Running Dry

Challenges and Opportunities in Restoring Healthy Flows in Georgia's Upper Flint River Basin

A Report by American Rivers
and Flint Riverkeeper

April 2013

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Flint Riverkeeper is an organization of farms, families, businesses and individuals working to restore and preserve the habitat, water quality, and flow of Georgia's Flint River for the benefit of current and future generations and dependent wildlife. Flint Riverkeeper is a fully-licensed member of the Waterkeeper Alliance and participates in the Georgia Water Coalition. Visit **www.flintriverkeeper.org** and **www.facebook.com/flintriverkeeper** to learn more.

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ACKNOWLEDGEMENTS:

Written by Ben Emanuel and Gordon Rogers

This report was made possible by funding from the Richard King Mellon Foundation, the Turner Foundation, the Park Foundation, and the Charles Stewart Mott Foundation.

For their assistance with accessing and interpreting various information sources for this report, we would like to acknowledge and thank staff at the Georgia Environmental Protection Division Watershed Protection Branch, including Linda MacGregor, Gail Cowie, Lebone Moeti, Cliff Lewis, Tammy Coppage, Danna Betts, Clay Burdette, Josh Welte, Gigi Steele, Renee Walker, Ted Jackson, Dr. Wei Zeng and Ade Oke.

For their helpfulness in sharing their detailed knowledge of water infrastructure in the upper Flint River basin, we would like to express our appreciation and gratitude to the staff of the water utilities in the basin, including: Michael Thomas, Kevin Osbey, Guy Pihera and Jim Poff, Clayton County Water Authority; Tony Parrott and Russell Ray, Fayette County Water System; Chris Hindman, City of Fayetteville; Brandon Lovett, Newnan Utilities; Jay Boren, Wanda Norris and Ellis Cadenhead (ret.), Coweta County Water Authority; Dr. Brant Keller and James Moore, City of Griffin; Susan Lee, Peachtree City Water & Sewer Authority; Patrick Comiskey, City of Thomaston; Wayne Selman, City of Hampton; Beth Vaughn, Town of Tyrone; Gene Fritz, City of Fairburn; Robert Lovett, Cities of Woodbury and Warm Springs; Danny Daws, City of Manchester; Rod Wilson, City of Zebulon; Stephanie Richardson, City of Concord; and Michael East, City of Greenville. We look forward to continuing the productive relationships that have begun with collecting information related to this report.

We also appreciate helpful dialogue on climatological and hydrologic data with Dr. Stephen Golladay, Woody Hicks and others who took time away from their day jobs to help us understand and interpret the available information on the upper Flint basin.

We would like to thank the staff at American Rivers and especially Jenny Hoffner, Chris Williams, Katherine Baer, Gerrit Jöbsis, Jeff Wiedner and Devin Dotson for their help with reviewing and publishing this report. We especially acknowledge Katherine Edmonds at American Rivers for her assistance in creating the maps in this report.
The authors are responsible for any factual errors. The recommendations are those of American Rivers and Flint Riverkeeper. The views expressed in this report are those of American Rivers and Flint Riverkeeper, and do not necessarily reflect the views of our funders, advisory council members, or those who provided input or review.

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Cover photo: Pasley Shoals, Flint River – courtesy B. Dallas

Authors' Note: This report is intended to be a working paper. As such it contains initial research, analysis, findings, and recommendations, and critical feedback is welcomed. American Rivers and Flint Riverkeeper have produced it to document observed hydrologic conditions in the upper Flint River basin, and to stimulate timely discussion on solutions to the basin's challenges.

Find this report and more resources online at www.AmericanRivers.org/RunningDry.

The upper Flint River of west-central Georgia is a river running dry. While rivers and streams in arid parts of the United States often dry up seasonally, the Southeast has historically been known as a water-rich area with plentiful rainfall, lush landscapes, and perennial streams and rivers. The upper Flint River supports recreation, fisheries, local economies, and threatened and endangered species that all depend on healthy and reliable flows which are becoming increasingly rare.

Examining and addressing low-flow problems in the upper Flint River basin is important in the context of the water scarcity issues throughout the entire Apalachicola-Chattahoochee-Flint (ACF) river basin. It is perhaps even more important in a much wider context, however, because the upper Flint serves as an illustrative example of what can and likely will happen to more rivers in urbanizing areas and in historically wet regions facing increasing water quantity stress.

Recent droughts have reduced sections of the upper Flint River in Georgia's Pine Mountain area to wide expanses of exposed rock with trickles of water running in between. In the basin's headwaters, major tributary streams such as Line Creek and Whitewater Creek have literally run dry as recently as 2012.

While individual instances of extreme low flows are troubling, dropping baseflows are perhaps more problematic for the river system. Baseflow is the water that comes into rivers and their tributary streams through the shallow groundwater flow that is part of the natural water cycle. Baseflow is crucial to supplying water to streams in a sustained manner during dry weather; if it is lacking, streams can run dry for extended periods of time.

This report focuses on the upper Flint River basin in the Piedmont region of Georgia, from the river's source near Atlanta to the Fall Line dividing the North Georgia Piedmont from the Coastal Plain to the south. It is not a complete hydrologic analysis of the upper Flint, neither examining all available gauging stations nor all aspects of the flow record in the Piedmont. It does, however, present new information and perspective on low flows in this portion of the Flint basin. This report seeks to bring greater awareness and understanding to the upper Flint's low-flow problems, to begin to identify their causes, and to point the way toward solutions to these problems. As such it is intended to begin productive dialogue among all stakeholders in a healthy upper Flint River, focusing especially on the local water utilities in the basin.

The decline in baseflow in the river system cannot be attributed to any single factor, but rather to many factors which have come into play over a period of decades. Among these factors are:

- Urbanization and land use change, including the ditching and draining of wetlands, channelization of streams, and the increase in impervious surface cover that has accompanied urban and suburban sprawl;
- Increased frequency of drought;
- An increase in ponds, lakes and reservoirs of all sizes throughout the tributary stream network, making for wetland loss and increased evaporative losses of water from the river system;
- Increasing demand on the river system for public water supply;
- A lack of direct return flows of water withdrawn from the river system for a variety of reasons including interbasin transfers, land application of treated wastewater, landscape irrigation (including "purple pipe" irrigation reuse), and un-sewered residential areas.

Public water supply systems play a role in bringing about the river's low-flow problems, but at the same time the operation of water systems is made more challenging by low flows. In the headwaters, where municipal water demand is greatest, the river and its tributary streams are small, and water withdrawals overall are large in relation to the small size of the streams.

Compounding this situation is an overall lack of sufficient return flows to the river system in relation to water withdrawals. The majority (roughly three-quarters) of the water drawn from the river system does not return to it directly via point source wastewater discharges. Instead, much water leaves the river basin entirely via interbasin transfers, is used for landscape irrigation, or is disposed of via septic systems, land application systems, or "purple pipe" water reuse for landscape irrigation. The complexity of interrelations among water systems in the basin further complicates this picture.

The state-level water policy decision-making of recent decades for the basin—which has maximized the potential for water withdrawals, has lacked sufficient streamflow protections, and (along with some local-level policies) has not sought to return water to the river system—is proving problematic now that somewhat drier conditions have set in. When drought years arrive, the river has lost its resilience against damaging low flows due to the various different demands on its water. In other words, it is now more vulnerable and delicate in the face of chronically dry weather conditions.

In addition to pointing the way toward solutions (see below), this report suggests several areas of inquiry that would benefit from further research on ecological, hydrologic, economic and other topics related to streamflow in the basin. Further research efforts on these topics and others would better inform all stakeholders' work in the basin in critically important ways.

Healthy flows can be restored in the upper Flint River basin, but it will take time and a broad group of stakeholders to leverage such a change. Recognizing that the river's flow issues are complex and multi-faceted, a collaborative, multi-stakeholder approach for developing, coordinating and implementing an array of short-term and long-term flow restoration opportunities is needed. A broad base of diverse stakeholders will include water utilities, water users, residents, businesses, landowners, congregations, and non-profit organizations who appreciate and depend on a vibrant, flowing Flint River.

Given the wide range of factors that have led to the upper Flint's low-flow problems, flow restoration opportunities include the following:

- Expand on the recent work by water providers to find areas of water loss in their systems and implement programs to eliminate "real water loss," or leaks;
- Improve end-use water efficiency and conservation, especially with regard to outdoor irrigation in the summer months;
- Employ green stormwater infrastructure to infiltrate more rainwater and restore baseflows and the natural water cycle;
- Examine water use by all water users who withdraw directly from streams, ponds, lakes and the river for farms, golf courses, commercial nurseries and other uses, and seek opportunities to improve water use efficiency;
- Increase the volume of return flows to the river system by retiring land application systems for wastewater treatment, managing and amending wholesale contracts between water systems, and through other methods including the return of flows in existing interbasin transfers;
- Explore more potable water reuse in the basin;
- Manage existing reservoirs to better ensure healthy flows downstream.

Many of the factors described here – especially characteristics of water and wastewater infrastructure – cannot necessarily be addressed in the short term, but identifying the importance of various impairments and potential solutions is an important step toward eventual flow restoration. Further, the proposed collaborative approach to finding and implementing solutions—with a central premise of mutual commitment—is critical to successful restoration of flows in this context.

Taking steps to restore healthy flows can reduce the stress on the river system and enable it to regain some of its natural resilience, better preparing the river for droughts to come and protecting the river for the benefit of communities today and for future generations.

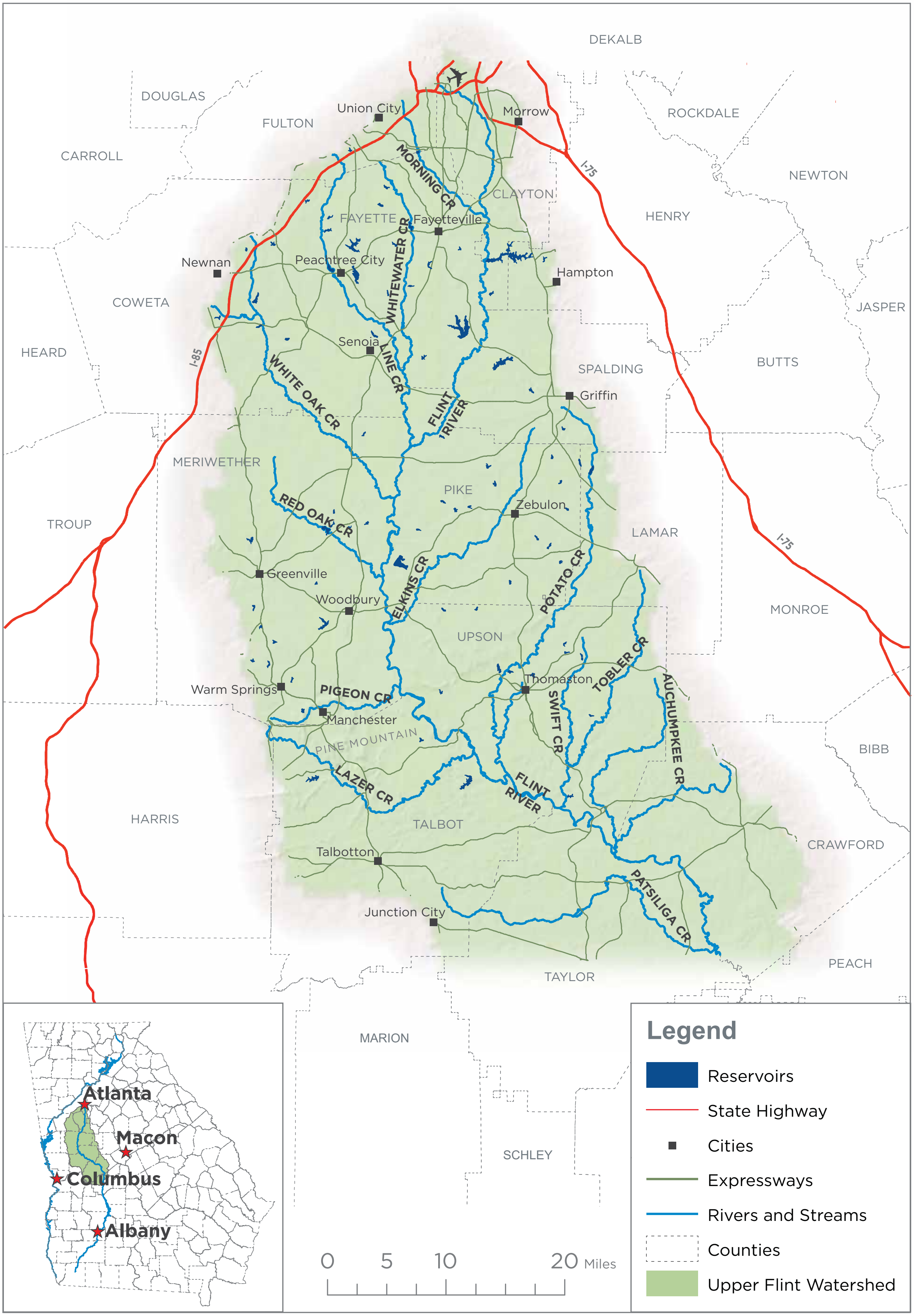
RUNNING DRY | INTRODUCTION

The upper Flint River system of west-central Georgia is running dry. The river and its tributary streams have suffered from extreme low-flow events and from declining baseflows in recent decades. Although the river basin is in a historically wet area of the country, water scarcity is increasingly a critical issue in the upper Flint.

The reasons for the decline in the river system's flows are many. The entire area of the river's headwaters has changed dramatically in the past half-century. Not far south of its urbanized source, the upper Flint drains much of the southern part of Metropolitan Atlanta, where suburban communities grew rapidly for more than three decades beginning in the 1970s. This extensive landscape change has damaged the river system's hydrology and decreased baseflows, and the associated population and economic growth have increased the demand on the river system for public water supply as well.

Gaining an understanding of these various issues, and beginning to find ways to address them, is an important task if the upper Flint is to continue supporting the recreational uses, fisheries, local economies, and threatened and endangered species that all depend on healthy and reliable streamflows. This report seeks to bring greater awareness and understanding to the upper Flint's low-flow problems, to begin to identify their causes and to describe the "plumbing" of public water supply on a basin-wide scale in the upper Flint, and to point the way toward solutions to the basin's low-flow problems. As such it is intended to begin productive dialogue among all stakeholders in a healthy upper Flint River, focusing especially on the local water utilities in the basin.

The Upper Flint River Basin



The Upper Flint River Basin

This report focuses on the upper Flint River basin of west-central Georgia, from the river's source near Atlanta to the geologic Fall Line dividing the Georgia Piedmont from the Coastal Plain to the south. The Flint River is one of only 40 rivers in the United States that flows for more than 200 miles unimpeded by dams on its main stem, and it is this Piedmont section that makes up the majority of this notably free-flowing stretch of river.

The land area of the upper Flint basin is largely rural in its southern portions and suburban or urban in the north. The source of the Flint is a heavily urbanized stream that begins on the south side of Atlanta in the city of East Point, Georgia and runs piped beneath Hartsfield-Jackson Atlanta International Airport before emerging into daylight again in northern Clayton County. The river and its tributaries drain suburban areas of Clayton, Fulton, Fayette, Coweta, Henry and Spalding counties. To the south of these suburbs, rural lands in the upper basin are largely in forest or pastureland for cattle, with limited areas of rock quarrying and row-cropping (although row crops, and largely cotton, dominated the landscape in the 19th and early 20th centuries). Textile manufacturing has historically been a major industry throughout much of the upper basin, although it has declined in recent years.

The southerly reaches of the upper Flint River flow through the rugged terrain of the Pine Mountain geologic formation, a dramatic disjunct spur of the Appalachian Mountains 60 miles south of Atlanta, rich in biodiversity and cultural heritage. In addition to the outstanding scenery and excellent recreational paddling afforded by these sections of the river, great expanses of shoal habitat are present where the river falls steeply and swiftly over beds of granitic bedrock. This shoal habitat is important for native fish species including the Halloween Darter *(Percina crypta)*, many native freshwater mussels (including threatened and endangered species, whose designated critical habitat extends upstream into Line and Whitewater creeks), the beautiful Shoals Spider Lily, and the native shoal bass *(Micropterus cataractae)*. The shoal bass is a black bass species endemic to the Apalachicola-Chattahoochee-Flint (ACF) basin, but the largest remaining populations are in the Flint River due to the extensive impoundments on the Chattahoochee River. The shoal bass is highly prized by anglers nationally and internationally for its sporting qualities. Just one indication of the Flint River's quality as a fishing destination was its inclusion in a list of the top 10 U.S. kayak-fishing locations for 2012 on the website YakAngler.com.

The Importance of Healthy River Flows

Certainly, few factors are as fundamental to a river's health as streamflow, or water quantity. The essence of a river is the water flowing within its banks. Put more simply, a river needs water. Naturally dynamic and sufficient streamflows are critical to sustaining the various benefits that rivers provide. In contrast, a lack of healthy flows can be as damaging to a river as any other problem it might face.[1]

A free-flowing river is a dynamic system; high flows, low flows, and everything in between are to be expected in any given year, and certainly in any given decade. In fact, a river needs naturally dynamic flows in order to be healthy. The timing, duration and magnitude of high flows and low flows drive many important natural processes in a river system, including channel formation and change, water quality, and the reproductive success of fish and many other animal and plant species, among others.

Throughout the seasons of the year in the Georgia Piedmont, streams and rivers typically see higher flows in winter and early spring, with lower flows in late summer and fall (although occasional tropical weather systems can bring higher flows in the fall). Overall, streamflow can vary greatly from season to season and year to year depending on weather and climatic conditions. Also, decade-by-decade cycles between periods of generally wet and dry weather superimpose a long-term pattern on rainfall and streamflow variation both within and among years.

The term "baseflow," used often in this report, refers to a very important component of streamflow: the water that comes into rivers and their tributary streams through the shallow groundwater flow that is part of the natural water cycle. In undeveloped areas, this water starts as rainfall which is absorbed into topsoil, flowing slowly and gradually through the ground toward surface streams. Baseflow is crucial to supplying water to streams in a sustained manner during dry weather.

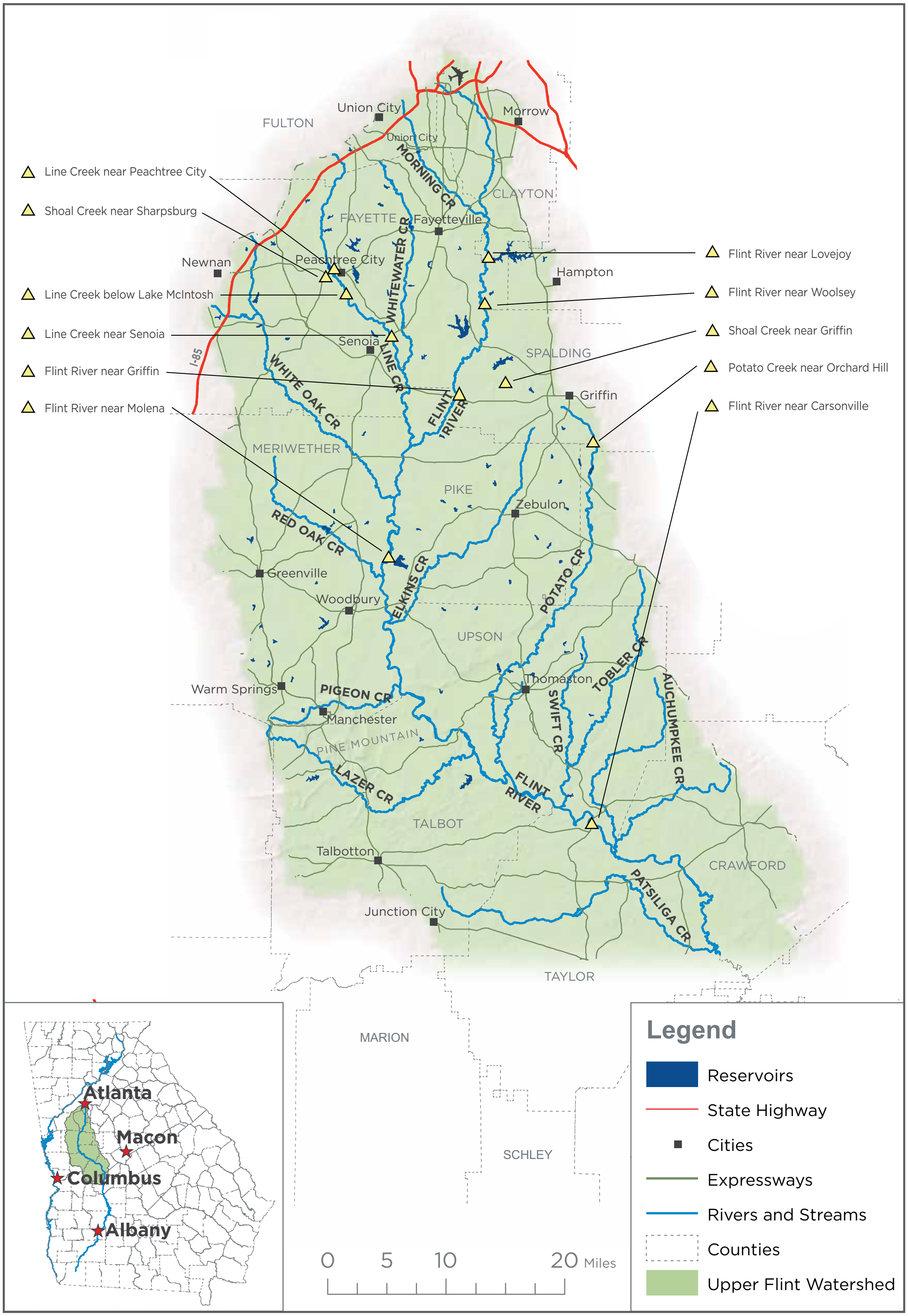
HYDROLOGIC ALTERATION IN THE UPPER FLINT BASIN: AN OVERVIEW

This report examines the upper Flint's declining baseflows and extreme low flows in the late 20th century and the early years of the 21st century. A look at the hydrology of the upper Flint River in recent decades—specifically at the lowest of its low flows in drought years, and at the "normal low flows" of non-drought years—shows a river in peril due to the downward march of its baseflows.

Observations of overall upper-basin hydrology are best made at the Fall Line, in part because of geologic and hydrologic differences between the Piedmont to the north and the Coastal Plain to the south. At the U.S. Geological Survey (USGS) river gauging station near Culloden, Georgia, where the river crosses the Fall Line, river flow measurements began in the early 20th century. This is USGS streamgauge number 02347500, labeled "Flint River at U.S. 19, near Carsonville, GA." Unless otherwise noted, streamflow statistics in this report are from this streamgauge. Continuous monitoring of the river's flow at this gauging station began in 1939 and continues to the present day. Many of the streamflow trends examined in this report, therefore, are focused on the period from 1940 to 2012. The threshold year of 1975 not only divides the period of continuous monitoring data at this streamgauge almost exactly in half, but also corresponds roughly to the beginning of the rapid growth of the communities in the Flint's headwaters, and the accompanying landscape urbanization and water resource development in the upper basin.

This report is not a complete hydrologic analysis of the upper Flint, neither examining all available gauging stations nor all aspects of flow at the Carsonville gauge. But, it does present new information and perspective on low flows in the Piedmont portion of the Flint basin. Prior analyses and planning processes by the Metropolitan North Georgia Water Planning District and the Upper Flint Regional Water Planning Council have separated the Flint's headwaters from the rest of the Piedmont Flint basin. The regional water planning process also utilized the USGS streamgauge at Montezuma, Georgia, rather than the Carsonville gauge, to examine the upper Flint's hydrology. The Montezuma gauge is in Georgia's Coastal Plain, significantly downstream of the Piedmont section of the Flint, and also downstream of significant groundwater input from upper Coastal Plain aquifers. As a result, prior analyses and management decisions have not examined or even noted the decline in low flows in the upper (i.e. Piedmont) Flint.

U.S. Geological Survey Streamgauges in the Upper Flint River Basin



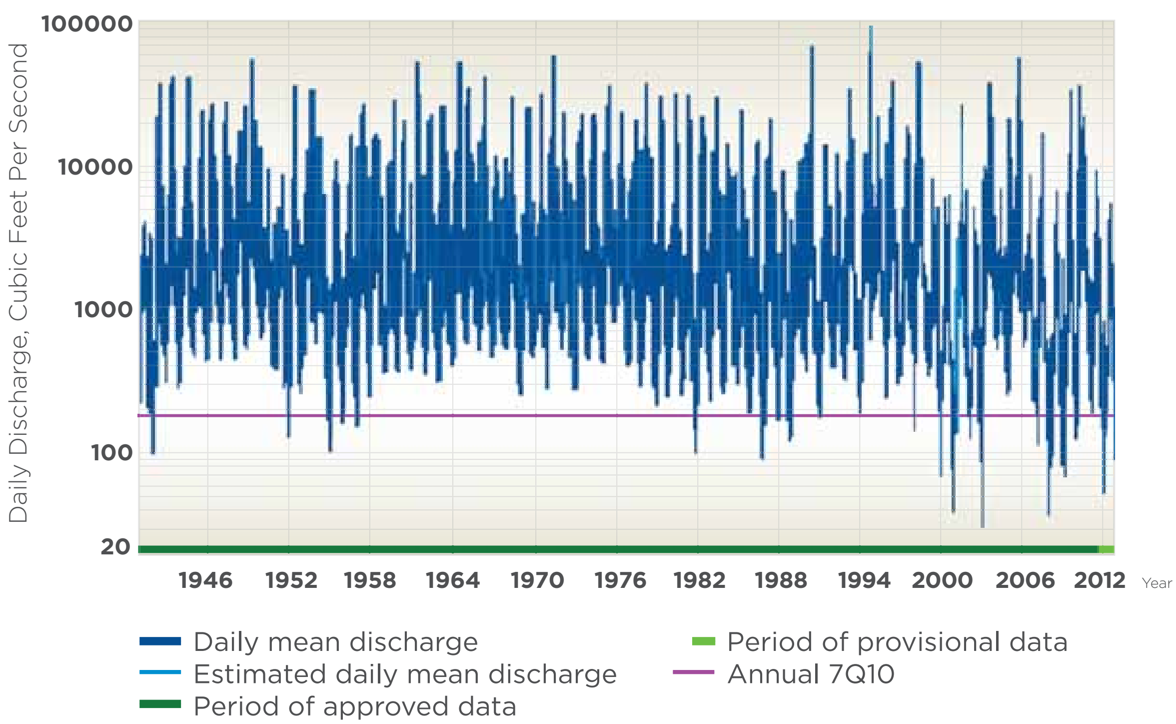
Drought Years and Extreme Low Flows in the Upper Flint

Data from the USGS Carsonville gauging station show river flows in various weather conditions over the past 70-plus years (See **Figure 1-1**). The lowest of river flows during the historic drought of the mid-1950s, measured as one-day annual minimum flows, were near 100 cubic feet per second (cfs); the river did not return to these low flows until the drought years of the 1980s.

Then, beginning in 1999 and continuing in several severe drought years at the outset of the 21st century, the river began setting new record low flows. The driest of days in recent drought years have found roughly 70% less water flowing in the Flint River at the Fall Line as compared to driest of days in the drought years of the 1950s and 1980s. Notably, various commonly-used low-flow statistics (one-day minima; 3-day, 7-day and 10-day averages; and 7Q10 values) tell the same story: During low flows, the upper Flint measured as it crosses the Fall Line has suffered a 70% decline in water passing down the main stem of the river. Increasingly, there appears to be a disconnection between drought as measured by precipitation and drought as measured by flow in the river. (For further hydrologic and climatological data for the basin, see Figures A-1 through A-3 in the Appendix.)

These extreme low flows, in turn, reduce the Flint's economically valuable, ecologically vital and beautifully scenic shoals to wide expanses of exposed rock with various trickles of water, the size of small tributary streams, running in between. Hydrologically speaking, at the driest of such times in the past decade the river has run effectively dry. The reaches upstream of the Pine Mountain-area shoals run critically low as well. In the headwaters, extreme low flows

Figure 1-1: Daily Discharge, Flint River at Carsonville Gauge, 1940-2012



Daily discharge, or streamflow, at the USGS Carsonville streamgauge (gauge number 02347500), 1940-2012. Data from U.S. Geological Survey, www.usgs.gov.

make several municipal withdrawal pumps physically unusable at times, and they almost certainly limit ecological function, reducing habitat for native mussels and likely restricting the distribution of the endemic shoal bass, to take just two examples.

Further research may yield insight as to the degree of disconnection between hydrologic drought in the river, as measured by streamflow, and meteorological drought as measured by rainfall and/ or other indicators. In summary, however, the low flows of the river have become lower than in decades past. Whether measured on a daily, weekly or monthly basis, minimum flow statistics show declines. Very significant is the fact that it does not matter what method of measuring low flows is used: all measures show declines.

Baseflow Decline in the Upper Flint and its Impacts

It's not just drought conditions and extreme low flows, however, that exhibit the river's problems. Statistics on annual average flows—including all years, drought and non-drought alike—also reveal a decline in river flows. Annual average flows after 1975 are nearly 18% lower than those before 1975.

Also, the "normal" low flows of any given year, to be expected in the late summer or fall, are now often lower than they were prior to 1975. During non-drought years prior to1975, the yearly low flows ranged in the 300-400 cfs regime in the absence of tropical storms. In years with similar rainfall patterns after 1975, yearly low flows are often in the much lower range of 100 to 200 cfs.

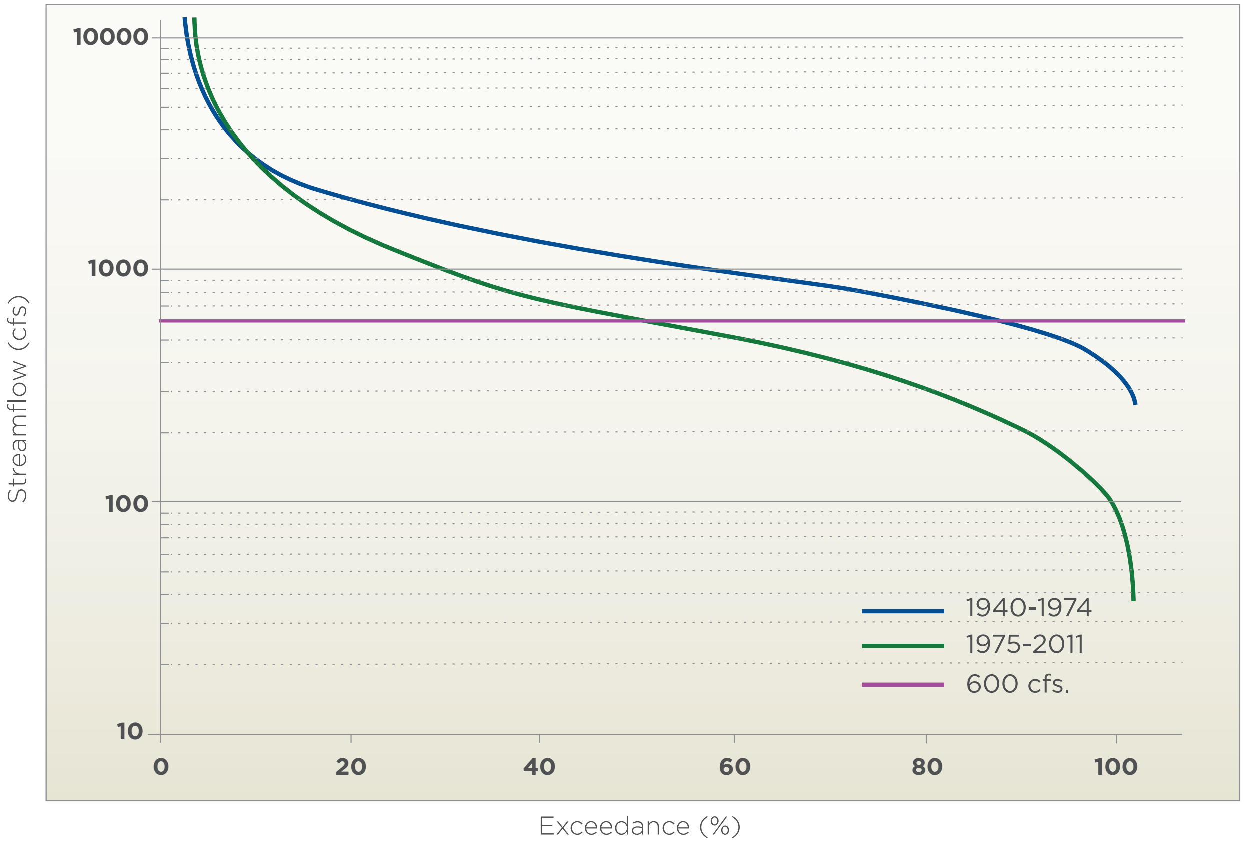
Further, a flow of 600 cfs, widely recognized as a minimum flow suitable for canoeing or kayaking the river's scenic lower Piedmont sections in the Pine Mountain area, has been observed less and less, including in moderately wet years. This has caused noticeable economic damage and probable damage to natural systems in recent decades. Year-round, there has been an approximate 15% decrease in the frequency of the availability of this flow level in the period since 1975. Most telling and damaging, however, is the decrease in this flow level during the prime months for businesses on the Pine Mountain section of the river. In July, from the period before 1975 to afterward, the ability of the river to support a flow level of 600 cfs has been cut in half, therefore halving the time available for paddlesports and the businesses that depend upon them (See **Figure 1-2**).

ECONOMIC IMPACTS

Participation in paddlesports is one of the fastest growing recreational activities in the country. As of 2009, 17.8 million Americans participated in paddlesports (canoeing, kayaking and rafting), and the number has been growing since then.[2] According to a 2012 report by The Outdoor Foundation, recreational kayaking was the single fastest-growing outdoor activity in the country from 2011 to 2012.[3] However, despite these trends and the upper Flint's proximity for millions of Georgia and Alabama residents, the use of the river's formerly premier paddling resources has decreased. On recent spring, summer and autumn weekends, the authors have observed the number of paddlers on popular reaches range from roughly 10 to well over 1,000, the difference being flows below or above 600 cfs as measured at the Carsonville gauge. "Just add water," said one local Chamber of Commerce affiliate and newspaper editor, "and the Flint comes alive."

Located on the Flint River in Upson County is the Gerald I. Lawhorn Scouting Base, home to Camp Thunder. Owned and managed by the Flint River Council of the Boy Scouts of America (BSA), the Lawhorn Base is among the very top destinations for scout groups in the eastern

Figure 1-2: July Flow Duration Curves—Flint River at Carsonville Gauge, 1940-2011



Flow duration curves for the month of July at the Carsonville gauge. The streamflow of 600 cfs is denoted because it correlates with the widely established minimum flow for canoeing and kayaking the popular river sections in the lower Piedmont. As shown, prior to 1975 the river was above this level roughly 85% of the time in the month of July across all years recorded. After 1975, however, the river runs above 600 cfs for only about 50% of the time in the month of July. 12-month statistics also show declines in exceedance of the 600 cfs level across the course of the year, though more moderate. Data from U.S. Geological Survey, www.usgs.gov.

United States. Drawing scout groups and their families from as far away as Miami, Florida, the camp brings 20,000-25,000 annual visitors and related economic impact to west-central Georgia. (By comparison, the BSA's well-known Philmont Scout Ranch in New Mexico registers approximately 40,000 annual visitors.) The camp offers various activities for scouts, but the Flint River is its centerpiece. During the summer camp season, in dry years the camp can no longer offer whitewater paddling on the Flint as one of the activities available to its scout campers.
In addition to summer camp, the base also serves as an outfitter to Boy Scouts, Girls Scouts, church groups and other youth groups, seeing roughly 3,000 visitors per year paddle the river on day trips or weekend excursions. This activity is challenged by low flows, and in dry years this service is limited to the spring and fall, with the water too low in mid- and late summer. Low flows are diminishing economic activity at the base and outdoor recreation opportunities for youth at Camp Thunder.

Similarly, the major paddling outfitter in the same section of the upper Flint has seen its

Walking the Flint's shoals due to low water during the Paddle Georgia event, June 2008. / Credit: Joe Cook

business model severely impacted. The Flint River Outdoor Center now faces weeks at a time of low-flow conditions that prevent paddling the river. The outfitter's owners are on record in past years arguing via public comments to the Georgia Environmental Protection Division (EPD) that new water withdrawals would inequitably affect their business and this traditional use of the river. Self-outfitted paddlers who would visit the Flint are equally affected by the decrease in the number of days—especially in the warm months of the year—when there is enough water flow to canoe or kayak the river.

These economic effects of flow loss in the upper Flint deserve further research, but are nonetheless disturbing. More difficult to assess and ultimately more widespread are economic damage to land values, unknown lost business opportunities, and damage to the function of the natural systems that support the upper Flint's fisheries.

Land valuations may soon reflect the lack of healthy river flows, in much the same way that land values and other economic activity around large reservoirs in the Southeast are at times decreased due to low lake levels. Both large-acreage and small-acreage riverfront tracts have higher value than similar real estate in the same county but without river frontage. The difference is flowing water, and it is likely a matter of time before valuations reflect flow losses, as river uses have already been greatly diminished.

IMPACTS ON NATURAL SYSTEMS

The lack of healthy flows also affects the natural systems of the upper Flint basin. This is an area in need of additional investigation. Retired U.S. Fish and Wildlife Service biologist Dennis Chase, a resident of Fayette County in the upper Flint basin, has recently observed the loss of endangered mussels in major tributaries of the upper Flint which ran dry in the autumn of 2012. The extent of mussel mortality and the effect of such mortalities on the overall status of mussel populations are unknown.

In the case of shoal bass, ongoing scientific research should yield important information about the impacts of flow alteration on this endemic species. Recent research by fisheries biologists with the Georgia Department of Natural Resources, the University of Georgia, and Auburn University has shown that shoal complexes in the upper and lower Flint are the critical spawning areas for shoal bass, and the only known areas of nursery habitat.[4] Especially important are the "mega-shoal complexes" that host springtime spawning aggregations of shoal bass in large numbers in the upper Flint—such well-known sections of river as Flat Shoals, Pasley Shoals, Yellow Jacket Shoals, Snipe Shoals and others in Upson, Pike, Meriwether and Talbot counties. Other research in the lower Flint, in areas of limestone shoals, points toward the need for sufficient depth and sustained inundation of shoal habitat during the crucial springtime spawning period from March to June of each year. When shoals are serially inundated and then dewatered, complete spawning failures occur. If similar dynamics are at play in the shoals of the upper Flint, then flow alteration could easily be harming shoal bass reproduction there as well.

CONSEQUENCES FOR PUBLIC WATER SUPPLY

Along with the harm done to the river's natural systems and river-dependent economies by low flows, the provision of public water supply is made more difficult as well. Reliable streamflow is important to public water utilities' ability to meet their mandate of providing water to their communities.

Rather than being able to withdraw water directly from the river at all times, the larger water providers in the upper basin have constructed large pump-storage reservoirs on small streams that store water pumped from the river, so that they can provide continuous water supply during low-flow conditions.

More details on water withdrawal infrastructure, including the low-flow thresholds included in most withdrawal permit conditions, are detailed in the following section. Water withdrawals for public water supply play a role in the impairment of healthy river flows in the basin (see next section), but at the same time the usefulness of much water supply infrastructure is itself also impaired by a lack of streamflow in the river system. In prolonged droughts (e.g., 2006 to 2009), water supply security for communities in the basin has been threatened by the problem of low flows.

Causes of Low Flows

The factors underlying changes to the hydrology of the upper Flint basin are many. Truly, the decline in baseflow in the river system is a death by a thousand cuts. It cannot be attributed to any single cause. Among the causes:

- Urbanization and land use change, including the ditching and draining of wetlands, channelization of streams, and the increase in impervious surface cover that has accompanied urban and suburban sprawl

- Increased frequency of drought
- An increase in impoundments—ponds, lakes and reservoirs—of all sizes throughout the tributary stream network, making for wetland loss and increased evaporative losses of water from the river system
- Increasing demand on the river system for public water supply
- A lack of direct return flows to the river system for a variety of reasons including interbasin transfers, land application of treated wastewater, landscape irrigation (including "purple pipe" irrigation reuse), and un-sewered residential areas

Land use change in what are now suburban areas of the upper basin has been dramatic in recent decades. Data from the University of Georgia's Natural Resources Spatial Analysis Lab show a sharp increase in urban and suburban land cover from 1974 to 2008 in the northern half of the upper Flint basin (that is, much of the southern part of metropolitan Atlanta), while forest and farmland disappeared in equal measure in this part of the basin. Urban and suburban land cover now makes up 27% of the upper basin, and certain headwater streams drain an almost completely paved landscape. (See landcover maps in Appendix.)

The expansion of urban and suburban land cover negatively impacts both water quality and water quantity by altering the natural water cycle. Rain that falls on paved surfaces or buildings in developed areas runs off quickly without replenishing groundwater and tributary streams. Amplified over a large area of a river basin—especially in its very headwaters—the hardening of the surface of the land without proper management of stormwater can have devastating effects on stream health and baseflows. Quantifying the impact of landscape urbanization on baseflows in this basin is an important task yet to be accomplished, but the figures are likely significant: a 2002 analysis estimated that in 1997 the Atlanta area, for example, may have lost between 56.9 and 132.8 billion gallons of groundwater infiltration due to land development as compared to 15 years earlier.[5]

The basin-wide impact on streamflow of land use change is not easy to quantify with great precision, and the same goes for many of the factors listed above. Fortunately, research is ongoing in some of these areas. One example is the cumulative impact of reservoirs and impoundments of all sizes. Researchers at the University of Georgia and Florida State University have recently employed Geographic Information Systems techniques to identify 24,613 small reservoirs, with storage less than 100 acre-feet each, throughout the ACF basin, in addition to the large and medium-sized reservoirs that provide hydropower, water supply and other functions throughout the basin. The Piedmont portions of the Flint and Chattahoochee basins are home to especially high concentrations of these small reservoirs, which include some working farm ponds and many amenity lakes for private homes, golf courses and subdivision housing developments.[6] These small impoundments' aggregate importance has previously gone under-recognized in scientific, policy and regulatory arenas, but the new analysis of their widespread presence alone has begun to bring more attention to them.

Functionally, during a drought, any impoundment of any size that does not have a release prescription or requirement evaporates 100% of the baseflow it receives once levels fall below the release structures (standpipes or spillways). This phenomenon, multiplied across literally thousands of impoundments, is capable of having a significant hydrologic affect. Continued research on this topic and its hydrologic implications will likely yield important information about the entire ACF basin and certainly the upper Flint.

Compounding Factors

Given the variety of different impairments and the competing demands for water supply in the upper basin alone, it appears that various factors affecting the river's flow compound one another. Baseflows in the river system have decreased for a number of reasons, decreasing the amount of sustained flow available in a reasonably consistent manner for withdrawal by the public water systems that depend on the river and its tributaries. Meanwhile, the hydrograph—or streamflow pattern—of the river system is made more "flashy" due largely to the urbanization of the landscape in the headwaters. This means that when rains come in the midst of a drought, tributary streams and the very upper river see a very brief peak of runoff-influenced flow, and the public water systems must quickly "harvest" water from this brief pulse of moderate flow. (Just one side effect of this situation is the increase in treatment costs to purify the relatively poor-quality water that drains the urbanized landscape, and then is withdrawn for water supply, in this brief flow pulse.) This moderate pulse of water, then, is removed from the river system—much of it for storage in pump-storage reservoirs, and a significant portion evaporated as an additional unfortunate side-effect—and the river, as it leaves the Piedmont on its journey southward, is deprived of a portion of the water that otherwise would have nourished its flows above its often-low baseflow conditions.

Line Creek

Line Creek rises in south Fulton County, near the towns of Fairburn and Palmetto, and flows southward, forming the county line between Coweta and Fayette counties for most of its length. Line Creek is the major headwaters tributary of the Flint River, contributing generally as much flow to the river system as does the nominal "Flint River" above their confluence.

Line Creek also illustrates the complexity of factors affecting streamflow in the upper Flint. There are two municipal water withdrawal points that can pump water from Line Creek for public supply: a Newnan Utilities intake near Peachtree City, roughly near the middle of Line Creek's length, and a Fayette County Water System intake not far downstream at the Lake McIntosh reservoir site. The creek, however, often runs dry at a point just above these municipal intakes, at the Georgia Highway 34/54 bridge on the west side of Peachtree City. Line Creek, under normal conditions, is no small stream at this location. It is a stark sign of the hydrologic damage in the upper Flint that the USGS streamgauge here (number 02344605) registered a flow of less than 1 cubic foot per second for fully half of calendar year 2012.

Above this point in the Line Creek drainage are a handful of permitted water withdrawals for golf courses and other private and industrial uses near Tyrone, as well as a number of ponds and lakes of various sizes, the largest of which (and likely the oldest), Wynn's Pond, has its dam directly above the section of the creek that is so often dry. The creek's uppermost headwaters are home to subdivision housing developments, a large rail yard, and small but dense zones of commercial sprawl along Interstate 85.

Line Creek, in other words, is in some ways a microcosm of much of the upper Flint River basin. It is suffering a death from a thousand cuts itself—cuts from changes in land use and hydrology over time, as well as current water use practices with varying degrees of intensity. In this case, it is the use of the stream for public water supply that is harmed by the damage to its flows from other factors.

PUBLIC WATER SUPPLY IN THE UPPER FLINT RIVER BASIN

As in most of the northern half of Georgia, the vast majority of the public water supply in the upper Flint basin is drawn from surface water sources—from streams and rivers, and from artificial reservoirs built by damming streams or rivers. A very small portion of the public water supply comes from groundwater wells due to the region's geology.

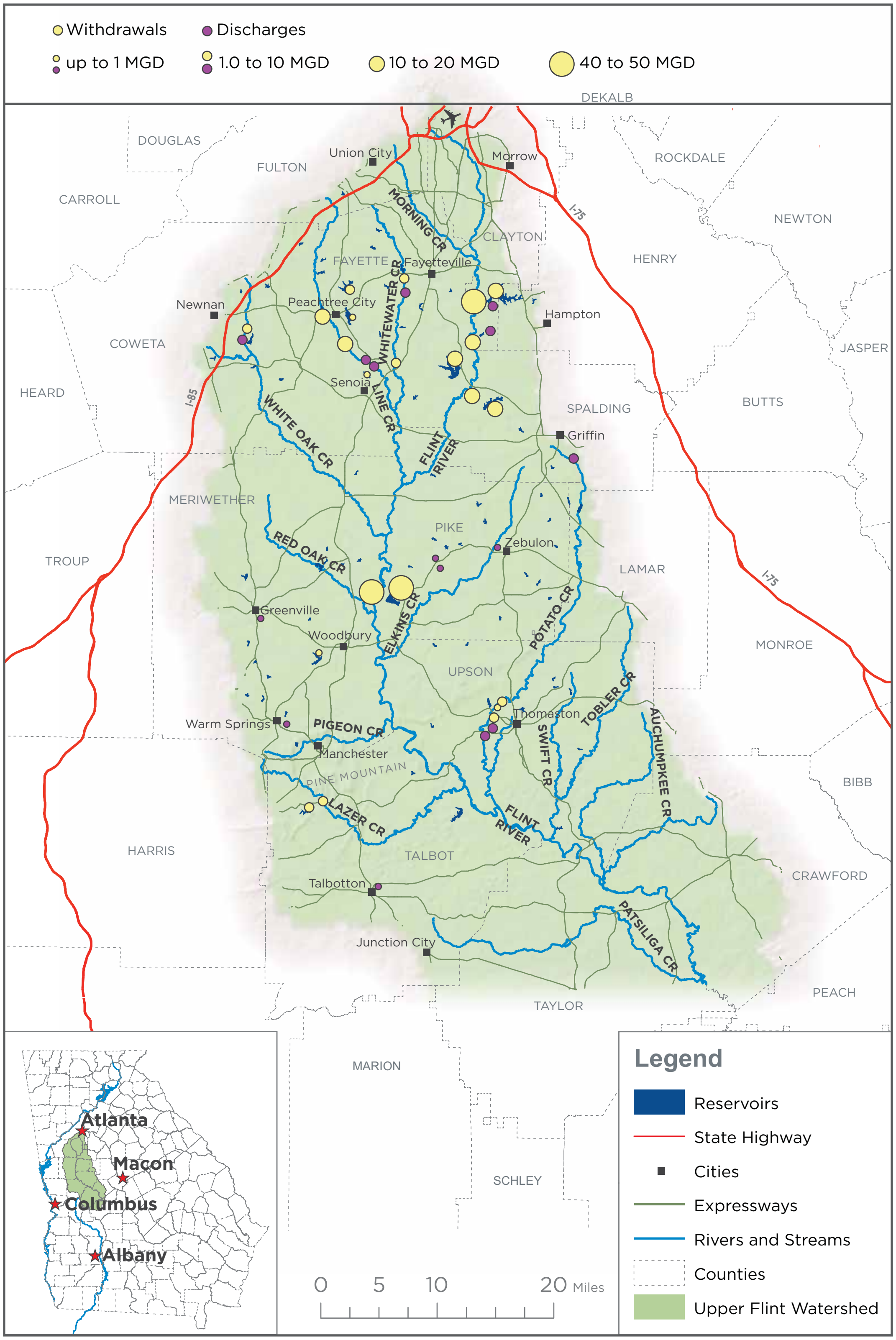
Public water supply systems draw water from the Flint River and its tributaries throughout the upper basin. Patterns of population density in the area dictate that water supply demand is much greater in the northern headwaters of the basin than in the southern portions of the upper basin. This means, critically, that the greatest municipal demand for water in the upper Flint basin occurs where the river and its tributary streams are small—and where the drainage areas feeding the streams are small, as well. The river itself, of course, is merely a collection of these small tributary streams.

Small Streams

The overriding characteristic of water supply infrastructure in the upper basin is that it relies on small streams in small drainage basins, or catchments—indeed, the very headwaters of the river system—in order to provide water supply for urban and suburban communities. (See map of municipal surface water withdrawal and discharge locations.) The magnitude of permitted water withdrawals is large in relation to the size of the streams and their catchments. This has meant, in part, that the larger water systems in the basin rely on pump-storage reservoirs to store river water for use during periods of low flow. (In long periods of dry weather and low flows, many in-stream pumps are not used at all. When streamflows rise, these water systems turn on their in-stream pumps to draw water while it is available.) There are six such pump-storage arrangements in the upper basin. Given its

Municipal Surface Water Withdrawals and Discharges – Upper Flint River Basin

Symbols represent maximum permitted volumes for municipal surface water withdrawals and discharges (monthly average in million gallons per day). Locations are approximate.



small streams and catchments, the upper Flint basin is probably more reliant than any other area of Georgia on this type of pump-storage water supply infrastructure.

The evolution of wastewater infrastructure in the basin, too, reflects the underlying fact that water systems of significant size rely on small streams in the upper Flint basin. Small streams have a lower capacity than larger streams to assimilate treated wastewater while maintaining water quality. Thus, a state-level strategy, beginning in the late 1980s, sought to avoid wastewater discharges to the upper Flint or its tributaries in order to protect water quality in the river system for existing and future water supply withdrawals. The management strategy instead directed local governments toward wastewater disposal through land application or through discharge of treated wastewater outside the Flint basin (i.e. interbasin transfers), with the unintended consequence of contributing to a dewatering of the upper Flint River system. (See Appendix for Georgia EPD internal memorandum titled "Wastewater Discharges – Flint River Basin.")

Although it is no longer the policy of the Georgia Environmental Protection Division, this past approach to managing water supply and wastewater infrastructure in the upper Flint was institutionalized, and now contributes to the problems that have become evident in the persistently dry conditions of recent years.

Lack of Sufficient Return Flows

Much of the water drawn from the upper Flint River system for municipal use does not return directly to the Flint, whether via treated wastewater discharges or otherwise.

WASTEWATER TREATMENT

A significant portion of the wastewater management in the basin is accomplished via land application systems (LAS). At LAS facilities, treated wastewater is sprayed on land often in pine silviculture or hayfields. While it is likely, depending on multiple site-specific factors, that some of the water treated at an LAS facility returns to streams over time, this is of little consequence in periods of drought when multiple users and the river itself compete for scarce water that is needed in a timely fashion. Further, in dry conditions plants' uptake and transpiration of the water discharged at an LAS facility is greatest, driving water returns during such conditions even further downward.

Some of the state-issued LAS discharge permits in the basin also cover non-potable irrigation water reuse (i.e. "purple pipe") systems. In non-potable irrigation reuse systems, typically relatively high-quality wastewater effluent is used for landscape irrigation, often for turfgrass such as on golf courses or playing fields. Although reuse irrigation is often characterized as an environmentally friendly practice, and can be one in certain settings, it can be quite the opposite in an area where streams are strained for supply and where return flows via public water systems are small in relation to withdrawals. In part for this reason, a 2012 National Research Council report on water reuse focuses on the beneficial potential of reclaimed water as a water supply chiefly in coastal areas of the country, noting that in inland regions, "extensive reuse has the potential to affect the water supply of downstream users and ecosystems in water-limited settings." [7] This is certainly a concern in the upper Flint. Again, these effects are accentuated in drought conditions, when water losses to evaporation and plant transpiration are greatest and when streams are most stressed for water supply. In the upper Flint basin, non-potable reuse irrigation constitutes one of many ways in which water drawn from the river system is not returned to it in equal measure.

In some upper-basin counties, local-level decisions around planning and development have resulted in very high proportions of households utilizing on-site wastewater treatment systems, typically septic tanks. As with LAS and irrigation reuse systems, the loss of water to the hydrologic system from septic systems is greatest during dry conditions, when plants' uptake and transpiration of the water discharging from a septic system is greatest, and when rivers and streams are lowest. A 2006 study by the Metropolitan North Georgia Water Planning District found proportions of septic systems among residential households as high as 50% in Fayette County, which is contained entirely within the Flint basin, and 70% in Coweta County, roughly one-third of which lies in the Flint basin.[8] Approximately 60% of households in Spalding County, roughly half of which is in the Flint basin, use septic systems.[9]

INTERBASIN TRANSFERS

Interbasin transfers of water out of the upper Flint basin are also a factor in the lack of sufficient return flows. Numerous towns and cities which today rely wholly or mainly on Flint water for their supply grew up originally along the railroads which follow the ridgelines dividing one basin from another. (The only counties contained entirely within the upper Flint basin are Fayette and Pike.) This fact of geography made interbasin transfers a low-hanging strategy for avoiding wastewater discharges to the Flint system under the policy established by Georgia EPD in the 1980s.

Various water systems drawing water from the upper Flint River system, or purchasing Flint water wholesale from other water providers, discharge significant portions of that water as treated wastewater in other river basins—in the Chattahoochee River basin to the west, or in the Ocmulgee River basin to the east. This water, of course, never returns to the Flint River.

Georgia EPD is required by statute to provide an annual accounting of interbasin transfers in the state. EPD documents show that the upper Flint experiences a net loss due to interbasin transfers, on the order of 12.2 million gallons per day (MGD) in 2010 and 13.5 MGD in 2011, to take two recent examples. The largest losses are in the water systems operated by Newnan Utilities, Coweta County Water Authority and Clayton County Water Authority. It is important to note that while the raw volumes of water lost to interbasin transfer are smaller in the upper Flint than in other parts of the Metro Atlanta area (e.g. the Chattahoochee River basin), these volumes are lost from the Flint's headwaters and are therefore quite large in relation to baseflows, making their impact on water quantity in the river system significant.

LANDSCAPE IRRIGATION

Other key management practices and water use patterns in the basin also act to amplify consumptive use of water and the lack of return flows to complement withdrawals, especially during drought conditions. One highly consumptive use of water, especially in hot and dry weather, is for landscape irrigation both residentially and commercially, including on golf courses. Landscape irrigation is a significant user of water in much of the suburban portions of the upper basin. While some irrigation water may return to

baseflow and streams, much of it is also lost to evaporation and plant transpiration, and these effects are accentuated in drought.
Whether in drought years or not, landscape irrigation is typically at its peak during the summer months, when streams and the river are often at their lowest and are most stressed for water supply. This issue of seasonal timing is a key point with regard to the impact of landscape irrigation on river flows.

In the Fayette County Water System, summertime peak demand is reported at approximately 17 to 18 MGD, while wintertime average demand is approximately 9 MGD—a doubling of demand on a seasonal basis, coinciding with low summertime river flows. Landscape irrigation on this scale is problematic from the perspective of healthy seasonal streamflow. Other water systems in the basin, such as the Coweta County Water Authority, also report a near-doubling of demand between baseline and peak demand.

Water System Interrelations

The "plumbing" of water and wastewater infrastructure, viewed on a basin-wide scale across the upper Flint, is far from simple. Understanding its complexity is fundamental to an understanding of where water goes when it is drawn from the river system, where and how some of it returns to the river, and where and how much of it does not. The following sections describe some of this complexity.

Just one area of complexity is in wholesale purchase of water by some public water systems from others. To take the most complex example, the City of Griffin water system functions as a regional water provider, selling raw water wholesale to: Spalding County, Coweta County, Meriwether County, Pike County, Lamar County, Butts County and the cities of Concord, Williamson and Zebulon. The Coweta County Water Authority, to take one Griffin wholesale customer as an example, also purchases water wholesale from Newnan Utilities, in addition to producing a small amount of water itself at its B.T. Brown Reservoir and treatment plant in the Chattahoochee River basin.

Griffin's regional wholesale operations make for only the most complex example among many. On a smaller scale, the City of Manchester supplies water to several neighboring communities from its Rush Creek Reservoir in Talbot County. The internal "plumbing" of the Clayton County Water Authority system alone, with its indirect potable reuse systems and infrastructure in two river basins, is worthy of its own extensive description. The Fayette County Water System provides drinking water throughout Fayette County but does not provide sewer services; these are provided by municipalities like Peachtree City and Fayetteville (the latter is a wholesale water customer of Fayette County, while the former is not), or not at all, as there is no public sewer system for unincorporated Fayette County.

Financial Arrangements

Much of the public water infrastructure in the basin, as throughout the state and the nation, is financed through long-term borrowing on the municipal bond market. Forecasts of water system revenues to pay down debt involve, in part, forecasts of water demand. For these reasons and more, recent years of drought conditions and economic recession have made water systems' finances as complicated as ever. Many upper Flint basin water utilities, like utilities around the country, are dealing with water demand at levels far below projections and what may become a "new normal" in the realm of demand and revenues. Finding sustainable revenue models despite these trends in demand is becoming an area of active work among public water supply stakeholders nationwide.

Meanwhile, further complicating the wholesale water purchases and sales described above are the long-term contracts governing some of these transactions between water systems. In some cases, the debt service requirements of the wholesaler—to pay down funds borrowed to construct large infrastructure projects such as pump-storage reservoirs—call for steady and long-term revenues via these wholesale contracts. In other words, multiple systems are hitched to certain demand and revenue projections which, as noted above, may not square with actual conditions. These financial arrangements, of course, govern much of the decision-making regarding water supply management and policy.

Water Sources and Destinations

Because a minority proportion of water drawn from the Flint system is returned directly to the river system, it is useful to think of the basin-wide "plumbing" in terms of the destination of water withdrawn from the upper Flint River system by any given municipal water system, rather than to think in terms of simple water withdrawal and return.

Available on American Rivers' website with this report is a Water Sources and Destinations Table which seeks to depict the complexity of this "source-destination" relationship schematically. (Please visit www.AmericanRivers.org/RunningDry for this information.) The table is designed to capture all possible destinations of water from any given original surface water withdrawal source, and thus it is redundant in multiple instances. Having a guide to the complexity of the basin-wide "plumbing" of public water supply is crucial to moving toward restoring healthy streamflow in the upper Flint River system.

Withdrawals, Returns and Streamflow

Taken together, the cumulative impact of all of the various consumptive "destinations" of upper Flint River system water, both inside and outside of the Flint River basin, is that return flows equal a minority proportion of the water withdrawn from the river system for public supply. For an array of reasons, most of the water drawn from the river does not return directly to it. Roughly speaking, approximately one-quarter of the public water supply used in the upper Flint basin is discharged to the Ocmulgee or Chattahoochee basins, and approximately one-quarter is returned directly to the Flint or its tributaries. The remaining half goes to other "destinations" within the basin that mostly do not result in direct return flows, especially during drought conditions.

Table 2-1 lists the municipal surface water withdrawal and discharge permits in the upper Flint basin, along with the permitted withdrawal and discharge volumes allowed under these permits. The actual operating volumes associated with these water withdrawals vary considerably; most range from zero up to the permit limits depending on conditions and needs. In some cases, multiple permits held by the same water system are not additive (e.g., water from multiple different withdrawal points cannot exceed a certain volume in aggregate on a given day). Overall, however, large quantities of water, relative to streamflows and drainage basin sizes, can be drawn from the river system on any given day. And, as **Table 2-1** indicates, permitted return flows via wastewater discharges do not come close to equaling the amount of water permitted to be withdrawn from the river system.

With regard to withdrawals from the river or its tributaries to fill pump-storage reservoirs, the maximum permitted withdrawal amount has little correlation to actual daily water usage in those water systems. The actual

Table 2-1 Municipal Surface Water Withdrawal and Discharge Permits in the Upper Flint River Basin

WITHDRAWAL PERMIT HOLDER	WATER SOURCE	MAXIMUM PERMITTED VOLUME	DISCHARGE PERMIT HOLDER	RECEIVING STREAM(S)	MAXIMUM PERMITTED VOLUME
		(monthly average in MGD)			(monthly average in MGD)
Clayton County Water Authority	Flint River	40	Clayton County Water Authority	Panhandle Wetlands/ Shoal Creek Reservoir*	4.40
Clayton County Water Authority	J.W. Smith Reservoir	17	City of Hampton	Bear Creek	1.75
Fayette County Water System	Flint River	16	City of Fayetteville	Whitewater Creek	5.0
Fayette County Water System	Lake Horton	14	Peachtree City WASA - Rockaway Plant	Line Creek	4.0
Fayette County Water System	Lake Kedron	4.0	Peachtree City WASA - Turner Plant	Line Creek & Flat Creek	2.0**
Fayette County Water System	Lake Peachtree	0.5	Coweta County Water Authority	White Oak Creek	2.0
Fayette County Water System	Whitewater Creek	2.0	City of Griffin***	Potato Creek	2.0
Fayette County Water System	Lake McIntosh	12.5	City of Concord	Birch Creek	0.038
City of Fayetteville	Whitewater Creek	3.0	City of Concord	Elkins Creek	0.10
City of Senoia	Hutchins Lake	0.3	City of Zebulon	Town Branch	0.286
Newnan Utilities	White Oak Creek	7.0	City of Thomaston	Bell Creek	2.0
Newnan Utilities	Line Creek	12	City of Thomaston	Town Branch	2.0
City of Griffin	Flint River (Spalding County)/ Heads Creek Reservoir	12	City of Greenville	Kennel Creek	0.25
City of Griffin	Flint River (Pike County)	50	City of Warm Springs	Cascade Branch	0.40
City of Griffin	Still Branch Reservoir	42	City of Talbotton	Edwards Creek	0.10
City of Zebulon	Elkins Creek	0.3			
City of Manchester	Lazer Creek	3.7			
City of Manchester	Rush Creek Reservoir	1.44			
City of Woodbury	Lake Meriwether	0.5			
City of Thomaston	Potato Creek	3.4			
City of Thomaston	Potato Creek	0.4			
City of Thomaston	Potato Creek	4.3			

* part of CCWA indirect potable reuse system
** 1.6 MGD summer/ 2.0 MGD winter
*** permitted for expansion up to 3.0 MGD

Table 2-2 Instream Flow Requirements in Municipal Surface Water Withdrawal Permits - Upper Flint River Basin

STREAM	PERMIT HOLDER	PERMIT NUMBER	LOCATION	FLOW REQUIREMENT PER WITHDRAWAL PERMIT
Flint River	Clayton County Water Authority	031-1102-07	Southern Clayton County	Multiple tiers from 12 cfs upward
Flint River	Fayette County Water System	056-1102-13	Near Woolsey	30 cfs or natural streamflow
Flint River	City of Griffin	126-1190-01	Northern Spalding County	10 cfs
Flint River	City of Griffin	114-1191-02	Pike County	Multiple tiers from 60 cfs to 247 cfs
Shoal Creek	Clayton County Water Authority	031-1101-01	Below J.W.Smith Reservoir dam	None
Horton Creek	Fayette County Water System	056-1102-12	Below Lake Horton dam, near Brooks	2.6 cfs or natural streamflow
Flat Creek	Fayette County Water System	056-1102-06	Below Lake Kedron dam, Peachtree City	1.6 cfs or natural streamflow
Flat Creek	Fayette County Water System	056-1102-03	Below Lake Peachtree dam, Peachtree City	None
Whitewater Creek	City of Fayetteville	056-1102-14	Near Fayetteville	3 cfs or natural streamflow
Whitewater Creek	Fayette County Water System	056-1102-10	Below Starr's Millpond dam	6.2 cfs or lake inflow, whichever is less
Line Creek	Newnan Utilities	038-1102-11	Near Peachtree City	2 MGD (3.1 cfs)
Line Creek	Fayette County Water System	056-1102-09	Below Lake McIntosh dam	3 MGD (4.7 cfs) or lake inflow, whichever is less
Keg Creek	City of Senoia	038-1102-05	Below Hutchins Lake dam	None
White Oak Creek	Newnan Utilities	038-1103-02	Coweta County	1.2 MGD (1.9 cfs)
Still Branch	City of Griffin	114-1104-03	Below Still Branch Reservoir dam, Pike County	0.31 MGD - 0.62 MGD (0.48 cfs - 0.96 cfs), seasonal range
Elkins Creek	City of Zebulon	114-1104-01	Near Zebulon	None
Pound Creek	City of Woodbury	099-1106-02	Below Lake Meriwether dam	None
Rush Creek	City of Manchester	130-1106-05	Below Rush Creek Reservoir dam, Talbot County	0.35 MGD (0.54 cfs) or streamflow, June-October
Lazer Creek	City of Manchester	130-1106-06	Northern Talbot County	2.3 cfs when pumps are operating
Potato Creek	City of Thomaston	145-1105-01	Thomaston - old Thomaston Mills	None
Potato Creek	City of Thomaston	145-1105-02	Thomaston - former WesTek site	None
Potato Creek	City of Thomaston	145-1105-03	Thomaston - near Hannah's Mill	11 cfs or streamflow, May-October

Snipe Shoals, Flint River / Credit: Stan Lumsden

withdrawal volumes to fill pump-storage reservoirs do depend, however, on municipal demand along with a variety of other factors including short-term and long-term weather and hydrologic conditions. (For the most part, a permitted withdrawal volume from the river and a permitted withdrawal from a pump-storage reservoir cannot be added together to examine total withdrawals from the system.) The timing of water withdrawal, and then either consumptive use or return flow, is made complex by pump-storage systems and what may be a long or short "residence time" for the river water stored in the reservoir.

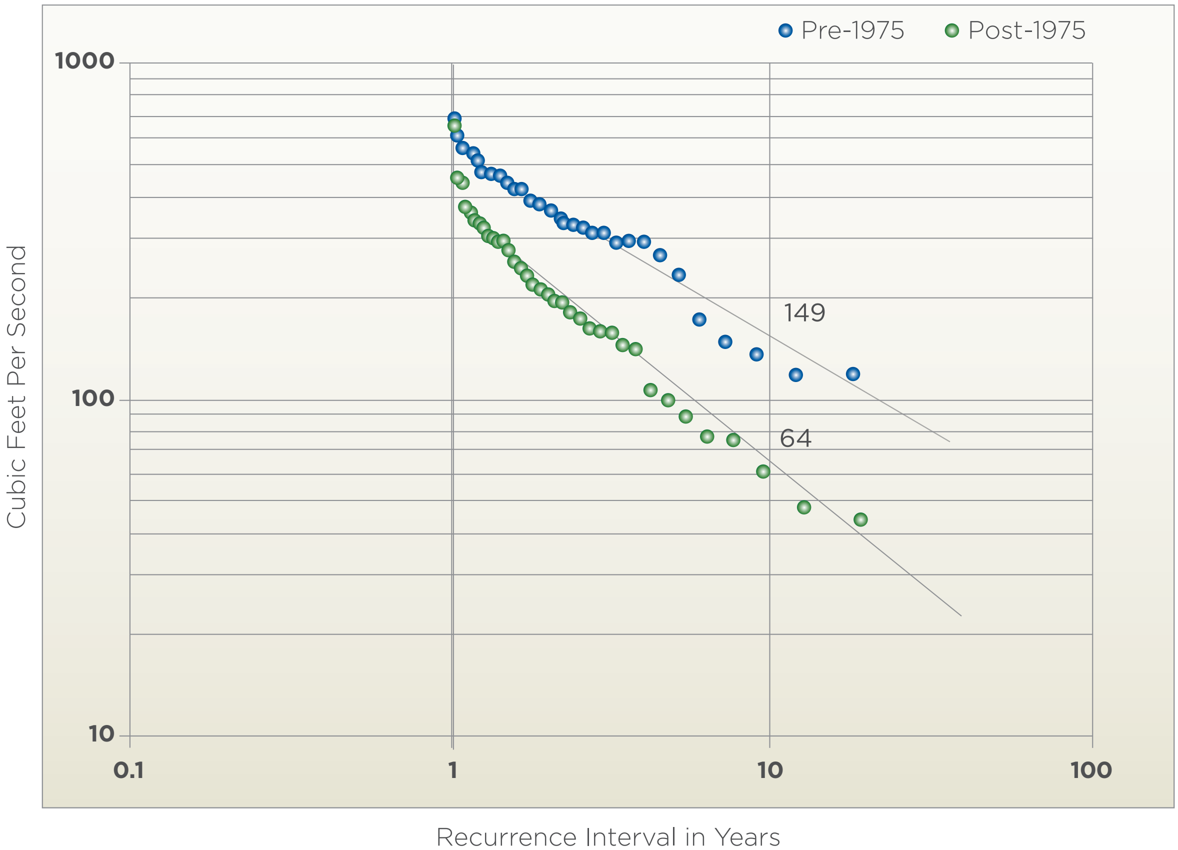
An important characteristic of pump-storage withdrawals from the upper river is their collective operation during drought and extended periods of low or moderately low river flow. In such periods, any "pulse" of higher flow that follows a rain event is very important for these water systems, as it gives them an opportunity to partially replenish the levels of their pump-storage reservoirs. In the river, much of the benefit of this flow pulse is lost, as these pumps compete to harvest water quickly from the very brief pulse of moderate or high flow, preventing a portion of it from flowing downstream.

The relation of actual water withdrawals to streamflow in a variety of conditions over a period of several years is a topic that needs more research and investigation, using standard hydrologic investigation techniques in a "test audit" fashion, examining multiple independent discharge events. Such investigation will be especially useful if it focuses on the river's baseflow depletion and on withdrawals from brief pulses of moderate flow during periods of drought. Yield analyses of such drought pulses might lead to particularly important insights about the quantity of water collectively withdrawn versus what is allowed to flow downstream, ultimately providing a platform for better management of low flows.

Instream Flow Requirements

An important characteristic of many of the surface water withdrawal permits in the basin is the wide range of instream flow requirements that they include. See **Table 2-2** for a list of instream flow requirements outlined in the municipal surface water withdrawal permits in the upper basin. While some permits include relatively complex conditions that regulate withdrawal volumes at a range of different river stages in a multi-

Figure 2-1: Seven-Day Minimum Flows—
Flint River at Carsonville Gauge, 1940-2011



Caption: Regression analysis of yearly 7-day minimum flows, 1940-2011, measured at the USGS Carsonville streamgauge. As shown, the 7Q10 value is now less than half of the pre-1975 7Q10 value. Data from U.S. Geological Survey, www.usgs.gov.

tiered fashion, others cite only a single minimum flow "floor" as the streamflow requirement, and several permits include no flow requirement at all. Although many of the withdrawal permits are designed to protect critical low flows and allow pumping only during periods of high flow, the instream flow thresholds used in many permits need assessment in light of hydrologic changes in the river system.

Georgia's interim instream flow policy, established in the 1990s and effectively based on 7Q10 values, provides an inappropriate measure of stream health, yet even it is not applied in some of the older withdrawal permits. (The 7Q10 value is the lowest 7-day average stream flow that is expected to occur once every ten years.) **Figure 2-1** shows the downward trend of 7Q10 values in the upper basin in recent decades as compared to the earlier part of the historic flow record.

While the majority of the water systems operating in the upper basin strive earnestly to operate in ways that are protective of river system sustainability, the combination of insufficient instream flow protections built into withdrawal permits with a lack of sufficient return flow to the river system is a factor in the loss of healthy flows in the upper Flint.

RESTORING HEALTHY FLOWS IN THE UPPER FLINT

Healthy flows can be restored in the upper Flint River basin. The current downward trend can be reversed, and there are restoration opportunities already at hand.

Several general areas of opportunities for restoring flows exist. These are described below, followed by specific opportunities at hand presently in the upper Flint. Many of the factors described here—especially characteristics of water and wastewater infrastructure—cannot necessarily be addressed in the short term, but identifying the importance of various impairments and potential solutions is an important step toward restoration, helping to prioritize and later implement flow restoration opportunities. Meanwhile, seizing on near-term opportunities can help to halt further degradation of baseflows and, especially, the occurrence of extreme low flows in drought years.

It must be noted that further work toward understanding healthy flow regimes for the upper Flint River remains a key step toward restoration. Ongoing research on shoal bass will likely yield significant insights about ecological flow needs to support that important species. Also, verification of economically productive flows in the Pine Mountain region should be undertaken, and a close examination of the critical habitat requirements of listed mussel species should be conducted. Assessment of other ecological flow needs, as well as further research into the relative hydrologic impact of various different impairments, will help set a clear agenda for restoring healthy flows. The authors do not contend that such assessments should aim to restore a pristine state or a wholly unaltered flow regime, given the heavily impacted state of the basin. Rather, such assessments would provide important goal-setting for flow thresholds on the path toward achievable restoration.

Water Efficiency

Water use efficiency results in lower water demand and, thus, less water needing to be withdrawn from rivers, streams and aquifers. Standard water efficiency and conservation practices, which have proven effective across the country and in much of Metropolitan North Georgia, still hold great potential for water demand management across the upper Flint basin. While some water utilities in the basin have implemented effective conservation and efficiency practices, others lag behind many of their fellow utilities in the Metropolitan Atlanta area. The various water systems serving customers in Fayette and Coweta counties, for example, have room for improvement when it comes to end-use water efficiency. The Clayton County Water Authority and the City of Griffin water system (in its retail service area) stand out for their progress on conservation and efficiency. In the realm of water system efficiency, the City of Thomaston, Clayton County Water Authority, the City of Zebulon and Coweta County Water Authority provide positive examples for their recent work on leak detection and repair and on water line replacement.

The wide variability in progress on water efficiency is evident in the 2011 Metrics Report of the Metropolitan North Georgia Water Planning District (a.k.a. the "Metro District").[10] While there has been progress on water efficiency overall in the Metro District, it has not been uniform in the Metro District systems which are in the upper Flint basin. This inconsistency is present across upper Flint utilities outside of the Metro District as well, and highlights an opportunity for water efficiency savings that can leave more water in the river system.

While many practices will necessarily vary by system, efforts to increase both system efficiency and end-use water efficiency would extend the life of public infrastructure and extend the availability of public water supply held in storage reservoirs in drought years. Any and all improvements in the realm of water conservation and efficiency are welcome for reducing drought-related water supply risks and, ideally, for reducing strain on surface water sources for water supply.

A more comprehensive approach to conservation and efficiency planning basin-wide has great potential for bringing long-term sustainability to the operations of the public water supply systems and for restoring sustainable flows in the river system. Initial goal-setting in this arena would do well to focus on bringing consistency to the demand management efforts of the various different water utilities in the basin.

The water loss accounting required of water utilities under the Georgia Water Stewardship Act of 2010 provides an excellent starting point for determining utility-specific management practices to increase both system efficiency and end-use efficiency.

Drought Management

Drought response, in particular, would benefit from greater consistency across different water systems through the stages of a drought.
For example, in the most recent drought, the Fayette County Water System did not impose conservation measures for landscape irrigation until October of 2012, fully 33 months after the drought began and 17 months after the severity of the drought became clear, and with Lake Horton at very low levels. The City of Griffin, on the other hand, instituted drought response measures more than a year earlier, in the late summer of 2011. Bringing greater consistency to drought response alone would more equitably manage the basin's water resources among its various water utilities and their customers, and among all users of the river.

Hightower Shoals, Flint River / Credit: Alan Cressler

Reducing Seasonal Peak Demands

An important focus area in certain areas of the upper basin is to reduce peak demand, which is primarily driven by landscape irrigation in the summer months. As noted above, summertime peak water demand is particularly impactful because it comes at a time when streamflows are already low.

Various local measures and incentives hold great potential for mitigating demand peaks in a cost-effective, economically prudent manner: water rate structures designed to incentivize efficient outdoor water use, requiring rain or moisture sensors on irrigation systems, requiring WaterSense certified landscape irrigation professionals, and others. In addition, educating the public about water-efficient landscape design and effective irrigation are important to reducing peak water use. Other water systems have successfully implemented programs to reduce or flatten seasonal peaks in demand and promote efficient landscape irrigation. An example is the town of Cary, North Carolina, with its local ordinances, "WaterWise" landscaping program and "Beat the Peak" campaigns.[11] Addressing seasonal peaks in demand is an important next step throughout the upper Flint basin.

Further work on reducing irrigation-related peaks in water demand should include specific attention to golf courses, as well, since they are numerous in the suburban portions of the upper Flint basin. While the golf course management community in Georgia has made significant strides in water use efficiency in recent years, this is a topic that deserves a closer look in the upper Flint basin in particular, and especially in areas where there might be site-specific opportunities to reduce particular streamflow impacts in upper Flint tributary streams. Golf course water efficiency strategies that are gaining popularity across the country include targeted watering, monitoring systems that prevent overwatering, raising mowing heights, and using hardier varieties of grass.

Mitigating Consumptive Uses

It is important to note that improvements in water efficiency have the potential to substantially mitigate the magnitude of consumptive losses to the upper Flint, be they via interbasin transfers or in-basin consumptive uses. While there are opportunities to alter infrastructure in order to reduce consumptive uses and return water to the Flint (and some examples are discussed below), fully eliminating these consumptive uses may not be feasible or cost-effective in many cases. In contrast, conservation and efficiency may present 'lower-hanging fruit' opportunities that are less expensive and disruptive than rearrangements of infrastructure. This is a strategy that could apply with equal effectiveness to interbasin transfers and to in-basin consumptive uses of water.

Reducing Consumptive Uses and Increasing Return Flows

Since the lack of sufficient return flows to the upper Flint stems mainly from the characteristics of wastewater infrastructure in the basin, there are opportunities for changes to infrastructure which would result in greater return flows. The retirement of land application systems is a major opportunity, as that form of wastewater treatment can be replaced with direct discharges to the upper Flint or its tributaries.

Accomplishing higher levels of wastewater treatment is far more feasible and cost-effective today versus when much of the basin's infrastructure was first built. This is a key point with regard to maximizing return flows to the small streams of the upper Flint. While greater treatment of wastewater may come with added costs, these costs must be weighed against the other costs being incurred in multiple ways by the loss of healthy flows in the river system.

In some cases, retiring LAS facilities can even return existing interbasin transfers of water to the Flint. The Clayton County Water Authority is currently examining this kind of opportunity, which is described below.

Similarly, prudence is in order with regard to non-potable water reuse in the basin. As noted above, non-potable reuse—for "purple pipe" landscape irrigation, for example—might seem an environmentally friendly strategy, but in fact it plays a role in the lack of sufficient return flows in the basin.

Potable Water Reuse

The upper Flint basin is home to a regionally pioneering innovation in water supply provision: the indirect potable reuse systems operated by the Clayton County Water Authority. The Authority's constructed wetlands (the Huie wetlands and Panhandle wetlands) help to secure sustainable water supply for this headwaters county.

Among its many benefits, the Authority's reuse system provided it with many more days' secure water supply during the severe drought and water supply shortage of 2007-2008 as compared with many North Georgia communities.[12] From the perspective of water quantity in the Flint River, the only downside to this particular system is that it ultimately results in a transfer of Flint water to the Ocmulgee River basin. The benefits of the system, however, are that it reduces the Authority's need to withdraw water from the Flint (thus mitigating the magnitude of the interbasin transfer) and that it enhances the security of the Authority's water supply.

It is highly possible that expanding indirect potable reuse as a water supply strategy in other upper Flint communities could be highly beneficial for water supply security in future drought conditions and for the sustainability of the river system. Certainly, any new engineering plan must be evaluated on its merits in any given location where it is proposed—and with downstream effects in view, as noted above and in last year's National Research Council report—but indirect potable reuse is a strategy that may hold promise and should be explored further and more widely in the upper Flint.

It must be noted that the benefit of indirect potable reuse systems would be to reduce the strain on surface waters for public water supply. Non-potable reuse systems for landscape and turf irrigation, as noted above, are often problematic from the perspective of consumptive uses of water and a lack of return flows to the river system. Such cases call for reducing non-potable reuse systems' consumption and working to return the water that they use to surface streams.

Green Stormwater Infrastructure to Restore Natural Hydrology

Due to the very high density of urbanized landcover in the Flint's headwaters, improvements to stormwater infrastructure may hold high potential for restoring baseflow in the basin's upper reaches. "Green infrastructure" for stormwater management can include both retrofits to stormwater infrastructure and new construction, and it seeks to restore or replicate natural hydrology as much as possible. Infrastructure elements specifically tailored to infiltrating water into soils in order to restore groundwater and baseflow could help remedy the upper Flint's water quantity problems in addition to improving water quality. Green stormwater infrastructure can be as small-scale as a residential rain garden or as large-scale as systems of bio-swales or bio-retention ponds, and can even extend to broader "natural infrastructure" strategies such as targeted land conservation to preserve wetlands and stream corridors, or in some cases restoring natural floodplains, wetlands and degraded streams.

There are many opportunities for improvements to stormwater management in the upper Flint's most urbanized areas—at and near Hartsfield-Jackson Atlanta International Airport—and also in suburban areas of Clayton, Coweta, Fayette, Fulton, Henry and Spalding counties.

Specific Restoration Opportunities

CLAYTON COUNTY WATER AUTHORITY

As noted above, the Clayton County Water Authority's water system results in an interbasin transfer of water from the upper Flint basin to the Ocmulgee River basin to the east. Fortunately, in 2012 the Authority was granted a wasteload allocation from Georgia EPD in an initial step toward retiring a large LAS facility and potentially creating a new discharge of treated wastewater to the upper Flint River, which would return a small portion of the existing interbasin transfer back to the Flint. Given the higher level of wastewater treatment now possible, this is a welcome development from the perspective of water quantity in the upper Flint River. As of this writing, Clayton County Water Authority officials are assessing potential next steps in this regard.

CITY OF GRIFFIN

Similarly, the City of Griffin has developed plans to create a surface water discharge at its Shoal Creek wastewater treatment facility in western Spalding County, where currently all of the wastewater flow is land-applied.[13] While these plans are effectively on hold pending additional demand growth in Griffin's retail water system, their timetable should be assessed in light of the potential benefit of returning flows of sufficient quality to the Flint River via Shoal Creek.

COWETA COUNTY WATER AUTHORITY

Coweta County is perhaps the best example of an upper Flint River basin community where the path toward more environmentally sustainable water supply includes hurdles that are financial and contractual in nature. In the 1990s, Coweta County entered into long-term wholesale water purchase contracts with the City of Griffin water system and with Newnan Utilities. Both contracts, which include minimum purchase amounts, were transferred from the county to the Coweta County Water Authority in 2007 along with the ownership and operation of the water and wastewater system. For various reasons (including a major program to fix leaking water distribution pipes), water demand in the Authority's service area has not grown in recent years. The Authority's own B.T. Brown Reservoir and Water Treatment Plant in the Chattahoochee River basin operates far below its 8 MGD capacity due to the requirements of the Authority's purchase contracts with Griffin and Newnan.

All of this results in a loss of water from the upper Flint River system. While the vast majority of the water used in the Authority's system comes from the upper Flint basin (all of the water that the Authority purchases from the City of Griffin and most of the water it purchases from Newnan Utilities), the Authority discharges only roughly one-tenth of its average annual demand back to the Flint. If the Authority were able to make better use of its own water production facility in the Chattahoochee basin, this would better balance the equation of withdrawals, consumption and returns to the Flint and Chattahoochee basins as compared to the present situation.

It must be noted that the City of Griffin financed and built its Still Branch regional reservoir in part to supply the Coweta County Water Authority and other wholesale customers. Financial arrangements between Griffin and its wholesale customers are not necessarily easily changed, as payments under these purchase contracts help support debt service payments on the City of Griffin system. Yet, in fall 2012 Griffin and Coweta re-negotiated their wholesale contract in a partial but positive step forward toward rectifying some of the negative environmental and financial aspects of this situation.

Good faith and further flexibility on the part of all parties, as well as continued efforts at cooperation and creative problem-solving, may yield yet more opportunities to restore flows to the Flint while cost-effectively securing water supplies for communities throughout the basin.

Upper Flint River Working Group

Recognizing that the river's flow issues are complex and multi-faceted, we propose a collaborative, multi-stakeholder approach for developing, coordinating and implementing an array of short-term and long-term flow restoration opportunities. The pursuit of every type of restoration opportunity described above would undoubtedly benefit from open communication and coordination on a basin-wide scale. Many of the factors described in this report cannot necessarily be addressed in the short term, but identifying the importance of various impairments and potential solutions is an important step toward eventual flow restoration. Just as important is engendering a cooperative spirit in approaching these impairments and their solutions.

We propose the convening of an Upper Flint River Basin Working Group to begin collaborative work toward finding solutions to the upper Flint's low-flow problems. This Working Group will be made up of a broad base of diverse stakeholders including water providers, water users, residents, businesses, landowners, congregations, non-profit organizations and all who depend on a vibrant, flowing Flint River. Geographically speaking, the Working Group should focus on the Piedmont region—on the river and its tributaries from the uppermost headwaters to the Fall Line.

The premise of this collaborative effort is that all types of stakeholders can play a role in pursuing restoration opportunities of all types and at all scales. In participating in the Working Group, any stakeholder can commit to pursuing opportunities that are available to them. Because there are so many factors in the low-flow problem on the upper Flint River, there are many opportunities for those who depend on the river system to help restore it. This central premise of the Working Group concept is one of mutual commitment to working to restore the river's health.

RUNNING DRY | FURTHER RESEARCH TOPICS

Further research topics noted throughout the report would benefit the collective understanding of certain topics primarily related to climate, hydrology and water use in the basin. Additional inquiry into these questions and others would provide important data on the reasons for the decline in upper Flint flows and provide further guidance on how to best restore healthy flows. As noted, a key area of further work is in identifying ecological flow needs in the basin.

THESE TOPICS INCLUDE:

- Developing an understanding of ecological flow regimes for various ecosystem functions in the river system, including those tied to production and reproductive success of shoal bass and of threatened and endangered species.
- Economic effects of flow loss in the river system, related to recreation, land values, municipal and industrial water supply, etc.
- Information-gathering on actual water withdrawals in the basin under industrial permits, agricultural permits (for working farms as well as other uses such as golf courses, horticultural nurseries, and others), and un-permitted withdrawals.
- Hydrologic effects of changes in climate, including any changes to seasonal patterns of rainfall, increased average temperatures, and repeated drought, as well as any changes in the relationship between observed meteorological drought and hydrologic drought.
- Evaporative water loss, especially in drought conditions, from impoundments of all sizes throughout the basin.
- Baseflow losses due to landscape urbanization.
- The relation of water withdrawals to streamflow in a variety of hydrologic conditions over a period of several years. Such investigation might be especially useful if it focuses on the river's baseflow depletion and on withdrawals from brief pulses of moderate flow during periods of drought. Yield analyses of such drought pulses might lead to particularly important insights, ultimately providing a platform for better management of low flows.
- Overall, further comparative analysis of the relative hydrologic impact of various different known flow impairments.

Conclusion

The factors impairing healthy flow in the upper Flint River basin are many and diverse; they did not come about overnight, and for the most part they will not be solved quickly. Those who depend on a healthy Flint River can, however, begin working now to reverse the trends of recent years and take solid steps to restore healthy flows to the river.

The opportunities for restoring flows are many. They include improving water efficiency and conservation among residents and businesses throughout the basin to reduce demands on the river system, reducing water loss in public water systems, using green stormwater infrastructure to restore the natural water cycle and baseflow to streams, and increasing the volume of return flows to the river system from public water systems.

Most important going forward is collaborative work by all types of stakeholders toward finding solutions to the upper Flint's low-flow problems. There are many opportunities for all who depend on the river system to help restore it to health.

The measures outlined here would reduce the strain on the river system and allow it to regain some of its natural resilience. Taking these steps to restore healthy flows in the upper Flint will better prepare the river for droughts to come and protect the river for the benefit of communities today and for future generations.

1 "The Natural Flow Regime: A Paradigm for River Conservation and Restoration." N. LeRoy Poff; J. David Allan; Mark B. Bain; James R. Karr; Karen L. Prestegaard; Brian D. Richter; Richard E. Sparks; Julie C. Stromberg. BioScience, Vol. 47, No. 11. (Dec. 1997), pp. 769-784.

2 "Special Report on Paddlesports – 2009," Outdoor Industry Association and The Outdoor Foundation, www.outdoorfoundation.org

3 "2012 Outdoor Recreation Participation Report," The Outdoor Foundation, www.outdoorfoundation.org

4 "Relations Between Shoal Bass and Sympatric Congeneric Black Bass Species in Georgia Rivers with Emphasis on Movement Patterns, Habitat Use, and Recruitment," report submitted to Georgia Department of Natural Resources Wildlife Resources Division by Steven M. Sammons and Matthew R. Goclowski, Department of Fisheries and Allied Aquacultures, Auburn University. December 2012.

5 "Paving Our Way to Water Shortages: How Sprawl Aggravates the Effects of Drought," American Rivers, Natural Resources Defense Council and Smart Growth America, 2002. p. 10.

6 "Assessing Spatial Hydrological Data Integration to Characterize Geographic Trends in Small Reservoirs in the Apalachicola-Chattahoochee-Flint River Basin." Amber Ignatius and Jon Anthony Stallins, Southeastern Geographer, 51(3) 2011: pp. 371-393.

7 "Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater," National Research Council. Washington, DC: The National Academies Press, 2012.

8 "Septic Systems Status and Issues Working Paper," Metropolitan North Georgia Water Planning District, March 2006. www.northgeorgiawater.com.

9 Pers. Comm., Dr. Brant Keller, City of Griffin, March 2013

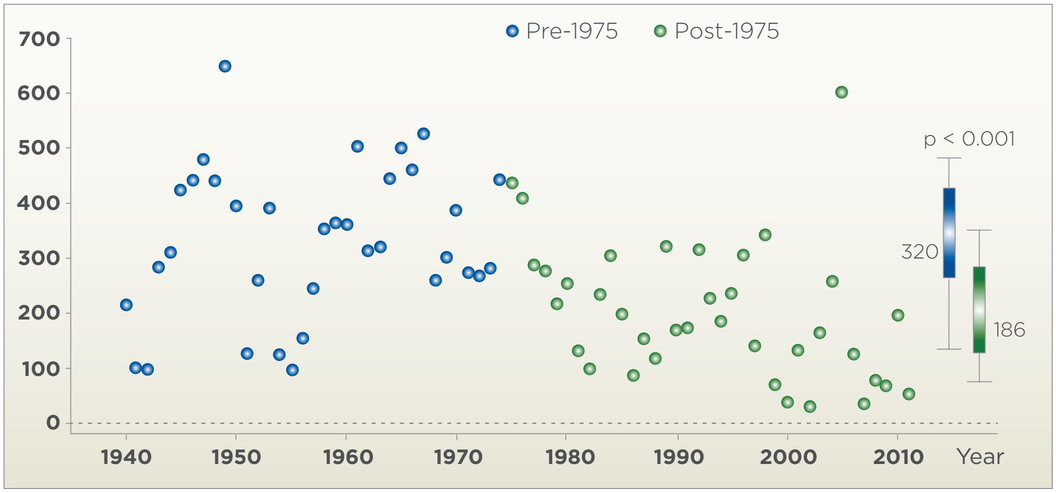
10 Water Metrics Report, Metropolitan North Georgia Water Planning District, February 2011. www.northgeorgiawater.com.

11 "Hidden Reservoir: Why Water Efficiency is the Best Solution for the Southeast," American Rivers, 2008, p. 18.

12 "Natural Security: How Sustainable Water Strategies are Preparing Communities for a Changing Climate," American Rivers, 2009. pp. 48-55.

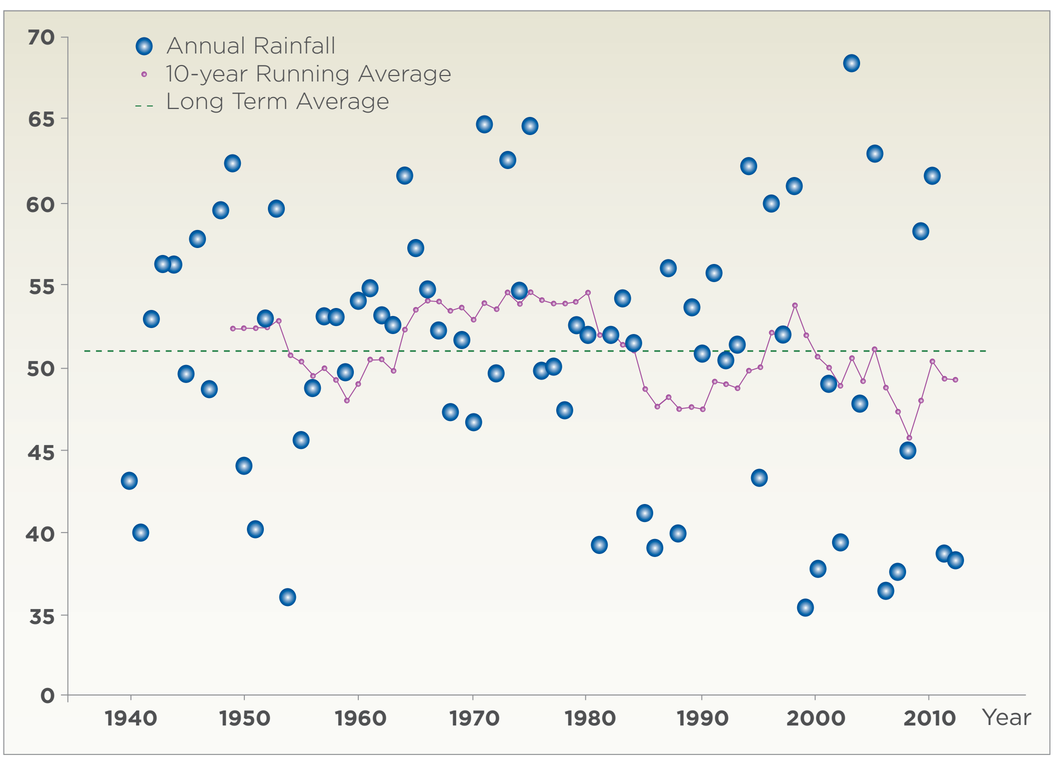
13 "Griffin/ Spalding County Wastewater Management Plan, 2005-2025," Engineering Strategies Inc. and Paragon Consulting Group.

Figure A-1: One-Day Minimum Flows—Flint River at Carsonville Gauge, 1940-2011



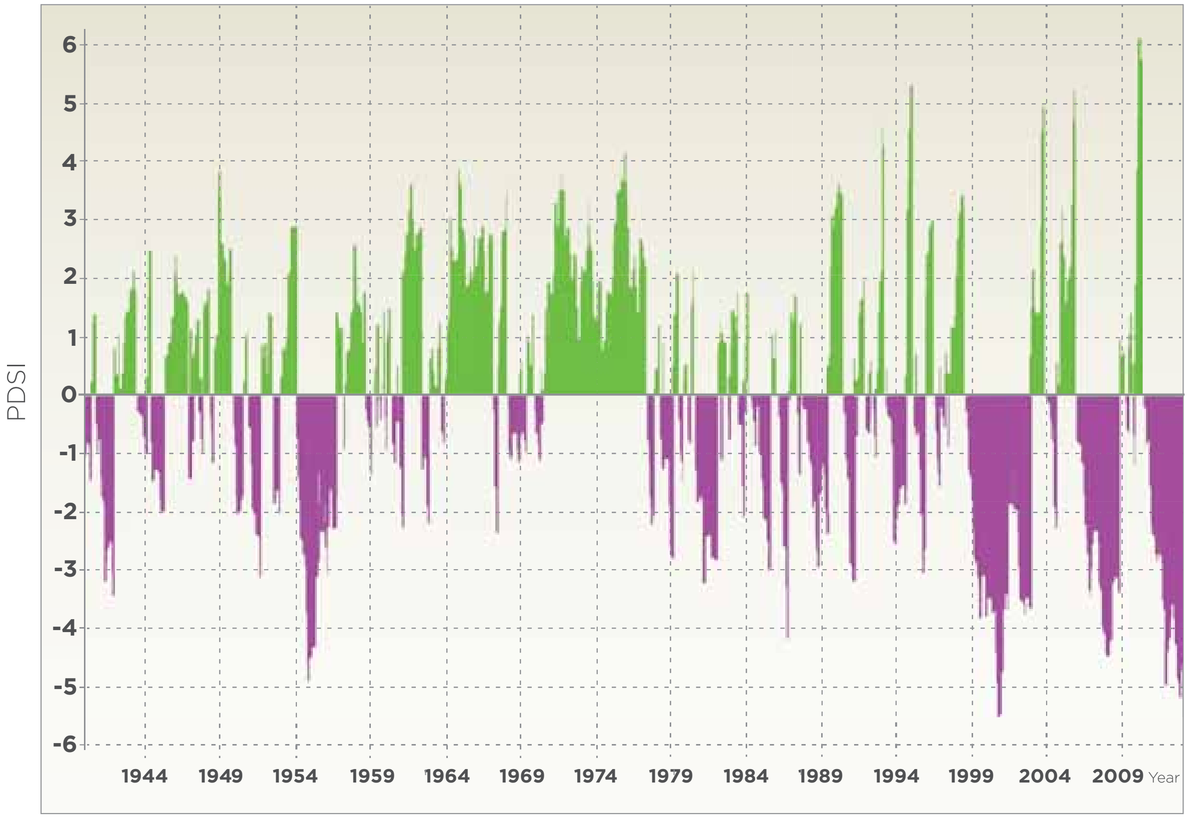
One-day minimum river flows by water year, 1940-2011, measured at the U.S. Geological Survey Carsonville streamgauge. The numbers accompanying the box plots at right show the median values of the data points for each time period noted. As shown at right, the median one-day minimum after 1975 is significantly lower than the pre-1975 median. Data from U.S. Geological Survey, www.usgs.gov.

Figure A-2: Annual Rainfall Data, West-Central Georgia, 1940-2012



Rainfall statistics by water year from weather stations in and near the upper Flint River basin, 1940-2012. Data from National Climatic Data Center (Georgia Climate Division 4), www.ncdc.noaa.gov.

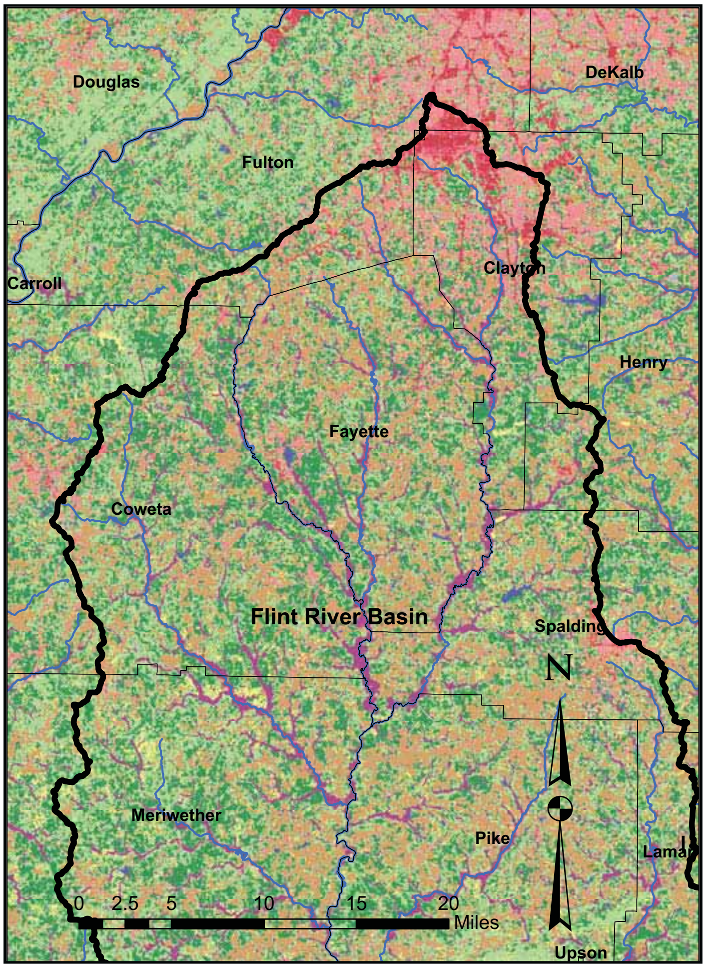
Figure A-3: Palmer Drought Severity Index—West-Central Georgia, 1940-2012



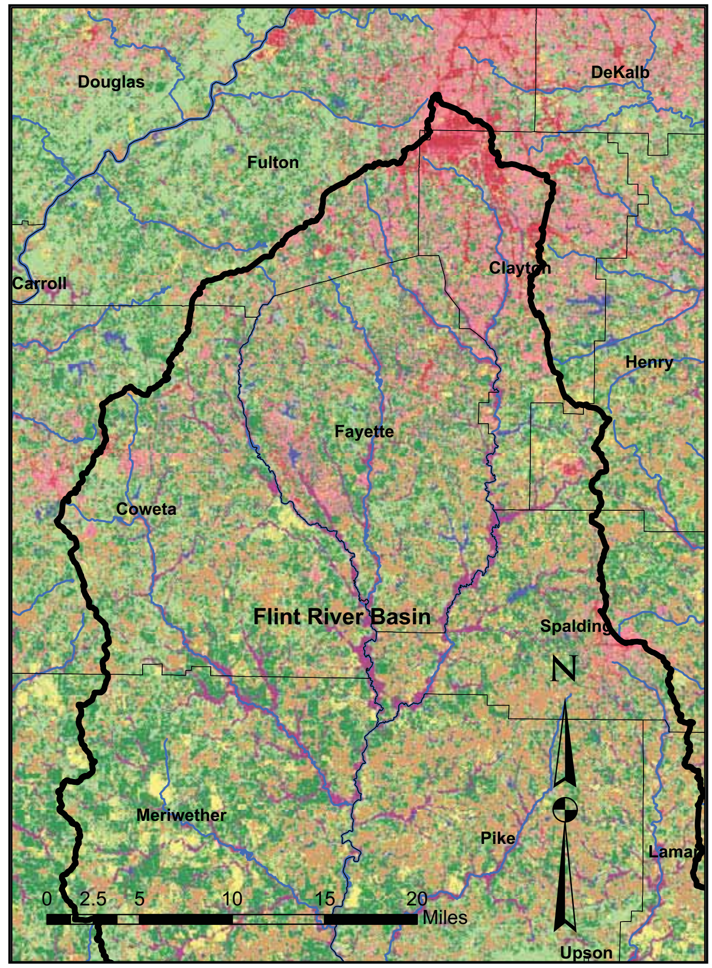
Palmer Drought Severity Index readings for the upper Flint River basin, 1940-2012. The Palmer index combines multiple measures to produce an overall assessment of locally contextualized drought conditions. Negative readings reflect drought conditions, positive readings reflect wetter-than-normal conditions, and 0 reflects long-term "normal" conditions for the area. Data from National Climatic Data Center (Georgia Climate Division 4), www.ncdc.noaa.gov.

Landcover: Upper Flint River Basin

1974



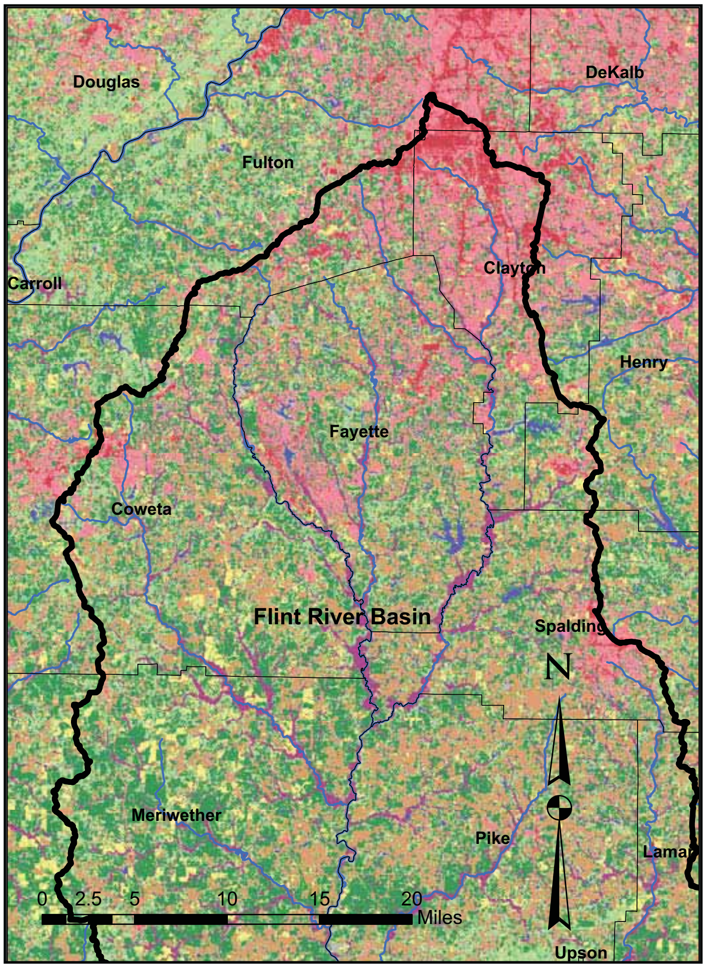
1991



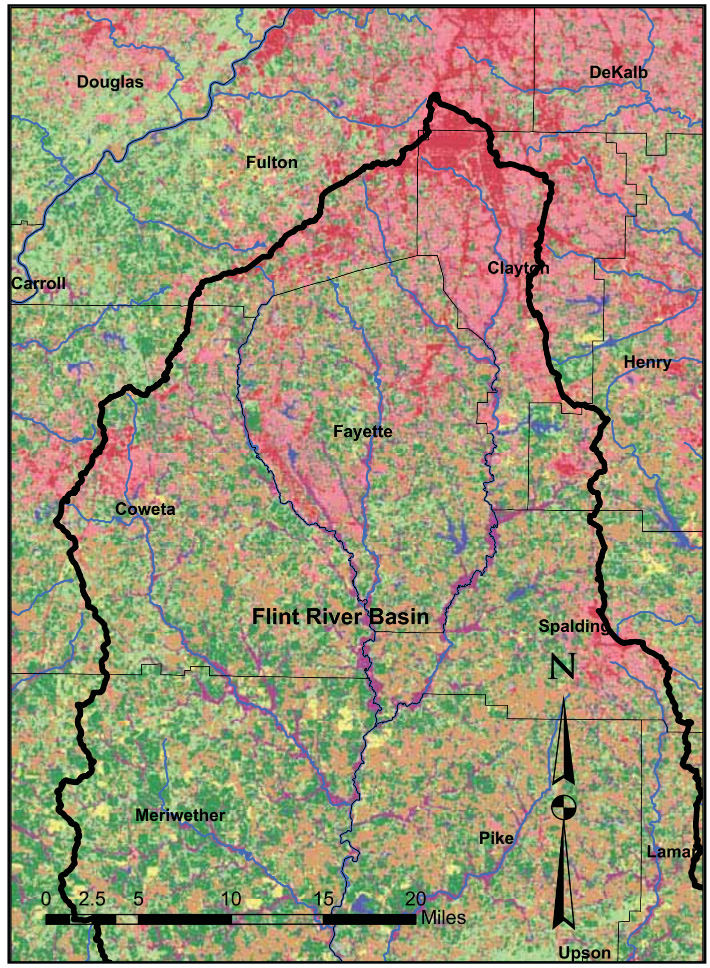
Landcover Descriptions

- Beaches, Dunes and Mud
- Open Water
- Low-Intensity Urban
- High-Intensity Urban
- Clearcut and Sparse
- Quarries/ Strip Mines/ Rock Outcrops
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Row Crops and Pastures
- Forested Wetland
- Salt/ Brackish Marsh
- Freshwater Marsh

2001



2008



Natural Resources Spatial Analysis Lab, University of Georgia (www.narsal.uga.edu)

Figure A-4: Georgia EPD memorandum, Wastewater Discharges – Flint River Basin

3/9/88

PMs
These procedures have
been approved by JLC
and are now in effect.
JD

Georgia Departme of Natural Resources

205 Butler Street, S.E., Floyd Towers East, Atlanta, Georgia 30334

J. Leonard Ledbetter, Commissioner
Harold F. Reheis, Assistant Director
Environmental Protection Division

February 26, 1988

Memorandum:

TO: Leonard Ledbetter

THRU: Harold Reheis

FROM: David Word and Jack Dozier

SUBJECT: Wastewater Discharges
Flint River Basin

The South Metro Water Supply Study identified several scenarios for water supply in the South Metro area (Fayette, Coweta, Spalding, Pike, Henry and Meriwether). Each scenario includes short term utilization of water supply reservoirs on small streams (Line Ck., Horton Ck, Towaliga R., etc.) and existing Flint River intakes and long term reliance on reservoirs off-stream of the Flint River. The report clearly documents that the Flint River and its tributaries will be the primary source of water in the future for the South Metro area.

The Division has discussed the report with each local government and the McIntosh Trail APDC. A task force is established (first formal meeting to be on February 26) to arrive at an areawide plan for water supply. Some local governments have already begun development of reservoir sites and some have adopted watershed protection ordinances.

It is appropriate for the Division to protect the quality of the Flint River Basin for future, and current, water supplies. This process has already taken shape by removal of the City of Atlanta and Clayton County wastewater discharges. To continue this process, the Division should not permit any new or expanded wastewater discharges (beyond that which EPD has permitted, approved or committed) in the Flint River Basin upstream of the most downstream proposed water intake, the Flint River at the Crescent (near Molena). This would require future land application systems and/or discharges outside of the Flint River Basin (Chattahoochee - Coweta County, Ocmulgee - Spalding and Henry County). It would not impede immediate wastewater plans since permits and approvals have been issued for wastewater discharges to accommodate short-term increases. The most pronounced impact would be on Fayette County in the future, since Fayette is projected for rapid growth.

Upon your concurrence, we will prepare letters to each local government and discuss this at the upcoming task force meeting.

DW:bb

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