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Water crisis: the metropolitan Atlanta, Georgia, regional water supply conflict

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Abstract

Many large population centres are currently facing considerable difficulties with planning issues to secure future water supplies, as a result of water allocation and environmental issues, litigation, and political dogma. A classic case occurs in the metropolitan Atlanta area, which is a rapidly growing, large population centre that relies solely on surface water for supply. Lake Lanier currently supplies about 70% of the water demand and has been involved in a protracted legal dispute for more than two decades. Drought and environmental management of the reservoir combined to create a water shortage which nearly caused a disaster to the region in 2007 (only about 35 days of water supply was in reserve). While the region has made progress in controlling water demand by implementing a conservation plan, per capita use projections are still very high (at 511 L/day in 2035). Both non-potable reuse and indirect reuse of treated wastewater are contained in the most current water supply plan with up to 380,000 m^3/day of wastewater treated using advanced wastewater treatment (nutrient removal) to be discharged into Lake Lanier. The water supply plan, however, includes no additional or new supply sources and has deleted any reference to the use of seawater desalination or other potential water sources which would provide diversification, thereby relying solely on the Coosa and Chattahoochee river reservoirs for the future.

Keywords: Reservoir management; Water dispute; Water litigation; Water reuse; Water supply management; Water supply planning

1. Introduction

Governmental bodies can react to a water crisis in a variety of different ways, ranging from careful analysis and planning to a purely political, rather superficial response. The approach taken to address a water crisis can directly influence the long-term viability of the selected solution. Where there are

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conflicts over the allocation of water resources, the proposed solution to a crisis can lead either to a regional consensus or to a series of protracted, long-term conflicts. The Atlanta, Georgia, water supply system provides an example of the complexity of resolving a water supply crisis within the framework of a conflict over allocation of water from primarily a single source. It also allows insights into the relationship between long-term water supply planning and the political process.

The Atlanta metropolitan area is located in Northwest Georgia (USA), consisting of 28 counties including the City of Atlanta. In 2010, the metro Atlanta area had a population of 5,268,860 according to the US Census Bureau (2012). The Metropolitan North Georgia Water Planning District (MNGWPD), created in 2001, contains 15 counties (Figure 1) and projects that the district population will increase to 7.49 million by 2035, which is their long-term planning horizon (MNGWPD, 2009a, b). The Atlanta Regional Commission projects that the population growth specifically in the metro-Atlanta area will reach 8.3 million by 2040.

Two watersheds, the Chattahoochee and Coosa River basins, provide nearly 87% of the water supply for the metro Atlanta area (Figure 2) with the Lake Lanier reservoir in the Chattahoochee Basin producing most of the water. The Chattahoochee River has its headwaters in Georgia but also passes downstream into the states of Alabama and Florida. Allocation of the water resources of the Chattahoochee River are in dispute based on a number of allocation and riparian issues (Glennon, 2009).

An extended drought beginning in 2004 and environmental lake management combined to cause the Lake Lanier water level to drop 4.6 m below its peak stage in October 2007 (Glennon, 2009). This reduction in the volume of stored water pushed the region into a severe water crisis, with a prediction that Lake Lanier would go dry within 3–4 months. The drought period occurred between 2004 and 2008, but rainfall and lake stages returned to more average conditions in 2009 (Figure 3).

The rivers used by the region for water supply are not adjudicated basins that have established water rights allocated to specific entities within a legal framework similar to that found in western US water law or in some international water agreements. Two reservoirs (Lake Lanier and Allatoona Lake) were created on these rivers by the US Army Corps of Engineers (USACE) under an authorization from the US Congress, which specified the uses of the reservoirs to include navigation, power production, flood control, and downstream water supply (affirmed by the 11th Circuit Court of Appeals). Uncertainty concerning specific allocation of water from the reservoirs adds complexity to the overall water supply system and has led to protracted litigation.

It is the purpose of this paper to explore the management of the water crisis by the metro Atlanta governmental agencies within the context of the ongoing dispute over the surface water allocation of Chattahoochee River and other water sources. Also, the fundamental issues of the reasonable use of water, water economics, and environmental considerations are explored by assessing water use, water reuse, and desalination to provide a long-term water supply solution. This is a case study on both water supply and water crisis management which is insightful and has widespread application to inland utilities throughout the United States and other countries.

2. Methodology

Research was conducted on the hydrology of the water sources for the metro Atlanta region and the riparian water rights issues involving the primary and proposed secondary water users of the rivers, currently and as proposed for the future. The reaction of the governmental agencies and residents was documented. Information on the water resources, population projections, and water supply plans were

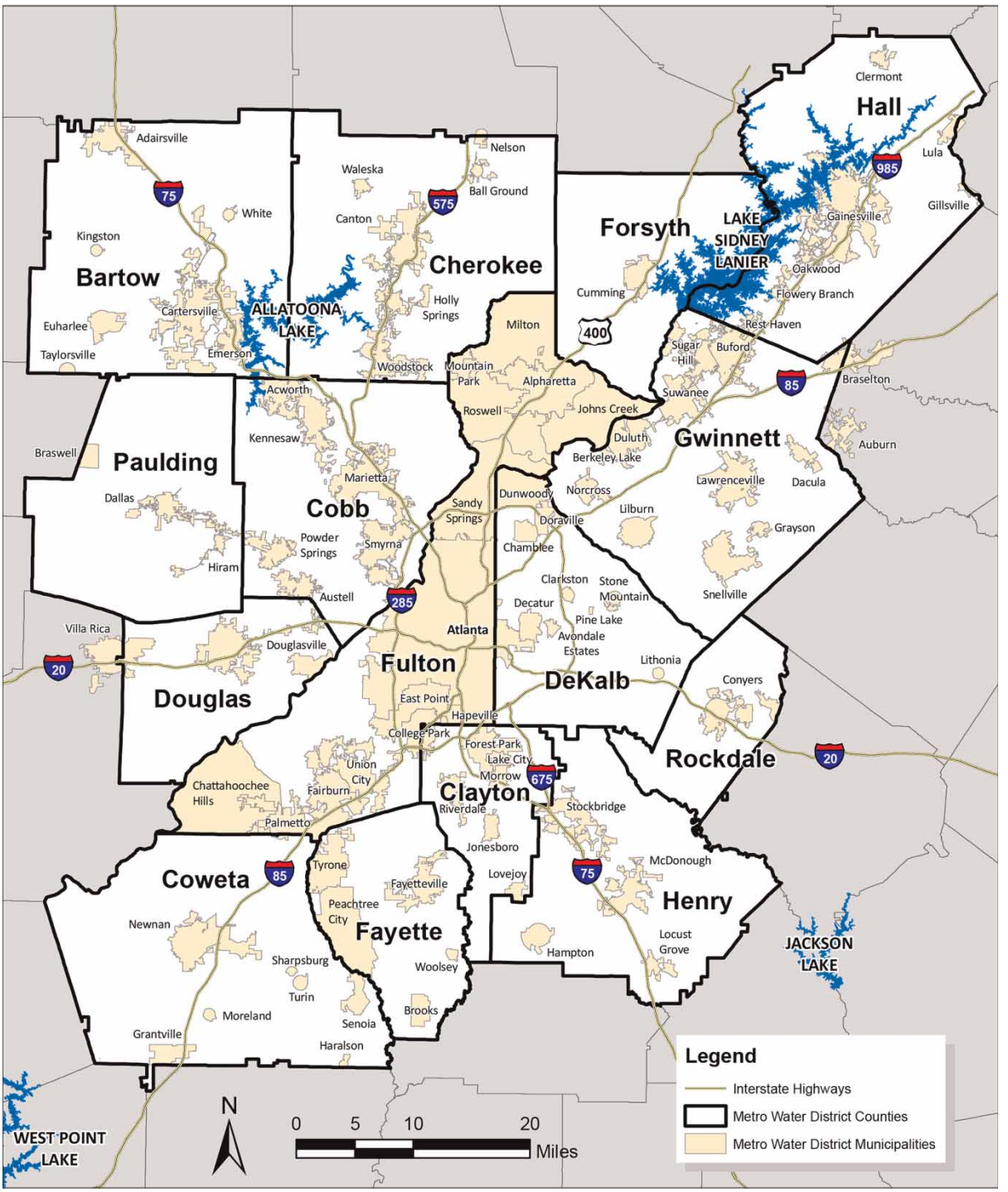

Fig. 1. Map showing the Metropolitan North Georgia Water Planning District (MNGWPD) area including Lake Lanier and Allatoona Lake, the two key water supply reservoirs (from MNGWPD, 2009a, b).

Fig. 2. Surface water basins in the Metropolitan North Georgia Water Planning District area (from MNGWPD, 2009a, b).

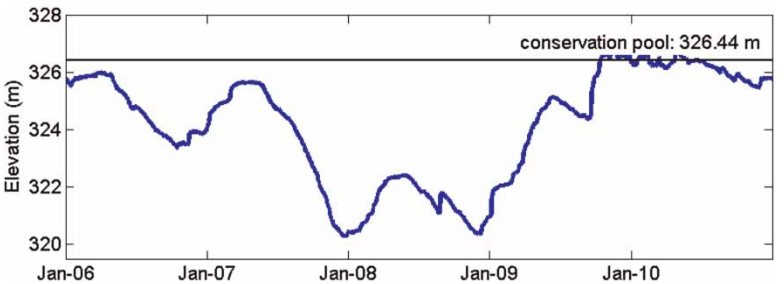

Fig. 3. Diagram showing the stage variation of Lake Lanier from 2006–11 (Anonymous, 2013). Note the extremely low stage of the lake during the critical part of 2008.

obtained to assess the viability of both the agreed upon short-term water supply solution and the proposed long-term solution to the water supply problem. The primary water policy issues were analyzed within the context of the availability of water resources as influenced by climatic variation and change, and based on legal issues arising in the water dispute.

3. Background

3.1. Water use in the Atlanta metropolitan area

Water use in the Atlanta metropolitan area has increased steadily with rapid growth of population and industry to a current demand of about 2.46 million m^3/day. Based on the Water Supply and Water Conservation Management Plan (2003) prepared by the Metropolitan North Georgia Water Planning District (MNGWPD, 2003), the demand will increase to 4.1 million m^3/day by 2030. The MNGWPD (2009a, b) plan revised the projected water use downward based on new population projections and a more intensive water conservation approach (Figure 4).

3.2. Water supply sources

The Atlanta metropolitan area currently utilizes surface water sources to supply the vast majority of water (99%), with a minor amount of groundwater used by individual homes and small communities (MNGWPD, 2009a, b). A permitted surface water allocation of 3.34 million m^3/day is available from six river basins. Most of the allocated surface water is pumped from Lake Lanier and Allatoona Lake which are federally managed reservoirs that have mandated multiple uses including hydropower production, flood control, navigation, water supply, recreation, and navigation. Lake Lanier is the larger of the two lakes with a catchment area of 2,700 km^2 and a surface area of 150 km^2. With a river stage of 326.4 m, the lake holds about 1.29 km^3 of water. Allatoona Lake has a surface area of 48.6 km^2 and an average water volume of 0.45 km^3. Both reservoirs have a generally low volume to surface area ratio and the average water depth is small. Additional surface water is obtained from smaller allocations from the Flint (5.0%), Ocmulgee (8.1%), Oconee (0.2%), and Tallapoosa (0.1%) river basins.

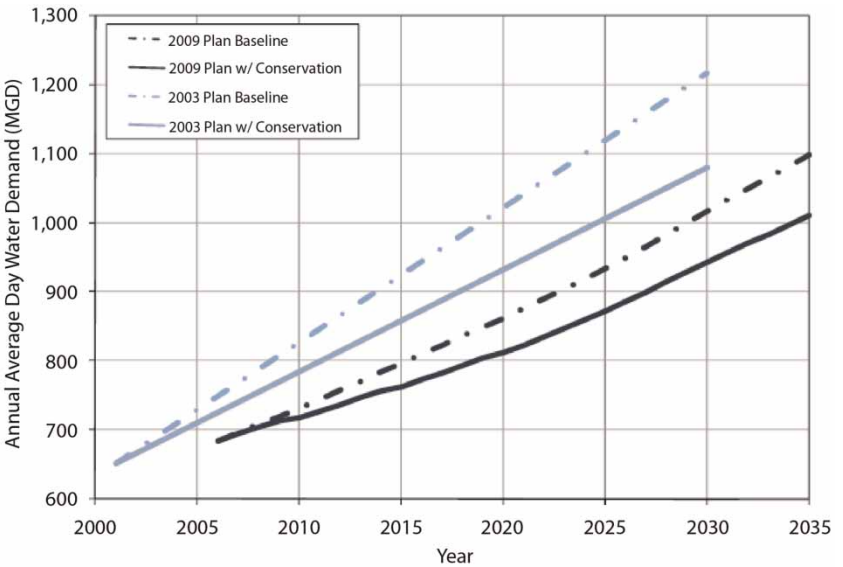

Fig. 4. Projected water use for the Metropolitan North Georgia Water Planning District with a comparison between the 2003 and 2009 projections with conservation overlays (from MNGWPD, 2009a, b) (MGD: million gallons per day; 1MGD = 3,788 m^3/day).

3.3. The 2005–2009 water crisis

Northern Georgia has a humid climate, receiving a mean annual rainfall of about 127 cm/year (and ranging from 76 to 178 cm/year). Below-average rainfall in four consecutive years from 2004 to 2008 caused a severe drop in the stage of Lake Lanier (Figure 3), causing a reduction of the lake stage to a critical level in 2007, triggering a level 4 drought emergency which, in turn, caused a ban on all outdoor watering except by essential businesses (Glennon, 2009). If Lake Lanier had indeed become completely depleted as a supply source, there was no backup water supply (Grillo, 2007).

Drought is not new to northern Georgia. Since 1950, the water flows and stages in northern Georgia have been close to the levels observed in 2007 in eight other years (Stevens, 1989). So, questions arise concerning why the 2004–2008 drought had such a significant impact. The water demand for the region was higher than in the past, but another significant factor impacted Lake Lanier. The USACE replaced the lake stage gauge in December 2005 but made an error in the calibration of the gauge, causing the stage to be overestimated by 0.5 m relative to the real value. Because of this error, environmental releases were allowed that caused more than 83 million m^3 of excess water, or 6.3% of the conservation pool capacity, to pass downstream through the Buford Dam. The Lake Lanier stage reached a record low on 26 December 2007 at an elevation of 320.28 m.

3.4. Lake Lanier and the Tri-state water wars

The Chattahoochee and Coosa river basins are shared by the states of Georgia and Florida and by Georgia and Alabama, respectively, and both are under dispute (Figure 5). Georgia's interests are primarily related to the maintenance and expansion of water supplies to meet the needs of the metro Atlanta

Fig. 5. Locations of the ACT and ACF river basins in Alabama, Florida, and Georgia.

region and other cities located along the course of the rivers, but also include power generation and recreation. Alabama's interests are downstream riparian water users who require water from the Alabama–Coosa–Tallapoosa (ACT) basin for agriculture, industry, fisheries, recreation, preservation of habitats and diversity (environmental flows), power generation, navigation, and water quality. Florida interests are in the Apalachicola–Chattahoochee–Flint (ACF) basin and are centred on the requirement for freshwater flows into Apalachicola Bay to maintain salinity balances for fisheries and shellfish harvesting. The USACE has primary management interests, including oversight of the reservoirs and stream flows, allocation of water resources, and maintenance of channel navigation.

The dispute began innocuously in September 1988 when the USACE recommended that some of the water stored in Lake Lanier allocated for hydropower generation should be reallocated for water supply in northern Georgia (Atlanta Regional Commission, 2013). A lawsuit was filed by the state of Alabama in 1990, later joined by Florida, to ban the USACE from creating water supply rights from Lake Lanier. Georgia, Florida, Alabama, and the USACE entered into an Interstate Compact Agreement in 1992 to allow a comprehensive study to be made of the basin water resources with a temporary provision to allow some water supply use. All parties to the compact negotiated from 1997 until 2003, when the ACF compact expired, but no agreement was ever reached.

Upon expiration of the compact the lawsuits were reinstated and the cases were assigned to Federal District Court Judge Paul Magnuson. The litigation was complex, including eight cases in two district courts. The judge separated the lawsuits into two cases, one concerning the ACF basin and the other the ACT basin. He further separated the cases into two phases; one challenging the authority of the USACE to operate Lake Lanier for water supply and recreation, and one dealing with the Endangered Species Act and its impact on water supply. The ACT basin litigation was stayed to allow negotiation. Judge Magnuson issued a ruling for the ACF Phase 1 case on 17 July 2009. This ruling concluded that: (1) the only congressionally authorized purposes for Lake Lanier are hydropower, flood control, and navigation; (2) the USACE was granted a window of 3 years to obtain approval from US Congress to make any operational changes necessary to allow water from Lake Lanier to continue to be used for water supply; and (3) failure to obtain permission in 3 years would result in the reversion of operation of the Buford Dam to the baseline operation of the mid-1960s which allows only 38,000 m^3 of daily withdrawals and zero storage for water supply (US District Court, 2009).

In September 2009 the state of Georgia and the USACE, along with multiple other parties in Georgia, appealed the ruling to the 11th US Circuit Court of Appeals, which agreed to hear it. Reasons for the appeal included the threat to the public safety of the 3 million people of the metro Atlanta are a who depend on Lake Lanier for water supply as well as to downstream water users in Georgia, a harmful economic impact on the entire Southeastern United States, and the conclusion that enough water is available in the ACF basin to meet the reasonable needs of all users if the reservoirs are managed properly and conservation practices invoked (Atlanta Regional Commission, 2013).

A ruling was made by Judge Magnuson on Phase 2 of the litigation (environmental issues) on 21 July 2010. This ruling denied all of Florida's claims under the Endangered Species Act and confirmed the necessity for a new Environmental Impact Statement to be prepared by the USACE that must evaluate all reasonable alternatives for operation of Lake Lanier, including for water supply.

The 11th US Circuit Court of Appeals overruled the District Court decision on 28 June 2011. The Court ruled the following: (1) the deadline to obtain permission from Congress was dismissed on the basis of cutting off the water supply to millions of people; (2) downstream water supply is an authorized purpose of Lake Lanier; (3) the USACE has the authority operate Lake Lanier to supply water downstream of the Buford Dam to the Atlanta metropolitan area; (4) the USACE analysis of the Water Supply Act (WSA) of 1958 was rejected; (5) the WSA of 1958 provides additional authority to operate the reservoir for water supply and the case should be remanded back to the USACE to determine the full extent of its authority; and (6) the USACE was given 1 year to determine the extent of its authority.

A number of the parties to the litigation appealed the Circuit Court decision to the US Supreme Court and on 6 July 2012 the Court refused to hear the appeal which affirmed the Circuit Court decision (Leithead & Austin, 2012; Tonsmeire, 2012). The following day, the USACE ruled that the agency did have jurisdiction to reallocate the reservoir water use without obtaining another congressional authorization. This means that the USACE will now have to perform an updated Environmental Impact Statement and decide on a reallocation plan for water uses within each basin and, ultimately, decide how much water will be reallocated for power production, recreational use, environmental flows and reservoir maintenance, and for water supply.

While it appeared that the litigation was based on the refusal of the US Supreme Court to overrule the Circuit Court of Appeals, on 1 October 2013, the State of Florida filed suit directly against the State of Georgia in the US Supreme Court. This was a direct request for injunctive relief (a request from the court made to overturn the other court decision).

4. The search for new water supplies and water supply planning

4.1. The Tennessee River

The Tennessee River lies about 4 km away from the northern border of Georgia at the river's southernmost bend in Chattanooga, Tennessee, and even closer at the junction between Alabama, Tennessee, and Georgia (Figure 6). It was considered as a potential source of water supply for the metropolitan Georgia area. The means suggested to access the river were unique, and included the revival of a historic border dispute between the states of Georgia and Tennessee, a plan bartering infrastructure for water, and tributary use by tapping creeks and streams of the Tennessee River that lie within the geographic boundaries of Georgia.

4.1.1. Water rights and the border dispute with Tennessee. Because of the severe drought in 2007, the Georgia General Assembly passed resolution GA 08SR822 directing Governor Sonny Perdue to pursue an extension of the Georgia border northward to access the Tennessee River. The resolution called into question the border between the states of Georgia and Tennessee. Erroneous surveys conducted in 1818 and 1826 placed the Georgia–Tennessee line 1.8 km south of the border that was originally defined by the US Congress to be located on the 35th parallel (Dewan, 2008). Shifting the border would allow Georgia to take a portion of the Tennessee River flow at Nickajack Lake, which receives an average daily flow of 91 million m^3/day (McWilliams & Mumper, 2012). While the resolution urged that the governors of Georgia and Tennessee negotiate a water use right, the legislature also stated that, if necessary, the Attorney General of the State of Georgia is authorized to escalate the matter to formal litigation via the federal court system to the US Supreme Court.

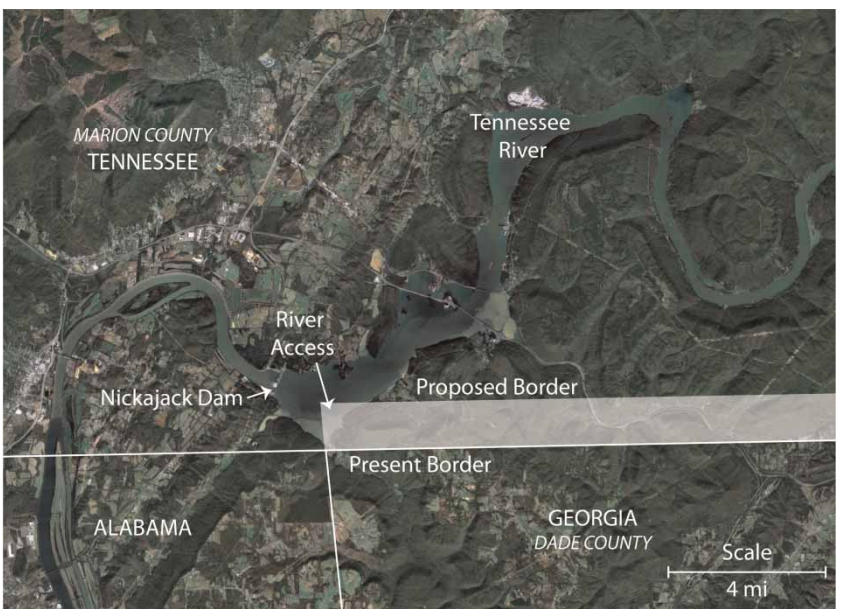

Fig. 6. The location of the Tennessee River in northern Georgia and Tennessee, and the disputed border area that would allow Georgia to gain access to the Tennessee River (modified from Severson, 2012).

The flawed surveys called into question were ratified by the State of Tennessee but were never formally accepted by the State of Georgia. As noted in the resolution, Georgia has periodically raised the border issue on twelve separate occasions dating from 1887 to (most recently) 1974. If the border were to be moved, Georgia would gain access to the Tennessee River but any water withdrawal would have to be approved by the Tennessee Valley Authority (Dewan, 2008). More recently, political support to resurrect the border dispute has waned based on interstate cooperation and legal cost issues.

4.1.2. Swapping road and rail for water. A more politically viable solution to gain access to the Tennessee River involves an offer by Georgia to Tennessee to trade transportation enhancements for water access. According to the Georgia House Speaker David Ralston, his state may be willing to make transportation enhancements within Georgia that would better connect the City of Chattanooga, Tennessee, with airport and port facilities in Georgia (Johns, 2011). Specifically, a high-speed rail link is being considered that would connect Hartsfield–Jackson International Airport (the world's busiest airport by passenger traffic) and the Chattanooga Metropolitan Airport. Funding for this project would be partially obtained from the US Federal Government. Improved transit infrastructure to the Port of Savannah, which handled 3 million twenty-foot (6.1 m) equivalent units (TEU) of container traffic during the fiscal year 2012, could also be made part of the deal (Georgia Ports Authority, 2012).

Any plan for the transfer of water from the Tennessee River to Georgia would need to be approved by the Tennessee Department of Environment and Conservation, which has the authority to evaluate requests for inter-basin water transfers by the state (Johns, 2011). The surface water basin map of Georgia (Figure 7) depicts the Tennessee River Basin from which the inter-basin transfer is being contemplated.

4.1.3. Tapping water from Georgia tributaries of the Tennessee River. Six percent of the flow of the Tennessee River originates in Georgia and the legislature sought to capture part of this flow before it exits the state (Bonner, 2011). In March 2011, the Georgia State Senate passed resolution GA 11SR228, urging a feasibility study be conducted for the withdrawal, storage, and distribution of water that flows within the State of Georgia into the Tennessee River Basin. Specific streams that were named in the resolution include Lookout Creek in Dade County, Chattanooga Creek in Walker County, and West Chickamauga and South Chickamauga Creeks in Catoosa County (combined flow of 2.75 million m^3/day) (Figure 7). The captured water would be conveyed by pipeline using existing railway and road right of ways to user communities, over a distance of about 177 km.

The centrepiece for the plan to utilize captured surface water from the north-flowing Tennessee River tributaries was a focus on water storage. The Georgia Senate Resolution specifically mentioned the Walker County Quarry (Figure 8) as a potential location to store untreated water from the stream capture scheme. The quarry is 76 m deep and has a storage capacity of 11.4 million m^3, which is believed to be able to provide metropolitan Atlanta with about 380,000 m^3/day of water for a period of 30 days during a drought (Johns & Sohn, 2009). Pumping from the streams would occur during high-flow periods to alleviate any significant impacts to the stream ecology or downstream riparian users. Since a railroad right of way passes through the property adjacent to the quarry, pipeline transport of the water from the storage site is feasible.

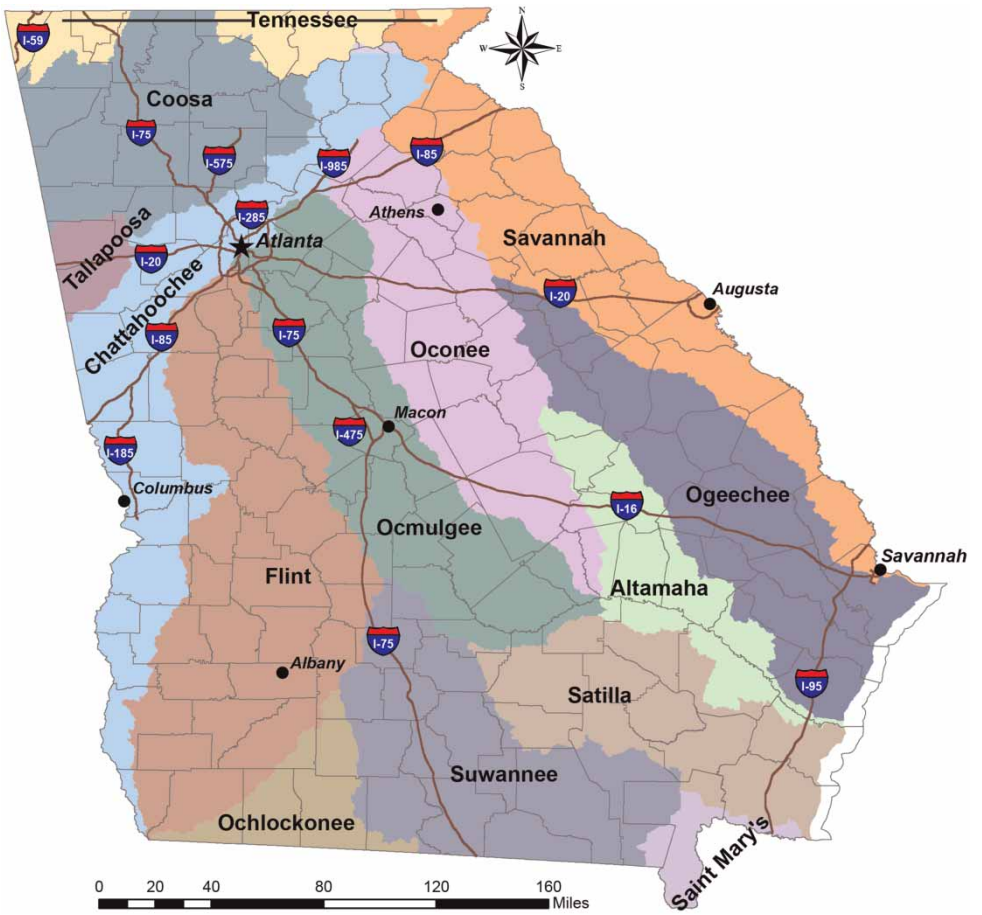

Fig. 7. Surface water drainage basins within the State of Georgia. Many of the 14 river basins are shared with neighbouring states. Note that the Tennessee River basin is shared between Georgia and Tennessee, and that the Savannah River forms the border between Georgia and South Carolina.

4.2. Use of quarries for water banking

Abandoned quarries have been considered for use as storage reservoirs to provide a type of 'water bank' in a scheme involving the withdrawal of surface water during periods of high to normal flow with storage for times of need. The scheme assumed that surface water would not be captured and pumped during flood periods, when turbidity would be high, or during low flow or drought periods. Northern Georgia has 18–20 quarries that could be potentially used for water storage (Johns & Sohn, 2009).

The Bellwood Quarry in central Atlanta was purchased in 2006 for approximately $40 million for conversion into a 9.1 million m^3 raw water storage reservoir for the drinking water system (City of Atlanta, 2006). An assessment of the inflow/outflow of water from the quarry showed that the low hydraulic conductivity of the rock limits water movement and potential contamination from adjacent parts of the groundwater system (Singleton *et al*., 2013). Conversion of the Bellwood Quarry into a

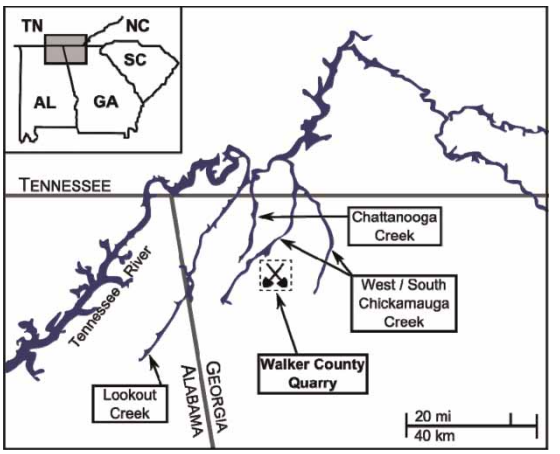

Fig. 8. Locations of the Tennessee River in Georgia and the quarry that could potentially be used for water storage.

drinking water reservoir was estimated by the City of Atlanta (2006) to cost $180 million and would take 3 years to complete. This conversion has not been completed to date.

4.3. Seawater desalination

4.3.1. Pumping treated water from the Georgia Coast to Atlanta. The State of Georgia is one of 23 US states to have an ocean coastline, making seawater desalination an option as a true source of 'new water'. To date, there are no large-scale seawater desalination plants operating in coastal Georgia. However, there are many brackish desalination plants and one major seawater desalination plant (Tampa Bay) operating in the neighbouring states of South Carolina and Florida. The City of Hilton Head Island, South Carolina, treats brackish groundwater from 200 m-deep wells constructed within the Middle Floridian Aquifer. Florida has numerous brackish water reverse osmosis (RO) water treatment facilities and a seawater RO facility operated by Tampa Bay Water. The Florida legislature suggested that Atlanta had two desalination options: (1) build a seawater desalination plant on the coast and pump the treated water to Atlanta; or (2) build a seawater desalination plant for the City of Savannah, trade it for the city's surface water allocation from the Savannah River, and convey the surface water to Atlanta (Figure 7).

Before the Tri-State Water War reached its most heated period and the drought emergency occurred, the City of Atlanta was considering the seawater desalination option, beginning in 2003. The Georgia state budget contained a line item allocating $250,000 to hire consultants to perform a feasibility study of desalination as a water supply option for Atlanta. Atlanta planners conducted an in-house assessment of building three desalination plants along the coastline of the state between St Mary's in the south and Savannah in the north (Anonymous, 2003). While the study would have covered this entire reach of coastline, it was found that Atlanta is located over 400 km from the coastline and the change in elevation from the coastline to the city is about 305 m. Therefore, the combined cost of the facility, the water treatment, and the treated water transport was considered to be quite intensive. In early 2004, the governor cut the $250,000 study from the state budget (Williams, 2004). However, the Joint Comprehensive Water Desalination Study Committee was created (GA 06HR1551) in recognition that seawater

desalination may be needed in the future to provide a safe and secure water supply for the state's predicted rapid population growth.

4.3.2. Water exchange with the city of Savannah. Another option considered by metropolitan Atlanta was a water rights exchange with the City of Savannah (though this 'right' may not have a true legal basis). In this case, surface water would be extracted from the upper basin of the Savannah River, which forms the boundary between the states of Georgia and South Carolina. A pipeline would have to be built from the extraction point to Atlanta. While the distance from the river to the city is roughly 62 km, the pipeline would have a downhill grade and the water would not have to be lifted 305 m uphill from the coast (unlike in the case of the desalination option outlined above). So, both the distance and the elevation change were favourable. The plan considered involved the metro Atlanta and the State subsidizing the construction of a coastal desalination plant to meet the short-fall water supply needs of the City of Savannah (Mahoney, 2006). The true value of this agreement to the City of Savannah would be economic rather than being a true water right.

The exchange plan was appealing to the City of Savannah because its use of the Upper Floridan Aquifer as a water supply source was capped at about 95,000 m^3/day based on seawater intrusion issues (Falls *et al.*, 2006). (Efforts to constrain the use of freshwater from the Upper Floridan Aquifer began in 1997 and resulted in the groundwater use cap.)

4.4. Conservation to reduce water use

The first MNGWPD (2003) water supply plan had recognized that per capita water use in the metropolitan Atlanta region was high and that conservation was needed to assert demand management, but that plan did not greatly reduce per capita water use or encourage water reuse (Pacific Institute, 2006). The MNGWPD (2009a, b) water plan contained a considerably more aggressive approach to water conservation and reuse, showing a reduction in projected water use in the last year of the planning period of 5% (Figure 9). The 2035 projected per capita water use rate shows a reduction of about 20% but the rate is still extremely high at 511 L/day (Figure 10).

4.5. Water reuse: potable direct and urban non-potable uses

The Georgia Environmental Protection Department suggests a planning standard of 10% for water reuse. Individual communities within the region do practise some non-potable reuse for outdoor irrigation depending upon their local circumstances but it is unclear how much water is actually reused. The Wastewater Management Plan (MNGWPD, 2009a, b) suggested that about 380,000 m^3/day of treated wastewater will be discharged into Lake Lanier and 136,000 m^3/day into Allatoona Lake by the 2035 planning horizon. Both plans note that the wastewater discharged to the reservoirs must be highly treated to eliminate any excess concentrations of nutrients. Also, it was recognized that the wastewater will contain some trace organic compounds (personal care products, pharmaceuticals, and others) which currently do not have any associated drinking water standards (MNGWPD, 2009a, b).

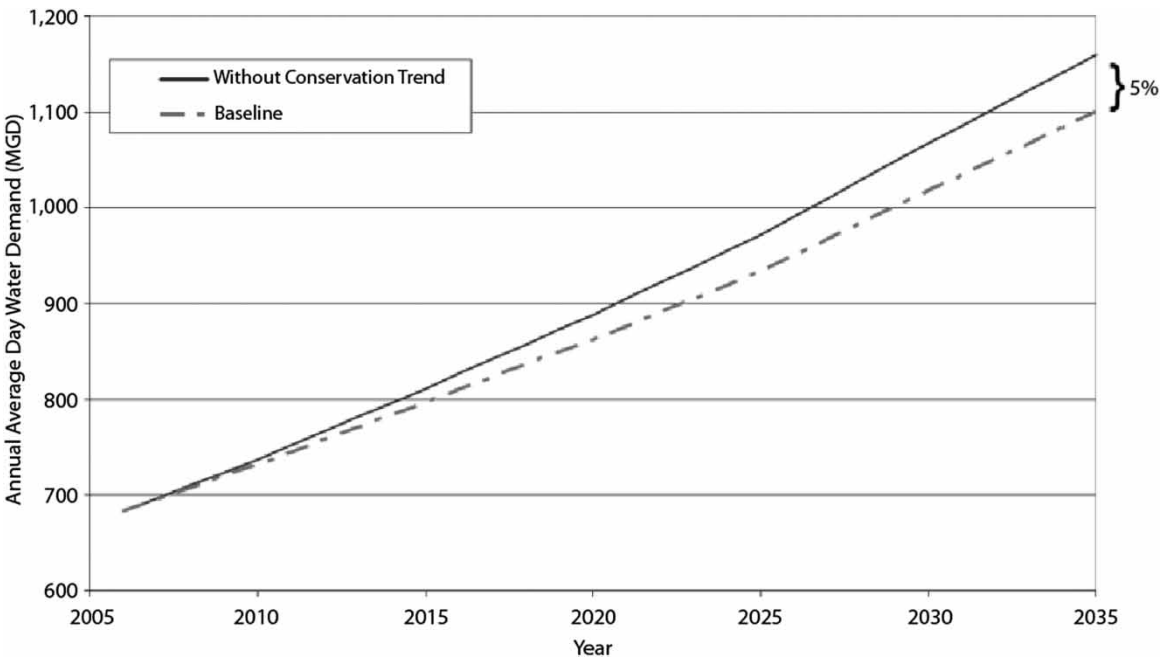

Fig. 9. Impact of water conservation on the long-term water use project (from MNGWPD, 2009a, b) (MGD: million gallons per day; 1MGD = 3,788 m^3/day).

5. Discussion

5.1. Reliance solely on surface water sources of water supply

The current situation in the MNGWPD region is that surface water from two river basins supplies about 86% of the total water use and surface water is used to meet 99% of all supply needs. Groundwater is used to supply only 1% of the demand and, because of the low yield of the aquifers in crystalline and fractured rocks in the region, it is unlikely that additional supplies can be obtained from this source.

There are two primary threats to the future viability of the surface water sources: uncertainty over the amount that will be made available by reallocation of water resources from Lake Lanier and Allatoona Lake by the USACE, and the extended droughts which will likely be exacerbated by future global climate change. Either of these issues could have an extensive impact on the viability of the water supply and economic growth in the region. While water planners and politicians are focused on providing the least expensive solution to water consumers, businesses and industries carefully analyze the reliability of water supplies and electric power before locating to a region; schools and amenities are also considered. Therefore, there are hidden economic impacts that should be considered along with the life-cycle cost of water supply sources.

There are critical links between various components of the water supply plan and the likelihood of achieving a favourable reallocation decision from the USACE, along with meeting the needs of

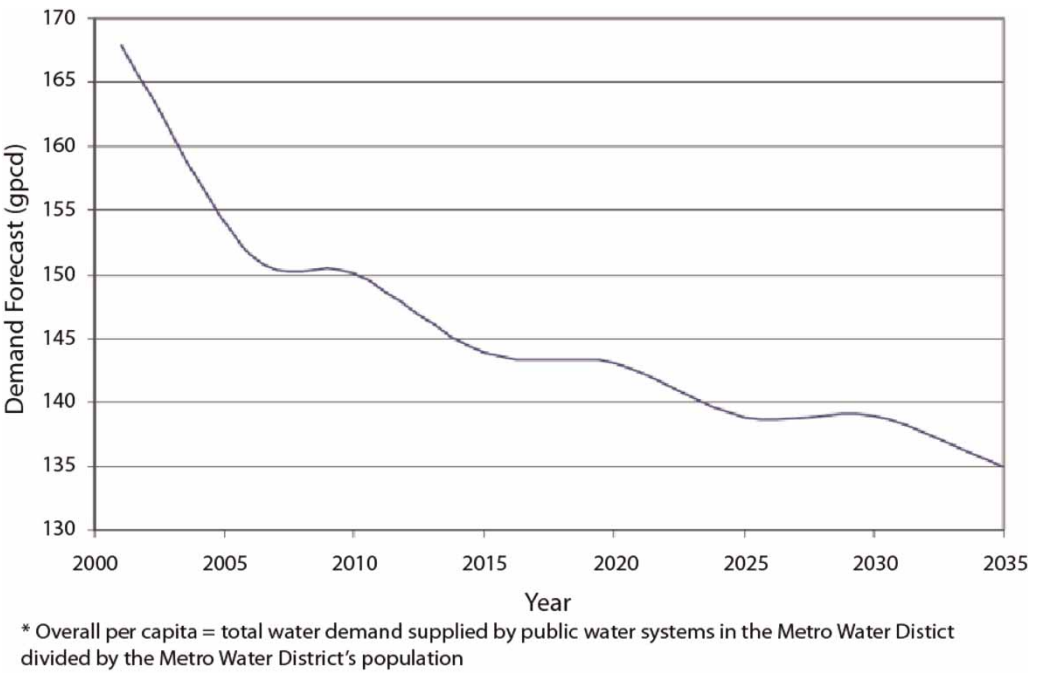

Fig. 10. Reduction in the per capita water use based on the implementation of the conservation plan (from MNGWPD, 2009a, b) (gpcd: US gallons per capita per day; 1 gpcd = 3.785 L/day).

downstream riparian water users, including the natural environment. There is, however, a rather provocative and dogmatic statement in the 2009 water supply plan (MNGWPD, 2009a, b):

> '*After reviewing alternatives to the use of the federal reservoirs, the water district has concluded that there are no alternatives to the Chattahoochee River and the Etowah River as major water supply sources for north Georgia.*'

5.2. Surface water supply reliability in northern Georgia

Both short-term and long-term droughts have affected the river basins upon which the region relies for water supply. The 2007 drought nearly had disastrous results, only averted by the occurrence of some rainfall. As the water demand in the region increases and the severity of drought events intensify, the reliability of using a sole source of water reduces.

All surface water bodies will be affected in the future by global climate change as the atmosphere warms and becomes more energetic. Milly *et al*. (2005) suggested that expected changes in runoff in the northern Georgia region will increase in one scenario by 0–5% and in another scenario by 3–9% for the period 2041–2060. However, virtually all climate change investigators agree that rainfall and associated stream discharge will become more variable in time with more intense flooding events and intensive droughts of longer duration occurring. Another issue is the 3–4°C increase in average temperature that will affect particularly summertime temperatures, thereby increasing the need for electricity to maintain air conditioning. Mulholland *et al*. (1997) concluded that the increased power demand

will place stress on reservoirs that require water flow through to generate power and also will affect the ecosystems of these reservoirs.

Adaptive water management strategies should be applied to the planning of water supplies to assure that they are sufficiently robust to meet the extremes of the coming climate changes. Bates *et al*. (2008) suggested that the supply-side measures to assure viability of water supplies for the future should include the development of additional groundwater supplies (where available), increased storage (reservoirs), desalination with connections into the distribution system, an increase in the amount of water reuse, rainfall harvesting, and water transfers. Tarlock (2000) suggested demand-side adaptations should include conservation, reallocation of existing uses, temporarily foregoing some uses, and permanently foregoing new uses (e.g., limiting future growth).

5.3. Water conservation programme

Water conservation is a critical issue when assessing actual water supply requirements versus current and future projected water use. While the MNGWPD (2009a, b) water supply and conservation plan is comprehensive and aims to produce significant reductions in water use, the projected 511 L/day per capita consumption in 2035 could be deemed as wasteful. The World Health Organization established 150 L/day as a minimum domestic water use for healthy living (Reed, 2011). The metropolitan Atlanta region lies in a humid climate that has an average rainfall of nearly 127 cm/year which makes the 511 L/day per capita use rate appear to be much higher than necessary. For comparison, the State of Florida, which receives an even higher annual average rainfall, has plans to require a maximum per capita rate of 464 L/day, and it is the current goal of the individual water management districts to reduce the per capita consumption goal below 387 L/day by the end of their 30-year planning horizons. The residential water use average per capita consumption, according to Conserve Florida, is about 340 L/day with the total consumption average being about 454 L/day. This is important, because there is a nearly 25% difference between the water conservation goals of the MNGWPD and the water management districts in the State of Florida, which is a litigant in the Tri-state water war.

5.4. Water reuse programme and analysis of indirect potable reuse in the reservoirs

Water reuse is another critical part of the water supply and water conservation plan, and is touted as meeting the State of Georgia planning goal to achieve a reuse rate of 10% of the treated water consumed. There are two aspects to the proposed reuse programme: non-potable reuse controlled by the individual communities within the region; and indirect reuse controlled by the central utilities and involving use of the federally controlled reservoirs (Lake Lanier and Allatoona Lake).

The non-potable reuse component has decentralized control and it is quite difficult to assess the impacts it will have on reduction of overall and per capita potable water use. If it is a replacement for potable water currently used to water park lands, recreational facilities (ball fields), or vegetation in road medians, then it would help reduce overall potable use. However, if it is to be used to supply new infrastructure of a non-critical or economic (new industry) nature, then it would not produce any positive result on the reduction of overall consumption but would still reduce the rate of increase in future water use.

Indirect potable reuse using a reservoir without an environmental barrier raises a number of intriguing questions. Some would classify this scheme not as indirect reuse but as direct reuse. The proposed

515,000 m^3/day of indirect potable reuse involves the recharge of the potable water supply reservoirs with treated wastewater. Since the treated wastewater is discharged into federal-government managed water bodies that have multiple uses, it will require a number of environmental permits including those needing approvals from the USACE and from the US Environmental Protection Agency (USEPA) for a National Point Discharge Elimination System (NPDES) permit. These permits will require a detailed evaluation of the water quality of the reuse water and its potential impact on the environment of the lakes/reservoirs and on the downstream rivers, and on each existing use for which the reservoirs were constructed (power, recreation, water supply, etc.). There is no guarantee that these permits will be approved, especially in light of the existing USACE evaluation and the high potential of additional litigation.

The water supply and wastewater plans mention the need to treat the wastewater that would be discharged into the lakes to remove nutrients to avoid eutrophication and other harmful impacts. The reports also mention the presence of trace organic compounds in the wastewater but dismiss the issue based on the non-existence of drinking water quality standards for these compounds. Unfortunately, very small concentrations of trace organic compounds can cause significant impacts to freshwater organisms, particularly fish (Parrott & Blunt, 2005; Fent *et al*., 2006; Woodling *et al*., 2006; Vajda *et al*., 2011). Therefore, it is likely that wastewater discharged into the reservoir will require a very high degree of treatment, including additional disinfection to kill all pathogens (with oxidant removal before discharge or use of ultraviolet disinfection), nutrient removal to meet very stringent standards, reduction of total dissolved solids, and advanced oxidation to remove trace organic compounds to an environmental standard that is not specifically defined.

The proposed reuse percentage is touted to meet the planning horizon set by the state of Georgia. However, the 10% target reuse percentage is far below the target goals of the neighbouring state of Florida where many comprehensive utility plans have set a goal of 100% of dry season water production. Again, there is a risk in setting a reuse standard that is lower that a downstream riparian user when water reallocation is being considered.

5.5. Water supply diversification by including seawater desalination

Development of a seawater desalination system at the coastline was summarily dismissed as being too costly and, in fact, was not mentioned in the most recent water supply and water conservation management plan (MNGWPD, 2009a, b).The trade involving the use of the Savannah River water rights for financial assistance in building a seawater reverse osmosis (SWRO) facility for the City of Savannah was also not considered in the plan.

Use of desalinated water would be considered to be a 'new' water supply and could be used to stabilize the overall system during times of severe drought, to assure the temporal viability of the water supply into the future. The statement in the water supply and water conservation management plan that dismisses other water supply alternatives is not based on technical feasibility and must, therefore, solely be an economic assessment. The construction and operating costs for SWRO systems are well known (Ghaffour *et al*., 2013), as are the construction and operating costs for a pipeline from the coast to the Atlanta area. Capital financing of a project like this would be a small part of the life-cycle cost of the system and could be financed using tax-free bonding at low current rates. The actual operating costs of a SWRO facility could be significantly reduced (up to 30%) by using some type of subsurface intake system, such as wells or galleries (Missimer *et al*., 2013). There is no question that the pumping cost from the coast to the use area would be the highest cost part of the system

operations; however, economies of scale could be explored to reduce this cost. For example, if the City of Savannah and the metro Atlanta region co-developed a 400,000 m^3/day facility, there would be a reduction in cost per cubic meter with at least those two water users, and with potential others located along the pipeline; industrial water users could be recruited to off-take the high-quality water at intermediate locations along the conveyance; or new industries in the rapidly growing Atlanta metropolitan area could be approached to assist in covering the cost of the facilities. Also, the federal government could assist in covering part of the project cost, especially if the reallocation process does not provide all of the water requested by the metro Atlanta region.

Economic analysis based solely on the cost of water does not take into consideration the benefits of providing system security during drought events or long-term needs for growth, especially beyond the 2035 planning horizon. The location of new industries is greatly dependent on assurances that adequate electric power and water supplies will be present. The diversification of water supplies and a potential end to litigation concerning use of surface water could lead to increased economic prosperity that would pay for the expanded infrastructure, including SWRO.

5.6. The future of the Tri-state water war and the USACE reallocation decision

The court decisions reached in the 20 years of litigation have returned water reallocation to the USACE to make a recommended agency action. Although the courts have ruled that the USACE does have the authority to reallocate the storage within Lake Lanier and Allatoona Lake, there are several legal, environmental, and political aspects governing the process. An analysis by Brougher & Carter (2012) brings clarity to various legal and agency procedural issues that must still be resolved. The authority to use water from federal facilities (reservoirs) comes from the WSA of 1958. The USACE also 'identified its process for evaluating requests for water supply under the WSA. First, it must examine the request "in its totality" and "in light of the Congressional intent for the project" ' (Brougher & Carter, 2012). A major issue is in the reallocation process, because Congress never defined the following phrase in the law: 'seriously affects the purposes for which the project was authorized'. Other parts of the WSA would require a new Congressional authorization or approval with legislative direction needed for the USACE to decide the reallocation of the water resources. A very important observation in the footnotes of the Brougher & Carter (2012) analysis states:

> '*The riparian doctrine of water rights, generally followed by eastern states, provides a right of reasonable uses of water to any person who owns land that borders a watercourse, and each right is reduced proportionally in times of shortage*.'

The need to comply with the 'riparian doctrine of water rights' in the reallocation process may require an analysis of metropolitan Atlanta water use in terms of 'reasonableness'. The fact that the regional per capita water use could be considered to be excessive or wasteful may impact the ruling on the requested water allocation in terms of what percentage may be deemed to be reasonable. Also, the low overall percentage of water reuse could also be considered within this context. Further, the dogmatic denial that all other potential sources of water supply are non-viable for development could also be considered.

The issue of minimum flows allocated for environmental purposes will also be considered by the USACE. Brougher & Carter (2012) noted that USACE contract allocations from reservoirs typically contain a provision that 'an amount of storage is expected to provide, during the critical period

(i.e., during the worst drought on record), a yield equal to the water supply withdrawals that are requested'. It should also be noted that the environmental flows within the disputed river basins are still legally unresolved.

Finally, after the agency action involving the reallocation, litigation may challenge the USACE opinion. Also, the US Supreme Court declined to review the 11th Circuit Court decision because the litigation was between states and a federal agency. In the event that the states of Florida and Alabama file suit against the state of Georgia, the US Supreme Court would hear the case, which has recently occurred. Based on the current context of the disputes, there is no end in sight concerning the dispute or litigation. The technical overall justification of the metro Atlanta region may not favour the granting by the USACE of the full requested allocation.

5.7. Planning for the 'ultimate water supply crisis'

The reliance strictly on surface water for water supply places the Atlanta Metropolitan area at risk, based on future drought scenarios. The 2007 event showed the extreme vulnerability to supply interruption with between 35 and 90 days of total supply left. Therefore, perhaps the question should be asked, 'What will the region do if it runs out of water?' No report produced by the Metropolitan Atlanta region addresses this issue. Logically, as a pending crisis emerged, non-essential uses of water would be curtailed but, once the reservoir storage is fully depleted, no other water would be available.

Emergency management scenarios employed during natural disasters, such as hurricanes and earthquakes, could present a model. When most of New Orleans was uninhabitable during Hurricane Katrina, a large portion of the population was temporarily removed and relocated. A certain quantity of water could be imported by trucks and bottled water could be used for drinking purposes. However, the cost of supplying 8.5 million people with a minimum quantity of water would be extreme and the overall economic loss would be staggering. The cost of seawater desalination for water supply diversification would be rather insignificant when considered against the cost of this type of disaster scenario.

6. Conclusions

The metropolitan Atlanta region's struggle over current and future water supplies provides an example of the future issues that many inland, high-population centres will face. Water supply planning decisions are commonly made based on rather superficial economic analyses and governing politics, even within the context of water rights disputes and shortages. The Metropolitan North Georgia Water Planning District (Atlanta region) utilizes surface water from two primary river basins, extracting about 87% from the Lake Lanier and Allatoona Lake reservoirs, which can be considered to be a sole-source. These reservoirs are subject to severe supply limitations caused by major droughts and will be affected in the future by global climate change. Also, the allocation of the water from these reservoirs is at issue in protracted litigation concerning the water rights of downstream riparian water users.

The political bodies in the region have strongly resisted the diversification of the water supply sources and have rejected desalination or even water-rights tradeoffs that could introduce a new surface water source into the system (the Savannah River). In fact, the region has considered such extreme measures as altering the state border between Georgia and Tennessee to forcibly access the Tennessee River to obtain additional water (currently not favoured politically).

Based on the current state of water supply planning, the metropolitan Atlanta region appears unprepared to meet current and future water demands to a standard that would assure economic prosperity and growth. The success of the entire water supply plan is based on an assumption that the USACE will grant the region as much water as it needs for the future, despite the disputes with downstream riparian users and the limited degree of water conservation and reuse. The water supply system plan for the future does not contain sufficient adaptive management potential to allow rapid reaction to droughts, climate change, or rapid growth. Perhaps the region needs to do an economic assessment of the scenario of a crisis during which the full water supply would be interrupted for an indefinite period to put the cost of its other options into perspective.

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References

Anonymous (2003). Georgia coast eyed as future water supply for Atlanta. *Savannah Morning News*, May 3.

Anonymous (2013). *US lakes, Lake Sidney Lanier Water Levels*. US Lakes Information. http://.uslakes.info/Level.asp, accessed 10 April 2013.

Atlanta Regional Commission (ARC) (2013) *Tri-state Water Wars*. www.atlantaregional.com/environmental/tri-state-water-wars, accessed 8 April 2013.

Bates, B., Kundzewica, Z. W., Wu, S. & Palutikof, J. P. (eds) (2008). Climate change and water. Intergovernmental Panel on Climate Change Technical Paper VI. IPCC Secretariat, Geneva, Switzerland, 210 pp.

Bonner, J. (2011). Lawmakers eye Tennessee River for Ga. water supply. Georgia Public Broadcasting. www.gpb.org/news/2011/03/22/lawmakers-eye-tennessee-river-for-ga-water-supply, accessed 8 May 2014.

Brougher, C. & Carter, N. T. (2012). Reallocation of Water Storage at Federal Water Projects for Municipal and Industrial Water Supply. SRS Report for Congress 7-5700. Congressional Research Service, Washington, DC.

City of Atlanta (2006). City of Atlanta completes purchase of the quarry. News release from the Mayor's Office of Communications. City of Atlanta, Atlanta, GA, June 30.

Dewan, S. (2008). Georgia claims a sliver of the Tennessee River. *The New York Times*, February 22.

Falls, W. F., Ransom, C., Landmeyer, J. E., Reuber, E. J. & Edwards, L. (2006). Hydrogeology, Water Quality, and Saltwater Intrusion in the Upper Floridan Aquifer in the Offshore Area Near Hilton Head Island, South Carolina, and Tybee Island, Georgia, 1999–2002. US Geological Survey (USGS) Scientific Investigations Report 2005–5134. USGS South Carolina Publications, 48 pp.

Fent, K., Weston, A. A. & Caminada, D. (2006). Exotoxicology of human pharmaceuticals. *Aquatic Toxicology 76*, 122–159.

Georgia Ports Authority (2012). Port of Savannah Total Annual Container Trade for Fiscal Year 2008 through 2012. Report of the Georgia Ports Authority, Savannah, GA.

Ghaffour, N., Missimer, T. M. & Amy, G. (2013). Technical review and evaluation of the economics of desalination: current and future challenges for better supply sustainability. *Desalination 309*, 197–207.

Glennon, R. J. (2009). *Unquenchable: America's Water Crisis and What to do About it*. Island Press, Washington, DC.

Grillo, J. (2007). Water worries. *Georgia Trend*, May 2007.

Johns, A. (2011). Georgia offers to swap road and rail for water. *Chattanooga Times Free Press*, June 7.

Johns, A. & Sohn, P. (2009). Quenching thirst in dry Atlanta. *Chattanooga Times Free Press*, June 7.

Leithead, T. & Austin, B. (2012). Georgia wins, where's the equity: commentary. *Atlanta Forward*, July 6.

Mahoney, R. (2006). Desalination is one option. *Atlanta Business Chronicle*, June 6.

McWilliams, M. & Mumper, M. (2012). Civic league's forum brings conservation to Georgia and Atlanta's water issues. *ATL Crossroads*, April 24.

Metropolitan North Georgia Water Planning District (MNGWPD) (2003). *Water Supply and Water Conservation Management Plan*. MNGWPD, Atlanta, GA.

Metropolitan North Georgia Water Planning District (MNGWPD) (2009a). *Wastewater Management Plan*. MNGWPD, Atlanta, GA.

Metropolitan North Georgia Water Planning District (MNGWPD) (2009b). *Water Supply and Water Conservation Management Plan*. MNGWPD, Atlanta, GA.

Milly, P. C. D., Dunne, K. A. & Vecchia, A. V. (2005). Global pattern of trends in streamflow and water availability in a changing climate. *Nature 438*(17), 347–350.

Missimer, T. M., Ghaffour, N., Dehweh, A. H. A., Rachman, R., Maliva, R. G. & Amy, G. (2013). Subsurface intakes for seawater reverse osmosis facilities: capacity limitation, water quality improvement and economics. *Desalination 322*, 37–51.

Mulholland, P. J., Best, G. R., Coutant, C. C., Hornberger, G. M., Meyer, J. L., Robinson, P. J., Stenberg, J. R., Turner, R. E., Vera-Herrera, F. & Wetzel, R. G. (1997). Effects of climate change on freshwater ecosystems of the south-eastern United States and the Gulf of Mexico. *Hydrological Processes 11*, 949–970.

Pacific Institute (2006). *A Review of Water Conservation Planning for the Atlanta, Georgia region*. Pacific Institute for Studies in Development, Environment, and Security, Oakland, CA.

Parrott, J. L. & Blunt, B. R. (2005). Life-cycle exposure of flathead minnows (*Pimephales promelas*) to an ethinylestradiol concentration below 1 ng/L reduces egg fertilization success and demasculinizes males. *Environmental Toxicology 20*(2), 131–141.

Reed, B. J. (2011). How much water is needed in emergencies? In: *WHO/SEARO, Technical Notes for Emergencies*. World Health Organization, Geneva, Switzerland.

Severson, K. (2012). Untangling a border could leave a mess for some. *The New York Times*, April 4.

Singleton, V. L., Jacob, B. M., Feeney, M. T. & Little, J. C. (2013). Modeling a proposed quarry reservoir for raw water storage in Atlanta, Georgia. *Journal of Environ Engineering 139*(1), 70–78.

Stevens, P.A. (1989). Water supply planning and coordination in the Atlanta region. In: *Proceedings of the 1989 Georgia Water Resources Conference*. Hatcher, K. J. (ed.). Institute of Natural Resources, University of Georgia, Athens, GA, pp. 88–90.

Tarlock, A. D. (2000). How well can international water allocation regimes adapt to global climate change? *Journal of Land Use & International Law 15*, 423–449.

Tonsmeire, D. (2012). Georgia wins, where's the equity. *Atlanta Forward*. July 6, 2012.

US Census Bureau (2012). Largest US metropolitan areas by population, 1990–2010. In: *World Almanac and Book of Facts*. Janssen, S. (ed.). Simon & Schuster, New York, NY, p. 612.

US District Court, Middle District of Florida (2009). Memorandum and Order. In re Tri-State Water Rights Litigation, July 17.

Vajda, A. M., Barber, L. B., Gray, J. L., Lopez, E. M., Bolden, A. M., Schoenfuss, H. L. & Norris, D. O. (2011). Demasculinization of male fish by wastewater treatment plant effluent. *Aquatic Toxicology 103*, 213–221.

Williams, D. (2004). Perdue cuts desalination study. *The Florida Times-Union*, January 10.

Woodling, J. D., Lopez, E. M., Maldonado, T. A., Norris, D. O. & Vajda, A. M. (2006). Intersex and other reproductive disruption of fish in wastewater effluent dominated Colorado streams. *Science Digest, Part C 144*, 10–15.

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