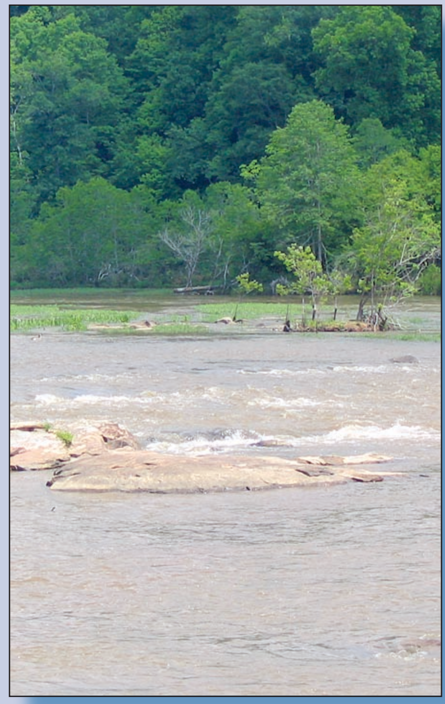
Water Availability for Ecological Needs in the Upper Flint River Basin, Georgia

The Flint River Science Thrust project of the U.S. Geological Survey is part of a federally funded program to address key national science priorities including landslides/debris flows, fire science, integrated landscape monitoring, and water availability. The purpose of the project is to advance the science needed to specify the hydrologic conditions necessary to support flowing-water ecosystems. This information is critical for management of water resources. Specific project goals include:

- Develop conceptual models that relate hydrology, geomorphology, and water quality to biological management objectives.
- Evaluate and determine the major factors driving the conceptual models and determine additional data needs.
- Use the upper Flint River Basin to demonstrate a spatially explicit predictive model for evaluating water-supply development options that links watershed conditions to biological management objectives.
- Identify research and monitoring needed to address critical uncertainties and data gaps determined during model development.



Sustaining the ecological integrity of aquatic ecosystems while meeting human needs for water resources is a major challenge facing society. In many regions, including the Eastern United States, the growing demand for water supply and changing land use, such as urbanization, are altering hydrologic regimes in streams and rivers that society depends on for ecological services. These services include drinking, irrigation, and industrial water supplies; assimilation and removal of waste; mitigation of droughts and floods; control of river channel erosion; recreation; fisheries; and maintenance of biological diversity. Meeting the challenge of balancing human needs for water resources with protecting aquatic ecosystems requires science-based information on what aspects of natural, or unaltered, hydrologic conditions are essential for the long-term maintenance of healthy aquatic ecosystems.

The U.S. Geological Survey (USGS) has the extensive research background and interdisciplinary capabilities that position the agency to take a lead role in developing the science needed to improve management of water supply and aquatic ecosystems, especially in urbanizing landscapes. To accomplish this goal, the USGS Director selected "Water availability for ecological needs" as a national priority science thrust program for 2006–2008.

UPPER FLINT RIVER BASIN

A number of factors make the upper Flint River Basin an appropriate setting for developing science to address water and ecosystem management issues. The upper Flint River flows unimpeded by major impoundments for about 195 river miles from its Piedmont headwaters onto the Coastal Plain Province and harbors habitats and biologically diverse communities that have been lost from impounded reaches of many other eastern rivers. The upper Flint River Basin also supplies water to a growing population in the Atlanta metropolitan area and is a major recreational resource for the region, providing canoeing, white-water rafting, and sportfishing opportunities.

Long-term streamflow gaging stations have provided flow data for more than 90 years in the upper Flint River Basin. Recently completed investigations of freshwater mussel distributions and fish-habitat relations in the upper mainstem, and an aquatic Gap Analysis Program (GAP), provide baseline data for the system. Continued growth in the Atlanta area will increase pressure on the ecological systems of the Flint River Basin because of the potential for increased water withdrawals, reservoir construction for water storage, urban runoff, and additional wastewater loadings. Thus, this setting incorporates problems common to many regions and rivers in the Eastern United States—how to balance water-supply development with protection of diverse aquatic ecosystem—and provides an opportunity for interdisciplinary innovation in providing science-based solutions.

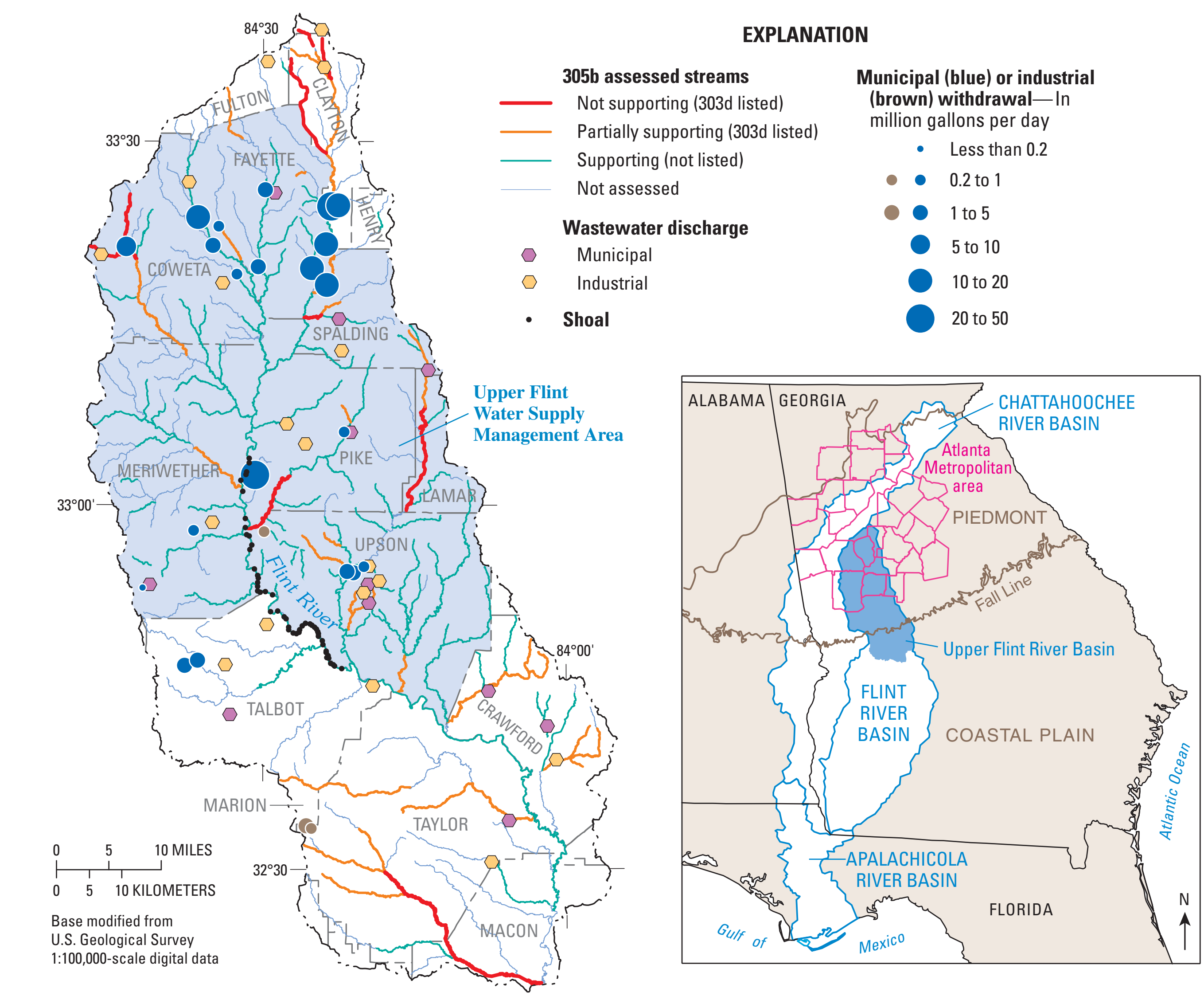
CHARACTERISTICS OF THE UPPER FLINT RIVER BASIN

The Flint River begins beneath Hartsfield–Jackson International Airport on the south side of Atlanta and flows southward across the Georgia Piedmont and Coastal Plain to its junction with the Chattahoochee River, later forming the Apalachicola River. The upper Flint River Basin has a drainage area of about 2,630 square miles. Land use in the basin, which includes parts of the upper Coastal Plain, consists of about 57 percent forest, 17 percent agriculture, and 12 percent urban, with most of the urban land concentrated in the extreme northern part of the basin (Georgia Land Use Trends, 1998).

Population growth in the six-county Upper Flint Water Supply Management Area (UFWSMA, shown below) has increased more than 200 percent since 1970, from 133,470 to 302,714 during 2000 (CH2MHill, 2003). Predictions are that more than 550,000 persons will live in the six-county UFWSMA by 2030.

Water-Supply and Instream-Flow Issues

Most of the water supply in the upper Flint River Basin comes primarily from the Flint River or its tributaries. Withdrawal from the 32 permitted municipal and industrial water-supply intakes totals about 108 million gallons per day (Mgal/d) and agricultural interests are permitted to remove an additional 90 Mgal/d from streams in the basin (Victoria P. Trent, Georgia Environmental Protection Division, written commun., 2005). Proposals have been submitted to increase surface-water supply capacity in the upper Flint River Basin by 12.7 Mgal/d (about 7 percent) by building two additional reservoirs and expanding



Most of the upper Flint River Basin is located in the Piedmont physiographic region of Georgia. The majority of the basin is relatively undeveloped; however, development spreading south from Atlanta will increase pressure on the available water in the basin.

an existing reservoir (Georgia Department of Natural Resources, 2003a). Under an interim State policy, required minimum flows below new reservoirs or stream withdrawals must adhere to one of three guidelines. Provide a minimum of:

- the monthly 7Q10 (the 7-day, consecutive low flow with a 10-year return frequency);
- 30 percent of the mean-annual flow for unregulated streams; or
- seasonally adjusted percentage of mean-annual flow for regulated streams.

The guidelines also suggest that site-specific studies can be used to determine minimum flows.

Advancing the science of linking hydrology and stream ecology

More than 200 methods for deriving "environmental" flow requirements have been developed to meet the needs of water managers (Tharme, 2003). Many of these methods focus on the minimum flows needed to support survival of aquatic organisms. Because flow conditions that drive ecosystem functions are complex, current emphasis in flow management is to identify *hydrologic regimes* necessary to protect and maintain differing levels of ecological integrity (Arthington and Pusey, 2003; King and others, 2003; Postel and Richter, 2003; Annear and others, 2004). Current limitations on quantifying the linkages between flow regimes and ecosystem processes underlie much of the uncertainty in predicting ecological effects of flow-regime alteration (Castleberry and others, 1996; Irwin and Freeman, 2002; Tharme, 2003). The USGS and its partners can advance the science underlying environmental flow specifications by applying multidisciplinary expertise and data from other studies of riverine processes to *build and evaluate alternative hypotheses regarding flow-regime effects on geomorphic and ecological processes*—in this case, for a Piedmont river system. Through this process, the USGS anticipates addressing questions such as:

- What are the appropriate spatial scales for identifying geomorphic variation in hydrologic-ecologic linkages?
- What are the relative roles of changes in sediment transport, water quality, and habitat conditions in altering ecological communities?
- How does altering the flow regime (magnitude, duration, frequency of occurrence, seasonality, rate of change) influence persistence of native aquatic species and communities?
- How are direct effects of flow regulation and water diversion on physical and biological processes altered by different land uses within the watershed?

Results of this effort will contribute to the global effort to improve the understanding of the effects of hydrologic alteration on the ecological integrity of flowing-water ecosystems, as well as supporting the development of a model-based framework for adaptively applying current scientific understanding to address stream-management issues.

Stormwater Runoff

Stormwater runoff increases as impervious surface increases. This affects stream geomorphology, water quality, temperature, aquatic ecosystems, and stream baseflows. No statewide policy currently exists to manage stormwater runoff except related to construction. Some municipal and county governments have implemented, or are in the process of implementing, stormwater-management programs.

Federally and State-Listed Aquatic Species

The upper Flint River Basin contains extensive shoal habitat that supports riverweed (*Podostemum ceratophyllum*), waterwillow (*Justicia* sp.), and shoal lily (*Hymenocalis coronaria*). At least five fish species that are endemic to the Apalachicola River Basin occur in the upper Flint River Basin. The upper Flint River Basin historically supported at least 25 species of mussels including 6 federally listed species. Recent surveys have reported only 20 species of native mussels remaining in the basin.

Water Quality and Aquatic Biological Integrity

Urban development in the upper Flint River Basin has resulted in water-quality problems in the headwaters. Studies in the early 1970s noted severe water-quality problems due to high levels of bacteria and nutrients in many of the tributaries and the mainstem reaches of the upper Flint River. During the period between 1972 and 1990, ammonia, dissolved nitrate, and phosphorous decreased in the mainstem reaches due to improvements in the quality of wastewater discharges. A study conducted during 1992 found that nutrient levels in the mainstem of the Flint River decreased by almost an order of magnitude from those found during the mid-1980s (Frick and others, 1996). From 1998 to 2002, 28 stream segments in the Flint River Basin were listed as not supporting or only partially supporting their designated water uses. Of the 28 stream segments, 14 are located in the upper Flint River Basin and were listed as having poor or very poor fish and invertebrate communities (Georgia Department of Natural Resources, 2003b).

The upper Flint River contains numerous shoal areas that provide habitat for endangered species (photograph by Jonathan Kennen, USGS).

Species of concern in the upper Flint River Basin

Endemic species

- Undescribed Halloween darter (*Percina* sp.)
- Shoal bass (*Micropterus cataractae*)
- Bluestripe shiner (*Cyprinella callitaenia*)
- Undescribed Greyfin redhorse (*Moxostoma* sp.)
- Greater jumprock (*M. lachneri*)

Endangered species (Georgia)

- Shoal lily (*Hymenocallis coronaria*)

Threatened species (Federal)

- Purple bankclimber (*Elliptoideus sloatianus*)

Endangered species (Federal)

- Shinyrayed pocketbook (*Hamiota subangulata*)
- Oval pigtoe (*Pleurobema pyriforme*)

Halloween darter and shoal bass (photographs by Noel M. Burkhead, USGS)

Shoal lily (photograph by Mary C. Freeman, USGS).

Mussels from top, purple bankclimber, shinyrayed pocketbook, and oval pigtoe, threatened or endangered species in the upper Flint River Basin (photographs courtesy of Sean Kelly and Stephen W. Golladay, J.W. Jones Ecological Research Center, Newton, Georgia).

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