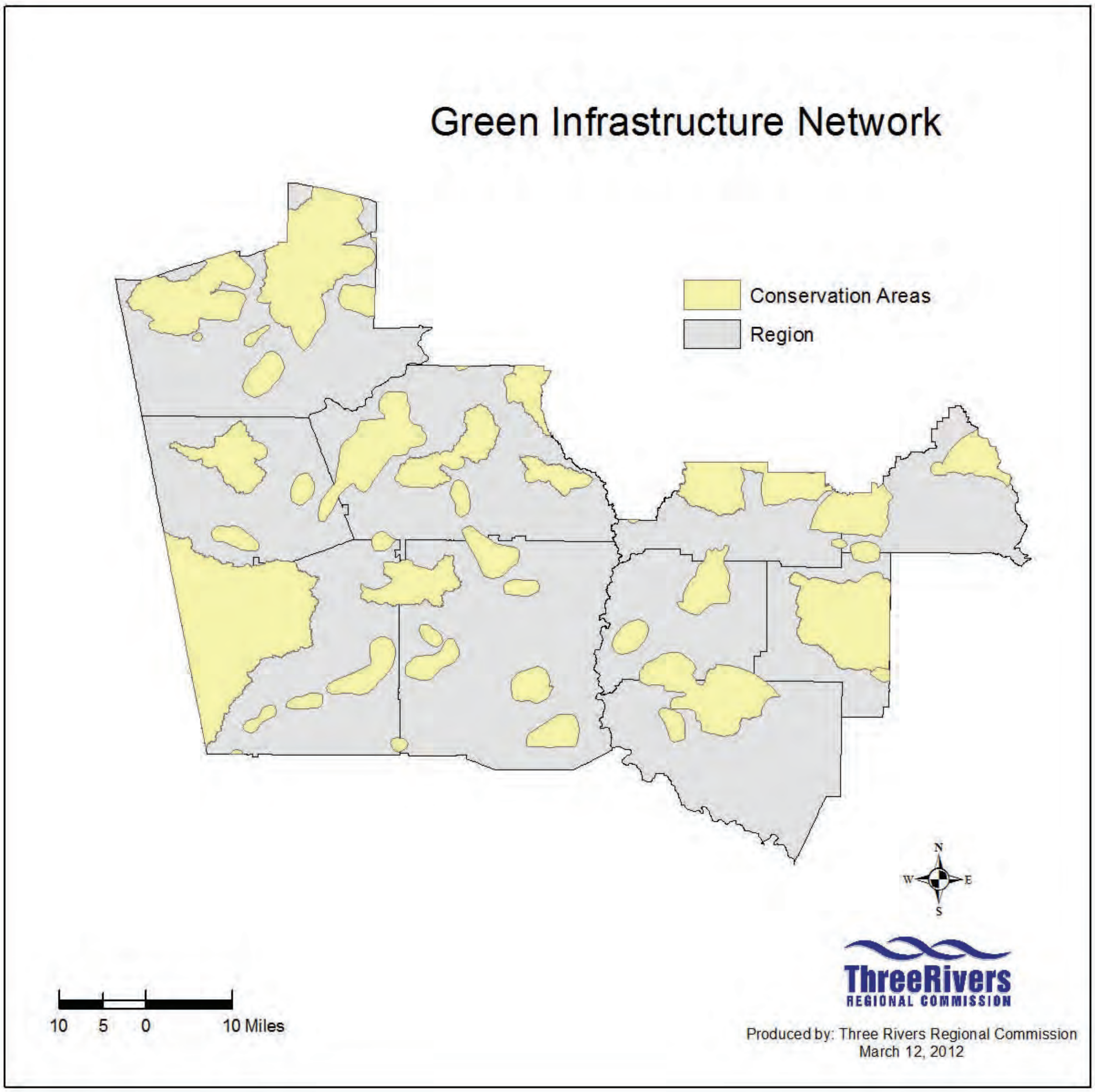
Regionally Important Resources Map

Regionally Important Resources Map

The RIR map is a visual representation of cultural, natural, and water resource within the boundaries of the Three Rivers Regional Commission. The map was created using layers from the state vital areas, submissions from our local governments, and suggestions from the Three Rivers staff.

Green Infrastructure Map

The Green Infrastructure Map is a union of the conservation areas within our Future Development Map, and the Regionally Important Resources Map. This union illustrates a network of both public and private areas of conservation and provides important linkages across the region.



Appendix

Resource Listing

Resource Listing

REGIONALLY IMPORTANT RESOURCE NOMINATION FORM

ThreeRivers REGIONAL COMMISSION

A Regionally Important Resource is defined as any natural or cultural resource, or resource area, possessing significant regional value and importance and which is vulnerable to human actions or activities.

ORGANIZATION/AGENCY/GOVERNMENT NOMINATING THE RESOURCE

NAME:

MAILING ADDRESS:

CONTACT PERSON:

TELEPHONE AND/OR E-MAIL ADDRESS:

RESOURCE TO BE NOMINATED

NAME OF RESOURCE:

LOCATION (Please list at least one available source of reference for the specific location):

- **PHYSICAL ADDRESS:** ____
- **TAX PARCEL #:** ____
- **LATITUDE/LONGITUDE:** ____

TYPE OF RESOURCE (Please select all that apply):

____ **NATURAL RESOURCE** ____ **HISTORIC/CULTURAL RESOURCE** ____ **PARK**

____ **ARCHEOLOGICAL RESOURCE** ____ **FOREST/WILDLIFE PRESERVE**

ATTACH A MAP OF RECOMMENDED RESOURCE BOUNDARIES

Is a map of the proposed resource included with this nomination?: _____**Yes** _____ **No**

PLEASE RETURN THIS FORM NO LATER THAN APRIL 30, 2011 to:

THREE RIVERS REGIONAL COMMISSION

- ***Griffin Office:***

Attn: Aronda Smith
PO Box 818
Griffin, GA 30224
Tel: (678) 692-0510
Fax: (678) 692-0513
Email: asmith@threeriversrc.com

- ***Franklin Office***

Attn: Paul Jarrell
PO Box 1600
Franklin, GA 30217
Tel: (706) 675-6721
Fax: (706) 675-0448
Email: pjarrell@threeriversrc.com

ThreeRivers REGIONAL COMMISSION

REGIONALLY IMPORTANT RESOURCE NOMINATION FORM

PROVIDE A BRIEF STATEMENT WHICH EXPLAINS WHY THIS RESOURCE IS BEING NOMINATED:

PROVIDE A BRIEF, STATEMENT WHICH EXPLAINS THE IMPORTANCE OF THE RESOURCE BEING NOMINATED AND ITS NEED FOR PROTECTION:

ThreeRivers REGIONAL COMMISSION

REGIONALLY IMPORTANT RESOURCE NOMINATION FORM

PROVIDE A BRIEF, WRITTEN DESCRIPTION OF THE RESOURCE'S VALUE THAT ADDRESSES ITS IMPORTANCE TO THE REGION:

REGIONALLY IMPORTANT RESOURCE NOMINATION FORM

PROVIDE A BRIEF, WRITTEN DESCRIPTION OF THE RESOURCE'S VULNERABILITIES INDICATING THE DEGREE TO WHICH THE RESOURCE IS THREATENED OR ENDANGERED.

REGIONALLY IMPORTANT RESOURCES SELECTION CRITERIA

ThreeRivers REGIONAL COMMISSION

REGIONALLY IMPORTANT RESOURCES **are defined as any natural or cultural resource areas identified as being of regional importance. Following identification of these resources, the Regional Commission will prepare a REGIONAL RESOURCE PLAN recommending best practices for their protection and management. This REGIONAL RESOURCE PLAN will be used by the Regional Commission to promote coordination of activities and planning by local governments, land trusts, and conservation or environmental protection entities to better manage their resources. Resources identified through this process will be mapped and linked to form a continuous regional green infrastructure network. This network will be presented on a Regionally Important RESOURCES MAP that will be widely distributed throughout the region.**

SELECTION CRITERIA FOR REGIONALLY IMPORTANT RESOURCES:

- Resource nominated by an individual, interested organization, local government/government agency;
- Resource identified by the Georgia Department of Natural Resources as a State Vital Area;
- A natural or natural resource that is already preserved by an existing conservation mechanism; and
- A natural or cultural resource identified by other state agencies and/or environmental protection organization.

SELECTION CRITERIA FOR NOMINATED RESOURCE:

The following criteria will be given priority in the review of all proposed nominations:

1. Preserves water quality and quantity by protecting drainage, flood control, recharge areas, watersheds, buffers etc.
2. Creates or preserves active or passive greenspaces including trails, gardens and informal places of natural enjoyment in areas currently underserved by greenspace.
3. Protects wildlife habitat by creating, buffering or preserving habitat areas and corridors.
4. Preserves areas that have historical or cultural value by virtue of history, place or time period represented.
5. Preserves significant working agricultural or forest resources and/or creates opportunities for local food production.
6. Areas that contribute to region-wide connections between existing and proposed regional resources.

TIMELINE

- Solicitation of nominations - March 1 through April 30, 2011
- The Planning Advisory Council will evaluate nominations May - June 2011 and recommend RIRs to RC Council for designation.
- RC Council will designate RIRs in June 2011.
- Development of Regional Resource Plan July— September 2011.
- Submit Regional Resource Plan to Georgia Department of Community Affairs - October 2011
- RC Council adopts Regional Resource Plan - December 2011.

REGIONALLY IMPORTANT RESOURCES PLANNING ADVISORY COUNCIL

PURPOSE:

The purpose of the ***Planning Advisory Council*** is to coordinate regional planning efforts and provide guidance to the Three Rivers Regional Commission in the task of updating its Regionally Important Resources Plan. The Planning Advisory Council is expected to play an advisory role in providing information and recommendations related to Regionally Important Resources.

COMPOSITION:

- The Planning Advisory Council shall consist of twenty (20) members appointed by the Three Rivers Regional Council.
- The Planning Advisory Council shall include at least two (2) representatives from each County within the Three Rivers Regional Commission.
- It is recommended that at least six (6) representatives be actively involved in a conservation, environmental, historic or cultural organization.

DUTIES:

The primary duties of the Planning Advisory Council shall include:

- Review nominations for regionally important resources;
- Recommend regionally important resources for approval by the Three Rivers Regional Council; and
- Recommend best practices to be considered by developers for designing new development to be located within one mile of any area included on the Regionally Important Resource Map.

MEETING DATES:

- The Planning Advisory Council will meet at least once a month.
- Meetings are scheduled to commence in July 2011 and end in September 2011.

NEXT STEPS:

- Each County is asked to nominate two (2) individuals to serve on the Planning Advisory Council.
- The Regional Council shall appointed the Planning Advisory Council at its April 2011 meeting.

REGIONALLY IMPORTANT RESOURCES PLANNING ADVISORY COUNCIL

PURPOSE:

The purpose of the ***Planning Advisory Council*** is to coordinate regional planning efforts and provide guidance to the Three Rivers Regional Commission in the task of updating its Regionally Important Resources Plan. The Planning Advisory Council is expected to play an advisory role in providing information and recommendations related to regionally important resources.

#1—INDIVIDUAL TO BE APPOINTED TO THE PLANNING ADVISORY COUNCIL
NAME:
ORGANIZATION:
COUNTY:
MAILING ADDRESS:
TELEPHONE AND/OR E-MAIL ADDRESS:

#2—INDIVIDUAL TO BE APPOINTED TO THE PLANNING ADVISORY COUNCIL
NAME:
ORGANIZATION:
COUNTY:
MAILING ADDRESS:
TELEPHONE AND/OR E-MAIL ADDRESS:

Shoreline Management Guidelines

GEORGIA POWER LAKES

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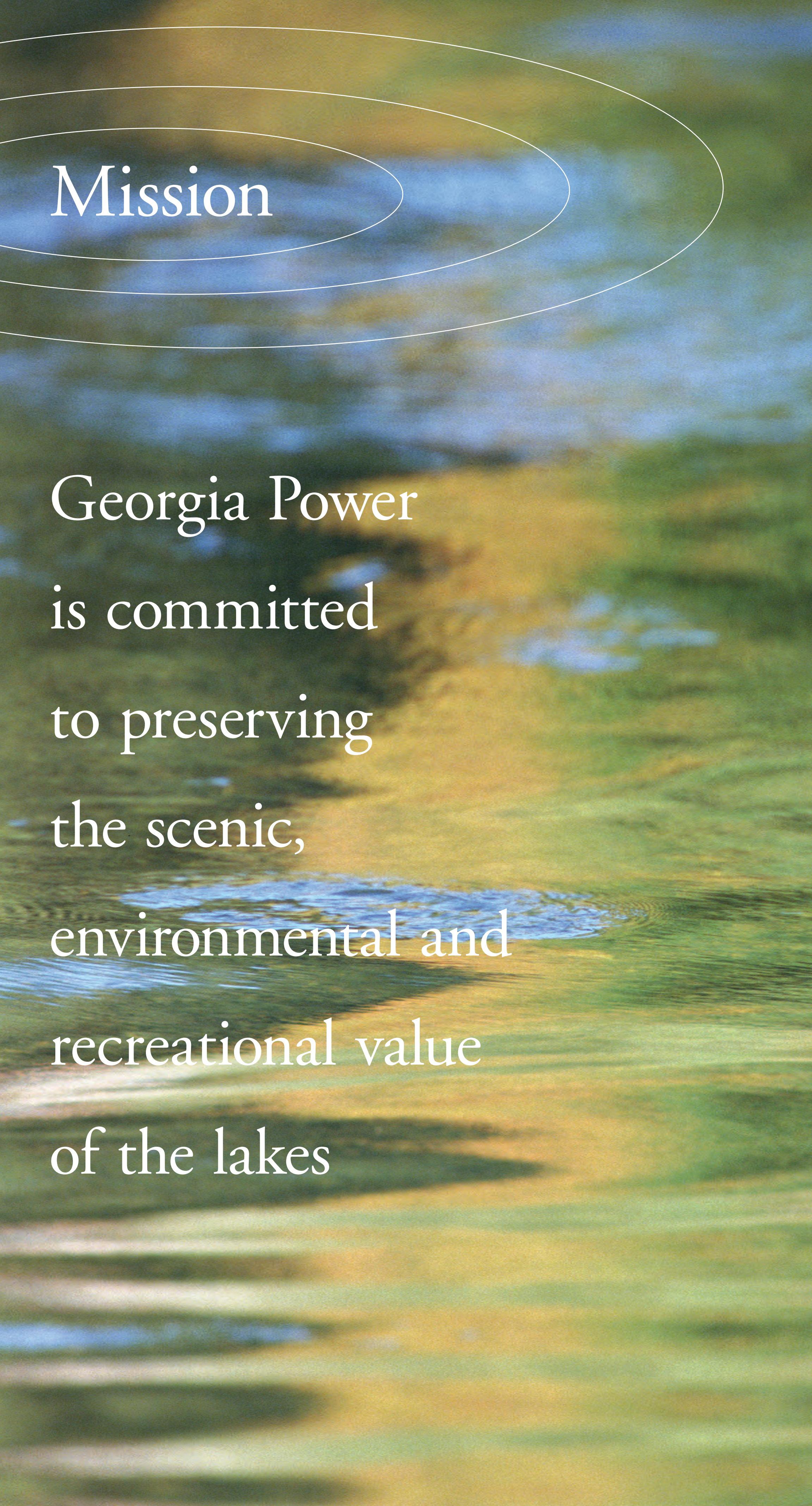

Mission
Georgia Power is committed to preserving the scenic, environmental and recreational value of the lakes

General Guidelines

- A valid lease agreement (GP lots & Access lots), license (deeded lots) or Multi-Use License Agreement is required in order to receive permits for construction on GP lakes and property. A current survey and/or deed are required before GP will issue any new agreement (license, access lease, etc.).

- Maximum dimensions found herein are a general standard, not a guarantee. Each permit request is handled on a case by case basis at the discretion of the GP Land Management Office.

- A GP permit must be applied for and issued before beginning any construction, renovation, clearing, tree removal, grading, etc., on GP land.

- A permit should be posted and be visible from the lake and/or road. Failure to post permit could result in work stoppage.

- All permits will have an approval date and a completion date. These dates are recognized as the starting date of the project and the expiration date of the permit. If construction will continue past the permitted completion date then a permit extension is required.

- Any changes in plans, after initial approval of construction, must be reviewed and approved by GP before change is executed.

- Unauthorized construction activities or failure to comply with GP's permitting process may result in construction delays, removal of unauthorized project, sterilization of shoreline, termination of lease/license and/or legal action.

- Regarding property lines: There is a minimum fifteen-foot setback from side lot line or any such extended imaginary lot line as determined by extending line lakeward. The imaginary line, extended lakeward, will be recognized by GP on a case by case basis. It is not reasonable to expect this extended line to be feasible in all cases.

- To protect the vegetative buffer surrounding the lake, no mechanical clearing shall be permitted within 25 feet of the shoreline or county setbacks, whichever is greater.

- Any ground disturbing activities shall require the proper installation of silt screen at least 26 feet from the shoreline or as determined by the GP Land Management Office and local county ordinances.

- Generally, older structures that do not conform with current policies or guidelines may be maintained, but not expanded or replaced. GP may require modification of these old structures to conform with current policies or guidelines, prior to transfer or renewal of a lease/license agreement or approval of other construction activities.

- It is the responsibility of the homeowner to properly dispose of any shoreline structure/s that have been replaced or removed.

- All construction adjacent to or within GP lakes shall be maintained in a good state of repair and shall comply with any and all federal, state, and local health and safety regulations as now or hereafter enacted.

- Dumping, burying or otherwise disposing of any portion of a downed tree on GP property or into the lake is prohibited. The disposal of leaves and lawn clippings into the lake is also prohibited.

Construction Permit

How to obtain a GP Construction Permit

1 Read and be familiar with the guidelines in this booklet.

2 Contact GP's Land Management Office for instructions on obtaining a permit.

3 Each permit request is handled on a case by case basis at the discretion of GP Land Management Office.

4 A valid GP lease agreement or license is required in order to receive permits for construction of GP lakes and property.

5 Submit your application containing the following information to the GP Land Management Office. Depending on the scope of the project, GP may require additional information before issuing a permit.

- Name
- Lake lot address (lot number/area number, if available)
- Phone number(s)
- Drawing of the proposed project
- Dimensions
- Distances from side lot lines
- Materials to be used
- Contractor's name and phone number
- Expected start date and completion date

NOTICE: It is the responsibility of the homeowner to make sure that all permits are obtained and properly posted before work begins.

Introduction

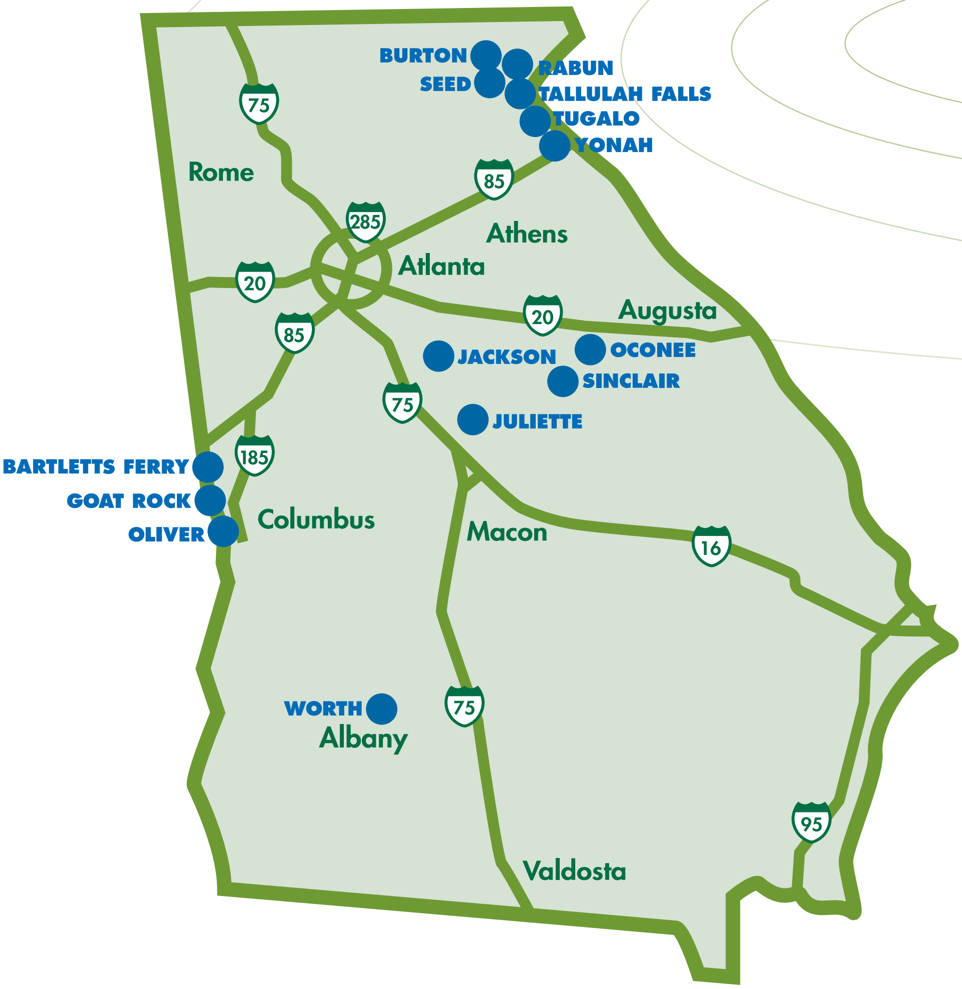
This booklet provides information and guidance to homeowners, prospective buyers, builders, realtors, and other interested parties regarding shoreline development on Georgia Power's (GP) lakes. The purpose of the booklet is to present a sound, consistent position on this development while protecting the environmental and aesthetic qualities of the lake. Above all else, the information in this booklet is intended to comply with all legal requirements — from our Federal Energy Regulatory Commission (FERC) license to all federal, state and local laws and regulations.

The proper management of shoreline development must balance the interests of a number of stakeholders and is vital to the life of the lake. It is our hope that communicating the guidance in this booklet will ensure that we will all enjoy the many beneficial opportunities the lakes afford for years to come. We ask that you read all the information contained in this booklet and that you call us if you have any questions.

Thank you for your interest in the GP lakes. We look forward to working with you to make your lake experience an enjoyable one.

enhance • wildlife habitat

protect water quality • reduce erosion



North Georgia Land Management Office
#4 Seed Lake Road
Lakemont, GA 30552
706-746-1450

Lake Jackson Land Management Office
180 Dam Road
Jackson, GA 30233
404-954-4040

Lake Oconee/Sinclair Land Management Office
125 Wallace Dam Road
Eatonton, GA 31024
706-484-7500

Bartletts Ferry Land Management Office
1516 Bartletts Ferry Road
Fortson, GA 31808
706-322-0228

or call **1-888-GPC LAKE**
(1-888-472-5253)
www.georgiapower.com/gpclake

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Information contained herein is subject to change without notice.

1101107

revised 2011

dredging

Georgia Power Lakes

- GP is authorized to permit dredging of up to 500 cubic yards per lot. Greater amounts will require approval from U.S. Army Corps of Engineers, FERC and additional agencies.
- Dredging plans must be submitted and approved before work begins.
- By obtaining a dredging permit from GP, the permittee agrees to:

  1 Abide by all governmental rules, laws, regulations, directives and statutes.

  2 Acquire all necessary governmental permits or licenses, which may include, but shall not be limited to, a soil disturbing activity permit.

- Applicants must provide the volume of material to be removed. A qualified engineer or surveyor should determine this information (especially for large projects over 400 cubic yards). An estimate sheet is to be attached to the permit request.
- Removal of original lake/river bottom is prohibited. The sole purpose for dredging is to remove silt or sedimentation that has accumulated over time.
- The material removed from the lake shall be disposed of in upland area so as to avoid re-entry into lake.
- Regarding deeded property, a property line agreement shall be executed prior to dredging activity to establish pre- and post-dredging property rights.

• Each permit request is handled on a case by case basis at the discretion of GP Land Management Office.
• A valid GP lease agreement or license is required in order to receive permits for construction on GP lakes and property. • A GP permit must be applied for, issued andposted properly before beginning any construction, renovation, clearing, tree removal, grading, etc., on GP land.
• Information contained herein is subject to change without notice.

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tree removal

Georgia Power Lakes

- Tree removal requires a written permit.
- Written approval from the local issuing authority (county) may be required if removing a tree from the lake side of the dwelling.
- To protect the vegetative buffer surrounding the lake, no mechanical clearing will be permitted within 25' of the shoreline.
- Tree removal is prohibited without a valid reason.
- Removal of trees may require a re-vegetation plan. GP promotes a 1 for 1 tree replacement policy (nursery grade). Native trees and hardwoods are recommended.
- GP reserves the right to receive reimbursement for merchantable timber.
- Tree removal is the responsibility of the homeowner.
- Tree removal requests must be accurate regarding the number of trees to be removed and detailed regarding process and disposal.
- If tree removal involves significant earth disturbance, proper erosion and sedimentation controls must be followed, including installing a silt fence to protect shoreline and re-vegetative plan.
- For land disturbances of 1.1 acres or greater: A copy of the county's land disturbance permit is required in order to receive a permit from GP.
- All portions of the tree/s (limbs, stump/s, etc.) must be properly removed from the lot. Dumping, burying, or otherwise disposing of any portion of the tree on GP property, lease lots, or lake is prohibited.
- The disposal of leaves, grass clippings or other yard debris into the lake is prohibited.

• Each permit request is handled on a case by case basis at the discretion of GP Land Management Office. • A valid GP lease agreement or license is required in order to receive permits for construction on GP lakes and property. • A GP permit must be applied for, issued and posted properly before beginning any construction, renovation, clearing, tree removal, grading, etc., on GP land. • Information contained herein is subject to change without notice.

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1101107

residential shoreline use

The requirements listed below are part of the GP shoreline management guidelines and are intended to protect and enhance the scenic, recreational and environmental values of the lake, and to be compatible with the overall lake project recreational use.

New lots

- A newly created residential lot must have a minimum lot width of 100' of shoreline and must recognize GP's existing shoreline property right. Shoreline footage from adjacent, existing lots may not be used to meet the 100' length for a new lot if the overall result is that either or both of the adjacent, existing lots have less than 100' of shoreline. This 100' width requirement must extend back from the shoreline of a depth and configuration that is acceptable to GP. Lots that would impact the environmental features of the lake (i.e., wetlands, vegetative buffers, etc.) or that do not comply with federal, state, or local rules or regulations will not be authorized for shoreline structures. Final determination of the required 100' of shoreline is at the discretion of the GP Land Department Representative.
- Certain lot configurations, such as pie shaped lots, whose side lot line projections across GP property towards the lake results in less than 100' of shoreline will not qualify for any shoreline structures.
- No shoreline structures will be permitted on a deeded or leased property without a single family residence being established prior to the construction of the shoreline structures. GP may require a recorded plat for deeded property prior to issuing any shoreline structures to ensure compliance with the shoreline footage requirement.

Established Lots

- An original lot that was created as part of an established subdivision prior to GP's shoreline management guidelines will be allowed to maintain shoreline structures with less than 100' of shoreline, unless the lot is split, altered or reconfigured in any way. The construction

continued

or modification of shoreline structures on an original lot with less than 100' may be restricted in size and/or number of structures. In some cases, only the maintenance of existing structures will be permitted. **Any splitting, alteration, or reconfiguration of the lot will make the lot a "new" lot, and it must then meet the 100' shoreline requirement as listed above.** Any existing agreements with GP authorizing the shoreline structures will be cancelled and GP may require any existing shoreline structures to be removed. GP may require a recorded plat for deeded property prior to issuing any shoreline structures to ensure the lot has not been altered and is in compliance with the shoreline footage requirement.

Commercial and Off-Shore Developments

- Permits for shoreline structures are intended to be used for single family, residential dwellings only, with the exception of authorized marinas. The use of permitted shoreline structures for commercial purposes or for access by off-shore developments is incompatible with the overall lake project recreational use. The single family, residential dwelling must be adjacent to the shoreline and meet the shoreline requirements listed above. Permits for shoreline structures for single family residential use may not be converted to use for commercial developments or for off-shore development areas. The unauthorized use of these shoreline structures will result in the cancellation of any existing agreement with GP and may result in the removal of the structures.

- Existing shoreline structures that were built prior to the shoreline management guidelines for commercial use or off-shore development use may not be expanded, altered or modified beyond the usage currently in place without prior authorization from GP.

• Each permit request is handled on a case by case basis at the discretion of GP Land Management Office.
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GEORGIA POWER
A SOUTHERN COMPANY

dwellings & additions

Lake Jackson

- Only one residential dwelling is permitted on GP lease lots.
- Residential dwellings shall be limited to two stories above ground.
- New residential dwellings must be at least 900 square feet or County minimums, whichever is greater. Mobile homes are prohibited.
- All new construction should be above the project boundary (545' MSL Contour). If this is not feasible, new construction shall be 75' from shoreline if inside project, at least 50' if outside GP project, and satisfy local county buffer setbacks. Side setbacks must meet county guidelines, or 15', whichever is greater.
- The following information should be provided to GP prior to issuing a construction permit:

  1 Architectural drawing/s, copies of plans from published plan books, or detailed sketches drawn by hand.

  2 Applicant's name, address, phone number/s, lot number and area number.

  3 Name and phone number of contractor or individual doing construction.

  4 Anticipated date of beginning and approximate date of completion.

  5 Floor plan depicting length, width, square footage, and height.

  6 A list of exterior construction materials to be used.

  7 A description of roof system (roof must be shingle or baked enamel).

  8 A description of exterior color scheme.

  9 Drawing or photograph showing how the structure will look from the lake.

  10 Drawing or photograph showing the side view of the structure.

  11 Site plan showing distances between proposed structure and:

  a both side lot lines

  b back lot line

  c closest point from shoreline

  12 Site plan showing proposed location of the County approved septic tank, drain fields, and well plans.

continued

dwellings & additions
continued

Lake Jackson

13 All pertinent State and Local permits including, but not limited to:

- **a** Septic tank permit (if applicable)
- **b** Building permit
- **c** Land disturbing permit (> 1.1 acres if applicable)
- **d** Local county buffer variance approval

14 Site plan depicting approximate number and size of trees (4" diameter or greater) to be removed within the building perimeter, driveway, and septic tank and drain field lines.

15 Landscape plan

- Structures must be completely underpinned with block or brick.
- Fences are prohibited on the shoreline and are restricted in other areas. If permitted, fences may not impede project access and may not block the view of adjacent neighbors.
- Fence location, description and typed of material must be submitted for approval prior to construction.
- The following objects may not be attached to the exterior of residences or accessory buildings or structures that are located on land owned by GP, nor installed or placed on land or property owned by GP, without GP's prior written permission:

a satellite dishes;

b security or surveillance cameras;

c stereo or sound systems;

d free-standing flagpoles;

e signs, placards, or banners with measurements greater than two feet by two feet;

f statues, figurines, artwork, or monuments with a height or width greater than 2'; or

g other objects that, in GP's judgment, may restrict a neighbor's view of the lake, may interfere with a neighbor's enjoyment of the lake, may be offensive to a reasonable person or inappropriate for viewing by minors, or may create a safety hazard or nuisance to persons using the lake or persons present on land owned by GP.

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GEORGIA POWER
A SOUTHERN COMPANY

1101107-J1

outbuildings

Lake Jackson

- Outbuildings include but are not limited to detached garages, storage buildings, and greenhouses.
- Outbuildings shall be limited to one story.
- A maximum of two outbuildings per lot. This includes a maximum of one detached garage in addition to one attached garage (an attached garage is described as one that is directly adjacent to and attached to the heated primary residential dwelling).
- Maximum size of a detached garage: 900 sq. ft.
- Detached garages may not include temporary or permanent living spaces. Plumbing is also prohibited.
- Storage buildings other than detached garages shall be limited to 12' x 16' or 192 sq. ft. Requests for larger structures will be reviewed on a case by case basis.
- Outbuildings should be located behind the dwelling and/or at least 75' from shoreline if inside the GP project, 50' from shoreline if outside, and satisfy county setbacks.
- Maintain the greater of County code or at least 15' setback from side property lines.
- All outbuildings should match the primary residential dwelling in color and design.
- A building permit from the county may be required in order to receive a GP permit.

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GEORGIA POWER
A SOUTHERN COMPANY

gazebos, picnic shelters & decks

Lake Jackson

- Enclosing the above structures is prohibited.
- Maximum size — 20' x 20'.
- Number of structures limited to discretion of GP Land Management.
- Plumbing, other than water spigots, and pumps is prohibited.
- The above structures may not be attached to shoreline structures.
- Maintain the greater of County code or at least 15' setback from side property lines.
- These structures must be in a location that satisfies local county buffer setbacks and/or 50' from the shoreline, whichever is greater.
- Regarding deeded property, these structures must be off of GP property and satisfy local buffer setbacks.
- Written approval from the local issuing authority may be required when placing accessory structures on the lake side of the dwelling.

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GEORGIA POWER
A SOUTHERN COMPANY

1101107-J2

seawalls

Lake Jackson

- All applicable state and local permits and variances must be obtained before constructing a new seawall.
- Due to changing environmental requirements, this document is to be used only as a guideline. Consult your local GP Land Management Office for current seawall regulations and requirements.
- Seawall construction will require proper erosion and sedimentation controls according to GP and local county requirements.
- Plans should show the following:

  1 the length of shoreline to be fronted by the seawall.

  2 the type of foundation to be installed and depth below ground line.

  3 the type of materials to be used for construction of the seawall.

  4 the height of the seawall (Max 6" above 530' MSL contour)

  5 a re-vegetation plan.

- The distance between the proposed seawall and the existing shoreline shall not exceed 2'. The location of the proposed seawall must be staked at 25' intervals in order for inspectors to assure the original contour is adhered to as close as possible. For very irregular shoreline, stakes shall be no more than 10' apart.
- Creosote timbers are prohibited for new seawall construction or additions to other than creosote seawalls.
- New seawalls constructed with concrete block will require the blocks to be filled solid with concrete and stucco must be applied to the lakeside of the wall.
- GP requires the placement of rip-rap along the base of all seawalls. This application helps reduce undermining and restores shoreline habitat. Recommended amount from normal (full pool) water level: slope ratio of 1' of width per every 1' of depth.

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GEORGIA POWER
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ramps

Lake Jackson

- Existing ramps may be maintained and renovated.
- Written approval from the local issuing authority (county) is required for ramp renovations.

If a permit is issued:

- Ramp may not be built so as to cross over the projected lot line as determined by GP by extending imaginary side lot lines lakeward.
- A 15' setback from side lot lines must be maintained.

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GEORGIA POWER
A SOUTHERN COMPANY

1101107-J3

wharves

Lake Jackson

Wharves are considered an alternative when other standard or typical shoreline structures are either not functional, prohibited, or when special needs are present. Wharves will not be permitted otherwise. If permitted, a maximum of one wharf may be permitted per lot.

- Regarding newly established lots or developments: A minimum lot width of 100' is required in order to have any shoreline structures. Seawalls are the exception.
- Wharf must be adjacent to shoreline.
- Maximum total width may not exceed 10'.
- Total length may not exceed 30'.
- Maintain at least 15' setback from property lines.
- Plumbing, other than water spigots and pumps, is prohibited.

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GEORGIA POWER
A SOUTHERN COMPANY

1101107-J4

boatslips

Lake Jackson

- Regarding newly established lots or developments: A minimum lot width of 100' is required in order to have any shoreline structures. Seawalls are the exception.
- There is a minimum 15' setback from side lot line or any such extended imaginary lot line as determined by extending line lakeward.
- A maximum of one double (2) stall structure is allowed (if no stall structure currently exists). The addition of a wet storage slip will require the removal of a dry storage structure if one exists.
- The size and length of all shoreline structures should be minimized when practical. The maximum standard overall length will be 50' from the shoreline. Some locations, such as narrow coves, wetland areas, etc., may require a shorter boatslip or may be prohibited from having any structure.
- Maximum exterior dimensions for boatslips are as follows (dimensions include walkways):

  Single – 16' wide x 32' long
  Double – 28' wide x 32' long
- The minimum width of walkway is 4'. Maximum width, 6'.
- Plumbing, other than water spigots and pumps, is prohibited.

boathouses (boatslip plus roof)

Lake Jackson

- Regarding newly established lots or developments: A minimum lot width of 100' is required in order to have any shoreline structures.
- There is a minimum 15' setback from side lot line or any such extended imaginary lot line as determined by extending line lakeward.
- Metal “carport” covers are prohibited for use as boathouse structures.
- The size and length of all shoreline structures should be minimized when practical. The maximum standard overall length will be 50' from the shoreline. Some locations, such as narrow coves, wetland areas, etc., may require a shorter boatslip or may be prohibited from having any structure.
- Maximum exterior dimensions for a boathouse structure are as follows (dimensions are from post to post):

  Single Stall — 16' wide x 32' long
  Double Stall — 28' wide x 32' long
- Roofs must be shingle or baked enamel and must match residential dwelling. Minimum pitch 2/12, maximum 6/12.
- Sun decks are prohibited
- Boathouse structures may not be constructed or renovated so as to allow temporary or permanent residence. Plumbing, other than water spigots and pumps, is prohibited.

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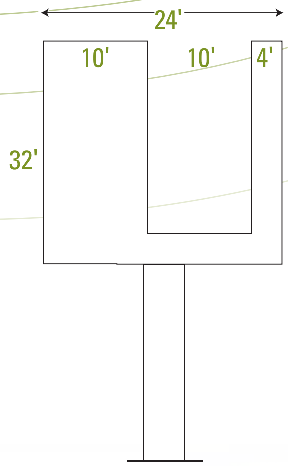
GEORGIA POWER
A SOUTHERN COMPANY

1101107-J5

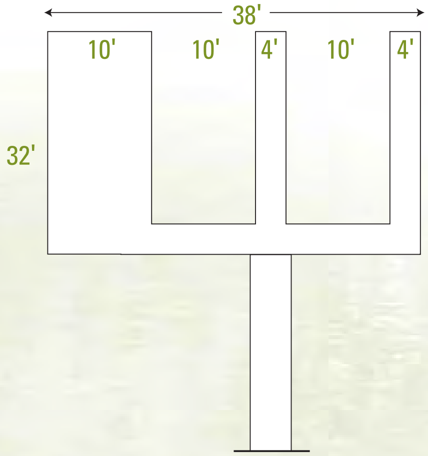
boathouse/boatslip

Lake Jackson

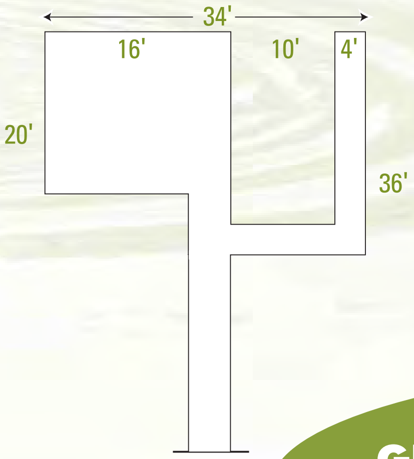
SINGLE FLOATING COMBO



DOUBLE FLOATING COMBO



SINGLE STATIONARY COMBO



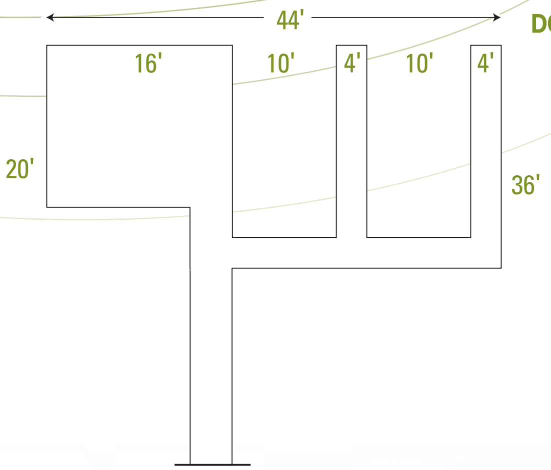
NOTE: 100' min. shoreline required for any boathouse

GEORGIA POWER
A SOUTHERN COMPANY

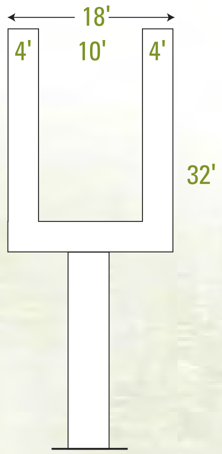
boathouse/boatslip

Lake Jackson

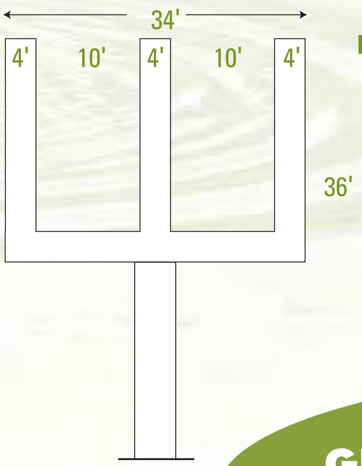
DOUBLE STATIONARY COMBO



SINGLE



DOUBLE



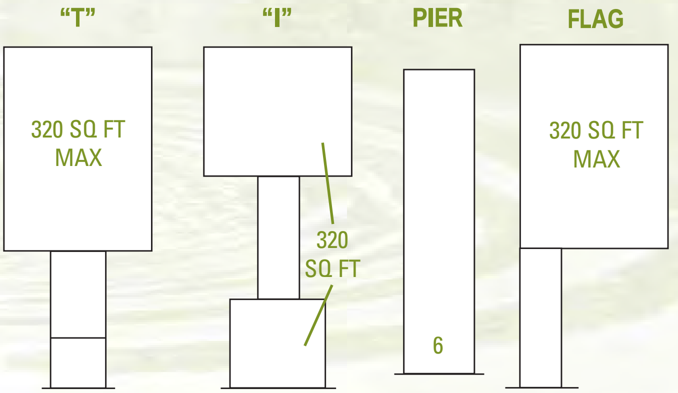
NOTE: 100’ min. shoreline required for any boathouse

GEORGIA POWER
A SOUTHERN COMPANY

docks

Lake Jackson

- Regarding newly established lots or developments: A minimum lot width of 100 feet is required for all shoreline structures. Seawalls are the exception.
- There is a minimum 15' setback from side lot line or any such extended imaginary lot line as determined by extending line lakeward.
- Only one dock is allowed per lot.
- Docks may be floating or stationary or a combination of both. Only approved encapsulated or Dow Polystyrene flotation will be permitted for use with floating docks. Metal drums, plastic barrels, modified pontoon boats and other such items or materials are prohibited.
- The stationary platform of a dock, which is adjacent to the shoreline, may be covered; however, screening or enclosing the structure is prohibited.
- Only one roofed shoreline structure allowed per lot.
- Docks cannot extend beyond 50' in length from the shoreline.
- Maximum dimensions on any portion of a dock are 16' x 20' with no single dimension exceeding 20'.
- The minimum width of walkway is 4'. Maximum width, 6'.
- Walkways may be located in the middle ("T" or "I" shape) or to either side of the platform (Flag shape).
- Plumbing, other than water spigots and pumps, is prohibited.
- Replacement of unapproved flotation may be required at the time of any dock renovation or replacement. Replacement of unapproved flotation will be required at time of lease/license renewal or transfer.



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GEORGIA POWER
A SOUTHERN COMPANY

dock, boathouse or boatslip combinations

Lake Jackson

The combination structure is offered to help the property owner reduce the cost and maintenance, and the impact on shoreline by eliminating the need for multiple structures. Therefore, this structure is available only if additional structures are not present, will be removed, or are not desired.

- Regarding newly established lots or developments: A minimum lot width of 100' is required in order to have any shoreline structures. Seawalls are the exception.
- There is a minimum 15' setback from side lot line or any such extended imaginary lot line as determined by extending line lakeward.
- A maximum of one double (2) stall combination is allowed (if no stall structure currently exists).
- Enclosing any portion of the combination is prohibited.
- The size and length of all shoreline structures should be minimized when practical. The maximum standard overall length will be 50' from the shoreline. Some locations, such as narrow coves, wetland areas, etc., may require a shorter boatslip or may be prohibited from having any structure.
- Maximum exterior dimensions for boatslip-dock or boathouse-dock combination are as follows (dimensions include walkways):

  Single Stall Combination — 34' wide x 36' long (16' x 32' under roof)
  Double Stall Combination — 44' wide x 36' long (28' x 32' under roof)
  • The maximum square footage of the swim platform may not exceed 320 sq. ft.
- The slip portion of the combination may be covered. The roof must be baked enamel or shingle. The roof should match dwelling regarding look and color.
- The minimum width of walkway is 4'. Maximum width, 6'.
- Plumbing, other than water spigots and pumps, is prohibited.
- Combination structures may not be constructed or renovated so as to allow temporary or permanent residence.

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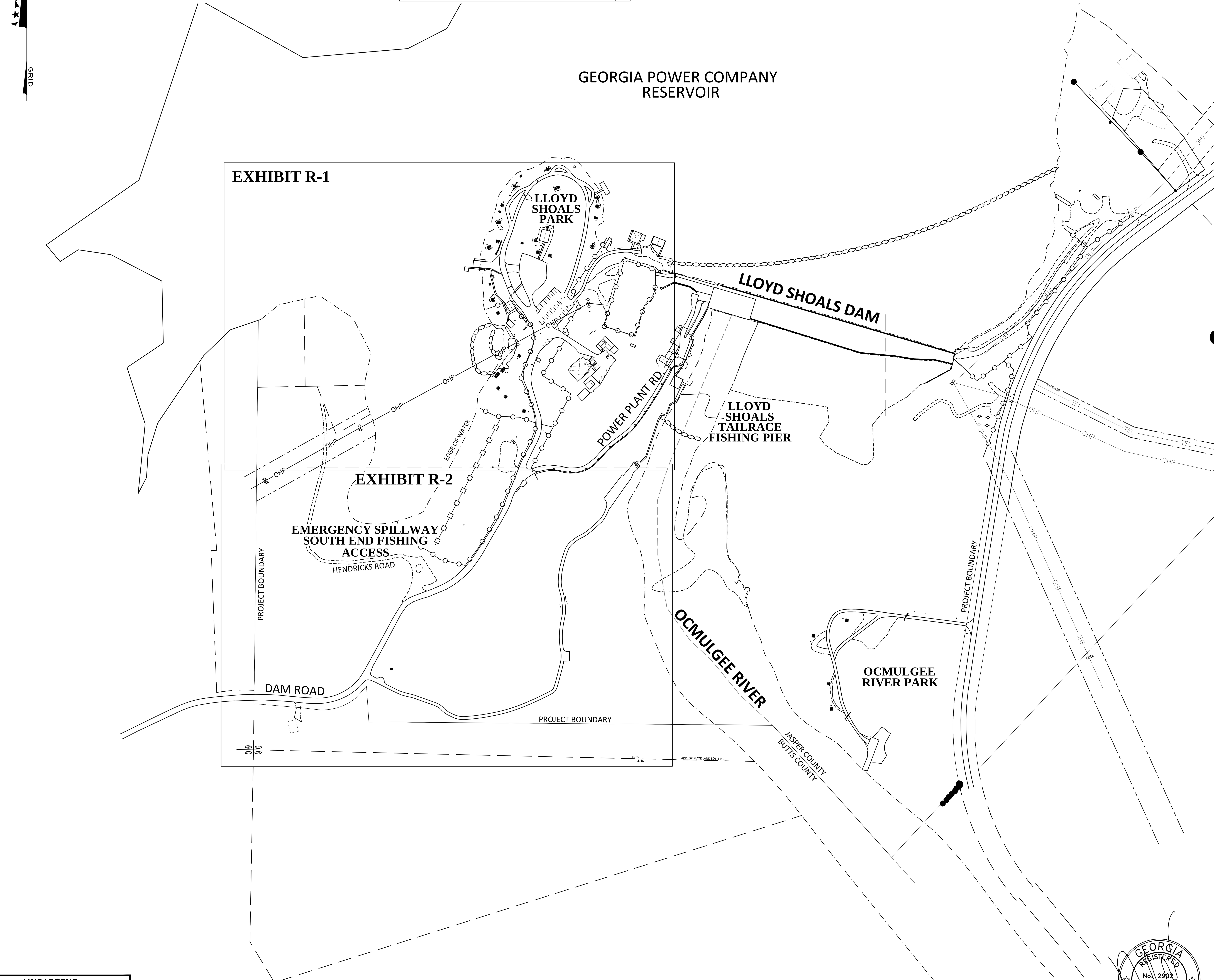
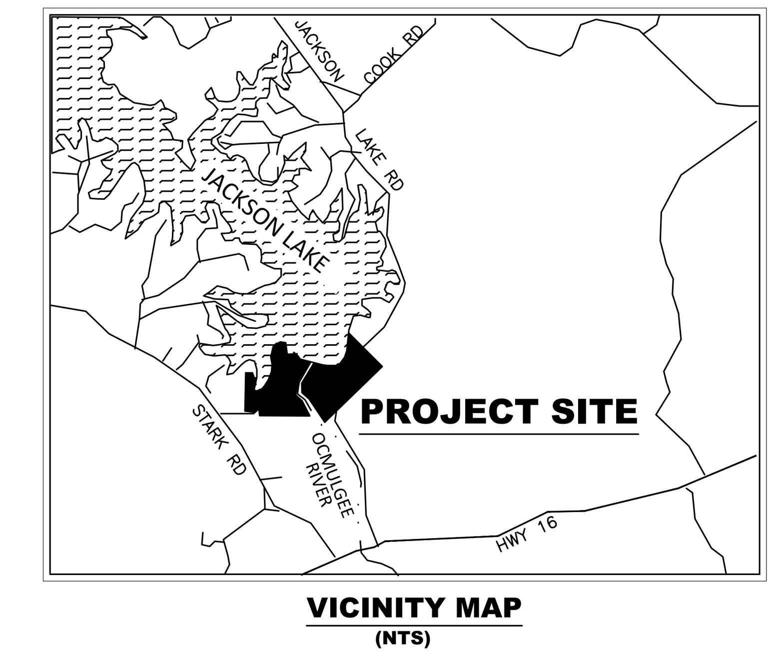
GEORGIA POWER
A SOUTHERN COMPANY

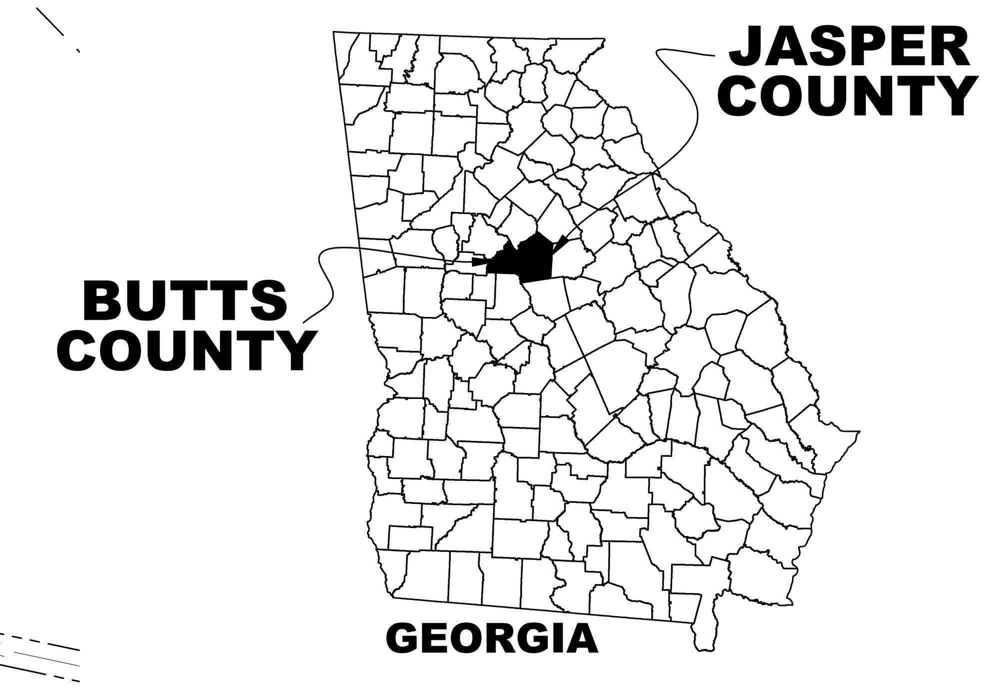
1101107-J6

IDENTIFICATION	EXHIBIT NO.	RECREATION SITE NAME
R-0		INDEX SHEET
R-1		LLOYD SHOALS PARK
R-1		LLOYD SHOALS TAILRACE FISHING PIER
R-2		EMERGENCY SPILLWAY SOUTH END FISHING ACCESS
R-3	EX R-3	OCMULGEE RIVER PARK (a.k.a. BOAT RAMP ACCESS BELOW LLOYD SHOALS DAM)





VICINITY MAP
(NTS)



SUBJECT PROPERTY INFORMATION:
CURRENT OWNER: GEORGIA POWER COMPANY
BUTTS COUNTY TAX RECORD: 00810-800-00
JASPER COUNTY TAX RECORD: 031A 033

FIELD DATA WAS COLLECTED USING A LEICA TS12 ROBOTIC TOTAL STATION AND A JAVAD TRIUMPH-LS DUAL-FREQUENCY RTK GLOBAL POSITIONING SYSTEM RECEIVER REFERENCING THE eGPS STATEWIDE NETWORK AND HAVING A RELATIVE POSITIONAL ACCURACY OF LESS THAN 0.04 FEET.

FIELD SURVEY COMPLETED IN FEBRUARY, 2017.

EASEMENTS OR RIGHTS-OF-WAY MAY EXIST WHICH ARE NOT SHOWN HEREON AND MAY BE RECORDED OR UNRECORDED.

COORDINATES DEPICTED HEREON REFERENCE THE GEORGIA STATE PLANE SYSTEM, WEST ZONE, NAD83, IN US FEET. VERTICAL INFORMATION PROVIDED HEREON REFERENCES NAVD88.

A 25-FOOT UNDISTURBED BUFFER IS ESTABLISHED BY THE STATE OF GEORGIA FROM THE TOP OF CREEK BANKS ON BOTH SIDES OF CREEKS FOR EROSION CONTROL PURPOSES.

OCMULGEE RIVER FROM HIGHWAY 16 BRIDGE NORTH TO BOAT BARRIER IS CLASSIFIED AS A HAZARDOUS BOATING ZONE.

0' 200' 400' 600'
SCALE 1" = 200'

PLAT ABBREVIATIONS

IPF – Iron Pin Found
IPS – Iron Pin Set w/plastic cap stamped "Jordan Engineering RLS 2902"
CTP – Crimp–Top Pipe
OTP – Open Top Pipe
CM – Concrete Monument
AI – Angle Iron
LL – Land Lot
D.B. – Deed Book
P.B. – Plat Book
P.C. – Plat Cabinet
SL – Slide
P.O.B. – Point of Beginning
P.O.R. – Point of Reference
FEMA – Federal Emergency Management Agency
OHP – Overhead Power
N.T.S. – Not to Scale
LL 128 – Land Lot Number
GPC – Georgia Power Company
NOF – Now or Formerly

MONUMENTATION LEGEND

Iron Pin Set w/plastic cap stamped "Jordan Engineering RLS 2902"
Iron Pin Found
Monument Set
Monument Found
Computed Point
CP1 Control or Traverse Point
TR1 Geodetic Control Point
Benchmark or Temporary Benchmark (TBM)

UTILITY LEGEND

Well
Power Pole
Transmission Tower
Guy Wire

LINE LEGEND

PROPERTY BOUNDARY
OHP OVERHEAD POWER
EASEMENT
ADJOINING PROPERTY LINE
CREEK OR SHORELINE
ASPHALT PAVEMENT
EDGE OF DIRT/GRAVEL
STRUCTURE (AERIAL LOC)
WIRE FENCE
DRAINAGE PIPE

GEORGIA REGISTERED No. 2902 LAND SURVEYOR ROBERT O. JORDAN

Corporate License No. LSF 000768

JORDAN ENGINEERING
144 N. WARREN ST. MONTICELLO, GA 31064
(706) 468-8999 www.jordan-eng.com
Engineering • Surveying • Soils Classification

T:\Working2\landmgt\LLOYD SHOAL (LAKE JACKSON)\20170001_Lloyd Shoals Recreational Facilities As-built Survey

REVISION BLOCK

APPROVALS

Georgia Power Company, Atlanta, Ga.
Land Department

LLOYD SHOALS HYDROELECTRIC PROJECT
LLOYD SHOALS RECREATION AREA
FERC PROJECT NO. 2336
LAND LOT 55, DISTRICT 9, G.M.D. 552, BUTTS COUNTY, GEORGIA
LAND LOTS 191 & 202, DISTRICT 18, G.M.D. 296, JASPER COUNTY, GEORGIA

DR. HSH	TR.	Checked ROJ
SCALE 1"=200'		DATE 04.17.2017
DRAWING NUMBER		SHEET NUMBER
		EXHIBIT R-0

S:\ZARCHIVES\SURVEY ARCHIVES\2017\GPC-LLOYD SHOALS REC AREA\LLOYD SHOALS REC AREA R6.DWG July 19, 2017

T:\Working2\landmgt\LLOYD SHOAL (LAKE JACKSON)\20170001_Lloyd Shoals Recreational Facilities As-built Survey
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REVISION BLOCK
APPROVALS
DR. HSH
TR.
Checked ROJ
SCALE 1" = 50'
DATE 04.17.2017
DRAWING NUMBER
SHEET NUMBER
EXHIBIT R-1
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PROJECT SITE
JACKSON LAKE
HWY 16
VICINITY MAP
(NTS)
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STRUCTURE (AERIAL LOC)
WIRE FENCE
DRAINAGE PIPE
0' 50' 100' 150'
SCALE 1" = 50'
GRID
LLOYD SHOALS PARK
PUBLIC RECREATION AREA
JACKSON LAKE
BOATHOUSES FOR GEORGIA DNR, BUTTS CO. SHERIFF'S DEPT., & GEORGIA POWER COMPANY
2' RETAINING WALL
PICNIC AREA
ASPHALT
FISHING PIER
BENCH
WOODED
PAVILLION
SIGN
TRASH CAN (TYP.)
GRILL (TYP.)
RETAINING WALL
FLOATING DOCK
DOCK
CONCRETE RAMP
STATIONARY DOCK
CONCRETE
ASPHALT PARKING
RAMP SIGN
PICNIC AREA
CONC. RAMP
GRAVEL
BOAT BARRIER
GEORGIA POWER COMPANY SUBSTATION
CHAIN LINK FENCE
RESTROOMS
CONC. WALL
ASPHALT PARKING
GATE
OHP
SOLAR POWER
CHAIN LINK FENCE
PICNIC TABLE & CONC. PAD (TYP.)
PAVILLION
BLOCK BLDG
SILO
CONCRETE WALL
BEACH AND SWIMMING AREA
SAND PILE
PROJECT MANAGEMENT OFFICE
OVERLOOK PLATFORM
SHED
18" RET. WALL
COVERED SHED
GATE
SWIM AREA BARRIERS
CONC. RETAINING WALL
ASPHALT
GUARD SHACK
WOODED
ASPHALT
12" RETAINING WALL
COVERED SHED
PROJECT MANAGEMENT OFFICE
OLD RAMP
NO ACCESS
CARPORT
OLD WALKWAY TO PIER (CLOSED)
CHAIN LINK FENCE
METAL SHED
PICNIC AREA WOODED
OCMULGEE RIVER
NOF
CHARLES R. MCCURRY
BOBBIE MCCURRY
D.B. 292, p.143
P.B. 14, p. 389
PROJECT BOUNDARY
NATURAL AREA
20' ASPHALT
LLOYD SHOALS TAILRACE FISHING PIER
FISHING PIER
LANDSCAPE WALL
APPROXIMATE LOCATION OF LLOYD SHOALS - JACKSON TRANSMISSION LINE 100' RIGHT OF WAY
POWER PLANT ROAD
BOAT BARRIER
GRAVEL
CHAIN LINK FENCE
GUARDRAIL
HANDICAP ACCESSIBLE FISHING DOCK RAMP
BUTTS COUNTY
JASPER COUNTY
MATCHLINE SHEET 1
MATCHLINE SHEET 2
GRATE INLET
ASPHALT
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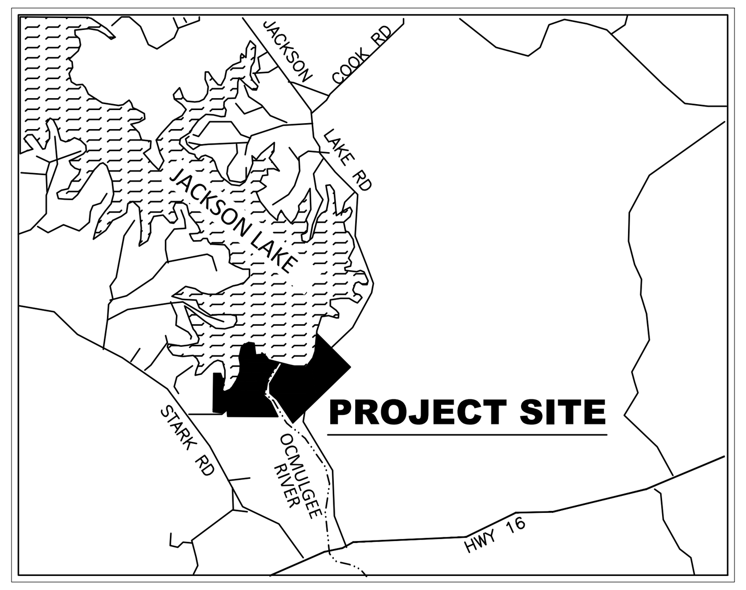


VICINITY MAP
(NTS)

SUBJECT PROPERTY INFORMATION:
CURRENT OWNER: GEORGIA POWER COMPANY
BUTTS COUNTY TAX RECORD: 00810-800-00
JASPER COUNTY TAX RECORD: 031A 033

FIELD DATA WAS COLLECTED USING A LEICA TS12 ROBOTIC TOTAL STATION AND A JAVAD TRIUMPH-LS DUAL-FREQUENCY RTK GLOBAL POSITIONING SYSTEM RECEIVER REFERENCING THE eGPS STATEWIDE NETWORK AND HAVING A RELATIVE POSITIONAL ACCURACY OF LESS THAN 0.04 FEET.

FIELD SURVEY COMPLETED IN FEBRUARY, 2017.

EASEMENTS OR RIGHTS-OF-WAY MAY EXIST WHICH ARE NOT SHOWN HEREON AND MAY BE RECORDED OR UNRECORDED.

COORDINATES DEPICTED HEREON REFERENCE THE GEORGIA STATE PLANE SYSTEM, WEST ZONE, NAD83, IN US FEET. VERTICAL INFORMATION PROVIDED HEREON REFERENCES NAVD88.

A 25-FOOT UNDISTURBED BUFFER IS ESTABLISHED BY THE STATE OF GEORGIA FROM THE TOP OF CREEK BANKS ON BOTH SIDES OF CREEKS FOR EROSION CONTROL PURPOSES.

OCMULGEE RIVER FROM HIGHWAY 16 BRIDGE NORTH TO BOAT BARRIER IS CLASSIFIED AS A HAZARDOUS BOATING ZONE.

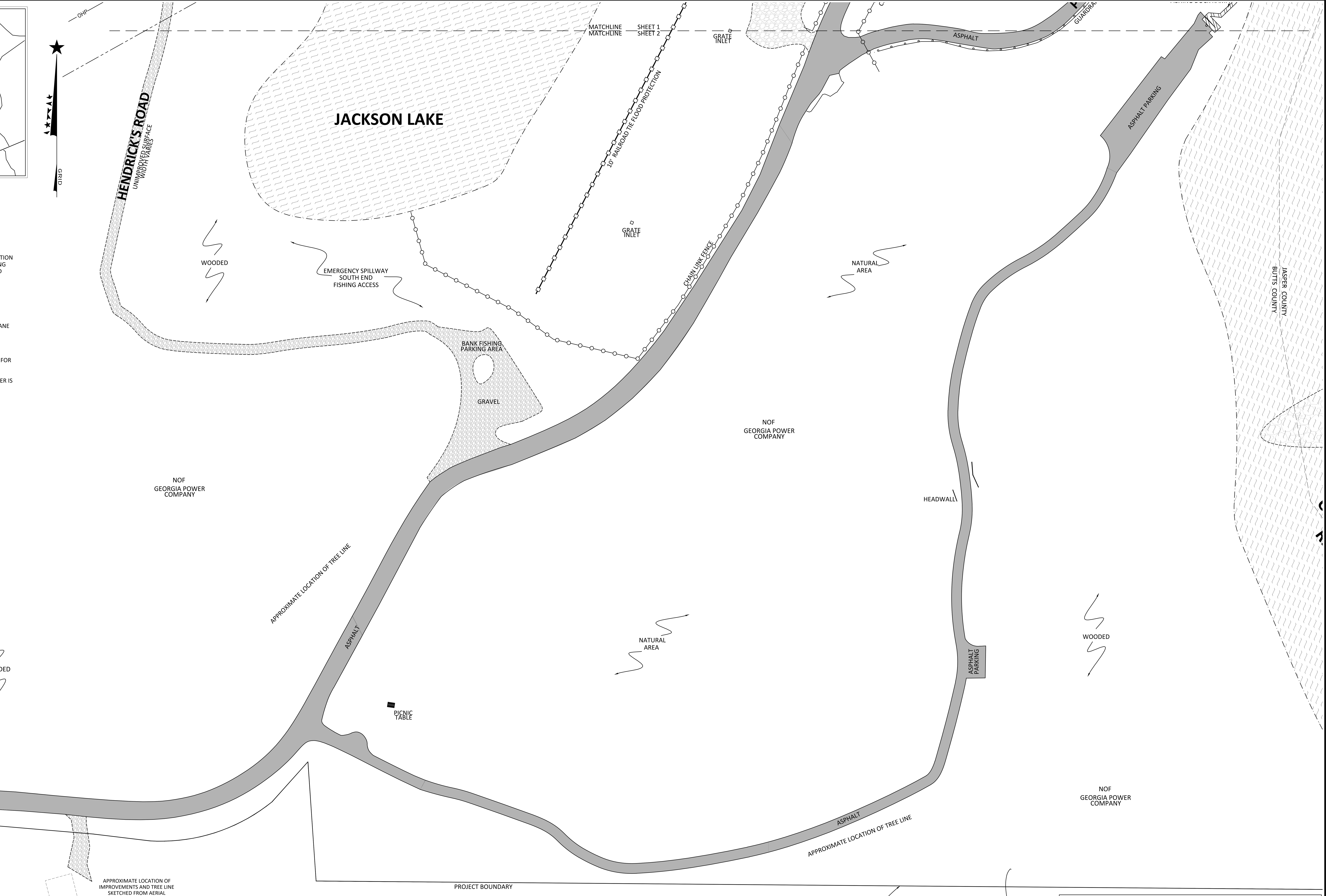
0' 50' 100' 150'
SCALE 1" = 50'

PLAT ABBREVIATIONS
IPF – Iron Pin Found
IPS – Iron Pin Set w/plastic cap stamped "Jordan Engineering RLS 2902"
CTP – Crimp–Top Pipe
OTP – Open Top Pipe
CM – Concrete Monument
AI – Angle Iron
LL – Land Lot
D.B. – Deed Book
P.B. – Plat Book
P.C. – Plat Cabinet
SL – Slide
P.O.B. – Point of Beginning
P.O.R. – Point of Reference
FEMA – Federal Emergency Management Agency
OHP – Overhead Power
N.T.S. – Not to Scale
LL 128 – Land Lot Number
GPC – Georgia Power Company
NOF – Now or Formerly

MONUMENTATION LEGEND
Iron Pin Set w/plastic cap stamped "Jordan Engineering RLS 2902"
Iron Pin Found
Monument Set
Monument Found
Computed Point
CP1 Control or Traverse Point
TR1 Geodetic Control Point
Benchmark or Temporary Benchmark (TBM)

UTILITY LEGEND
Well
Power Pole
Transmission Tower
Guy Wire

LINE LEGEND
PROPERTY BOUNDARY
OHP OHP OVERHEAD POWER
EASEMENT
ADJOINING PROPERTY LINE
CREEK OR SHORELINE
ASPHALT PAVEMENT
EDGE OF DIRT/GRAVEL
STRUCTURE (AERIAL LOC)
WIRE FENCE
DRAINAGE PIPE



GEORGIA REGISTERED No. 2902 LAND SURVEYOR ROBERT O. JORDAN

Corporate License No. LSF 000768

JORDAN ENGINEERING
144 N. WARREN ST. MONTICELLO, GA 31064
(706) 468-8999 www.jordan-eng.com
Engineering • Surveying • Soils Classification

T:\Working2\landmgt\LLOYD SHOAL (LAKE JACKSON)\20170001_Lloyd Shoals Recreational Facilities As-built Survey

REVISION BLOCK

Georgia Power Company, Atlanta, Ga.
Land Department

LLOYD SHOALS HYDROELECTRIC PROJECT
LLOYD SHOALS RECREATION AREA
FERC PROJECT NO. 2336

LAND LOT 55, DISTRICT 9, G.M.D. 552, BUTTS COUNTY, GEORGIA
LAND LOTS 191 & 202, DISTRICT 18, G.M.D. 296, JASPER COUNTY, GEORGIA

APPROVALS

DR. HSH	TR.	Checked ROJ
SCALE 1" = 50'		DATE 04.17.2017
DRAWING NUMBER		SHEET NUMBER
		EXHIBIT R-2

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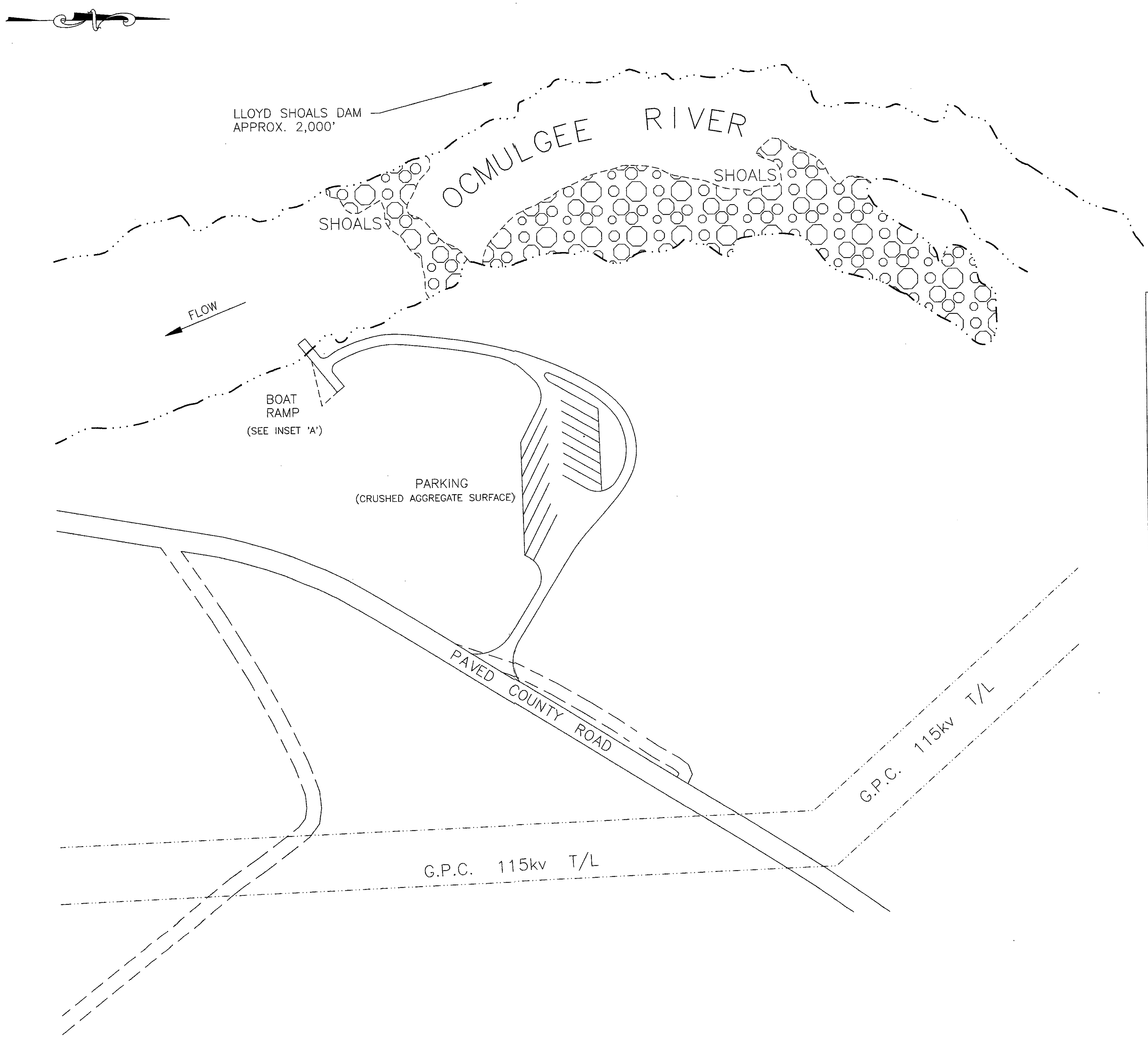
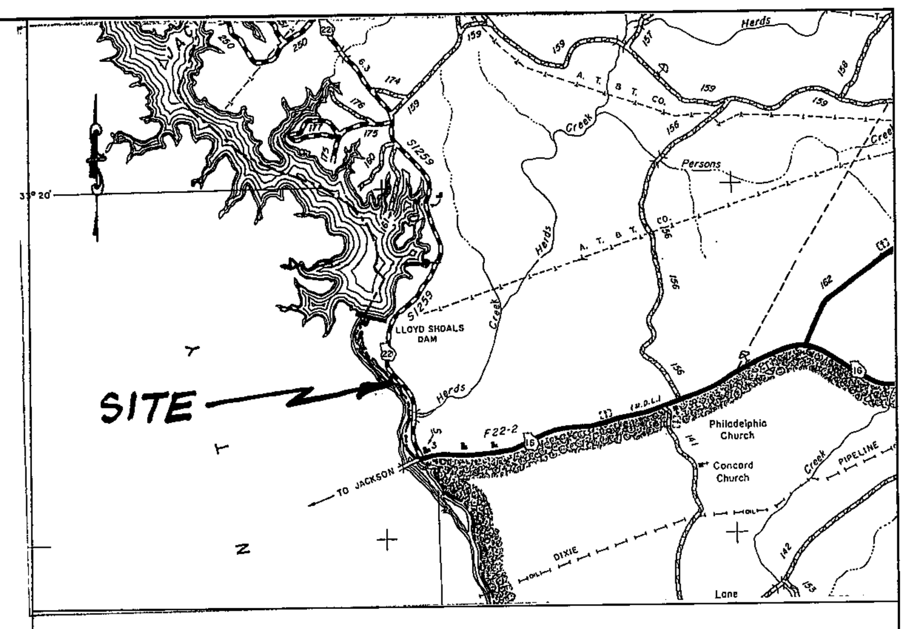
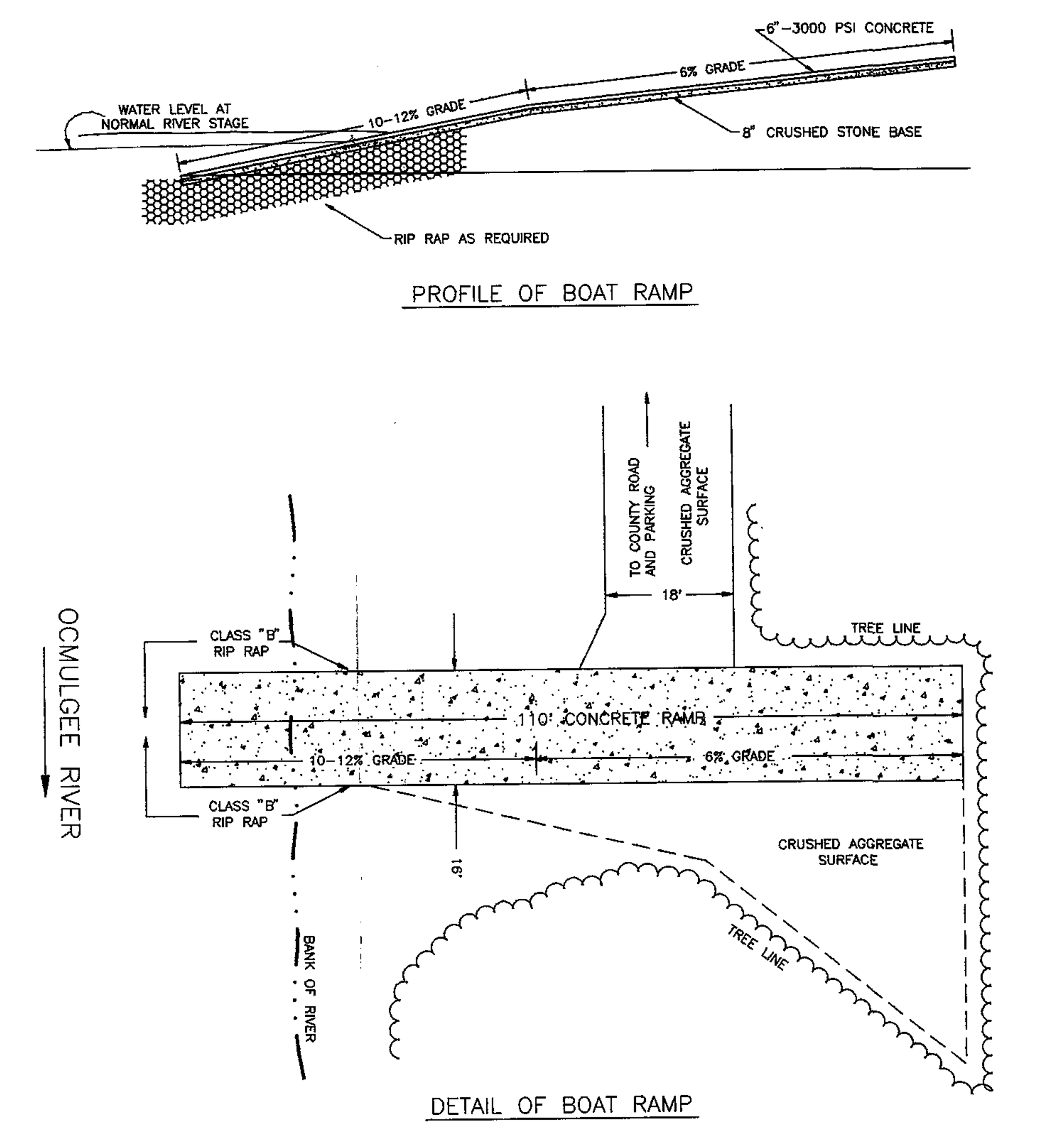




Location Map – Not to Scale

EXHIBIT R-3



INSET A
SCALE: 1" = 20'

GRAPHIC SCALE

100 0 50 100 200 400

(IN FEET)
1 inch = 100 ft.

GEORGIA POWER CO., ATLANTA, GA. LAND DEPARTMENT					
LLOYD SHOALS PROJECT AS-BUILT DESIGN DRAWING Boat Ramp Access Below Lloyd Shoals Dam					
DR. GLSease	TR.	CH'K [signature]	SCALE As Shown	DATE 2-13-95	DRAWING NUMBER L 530 – 11

FERC NO. 2336-52