Jordan Lake
Water Supply Storage
Allocation Request

CITY OF RALEIGH
AND MERGER PARTNERS

JANUARY 13, 2015

The City of Raleigh is requesting a 4.7% (4.7 mgd) Level II Jordan Lake water supply storage allocation to ensure its ability to meet future water supply needs. This amount represents only a small fraction of the City's projected outstanding need through 2045. While the City hopes that the development of identified supply options within the Neuse River Basin will be able to satisfy its needs over the 30-year and 50-year planning windows, each of the supply options involves difficult environmental, social, and economic questions. Considering the magnitude of City's projected needs for 2045, and 2060, together with the length of each water supply permitting process, and its uncertain outcomes, the City has determined it must begin to pursue multiple promising supply sources concurrently to have the best chance of ensuring its future water supply reliability. Incorporating a Jordan Lake allocation into the City's water supply portfolio will enhance not just the City's water supply reliability and resiliency, but that of the entire Triangle metropolitan region.

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January 13, 2015

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Introduction

The City of Raleigh and its merger partners expect the population within their service area to grow from just over half a million people as of 2015 to over 1 million by the year 2045. During that period water demand is expected to increase by 87% (from 52 mgd to 97 mgd) despite an anticipated 16% reduction in per capita demand that will be achieved through an expanded reuse system, continued support for water fixture upgrades, and reduced discretionary use achieved through tiered rate implementation. The challenges the City faces to meet this demand growth are monumental and the stakes are equally high. The future growth and success of Raleigh and the Triangle metropolitan region hinge upon the ability of each of the region's communities to ensure a safe and reliable supply of water for their constituents.

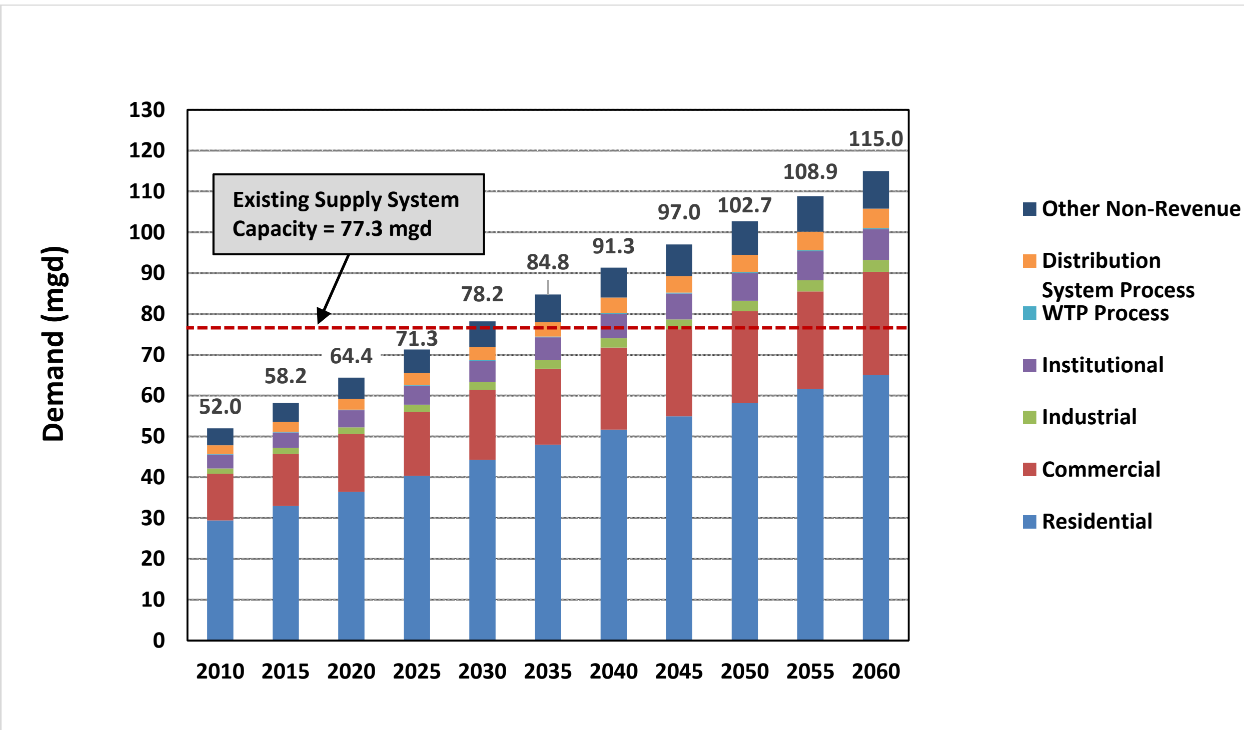

Figure ES.1 – City of Raleigh Demand Projections and Current Supply Capacity

Well aware of both the significance and complexity inherent in this impending task, Raleigh has spent the last 8 years attempting to permit its next water supply expansion, which it had initially assumed would be a new reservoir on the Little River. The Little River Reservoir permitting process has led the City to shift its focus away from the proposed Little River Reservoir to lower impact alternatives which, based on the "least environmentally damaging practicable alternative" (LEDPA) principle, must be pursued prior to building the Little River Reservoir. One of these alternatives, a reallocation of storage within the Falls Lake Conservation Pool to increase the City's water supply storage, has conceptual support from the applicant as well as State and Federal regulatory agencies and the City is actively pursuing this potential source. However, there is no certainty that the lead review agency, the U.S. Army Corps of Engineers (USACE), will complete the Reallocation Study with a favorable decision that increases the City's water supply.

Several of the other potential sources identified through the Little River EIS process have been incorporated into the City's long-range water supply plan and are included in the Triangle Regional Water Supply Plan (TRWSP). The crux of the problem facing Raleigh and its merger partners is that there are no easy water supply expansion options that will not face significant and time intensive opposition from some set of stakeholders. Until now the City has pursued new supply sources one at a time, a so called sequential source development strategy. Considering the magnitude of City's projected needs for 2045, and 2060, together with the length of each water supply permitting process, and its uncertain outcomes, Raleigh cannot afford the luxury of pursuing each potential water supply in a sequential fashion. Rather, the City has determined it must begin to pursue multiple promising supply sources concurrently to have the best chance of ensuring its future water supply reliability. This strategy, in contrast to the sequential source development strategy previously employed, will be referred to as the parallel source development strategy.

Each of the supply options involves difficult environmental, social and economic questions. The Reservoir option has particular issues of note and it is unlikely that a new reservoir can be permitted and constructed until all other water supply options with lower environmental impact are either implemented or shown not to be feasible. Several permitting complexities extend across potential sources. These complexities include water resource development guidance unique to EPA Region 4, new case law on water resource use unique to North Carolina and a potential expansion of federally listed species over the entire Southeastern United States.

This Jordan Lake Allocation Application represents the beginning of the parallel source development strategy described above, as the City is simultaneously pursuing the Falls Lake Reallocation. The 4.7 MGD (4.7%) Level II allocation request for the Jordan Lake Water Supply Pool represents only a small portion of the City's projected water supply capacity needs through 2045 and assumes the City will have success in at least one of its other parallel pursuits. The 4.7 MGD (4.7%) figure is also much less than the 13 MGD transferred out of the Neuse River Basin up-stream of the City's primary water supply by grandfathered interbasin transfers (IBTs). Raleigh recognizes that this application was not foreseen when the TRWSP was last updated in early 2014, but it is in keeping with the TRWSP assumption that "Raleigh may be compelled to pursue alternate, supplemental or interim sources until their Neuse River Basin sources can be developed as planned." Under the prior sequential source development strategy, the city had stated a preference for refraining from applying for an allocation from the State's Jordan Lake Water Supply Pool. Nevertheless, this application does not represent a change in the City's preference to meet its needs from within the Neuse River Basin. Rather, it is spurred by a growing concern that its pursuit of the four Neuse Basin sources identified in the TRWSP, two or three of which are needed to meet its 2060 projected demands, may not result in the permits needed to maintain a reliable water supply over the 30-year and 50-year planning horizons. Beyond the 2045 planning horizon, if the City's preferred route to meeting its anticipated supply needs over the 50-year planning timeframe cannot be achieved, the City may request additional allocations from the Jordan Lake Water Supply Pool.

The City understands that NCDENR and the EMC are charged with balancing the needs of the region and assigning allocations from Jordan Lake in a fair and consistent manner. In turn, the City needs a clear directive regarding whether or not Jordan Lake can be considered as part of its future water supply portfolio. A decision from the EMC to not grant an allocation based on this present application, but that leaves the door open for a future allocation, would unfortunately leave the City in a position of continuing uncertainty with regard to its water resource planning efforts, and will make it more difficult to develop other sources.

Alternative Water Supply Options

There are six potential sources identified in this application which must be compiled in combinations of two to four individual sources to meet the City's projected demands for 2060. They are listed below:

1. Reallocation of Falls Lake Conservation Pool
2. Neuse River Intake Upstream of the Neuse River Wastewater Treatment Plant (NRWWTP)
3. Jordan Lake Allocation
4. Little River Reservoir
5. Raleigh Quarry as Off-stream Storage
6. Water Purchase Agreement

Four of the sources lie in the Neuse River Basin, and one, Jordan Lake, in the Cape Fear River Basin. The sixth source assumes the City would develop a purchase agreement with one of its neighbors and is vague in source basin assignment since the details of the arrangement have not been worked out and could potentially come from several basins in the region. A brief description of the sources is provided below. A description of how the City plans to assemble a combination of these sources to satisfy its needs over the next 50 years is provided after the description of the individual sources.

Source 1: Reallocation of Falls Lake Conservation Pool to Increase Storage Volume in the Water Supply Pool

The Falls Lake Conservation Pool serves two of the authorized purposes of the Falls Lake Project; it supplies drinking water for the City (from the Falls Lake Water Supply Pool [FLWSP]), and it is used to meet minimum downstream flow requirements below the dam (from the Falls Lake Water Quality Pool [FLWQP]). See **Figure ES.2** for a schematic of the storage allocations within Falls Lake. The City withdraws water from the FLWSP, treats it at the E.M. Johnson Water Treatment Plant, delivers it to its customers, and returns nearly 90% of the water withdrawn to the Neuse River at the Neuse River Wastewater treatment Plant (NRWWTP). Because the NRWWTP is upstream of the flow target location that guides releases from the FLWQP, and the fact that such a high fraction of the City's raw water withdrawals are returned to the riparian environment as highly treated wastewater, demand growth in the City's service area will continue to reduce the burden on the FLWQP to meet the downstream flow target. This project would provide the City with 14 mgd of additional operational yield by moving 4.1 BG of surplus storage currently allotted to the Falls Lake Water Quality Pool (FLWQP) to the Falls Lake Water Supply Pool (FLWSP). Modeling has shown that the FLWQP could still meet the downstream minimum flow targets under the historical hydrologic conditions when the City uses the reallocated storage volume for water supply. Surplus in the FLWQP at the worst point of the 2007 drought of record would be reduced by about half (25% to 12%) as compared to the present storage allocation arrangement. Modeling of water quality within Falls Lake, using the EFDC model, which is currently the best available tool for such an analysis, provides what could be interpreted as inconclusive results regarding potential impacts of this project. This uncertainty is the major sticking point in the evaluation of this source, and is a major concern for upstream stakeholders who must abide by the Falls Lake Nutrient Management Strategy. Furthermore, the USACE process for considering reallocations in USACE projects is under revision due to recent litigation and this status adds to the uncertainty associated with this option. Nevertheless, the City continues to believe this project is a leading candidate to fortify its water supply portfolio in the face of growing demand.

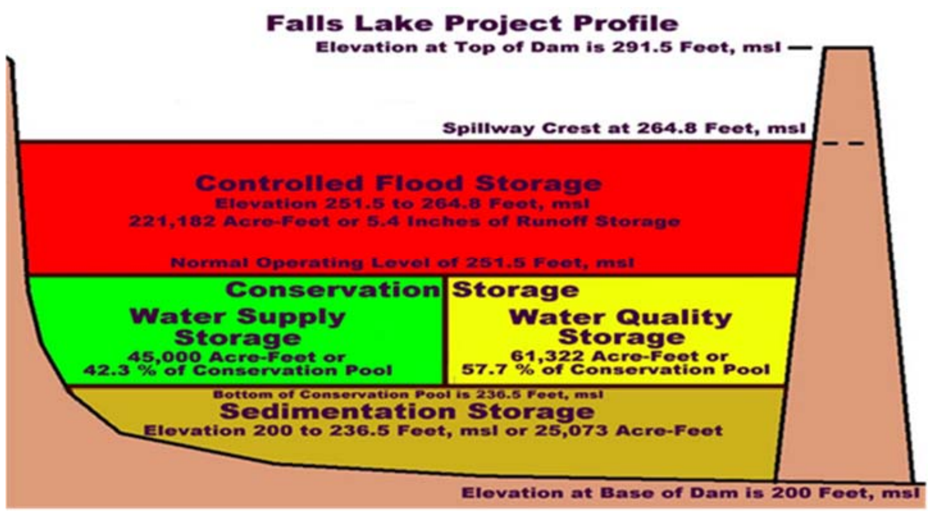

Figure ES.2 – Storage Profile for Falls Lake

Source 2: Neuse River Intake Upstream of NRWWTP

A run-of-river intake on the Neuse River upstream of the NRWWTP could provide the City and its Merger Partners an additional 15 to 25 mgd of yield, depending upon the operational constraints at the intake. The location along the Neuse River just upstream of the NRWWTP offers several advantages over other sites along the river in Wake County including the ability to utilize an additional drainage area of over 320 square miles below Falls Lake, the City owns the property at the site, and it is upstream of the City's principal wastewater discharge (See **Figure ES.3**). It is assumed the withdrawal rate from the intake would range up to 30 mgd and that the raw water withdrawn would be pumped to an expanded D.E. Benton WTP for treatment.

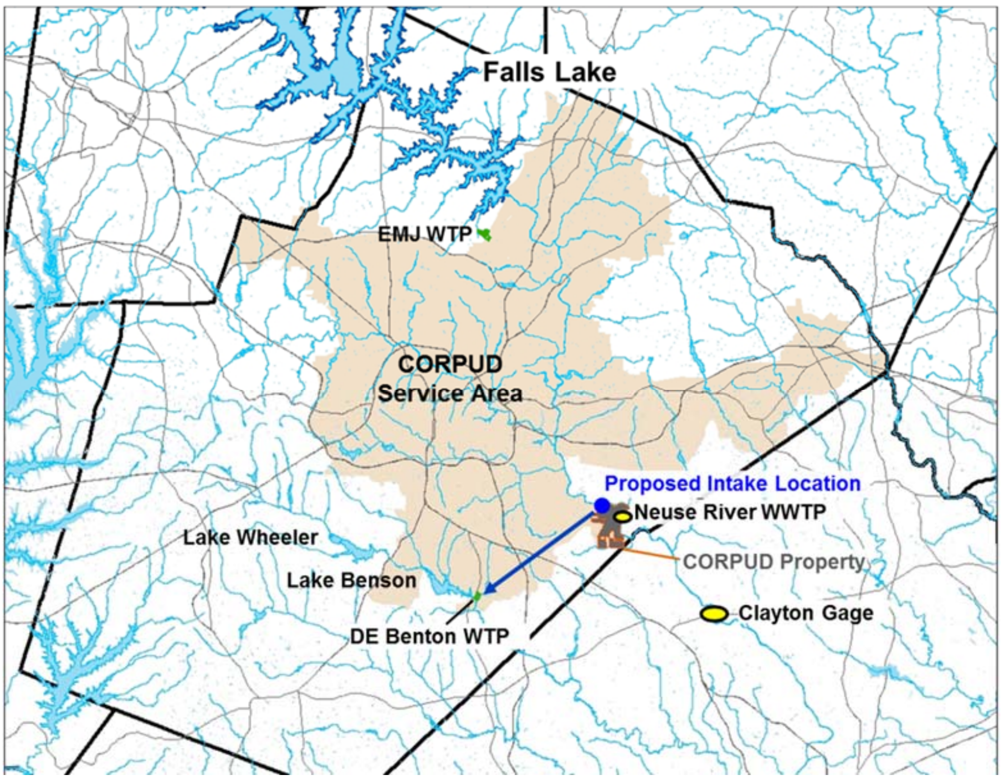

Figure ES.3 – Location of Proposed Downstream Neuse River Intake

Source 2 has been divided into two versions, both having identical infrastructure but different operational protocols, dependent upon whether or not an impact on the Falls Lake Water Quality Pool will be allowed. Source 2, Option A, assumes a modest impact to the water quality pool is allowed, while Source 2, Option B, assumes no negative storage impact is permitted. Under both options the Falls Lake minimum release and Clayton Gage flow targets continue to be met at all times. Generally, the minimum release from Falls Lake and the runoff from the intervening drainage area below Falls Lake (including the City's wastewater discharge) is sufficient to meet the Clayton Gage flow target. However, during especially dry periods, under option 2a it is assumed that the USACE would release additional flow as necessary to accommodate the withdrawal from the river and still provide sufficient flow in the river to meet the Clayton flow target. The storage in the FLWQP under the 2007 drought of record would decline by about 3% under Option A. Under Option B, the intake on the river would have to reduce withdrawals or shut down completely on days when the USACE would otherwise need to increase the release rate from the Falls Dam to assure the Clayton Gage target will be met. The restricted operating protocol would reduce the additional yield to 15 mgd on a 50-year yield basis of comparison. If the City used all of the additional yield afforded under Option B, the “surplus” in the FLWQP under the 2007 drought of record would increase by about 7% due to an increase in treated wastewater effluent from the NRWWTP. The major obstacle to Source 2, in either operational scenario, is that the water quality classification for this section of the Neuse River is C, NSW and would require reclassification to WS-IV. The reclassification would place a water supply watershed overlay over a third of Raleigh, including much of downtown, a quarter of Garner, and approximately half of Knightdale. Such a reclassification, with the associated limitations on development, is anticipated to be challenging and the environmental justice concerns in the overlay area may result in a need for additional permit conditions. See **Figures ES.4** and **ES.5**. An evaluation of environmental justice impacts would invariably be part of any final decisions on watershed classifications, with the Environmental Management Commission (EMC) acting as final agency decision maker.

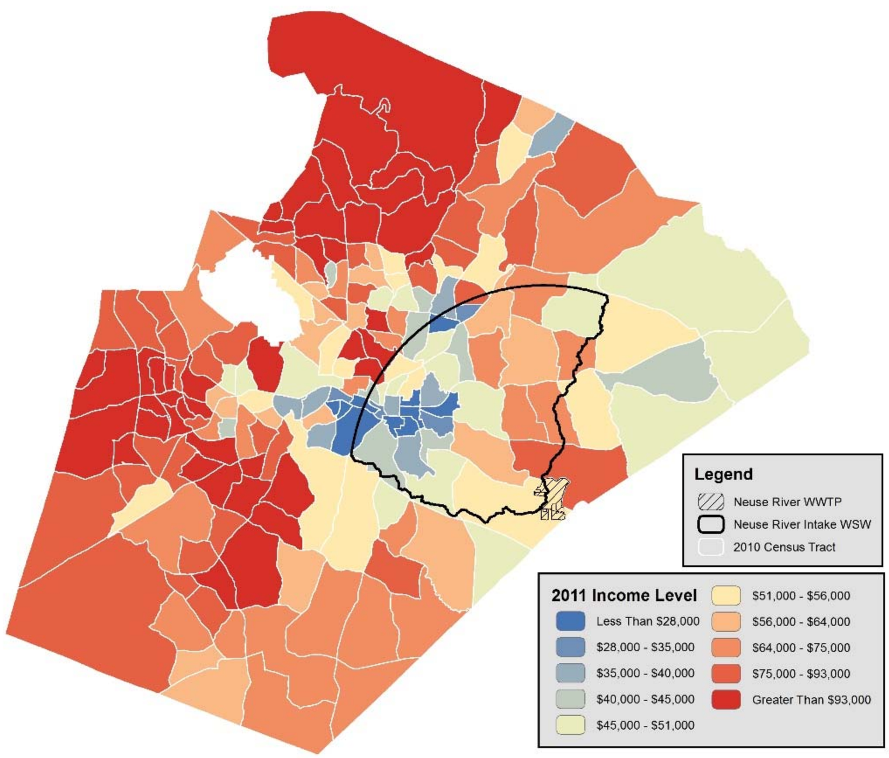

Figure ES.4 – Map of Water Supply Watershed Overlay and Income by 2010 Census Block

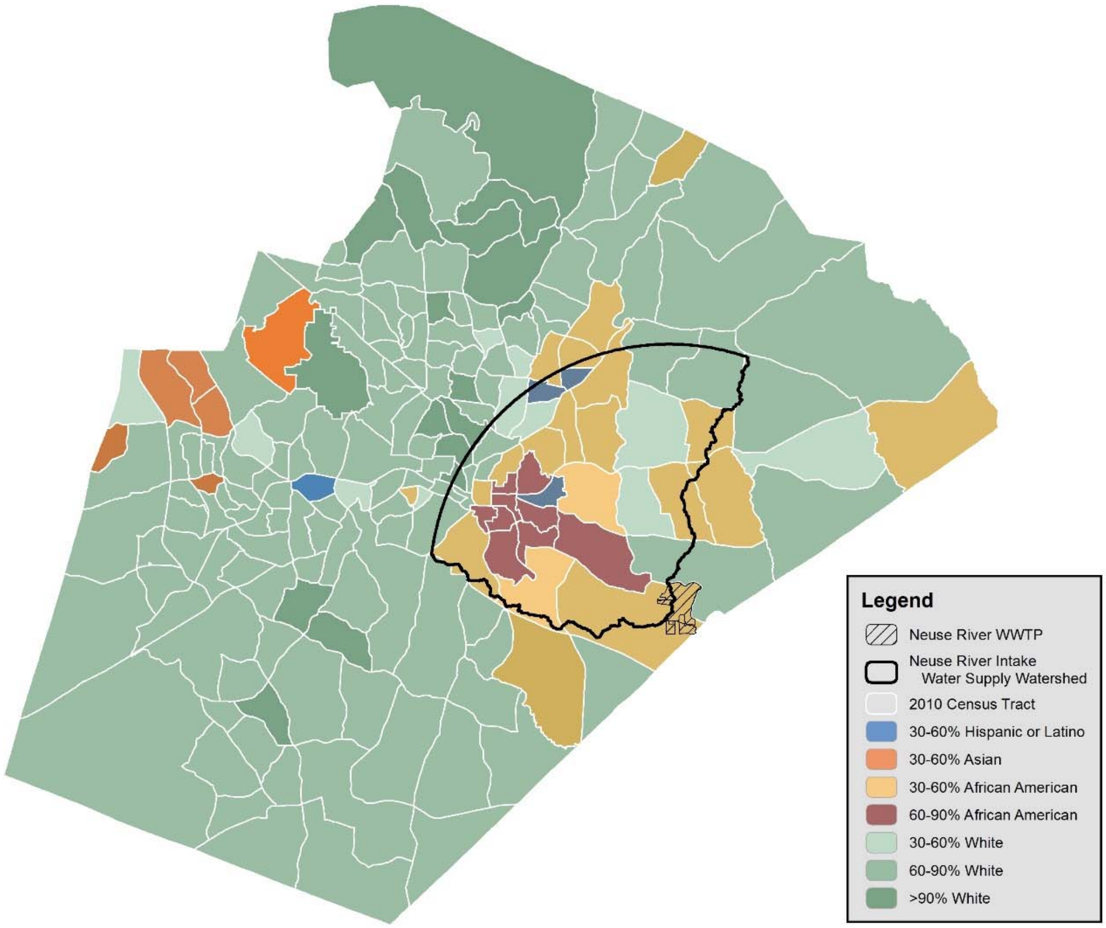

Figure ES.5 – Map of Water Supply Watershed Overlay and Demographics by 2010 Census Block

Source 3: Jordan Lake Allocation

The City of Raleigh is one of the 13 members of the Jordan Lake Partnership (JLP) and has been committed to the sustainable development of water resources in the region for many years. Until now the City has not requested an allocation from the Jordan Lake Water Supply Pool and until very recently it had not planned to request an allocation. The reason for the prior position has to do with the more promising perspective it held for the potential to develop sources within the Neuse River Basin (Sources 1, 2, 4, and 5) and because North Carolina's Interbasin Transfer Rule is expected to be an obstacle to the utilization of Jordan Lake water for a service area entirely within the Neuse River Basin. However, due to increasing concerns regarding obstacles facing the City's preferred future water supply sources in the Neuse Basin, the City is now seeking an allocation on Jordan Lake as part of its parallel source development strategy to maximize its ability to ensure a safe and reliable water supply in the coming decades.

The City is applying for a 4.7 mgd level II allocation of the Jordan Lake Water Supply Pool. If the City is successful in obtaining an allocation, its preferred approach to developing the supply would be to work out an arrangement to purchase treated Jordan Lake water from one of the JLP members. Similarly, if the wastewater from the allocation is required to be returned to the Cape Fear Basin, Raleigh would first approach members of the JLP to see if one of the dual basin JLP members could offset a similar amount of their Neuse Basin discharge and instead return it to the Cape Fear Basin. Alternatively, the City could pump some of its own wastewater to one of the region's WWTPs that discharge to the Cape Fear basin. However, since such arrangements have not yet been worked out, the more conservative plan presented here assumes the City would develop a new intake across the river from the Harnett County intake (or share the cost of a capacity expansion with Harnett County) where a water supply designation currently exists (**Figure ES.6**). Arrangements would need to be made to address the need to build a supply pipeline within Harnett County. Withdrawals from the Cape Fear River would be made in coordination with an additional release from the Jordan Lake Water Supply Pool into the Cape Fear River. Treated wastewater could be discharged along the same pipeline route, if required, also shown in **Figure ES.6**. The point of discharge for the effluent shown here is near the discharge point for Harnett County's wastewater plant and would also allow a common corridor to be used for much of the raw water supply line and the effluent discharge line.

Interbasin transfer considerations and the potential for total allocation requests in the future to exceed available supply may be significant issues affecting the City's use of Jordan Lake water. Mitigation of the interbasin transfer from the Cape Fear River Basin to the Neuse River Basin could require that all or a portion of the water withdrawn from Jordan Lake be returned to the Cape Fear River. Nevertheless, the City would ask that this IBT be viewed as a partial offset for the long standing Durham IBT that is larger and moves water in the opposite direction, from the smaller Neuse Basin to the larger Cape Fear River Basin, and adversely affects the City's primary water supply, Falls Lake.

It is critical that the City receive a definitive and atemporal response to this allocation request so that as it pursues other sources the City and other stakeholders have a clear understanding of its future ability to rely on Jordan Lake to meet a portion of its future supply need.

Jordan Lake

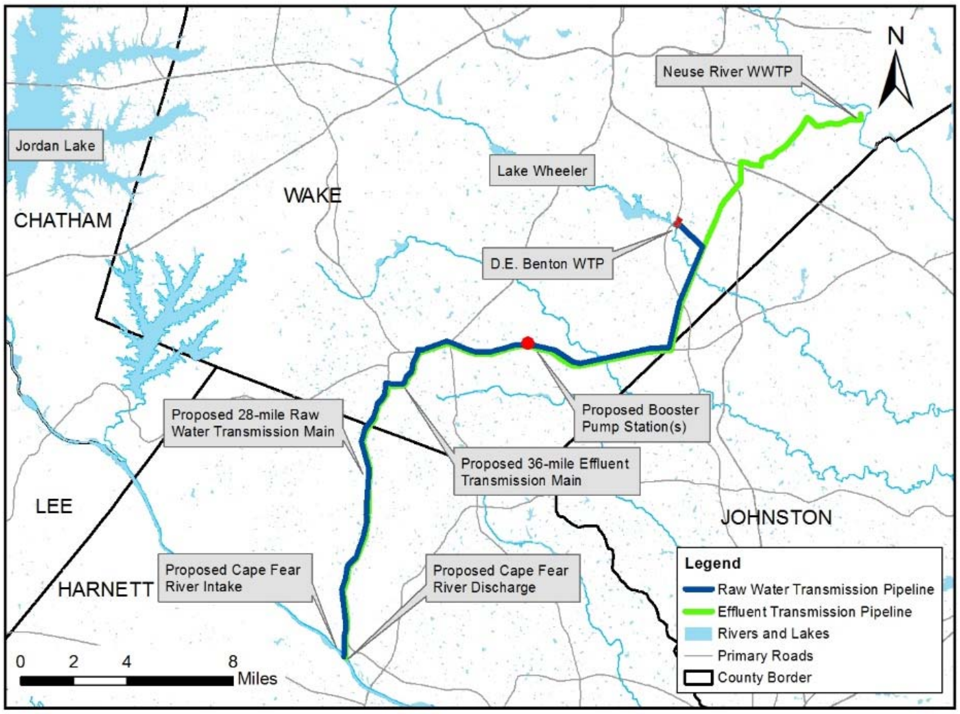

Figure ES.6 – Map Indicating Potential Routes for Raw and Effluent Pipeline Associated with use of a Jordan Lake Allocation

Source 4: Little River Reservoir

The City's long range water resource plan has been tied extensively to the construction of a new reservoir on the Little River. The watershed and dam site were identified over four decades ago and the City and Wake County have been in various stages of planning over the intervening period. In 1995, Wake County began a multi-year program of acquiring property to be inundated by the proposed project. The County effort was substantially completed by 2007 and a total of approximately $15 million expended to acquire the land that would be inundated if a reservoir is built. From 2007 through today the City's permitting effort for the Little River Reservoir has evolved into a larger, more complex water resource planning program driven by permitting difficulties. As with all federal law, the reach and complexity of the Clean Water Act (CWA), the Endangered Species Act (ESA) and the National Environmental Policy Act (NEPA) continues to evolve as new scientific data, changing regulatory guidance, and litigation precedents shape the permitting process. It is unlikely that a new reservoir can be permitted and constructed until all other water resource alternatives with lower environmental impact are either implemented or shown to be a infeasible (Sources 1-3, and 5). This likely places the Little River Reservoir project in a later timeline than previously reported to the public, as it appears probable that at least one other alternative will prove to be more feasible when considering the “least damaging practicable alternative” criteria.

The dam and reservoir would be located near the Towns of Wendell and Zebulon, approximately fifteen (15) miles east of the City of Raleigh - see **Figure ES.7**. The proposed reservoir would impound approximately 3.7 billion gallons and have a 50-year safe yield of approximately 13.7 mgd, adjusted for sedimentation, other losses, and minimum downstream release. The project would also include a water intake, pumping station, and a water treatment plant with a capacity of 20 mgd. The current WS-II classification is a key factor that makes this site particularly suitable for water supply development.

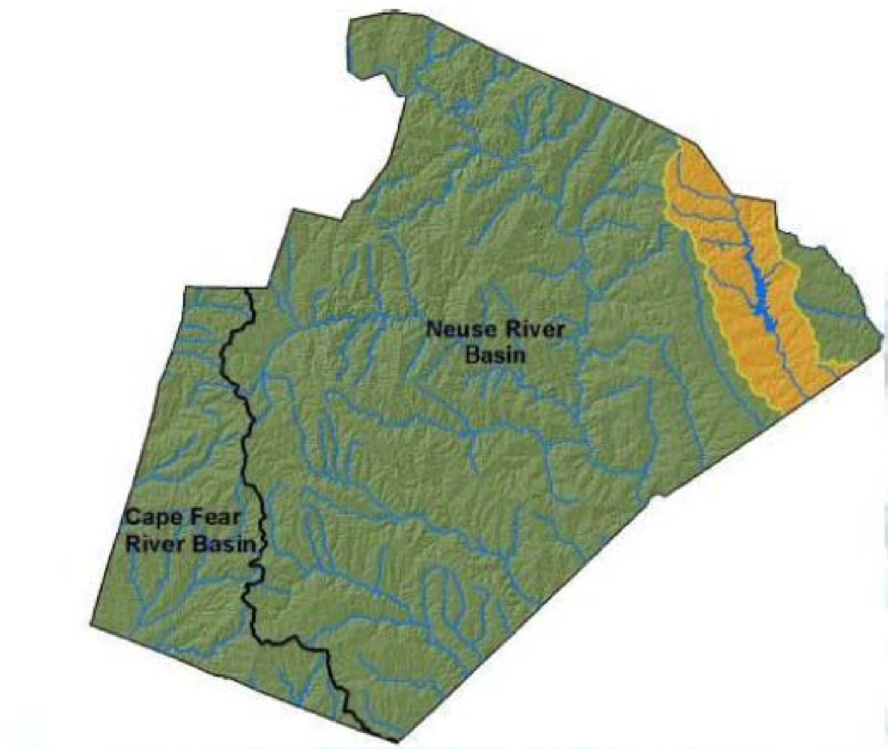

Figure ES.7 – Proposed Little River Reservoir Watershed (shown highlighted)

Source 5: Raleigh Quarry as Off-stream Storage

This supply expansion concept involves the construction of a new raw water intake and pumping station on the Neuse River near the Neuse River confluence with Richland Creek. A pump station at the Quarry, new raw water transmission lines, and an expansion of the E.M. Johnson WTP would be associated with the development of this source. The existing Raleigh Quarry is adjacent to the Neuse River – See **Figure ES.8** below.

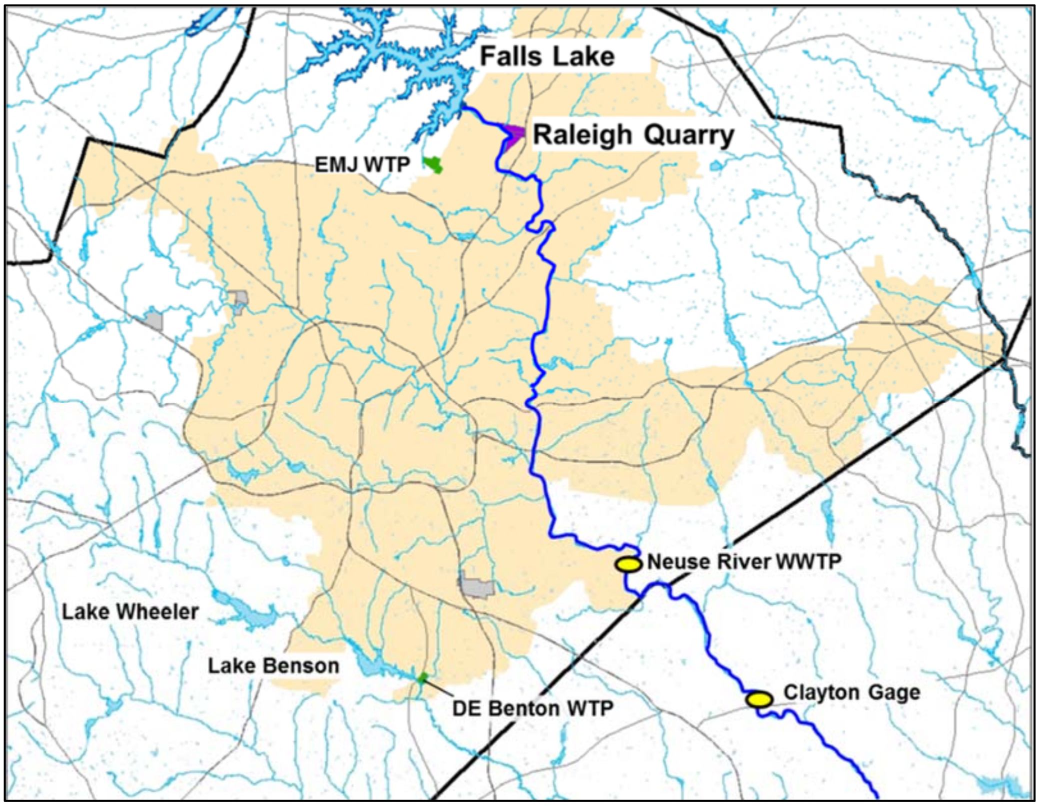

Figure ES.8 – Map Locating Raleigh Quarry and Associated Features

The quarry storage would be used to partially offset the withdrawals from Falls Lake when Falls Lake elevation is less than an elevation of 251.0 feet MSL, or 0.5 feet below the top of the conservation pool. During these conditions, raw water would be withdrawn from the quarry and pumped to the E.M. Johnson WTP at a rate of approximately 15 mgd. The quarry would be refilled when the Falls Lake level is above the guide curve (elevation of 251.5 feet MSL) and the USACE is releasing water from the dam at a rate exceeding the minimum release. Water would be pumped from the intake to the quarry at a rate up 50 mgd to refill the quarry.

At the current estimated usable volume of the quarry, which is about 3 billion gallons (BG), the calculated marginal operational yield is on the order of 8 mgd. However, the quarry is still being actively mined. The terminal volume of the pit is expected to reach 8 BG, well over twice the current volume. The time frame for completion of quarrying is inexact, but under previous ownership was estimated to be 40 – 60 years into the future. The additional storage volume would provide a significant increase in yield, but to achieve that gain requires relying on other sources until mining is complete. However, a change in ownership of the quarry and shift in the owners' policy to extend the life of the quarry as long as possible makes it probable that quarry mining will continue well beyond the City's current 50 year water supply planning horizon. The addition of adjacent land parcels could extend the life of the quarry even further. Recently, another potential obstacle to utilizing this source arose when it was suggested that Duke Energy may pursue quarries across North Carolina for the purpose of coal ash disposal.

Storage of coal ash in all or part of the Raleigh Quarry would likely render the site unsuitable for water supply purposes in perpetuity. Due to these significant obstacles and the value of allowing the mining work to expand the usable storage volume available, this source is last on the City's implementation timeline and likely falls outside the current 50-year planning horizon.

Source 6: Water Purchase Agreements

Purchase agreements with neighboring utilities could help the City meet the remaining projected shortfalls in the combination of sources presented under Alternatives 2 and 3. While the purchase agreements have not been arranged, there is a long precedent for such agreements between utilities in this region to support mutual water supply reliability. Furthermore, the magnitude of the purchase agreements needed under these alternatives (under 4 mgd) are well within the range of past interlocal purchase agreements. The infrastructure to convey treated water from neighboring utilities to the City and its merger partners is already in place.

Summary of Supply Alternatives

No single source is capable of meeting the City and its Merger Partners long term supply needs. Therefore, each of the three alternatives in this document consists of a combination of the sources described above. There are more possible combinations of sources than is practical to present here, but the three alternatives presented are representative plausible paths forward with increasing levels of difficulty from Alternative 1 through 3. Alternative 1 assumes the City develops the sources within the Neuse River Basin, while Alternatives 2 and 3 represent possible paths forward if particular obstacles to Alternative 1 become insurmountable. The amount of supply available from certain sources is dependent upon timing, assumed operations, and whether or not other sources are developed and used concurrently. The sources within the Neuse River Basin have been modeled in combination together so the interactions between them with respect to operational yield are generally well understood.

Alternative 1:

Alternative 1 assumes that all of the City's water resource needs at the 2045 and 2060 planning dates are met with sources within the Neuse River Basin. As noted in the TRWSP, any combination of sources 1, 2, 4, and 5 that will allow the applicant to meet its 2060 projected demand would satisfy the City's ideal path forward. As such, there are several viable combinations that are grouped under Alternative 1. The City's other goals, beyond providing water supply reliability, in pursuing these sources is to minimize environmental disruption and to minimize cost to its users. The Falls Lake Reallocation (Source 1) and Neuse River Intake (Source 2a) are capable of providing for the City's projected need through 2060 and **Figure ES.9** illustrates the ideal timing and relative impact that these sources would provide as the service area demand continues to grow over the next 45 years. The other two options available (Sources 4 and 5) in the Neuse River Basin are perceived to have significantly greater obstacles to their development. The Little River Reservoir (Source 4) has both a high price tag and high perceived environmental impacts while the Raleigh Quarry (Source 5) has a quarrying lifespan that is not compatible with water supply development within the 50-year planning horizon.

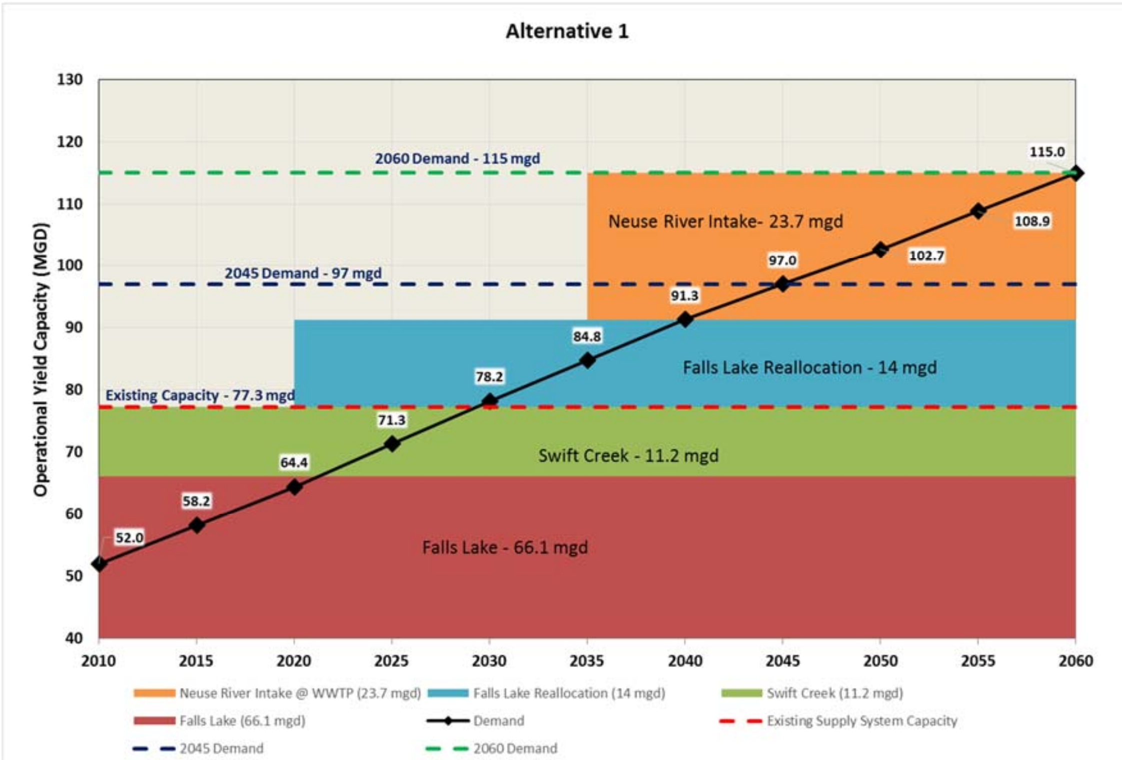

Figure ES.9 –Sample timing and selection of sources for Alternative 1

Alternative 2:

One potential obstacle to successfully proceeding with Alternative 1 pertains to uncertainty regarding impacts to water quality in the Falls Lake Conservation Pool if Sources 1 or 2a are developed. Although the City believes these impacts will be de minimis relative to the value of the additional water supply provided, other stakeholders may not agree. Under Alternative 2, the first source to be developed would be Source 2b which, like Source 2a, involves placing an intake on the Neuse River, but assumes a more limited operation wherein no streamflow augmentation from the FLWQP is allowed for meeting supply needs during dry periods. This arrangement provides 10 mgd less yield than operating under Source 2a assumptions, but requires the same infrastructure investment. Once additional supply is needed after bringing Source 2b on-line, the City could turn to either a Jordan Lake Allocation (Source 3) or the proposed Little River Reservoir (Source 4). Both have drawbacks and would find strong critics. A Jordan Lake Allocation would have fewer marginal environmental impacts since it relies on an existing reservoir. However, it would involve an interbasin transfer and if neither Cary nor Durham are willing or able to partner with Raleigh, utilizing a Jordan Lake allocation could involve a costly pipeline to access from and return water to the Cape Fear Basin. Developing the Proposed Little River Reservoir would avoid the need for an interbasin transfer, but would have significant ecological impacts and carry a very high price in terms of economic, social and environmental cost. While the City cannot judge with certainty which of the two would be easier to permit, both would be needed under this path forward and we assume here that utilization of an existing source (Jordan Lake) would offer the preferred path. Technically, the combination of aforementioned sources would leave a small shortfall of 0.2 mgd in 2060, so for the sake of diligence a purchase agreement is assumed to cover the remaining need. **Figure ES.10** illustrates the timing and yield that the sources comprising this alternative offer.

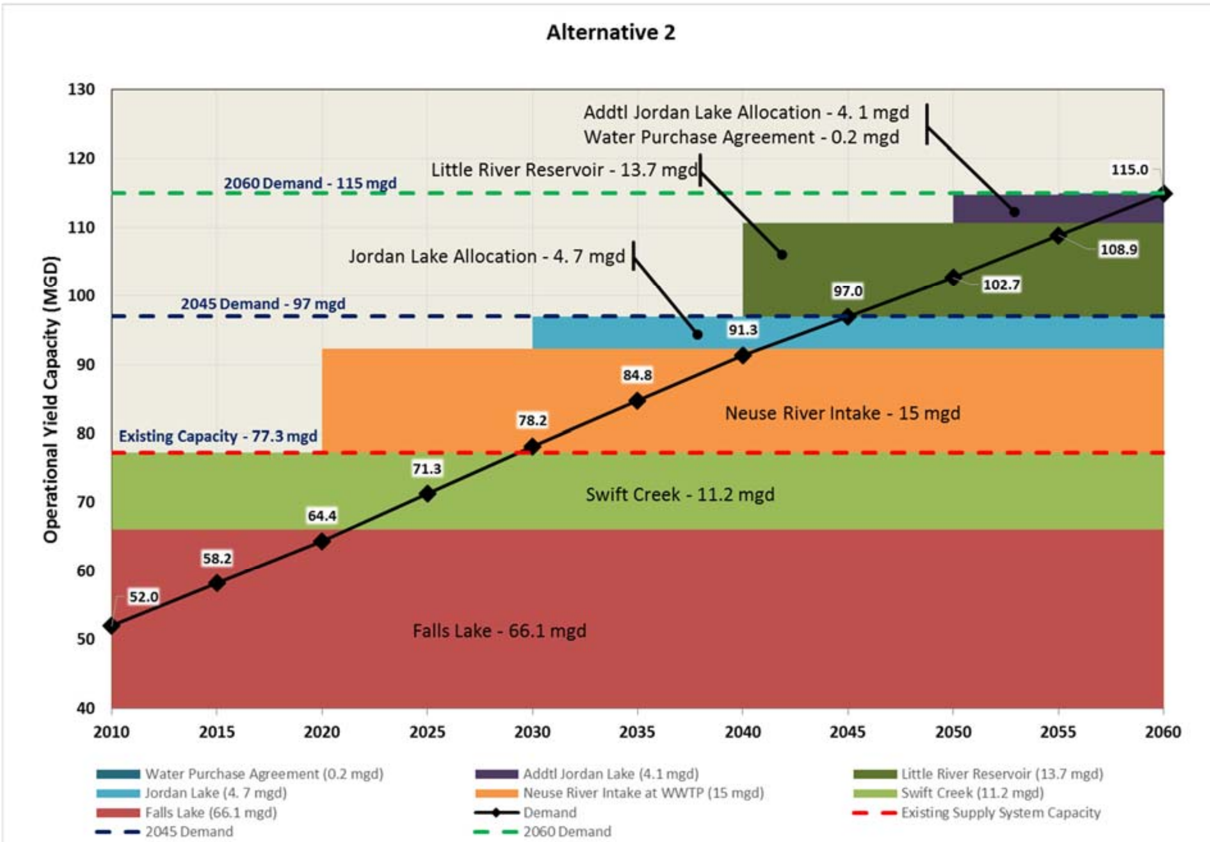

Figure ES.10 –Approximate timing and selection of sources for Alternative 2

Alternative 3:

Alternative 3 covers a case similar to Alternative 2 wherein sources that could have any adverse impact to the storage in the FLWQP, or water quality in the Falls Lake conservation pool are not able to be developed. Furthermore, here we assume that permitting a new reservoir is not possible due to the perception that its environmental impacts are unacceptable. This would remove Source 4 (Little River Reservoir) from the potential supply portfolio, force the City to develop the Raleigh Quarry (Source 5), and increase the amount of water purchased from neighboring utilities (Source 6). Furthermore, the City would look into arranging purchase agreements ahead of bringing Source 5 on-line to allow the quarry pit volume to be maximized. Even so, the Quarry would need to come on-line around 2045 to guarantee supply reliability. **Figure ES.11** graphically illustrates timing and composition of this alternative.

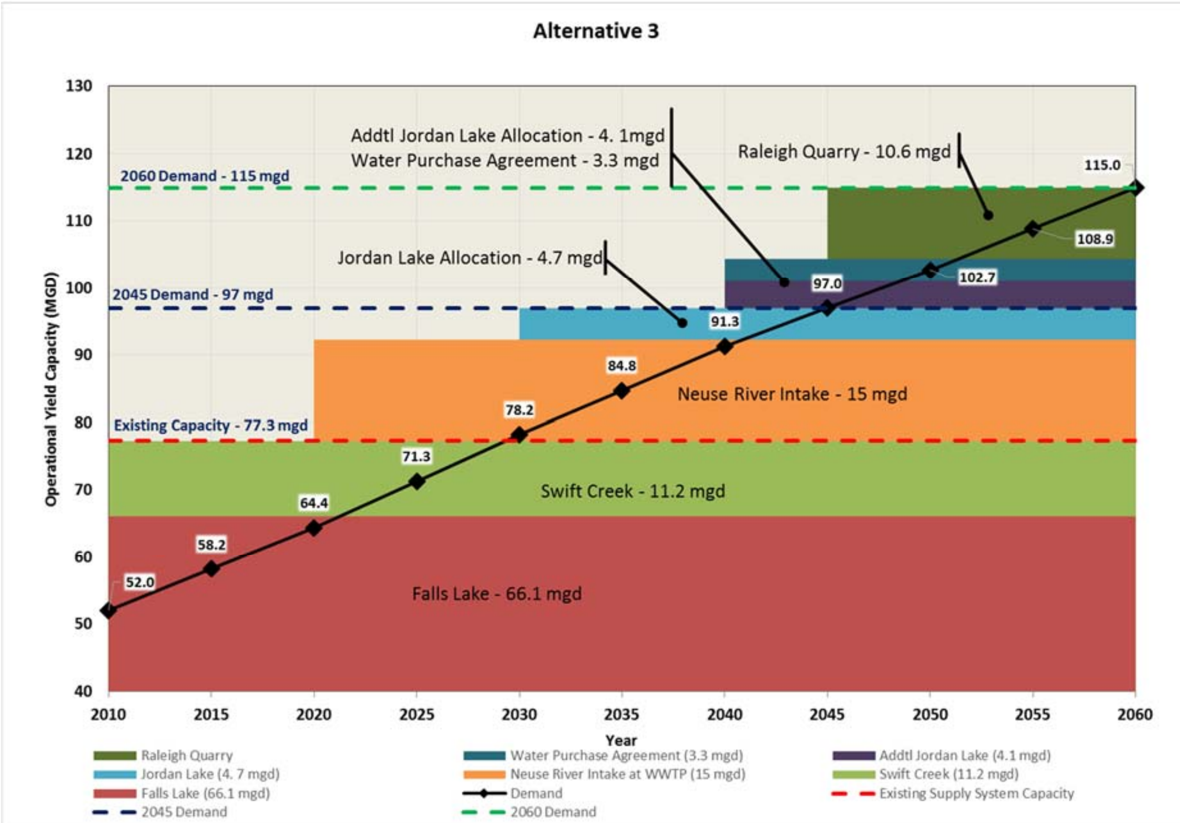

Figure ES.11 –Approximate timing and selection of sources for Alternative 3

Plans to Use Jordan Lake

As indicated above, the City of Raleigh and its Merger Partners are pursuing a Level II allocation of 4.7 mgd. If the City's allocation request is approved, it will immediately begin working with its fellow members of the JLP, or other utilities if necessary, to develop an agreement to purchase treated water and make use of existing or newly developed interconnections to transfer treated Jordan Lake water to Raleigh and its merger partners. In order to bring this allocation on-line in the most efficient manner possible the City would access the allocation in cooperation with other members of the JLP and be ready to begin using it by 2030. However, if the City is unable to permit the Neuse River Intake (Source 2) in a timely manner, then the City may need to utilize a Jordan Lake Allocation before 2030. These plans will need to be incorporated into the City's and other regional partner's water supply master plans so that capacities for water treatment, conveyance, wastewater treatment and conveyance can be properly planned and budgeted. The City will pursue all avenues to utilize this allocation in an environmentally benign and cost effective manner. Even if the City successfully pursues water supply sources identified under Alternative 1, the effort and planning to develop a Jordan Lake allocation will serve to strengthen the City's and the region's water supply reliability and resiliency. As such, the City looks forward to a positive response from NC DENR and EMC to this application.

The City understands the critical task at hand for NCDENR and the EMC. At the same time, it is important to receive a definitive response to this allocation request that will stand the test of time so that as it pursues other sources the City and other stakeholders have a clear understanding as to whether the City can rely upon Jordan Lake to meet a portion of its future supply need. Such a response will help provide clarity for the City's long-range planning for decades to come.

INTRODUCTION

The City of Raleigh and its Merger Partners of the Towns of Garner, Knightdale, Rolesville, Wake Forest, Wendell and Zebulon are submitting this application for a Round 4 Jordan Lake Allocation application to the North Carolina Department of Environment and Natural Resources, Division of Water Resources. This application has been developed independently from the City's participation in the Jordan Lake Partnership (JLP). It has been the shared hope of the City and its fellow JLP members that Raleigh will not need to use Jordan Lake and would not submit an allocation request. However, recent events that bear upon the City's identified Neuse River Basin water supply options for meeting 2045 and 2060 demand projections led the City's water management team to the conclusion that a Round 4 application for a 4.7 MGD (4.7%) allocation of the Jordan Lake water supply pool is prudent and necessary. It is noted in the TRWSP that 2 of the 4 proposed alternatives are needed to meet 2045 projected demands and 3 of the 4 may be needed to satisfy 2060 projected demands. That document also notes that the City's ability to develop the Neuse River basin supply options for meeting 2045 and 2060 long-term needs were uncertain at the time the report was published, and doubts regarding the feasibility have only increased since then. These concerns are explained throughout this document and specific concerns for each option are presented in Section VI. The City's position remains that the source options identified in the Neuse River Basin are preferable to the use of Jordan Lake, but it is incumbent upon the City to begin a parallel planning process that accounts for the possibility that the development of these sources may encounter political and regulatory opposition that will render them impossible to develop. It is because of these concerns and the associated need to begin planning for alternate paths to meet its anticipated water supply needs, the City is submitting this Jordan Lake Allocation request.

Background (Complexity)

As indicated above, several potential sources identified in the TRWSP have been incorporated into the City's long-range water supply plan. While these sources appear technically promising after thorough internal consideration, including rigorous modeling, the problem facing Raleigh and its Merger Partners is that none are expected to be straightforward to permit and each will face significant opposition from some set of stakeholders. Until now the City has pursued new supply sources one at a time, known as a 'sequential source development strategy'. Considering the magnitude of City's projected needs for 2045, and 2060, together with the length of each water supply permitting process, and its uncertain outcomes, Raleigh cannot afford the cumulative time that pursuing each potential water supply in a sequential fashion would require. Therefore, the City has determined it must begin to pursue multiple promising supply sources concurrently to have the best chance of ensuring its future water supply reliability. This strategy, in contrast to the 'sequential source development strategy' previously employed, will be referred to as the 'parallel source development strategy'.

Each of the supply options involves difficult environmental, social and economic questions. To meet the need of our communities for the 50-year planning window, the applicant is seeking to permit four identified options in ascending order of difficultly in addition to the applicant's requested allocation from Jordan Lake. This action is taken under the prudent assumption that one or more of the identified alternatives will fail to be successfully developed. Several of the sources face significant obstacles unique to the particular source and these anticipated difficulties are discussed in the description of each source in Section VI. Several permitting complexities extend across potential sources. These complexities include water resource development guidance unique to EPA Region 4, new case law on water resource use unique to North Carolina and a potential expansion of federally listed species over the entire Southeastern United States.

This Jordan Lake Allocation Application represents the beginning of the parallel source development strategy described above. The 4.7 MGD (4.7%) Level II allocation request for the Jordan Lake Water Supply Pool represents only a small portion of the City's projected water supply capacity needs through 2045 and assumes the City will have success in at least one of its other parallel pursuits. The 4.7 MGD (4.7%) figure is also much less than the 13 MGD transferred out of the Neuse River Basin up-stream of the City's primary water supply by grandfathered interbasin transfers (IBTs). Again, Raleigh recognizes that this application was not foreseen when the TRWSP was last updated in early 2014, but it is in keeping with the TRWSP assumption that "Raleigh may be compelled to pursue alternate, supplemental or interim sources until their Neuse River Basin sources can be developed as planned." Beyond the 2045 planning horizon, if the City's preferred route to meeting its anticipated supply needs over the 50 year planning timeframe cannot be achieved, the City may request additional allocations from the Jordan Lake Water Supply Pool.

The City understands that NCDENR and the EMC are charged with balancing the needs of the region and assigning allocations from Jordan Lake in a fair and consistent manner. In turn, the City needs a clear directive regarding whether or not Jordan Lake can be considered as part of its future water supply portfolio. A decision from the EMC to not grant an allocation based on this present application, but that leaves the door open for a future allocation, would leave the City in a position of continuing uncertainty with regard to its water resource planning efforts, and will make it more difficult to develop other sources.

The Jordan Lake Partnership – What It Is

The Jordan Lake Partnership (JLP) is a consortium of 13 local water supply utilities in the Triangle Region which has been working collaboratively since 2009 to develop a long-range plan for the Triangle's water supply. The Partnership has developed a Triangle Regional Water Supply Plan (TRWSP) that addresses the 50-year water supply needs of the 13 members that are listed below and whose service areas are shown in **Figure 1**:

- ***Town of Apex***
- ***Town of Cary***
- ***Chatham County (North water system)***
- ***City of Durham***
- ***Town of Hillsborough***

- ***Town of Holly Springs***
- ***Town of Morrisville***
- ***Orange Water and Sewer Authority (OWASA)***
- ***Orange County***
- ***Town of Pittsboro***
- ***City of Raleigh and Merger Partners***
- ***City of Sanford***
- ***Wake County (Research Triangle Park - South)***

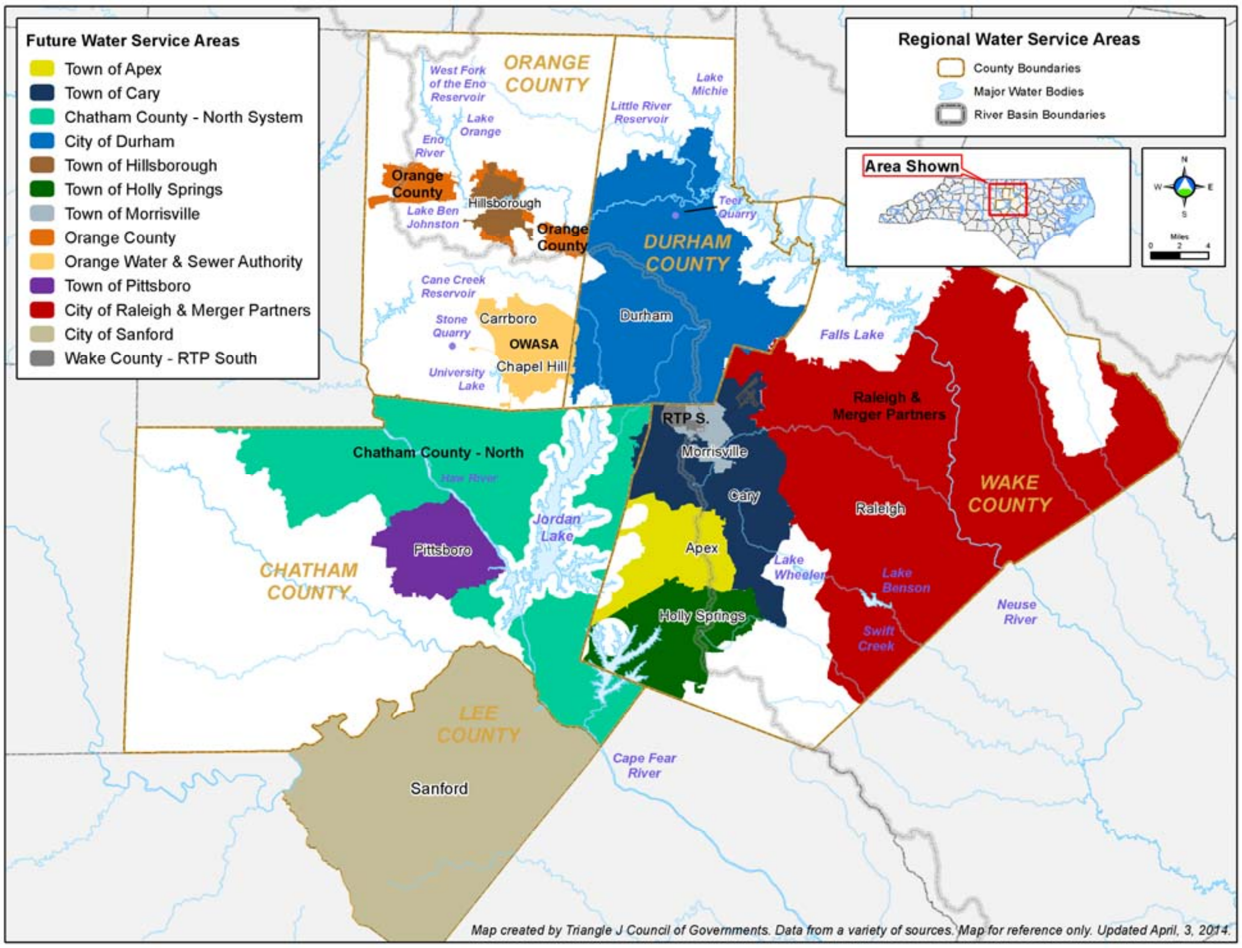

Figure 1 – Future (2060) water service areas of the Jordan Lake Partners.

The JLP has provided the Triangle Regional Water Supply Plan to the NC Division of Water Resources (DWR) in support of the Jordan Lake allocation requests submitted by individual JLP members. The TRWSP describes the planning process with which the regional water supply plan, including the Recommended Regional Alternative, was developed. The Recommended Regional Alternative includes the individual Jordan Lake allocation requests that Partners are expected to submit. This Introduction briefly presents the Recommended Regional Alternative and provides the larger context of Raleigh's request.

As part of the regional planning process, JLP members collaborated on the development and evaluation of water demand projections, water supply source options and alternatives, and a mutually supported plan that can meet the future water supply needs of the Triangle Region through 2060. Other accomplishments of the JLP included (1) the compilation of a detailed inventory of finished water interconnections among the Region's distribution systems, (2) the development (currently underway) of a regional hydraulic model of those interconnections and potential improvements, and, (3) a feasibility study for a new intake, water treatment plant, and major transmission facilities on the western side of Jordan Lake. All of these efforts have been planned, directed, and funded by the Partnership.

Developing the Triangle Regional Water Supply Plan

The TRWSP has two basic components: (1) the identification of water needs through 2060, and (2) a plan for meeting those needs. The *Triangle Regional Water Supply Plan: Volume I – Water Needs Assessment* (May 2, 2012) presented the demand projections and initial estimates of water supply needs of all 13 JLP members. The *Triangle Regional Water Supply Plan: Volume II – Regional Water Supply Alternatives Analysis* (October 24, 2014) presents the methodology used to compile and evaluate water supply alternatives and provides details of the preferred alternative and regional water supply plan. The following information summarizes those regional needs, the Recommended Regional Water Supply Alternative, and lists the proposed Jordan Lake allocation requests for all of the Partners, in terms of the preferred regional alternative.

The Recommended Regional Alternative as presented in the TRWSP does not include a Jordan Lake Allocation request for the City of Raleigh and its Merger Partners. As noted in the TRWSP, the City recognizes that its ability to meet its projected demands from source options identified in the Neuse River Basin significantly strengthen the regional supply picture, and avoid putting the City in potential conflict with other Partnership members. However, the City ultimately decided to seek an allocation from Jordan Lake given the increasing level of uncertainty in its ability to develop sources within the Neuse River Basin. The TRWSP recognizes this possibility, in deference to the difficulties and uncertainties associated with the development of new water resources. As quoted from the last paragraph of page 87 of volume II of the plan:

"The recommended alternative for Raleigh is based upon several key assumptions, but represents the best available information at the present time. Given the challenges and current uncertainty as to the potential impacts of their preferred sources on water quality in Falls Lake, Raleigh may be compelled to pursue alternate, supplemental or interim sources until their Neuse River Basin sources can be developed as planned."

Triangle Region Water Demand Projections and Needs for Future Supply

Figure 2 illustrates the total regional water demand projections with reference to the total water supply of 199 MGD (horizontal line) currently available to the 13 JLP members. Each partner initially developed its own projections, which were then reviewed by the other partners and subsequently revised. The resulting revised, peer-reviewed projections were approximately 10-15% lower than the initial projections, as shown by the red shaded boxes in **Figure 2**, and represent a historic consensus among local water system professionals about the Region's water supply status and long-term needs.

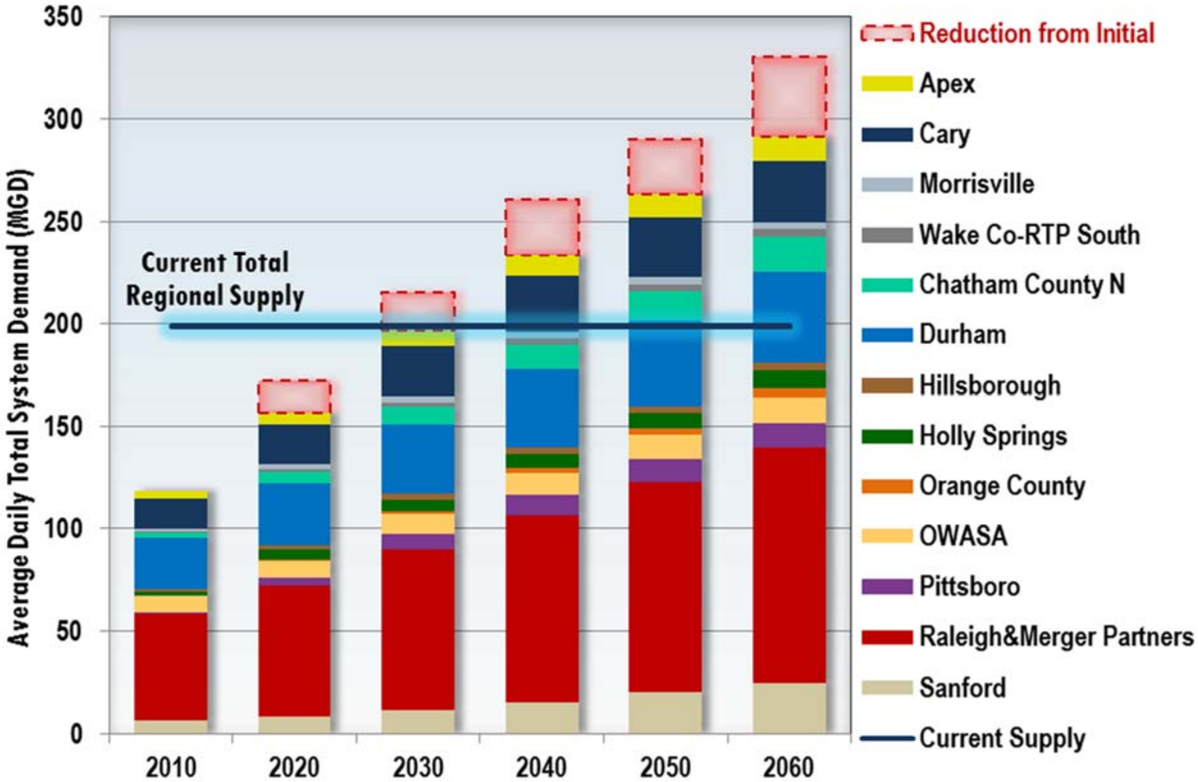

Figure 2 – Regional demand projections, current supply, and reductions resulting from peer review.

Table 1 presents each water system's need, which is defined here as each system's *average day demand minus the operational yield of its existing water supply sources, including existing Level I Jordan Lake allocations*. Based on demand projections and existing supply, the need for each partner was computed for the 2010 -2060 planning period at five year intervals as shown. The highlighted columns for 2045 and 2060 denote the key planning years for this current (Round 4) cycle of Jordan Lake allocations and the 50-year planning horizon of the TRWSP.

Table 1 – Projected Water Supply Needs (MGD) of the Jordan Lake Partners

Partner	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Apex *	0.0	0.0	0.0	0.0	0.0	0.3	1.4	2.1	2.5	2.8	3.1
Cary *	0.0	0.0	0.0	0.0	0.8	2.5	3.9	5.1	6.3	6.3	6.3
Morrisville *	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Wake Co. (RTP S.) *	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chatham County N *	0.0	0.0	0.0	0.8	2.3	4.1	5.9	7.0	8.2	10.1	12.1
Durham *	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.1	4.0	5.2	6.5
Hillsborough	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.6	0.8	0.9	1.1
Holly Springs *	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	1.1	1.6	2.1
Orange County *	0.0	0.1	0.5	0.9	1.3	1.8	2.2	2.6	3.0	3.3	3.7
OWASA *	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pittsboro	0.0	0.0	1.3	3.6	5.8	6.9	8.1	8.4	8.8	9.3	9.8
Raleigh & Merger	0.0	0.0	0.0	0.0	0.9	7.5	14.0	19.7	25.4	31.6	37.7
Sanford	0.0	0.0	0.0	0.0	0.0	1.3	3.2	5.8	8.4	10.6	12.8
Total	0.0	0.1	1.8	5.3	11.2	24.7	39.4	54.0	68.4	81.8	95.2

**** "Need" assumes that existing Level I Jordan Lake allocations are fully utilized***

The Recommended Regional Alternative

The JLP evaluated an array of water supply alternatives that could meet the Region's needs as presented in **Table 1**. The Triangle Regional Water Supply Plan: Volume II – Regional Alternatives Analysis presents the methodology and analyses used to compile and evaluate those alternatives. A preferred regional alternative for meeting the future needs of all partners through 2060 emerged from this effort and is referred to hereinafter as the "JLP Recommended Alternative."

Table 2 presents new water supply sources that would be brought online per the JLP Recommended Alternative. The Projected New Supply column lists the estimated yields of proposed new supply sources in addition to yields currently available. Those sources include new supplies as well as the expansion of existing sources.

The City of Raleigh's preferred source options remain uncertain with regard to timing and order of implementation, but Raleigh's options as presented in the TRWSP include four priority sources, any of which could provide an estimated additional yield of 13.7 MGD: (1) a new Little River Reservoir in eastern Wake County, (2) the reallocation of Falls Lake storage to increase the available Falls Lake water supply pool, (3) a direct withdrawal from the Neuse River upstream of Raleigh's Neuse River Wastewater Treatment Plant (NRWWTP), and (4) a quarry reservoir adjacent to the Neuse River near Richland Creek. **Figure 3** locates these four supply options as well as Jordan Lake on a regional map for the reader's reference. Under the JLP Recommended Alternative, Raleigh would meet its future demands from a combination of these Neuse Basin sources and would not require a Jordan Lake allocation. This also reflects the critical nature of regional and State support for Raleigh's Neuse River Basin options since a failure to develop two or more options destabilizes regional water supply planning.

Table 2 –Supply sources to be developed per the JLP Recommended Alternative

Partner	Source Name	Basin	Type	Year Online	Projected New Supply [MGD]
Multiple	Jordan Lake – Round 4	Haw	Storage Allocation	2015	28.2
Multiple	Jordan Lake – Future Rounds	Haw	Storage Allocation	2025 – 2045	8.2
Sanford	Cape Fear River Withdrawal	Cape Fear	River Withdrawal	2025, 2045	12.8
Pittsboro	Haw River Withdrawal	Haw	River Withdrawal	2015, 2020	4.0
Hillsborough	W. Fork Eno Reservoir Expansion	Neuse	Reservoir Expansion	2015	1.2
OWASA	Stone Quarry Expansion	Haw	Quarry Reservoir	2035	2.1
Orange County	Town of Mebane Purchase	Haw	Purchase	2015-2020	2 (0.5 – 2.5)
Raleigh	Neuse Basin Option 1	Neuse	TBD	2025	13.7 (9-15)
Raleigh	Neuse Basin Option 2	Neuse	TBD	2035-2045	13.7 (9-15)
Raleigh	Neuse Basin Option 3	Neuse	TBD	2050-2055	13.7 (9-15)
TOTAL	**All New Sources**				**96.2-100**

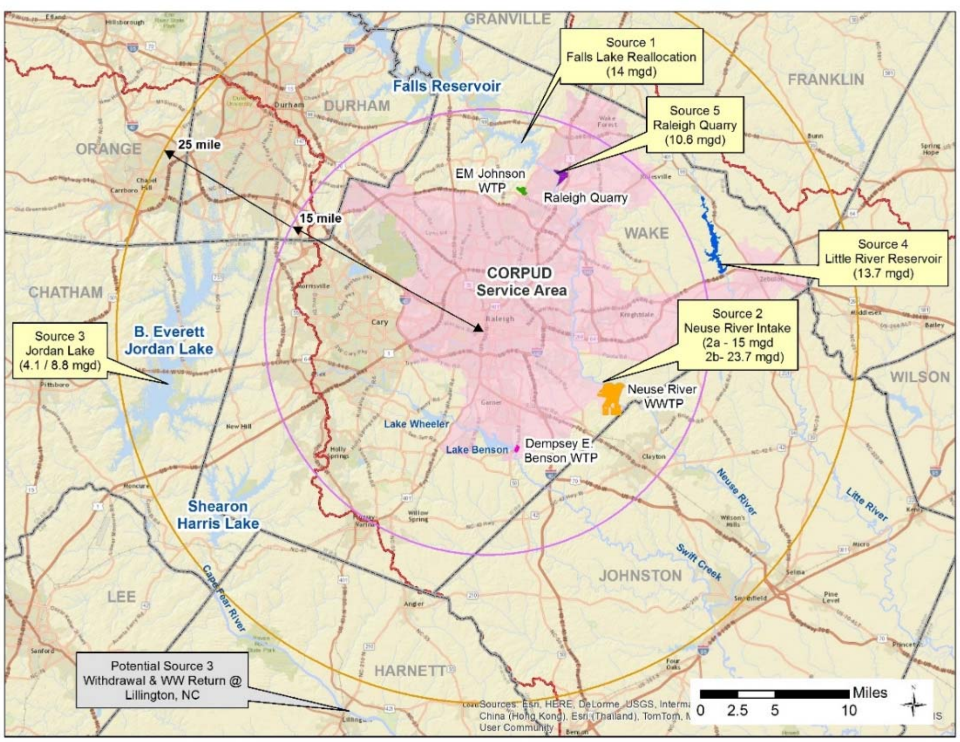

Figure 3 – Reference Map for Potential Sources.

In total, the JLP Recommended Alternative would meet the Region's projected cumulative need of 95.2 MGD, and utilize nearly all of the approximately 100 MGD of water supply in Jordan Lake by 2060. These alternative sources would reduce the risk of a supply deficit for any of the Partners – even during a recurrence of the most severe droughts recorded in the Triangle during the past 85 years.

Jordan Lake Allocations

The JLP Recommended Alternative includes new or expanded Jordan Lake allocations for several partners, both in this current Round 4 and in future allocation cycles. At the present time, 63% of the Jordan Lake water supply pool has been allocated. A 1% storage allocation is assumed to yield approximately 1 MGD of average day supply. All existing allocations are currently held by Jordan Lake Partnership members, and the JLP Recommended Alternative proposes that all existing allocations either be maintained or increased.

Table 3 presents current allocations, and Round 4 allocations as proposed in the TRWSP prior to Raleigh's decision to seek an allocation, and future requests, also prior to Raleigh's decision. **Table 4** presents current allocations, and Round 4 allocations that reflect Raleigh receiving an allocation of 4.7 mgd from Jordan Lake. Round 4 would meet water supply needs through 2045, with future allocations meeting needs through 2060. These tables indicate the total allocation amounts for each partner, who are expected to distinguish between Level I and Level II requests in their respective applications.

Table 3 includes all 13 JLP members, even though Raleigh (and its Merger Partners) and Sanford, are expected to meet their needs from other non-Jordan Lake sources. The Towns of Apex and Cary currently hold a combined Jordan Lake allocation for both communities. Cary has also finalized long-term agreements to serve the Town of Morrisville and the Wake County – RTP South service areas, and is expected to submit a joint allocation request on their behalf. **Table 3** therefore includes the combined (total) proposed request, but also indicates the individual amounts of each. **Table 4** is identical to Table 3, but includes the requested allocation for Raleigh, and serves to illustrate that the current request would not affect the near term plans for use of Jordan Lake, and only moderately affects these plans if an additional 4.1 mgd is required for Raleigh to meet its 2060 demands.

Hydrologic effects of the JLP Recommended Alternative were modeled with the recently updated Cape Fear-Neuse Basin OASIS model and the last 85 years of daily streamflow data. The model results indicated that all of the partners and downstream water users would be able to meet their demands for all days, and that no water shortages would be experienced; i.e., the water supplies that comprise the JLP Recommended Alternative are able to meet the future water demands of the region under the full range of recorded hydrologic conditions, while at the same time allowing downstream water users to meet their future demands as well. While not modeled, it is anticipated the City's requested allocation would produce similar results due to its small size, thereby also allowing the downstream water users to meet all of their future demands.

Table 3 – Jordan Lake allocations (MGD) proposed per the JLP Recommended Alternative

<table>
<tr><th>Partner</th><th colspan="2">Current</th><th colspan="2">Total Round 4 Requests</th><th colspan="2">Future Rounds (2060 Need)</th></tr>
<tr><td>Apex</td><td>8.5</td><td rowspan="2">32.0</td><td>10.6</td><td rowspan="4">46.2</td><td>11.6</td><td rowspan="4">48.5</td></tr>
<tr><td>Cary</td><td>23.5</td><td>28.6</td><td>29.8</td></tr>
<tr><td>Morrisville</td><td colspan="2">3.5</td><td>3.5</td><td>3.6</td></tr>
<tr><td>Wake County (RTP South)</td><td colspan="2">3.5</td><td>3.5</td><td>3.5</td></tr>
<tr><td>Chatham County – N</td><td colspan="2">6</td><td colspan="2">13</td><td colspan="2">18.2</td></tr>
<tr><td>Durham</td><td colspan="2">10</td><td colspan="2">16.5</td><td colspan="2">16.5</td></tr>
<tr><td>OWASA</td><td colspan="2">5</td><td colspan="2">5</td><td colspan="2">5</td></tr>
<tr><td>Orange County</td><td colspan="2">1</td><td colspan="2">1.5</td><td colspan="2">2</td></tr>
<tr><td>Holly Springs</td><td colspan="2">2</td><td colspan="2">2</td><td colspan="2">2.2</td></tr>
<tr><td>Hillsborough</td><td colspan="2">0</td><td colspan="2">1</td><td colspan="2">1</td></tr>
<tr><td>Pittsboro</td><td colspan="2">0</td><td colspan="2">6</td><td colspan="2">6</td></tr>
<tr><td>Raleigh & Merger Partners</td><td colspan="2">0</td><td colspan="2">0</td><td colspan="2">0</td></tr>
<tr><td>Sanford</td><td colspan="2">0</td><td colspan="2">0</td><td colspan="2">0</td></tr>
<tr><td>TOTAL JLP</td><td colspan="2">63</td><td colspan="2">91.2</td><td colspan="2">99.4</td></tr>
</table>

Table 4 – Jordan Lake allocations (MGD) with Raleigh using Jordan Lake as a Source Water

<table>
<tr><th>Partner</th><th colspan="2">Current</th><th colspan="2">Total Round 4 Requests</th><th colspan="2">Future Rounds (2060 Need)</th></tr>
<tr><td>Apex</td><td>8.5</td><td rowspan="2">32.0</td><td>10.6</td><td rowspan="4">46.2</td><td>11.6</td><td rowspan="4">48.5</td></tr>
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<tr><td>Orange County</td><td colspan="2">1</td><td colspan="2">1.5</td><td colspan="2">2</td></tr>
<tr><td>Holly Springs</td><td colspan="2">2</td><td colspan="2">2</td><td colspan="2">2.2</td></tr>
<tr><td>Hillsborough</td><td colspan="2">0</td><td colspan="2">1</td><td colspan="2">1</td></tr>
<tr><td>Pittsboro</td><td colspan="2">0</td><td colspan="2">6</td><td colspan="2">6</td></tr>
<tr><td>Raleigh & Merger Partners</td><td colspan="2">0</td><td colspan="2">4.7</td><td colspan="2">8.8</td></tr>
<tr><td>Sanford</td><td colspan="2">0</td><td colspan="2">0</td><td colspan="2">0</td></tr>
<tr><td>TOTAL JLP</td><td colspan="2">63</td><td colspan="2">95.9</td><td colspan="2">108.2</td></tr>
</table>

The applicant believes the Neuse River Basin sources are collectively the lowest impact water supply expansion sources available to it, but there is concern that parties with standing in a reallocation at Falls Lake or federal 401/404 permitting process involving Neuse River options may contest any project that has potential impact on the Falls Lake Nutrient Management Strategy and Rules. This could negatively affect the feasibility of Sources 1 and 2. If these options are significantly delayed or denied for this or any reason, it will force the City to utilize water from other areas, and Jordan Lake is an attractive regional supply that could be tapped.

Two of the City's Neuse River Basin options include assumptions that potentially affect the amount of water available in the water quality portion of the Conservation Pool in Falls Lake. Falls Lake is designated as a nutrient –sensitive waterbody and is listed on the North Carolina Draft 2014 303(d) list for chlorophyll-a. Consequently, the City utilized NCDENR's Falls Lake Environmental Fluid Dynamics Code (EFDC) to evaluate the effects of increased water withdrawals on chlorophyll-*a* in Falls Lake. The results of the evaluation indicate the impacts of increased withdrawals from Falls Lake on water quality are smaller than the margin of error of the model itself. The EFDC model also indicates the marginal impact on water quality resulting from a reallocation from the water quality pool to the water supply pool is less than the influence of a number of other variables like reservoir inflow, wind, and cloud cover. By this measure, projects that require a reallocation from the water quality to the water supply pool would appear to have minimal adverse environmental impact on water quality within the lake. Nevertheless, based on a direct comparison of the modeling results, it could be argued that increased withdrawals from the Falls Lake Conservation Pool might make it more difficult for the lake to come into compliance with the stated water quality objective of the Falls Lake Nutrient Management Strategy and that this may affect the upstream communities that are charged with reducing the impact that their discharges (stormwater and wastewater) have on water quality in the lake. This is explained in more detail in Section V.

The remainder of this document presents the City of Raleigh and its Merger Partners specific allocation request.

SECTION I. WATER DEMAND FORECAST

Raleigh and its Merger Partners' demand forecasts are based on gallons per capita day methodology as described in the text and summarized in the tables and figures below.

Population Estimates

Population projections prepared for the City of Raleigh and its Merger Partners in recent years uniformly predict continued growth. Growth of up to 15,000 additional citizens in all seven communities has occurred between 2010 and 2013. Several population estimates have been developed; most are primarily based upon the Water Quality Study and Master Plan Update (Hazen and Sawyer, 2008a) and subsequent updates to the data for Traffic Analysis Zones (TAZs) from the Capital Area Metropolitan Planning Organization (CAMPO).

The most recent projections, shown in **Table I.1**, are based on population projections through 2035 that were developed by the Capital Area Metropolitan Planning Organization (CAMPO), and that were the basis for the 2035 Long-Range Transportation Plan (LRTP). The 2035 LRTP was approved by the Transportation Advisory Committee, the CAMPO policy board in May 2009. The population projections for 2040 were generally calculated based on extrapolation of the CAMPO projections from the 2035 LRTP, corrected for annual population figures announced by the North Carolina Office of State Budget and Management. During this review period, CAMPO developed new base data sets for revised population projections. Review of those data sets and projections indicated no significant differences between previous population projections and new 2040 LRTP population projections, which were published in the newly renamed 2040 Metropolitan Transportation Plan.

Water Demand Projections

Raleigh's demand projections are based on gallons per capita day methodology. Thus, for each projection year, a total population number and use rate in terms of gpcd are needed. The use rates were not forecast to remain the same throughout the projection window.

A description of Raleigh's water use sectors is provided in **Table I.2**. Raleigh's projection methodology lumps all demand and non-revenue uses together. In order to disaggregate the sector usage for the purpose of this report, the percentage breakdowns for each the sectors from 2010 are simply carried forward to all the projection years. As a result, Raleigh's sector-based demand estimates, as shown in **Figure I.1** are only representative of current conditions, and should not be used to interpret how the water use by sector will change.

Table I.1 – Projected Population and Water Demand (MGD) for the Raleigh & Merger Partners Service Area

Sector	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Population	485,219	561,882	638,500	718,843	799,100	879,441	963,200	1,048,700	1,134,200	1,225,200	1,316,200
Residential	29.43	32.94	36.45	40.35	44.26	47.97	51.67	54.91	58.12	61.61	65.08
Commercial	11.42	12.78	14.17	15.66	17.16	18.61	20.09	21.31	22.56	23.91	25.26
Industrial	1.30	1.45	1.61	1.78	1.96	2.12	2.28	2.43	2.57	2.72	2.88
Institutional	3.40	3.81	4.19	4.66	5.08	5.54	5.93	6.34	6.72	7.12	7.52
WTP Process	0.13	0.15	0.16	0.18	0.19	0.21	0.23	0.24	0.26	0.27	0.29
Distribution System Process	2.16	2.42	2.66	2.96	3.28	3.52	3.83	4.03	4.26	4.52	4.77
Sector	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Other Non-Revenue	4.16	4.66	5.15	5.70	6.25	6.78	7.30	7.76	8.22	8.71	9.20
TOTAL (MGD)	**52.0**	**58.2**	**64.4**	**71.3**	**78.2**	**84.8**	**91.3**	**97.0**	**102.7**	**108.9**	**115.0**
GPCD	**107.2**	**103.6**	**100.8**	**99.2**	**97.8**	**96.4**	**94.8**	**92.5**	**90.6**	**88.8**	**87.4**

Table I.2 - City of Raleigh Water Use Sectors

Use Sector	Sub-sector/Description	
Residential	Includes all single family and residential irrigation use	
Commercial	Includes all commercial users and multi-family units	
Industrial	Includes all industrial users	
Institutional	Includes all institutional users (i.e. Universities, Schools, Hospitals, etc.)	
Non-Revenue	Water Treatment Process Water	Calculated as ~0.25% of total water demand for 2010 and carried forward to future projection years.
	Distribution System Process Water	Includes line flushing and hydrant testing. Calculated as ~4.75% of total water demand for 2010 and carried forward to future projection years.
	Other Non-Revenue Water	Includes unbilled water, construction, waterline breaks, street cleaning, and Fire Department use. Calculated as ~9% of total water demand for 2010 and carried forward to future projection years.

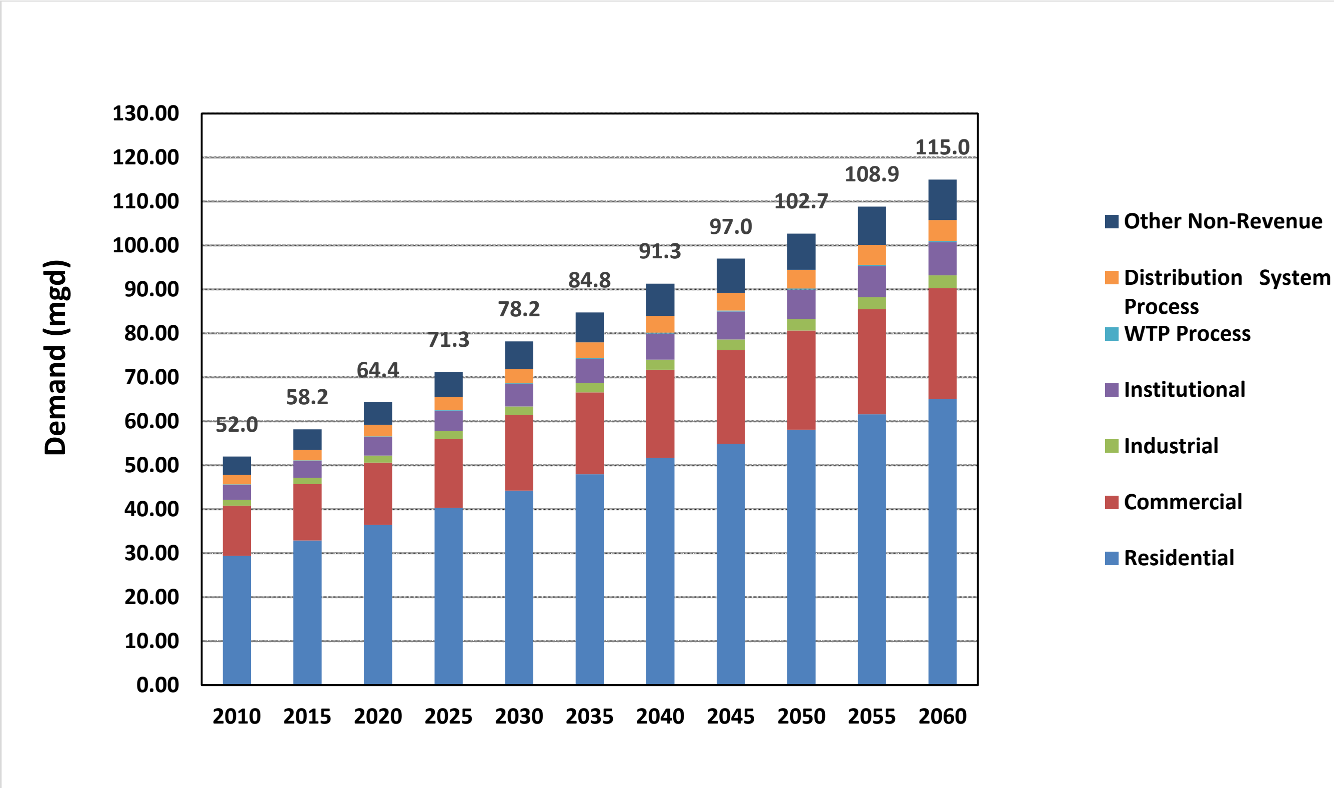

Figure I.1 – City of Raleigh Demand Projections by Customer Sector

Projected Reductions in Per Capita Demand

Raleigh has paid and continues to pay an increasing amount of attention to water conservation and efficiency. Efficiency is a term used to describe the minimum water use of certain plumbing fixtures or water using appliances. Conservation, on the other hand, is a term that is used to describe the water use habits of individual customers. Based on the averaged potable water consumption data from 2009 and 2010, the City of Raleigh service area (i.e. Raleigh, Zebulon, Rolesville, Wendell, Knightdale, Wake Forest and Garner) consumed an average of 103.8 gallons per capita day (gpcd). There is inherent variability in annual gpcd that must be accounted for in demand projections. Weather and economic activity can have significant impacts on gpcd from year to year. From the historic record shown in **Figure I.2**, it is apparent that gpcd varies year-over-year, and its fluctuations influence total demand by up to 10% of total demand in any year. The calendar year 2013, for example, was the 8th wettest year on record for our region, with a total rainfall of 53 inches, as opposed to the 43 inches the region receives on average, and the gpcd metric reached its lowest recorded annual value in over 15 years.

Variability in year-over-year gallon per capita demand is, however, a significantly smaller driver in long term projections than variability in potential population growth scenarios. In 2013 the gpcd average demand was 97 gpcd. Because this falls within the known variability for the service area, no changes in assumed gpcd in forward projections is recommended at this time, thus the present day base planning number remains 103.8 gpcd.

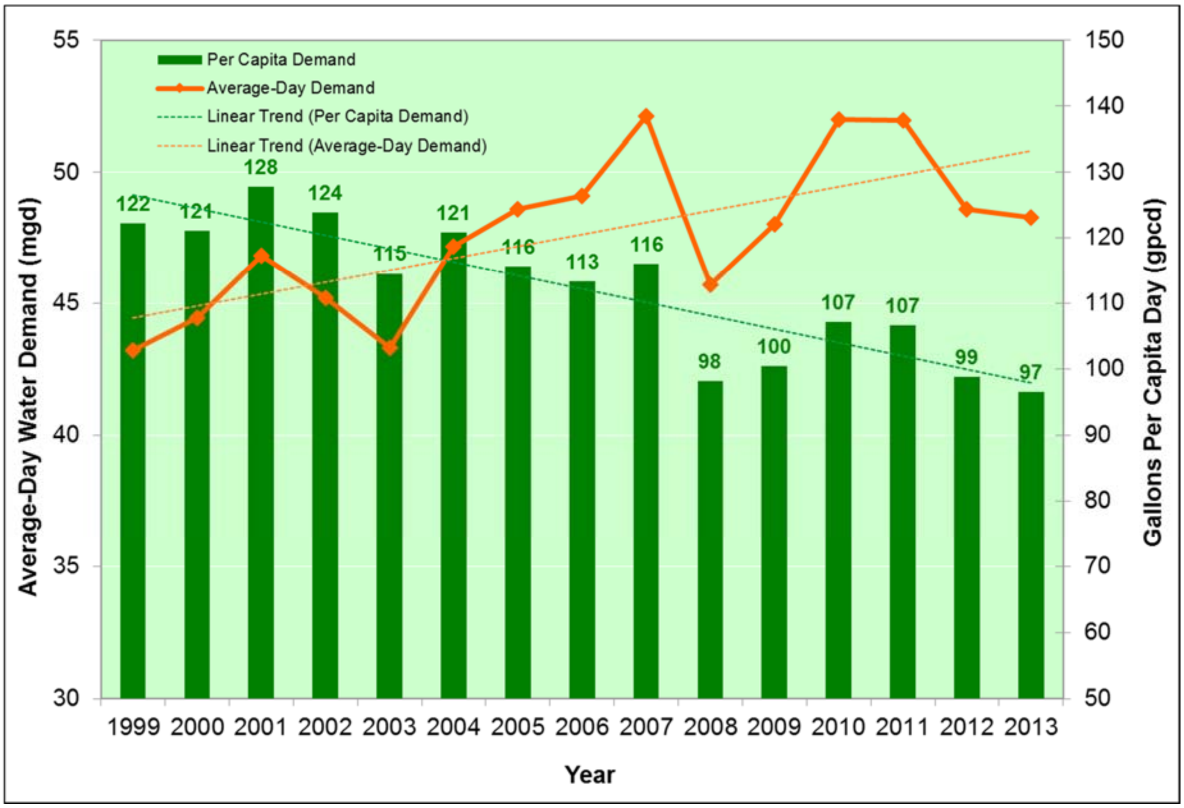

Figure I.2 - Impacts of Water Conservation Programs on Per Capita Demand

While Raleigh's gpcd usage compares very favorably with other similarly sized systems throughout the United States, it is anticipated that further reductions will be realized in the future through the following actions:

- continued development of the Reuse system,
- continued support of water fixture replacement incentives, though use of cost benefit analysis may result in individual program modifications,
- reduction of elective use demand due to tiered rate implementation,
- continued indoor water fixture efficiencies through Federal regulation.

From 2009 to 2013, water supply demand projections assumed that significant reductions in per capita water consumption would be realized from personal conservation efforts and the installation of more efficient fixtures and appliances by our customer base. The projections also assumed continued growth of the reclaimed water system and the eventual prohibition of outdoor irrigation with potable water. At least for the near term, there is significant uncertainty regarding the social or political acceptability of proposed per capita reduction strategies or the degree with which those reductions strategies will be implemented.

As an example, the 2007 City of Raleigh reclaimed water master plan assumed 3 mgd average daily demand and 8-10 mgd peak day demand from a 187 mile reclaimed water distribution system networked throughout the City's service area. Implementation of the first of seven plan phases has raised questions regarding final system costs and the ultimate consumption demands for reclaimed water by current and future customers. A revised reclaimed water master plan is expected to address these questions and will be available in mid-2015.

Other water conservation and efficiency assumptions have been similarly challenged. The City Attorney's Office concluded that the City is not able to require the installation of cutting edge water efficiency fixtures and appliances. In addition, the City Attorney's Office advised that the City's program to incentivize such fixtures and appliances should be limited to fixtures or appliances expected to stay in the residence when ownership changes. City proposals to ban outdoor irrigation have met with mixed responses, which demonstrate lack of politically cohesive support for this measure.

Because of this evolving understanding, the water conservation and efficiency assumptions in the development of the projected water demands are as follows:

- Total water demands are based on the average of 2009 and 2010 water demand characteristics of the combined services area.
- Reductions due to residential efficiency based only on retrofitting of residential housing units to incorporate fixtures that meet 1994 water use standards, not WaterSense™ standards.
- Reductions due to reuse will be based on commercial and industrial non-irrigation demands and unregulated irrigation demands until the City's reclaimed water master plan is updated.
- Reduction due to limits on outdoor irrigation will be based on one-half of projected outdoor irrigation demands.

As of November 1st, 2010, the CORPUD implemented a tiered rate pricing structure for our all residential potable water service customers. It important to note that Raleigh has upwardly adjusted the rates associated with sanitary sewer service, continuing to place financial pressure on rate payers who then look to water conservation as a means to reduce costs.

It is not yet clear how further rate increases will impact demand. Based upon the experience in many other communities with tiered or "conservation" rate structures, it is likely that average and maximum demand will continue to decrease in response to the acute financial impact on elective uses such as irrigation. It is difficult to quantify the overall impact of the rate structure at this time, but it is expected that it will have a substantial impact on the current irrigation demand and other similar uses. Assuming that the irrigation demand is reduced by 50 percent, the reduction for outdoor irrigation is estimated to represent 2.5 gpcd.

The United States Environmental Protection Agency (EPA) established the Water Sense Program in 2006 to promote high levels of water efficiency in common indoor water fixtures such as toilets, faucets and showerheads. In addition, the EPA created the Energy Star Program to encourage the purchase of energy efficient appliances such as clothes washers and refrigerators. The Energy Star Program also includes water efficiency as a criterion for some products such as clothes washers. It is estimated that the appliance/fixture replacements will reduce demand by an additional 5.0 gpcd over the fifty-year planning period due to the improved efficiency of the new models.

Future reductions in potable water consumption attributed to the City's reclaimed water program are based on historical water demands for commercial and industrial non-irrigation uses and unregulated irrigation usage. These reductions could represent an additional 1.5 gpcd savings by 2040.

In summary, it is estimated that the combined savings of the reclaimed water distribution program, expansion of the water fixture replacement incentive program, residential demand impact from the tiered rate structure, and improved efficiency of replacement water fixtures and appliances will result in an additional 9% reduction beyond the current average demand of 103.8 gpcd by 2040.

For the 2050 and 2060 estimates, Raleigh's projections further assume that all outdoor irrigation with drinking water will be phased out. This water need may be met in the future by on-site reuse, reclamation, rainwater harvesting or other measures. This change will lead to an anticipated reduction of 2.4 gpcd. It is also assumed that building code standards will dictate new levels of efficiency, acquiring an additional 5 gpcd in reductions for the service area between 2040 and 2060. At this time it remains uncertain when the actions required to acquire all assumed reductions for the planning period will become socially or politically acceptable. Without continued conservation/efficiency gains and increased use of reclaimed water, water supply demand projections will need to be revised upward.

Bulk Water Sales

Raleigh has emergency sales/purchase agreements in place with Cary, Durham, Holly Springs and Johnston County as summarized in **Table I.3**. In addition to the emergency purchase agreements Raleigh has an agreement to provide water to a portion of Fuquay-Varina's service area on a regular basis until the year 2021. Raleigh anticipates that Fuquay-Varina's own water system will be built out sufficiently in 2021 such that the agreement will not need to be extended.

Table I.3 – Sales to other systems

Purchaser	PWSID	Agreement Amount (MGD)	Begin Year	End Year	Regular or Emergency	Pipe Size (in.)
Cary	03-92-020	1.2	N/A	2032	Emergency	24
City of Durham	03-32-010	1.3	N/A	2026	Emergency	24
Fuquay-Varina	03-92-055	0.75	N/A	2021	Regular	16
Holly Springs	03-92-050	1.2	N/A	2029	Emergency	16
Johnston County	03-51-070	2.15	N/A	2028	Emergency	16

SECTION II. CONSERVATION AND DEMAND MANAGEMENT

Water Conservation Ordinance and Policy

Raleigh has a water conservation ordinance in Section 8, Article E of the City Code of Ordinances. This article describes short-term mandatory conservation measures which are employed during droughts or other supply emergencies. This measures include water conservation actions such as restaurants only serving water upon request and local hotels/motels replacing towels and linens upon request, large water users (i.e. >100,000 gallons per day) conducting an AWWA audit, and water use restriction implementation triggers.

In addition to this ordinance language, the City of Raleigh Public Utilities Department (CORPUD)also has a NC Division of Water Resources approved *Water Shortage Response Plan* which provides information on specific water use restrictions, water conservation and water efficiency concepts, and available water supply resources. It should also be noted that CORPUD adopted a seasonal water use restriction trigger system developed using the OASIS hydrologic model in June 2012. Previously, the water use restriction triggers were based on the volume remaining the water supply pool at Falls Lake, regardless of time of year. However, using the OASIS model to evaluate this system, it became apparent water use restrictions would likely be implemented as often as once every 3 years, and in many cases would be unnecessary. Conversely, there was also significant risk that water use restrictions would not be adopted in sufficient time if drought conditions occurred in the late spring. Thus, the seasonal trigger system takes the traditional drawdown and refill cycles of Falls Lake into account, which in turn will significantly improve the management of the City's water resources. The seasonal trigger system action points are illustrated in **Figure II.1** and **Figure II.2** for implementation and recession, respectively.

Figure II.1 - Implementation Triggers

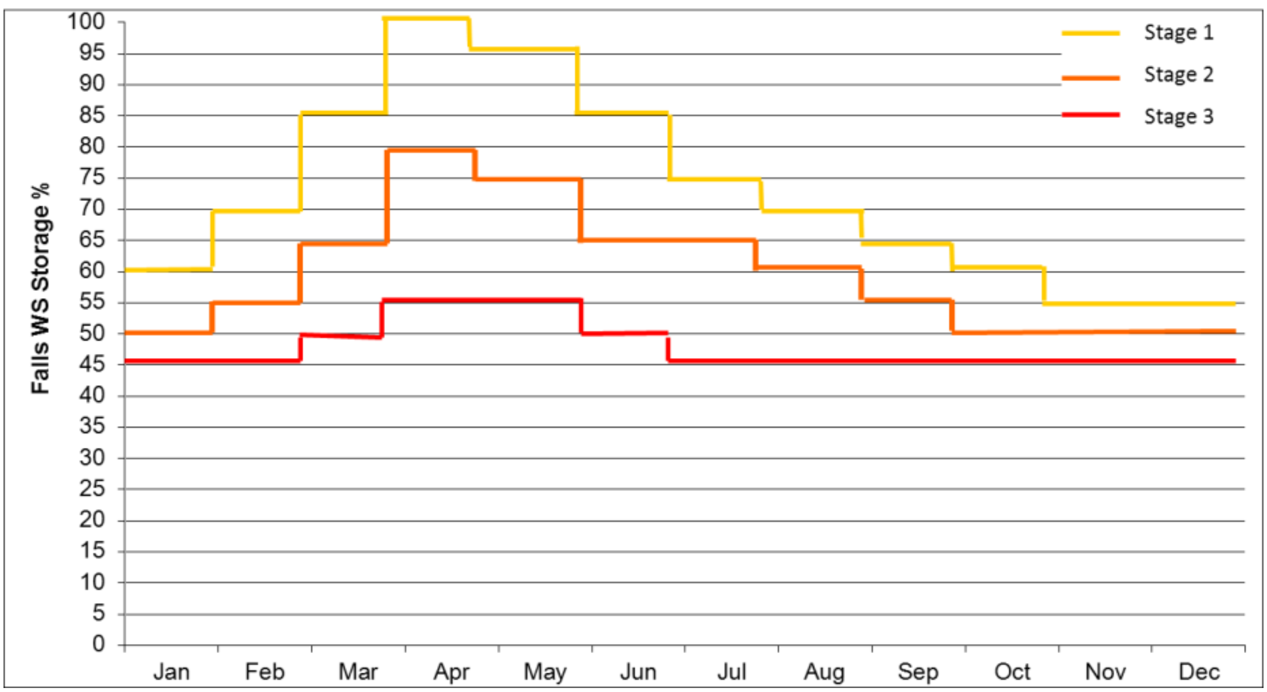

Figure II.2 - Rescission Triggers

Water Conservation Pricing

In regards to conservation pricing, CORPUD continues to maintain the residential tiered rate structure which was approved and adopted in November of 2010 as shown in **Table II.1**.

Table II.1 - Residential Consumption Charges

TIER	VOLUME IN CCF	RATE PER CCF
1	0 - 4	$2.28
2	4 - 10	$3.80
3	10 +	$5.07*

*ALL IRRIGATION ACCOUNTS BILLED AT TIER 3 RATES

It should also be noted that all new irrigation systems are required to have a separate meter and are billed at the highest tier. Since the implementation of the irrigation rate and the residential tiered system, the result has been a significant decline in high volume water users as described in **Figure II.3**. The data presented in **Figure II.3** is from a study conducted by Mary Tiger of the UNC-School of Government and is it worth noting this trend has continued since 2010.

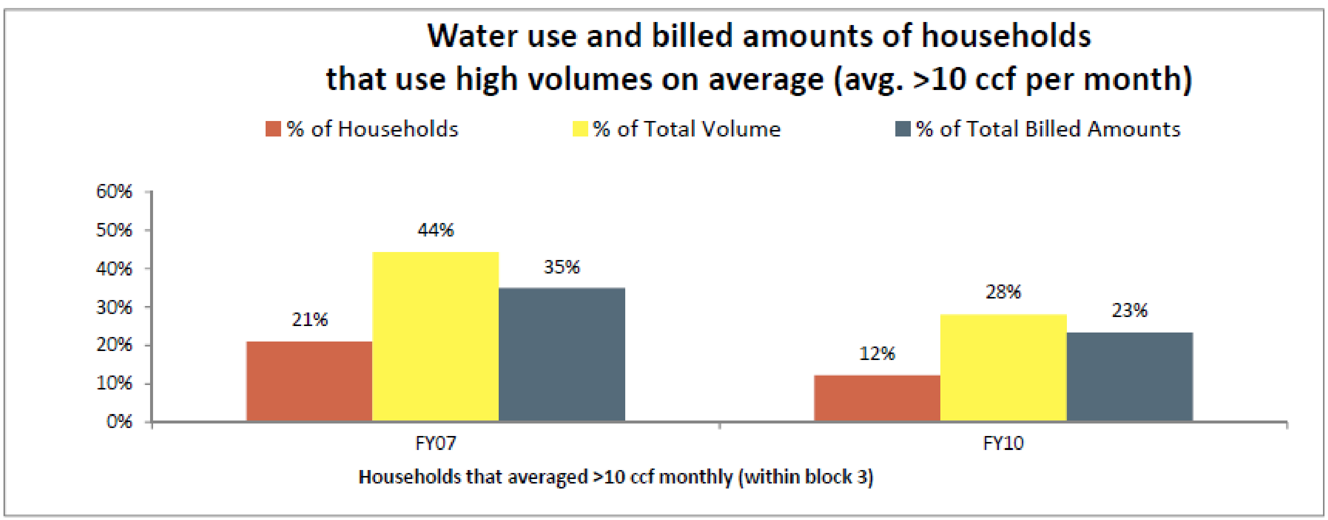

Figure II.3 - Decline in High Volume Users

Leak Detection and Repair

Leak detection and repair efforts continue to be addressed through the use of permaloggers and specialized acoustic equipment, which record audio data that is subsequently reviewed to determine if leaks are present in a given part of the distribution system. Noted leaks are then accurately located with ground microphones and correlating system, which allows for efficient and timely repairs. Water Distribution staff are assigned and trained for this program, and CORPUD makes their expertise and equipment available to other systems without such resources.

Annual Water Audits

Per the direction of the City Council appointed Water Utility Transition Advisory Taskforce, CORPUD conducts annual AWWA water system audits. The most recently compiled audit is 2013 reflects an exceptionally low volume of water loss. In addition, the Utility Billing Division provides monthly updates which, among many metrics, compares pumped potable water volume to billed potable water, and this consistently indicates only a 10% differential, which further validates the efficiency of the City's distribution system.

Public Education

CORPUD's public education efforts include manning a booth at public events (e.g. Earth Day, Viva Raleigh, Artsplosure, etc…), visiting all Citizen Advisory Council locations to discuss Department initiatives, the creation and updating of a water conservation webpage, and making water resource presentations to area schools and civic groups.

Plumbing Retro-fit Program

CORPUD offers free water conservation kits, high efficiency aerators, and high efficiency showerheads to all water customers. In order to further promote the efficiency program and improve customer access to the free fixtures, it is also planned to distribute the high efficiency showerheads and aerators to community centers within the service area. In addition, CORPUD funded a toilet rebate program from 2009 to 2013 that provided $100.00 for each older model toilet replaced with a new Water Sense labeled model. The program resulted in the replacement of over 12,500 toilets in the CORPUD service area.

Reclaimed Water

The Reuse Water Master Plan was originally developed in 2007, and is currently in the process of being updated by CDM Smith and CORPUD staff per direction of City Council (estimated completion in the middle of 2015.). Currently, the average Reuse water demand is approximately 0.4 MGD with more than 20 connections, ranging from three golf courses, a hospital physical plant, and several City of Raleigh facilities. The City also expects to provide reuse water the NC State's Centennial Campus. In 2013, City staff co-wrote legislation with NCDENR to allow reclaimed water to be used as a source water under certain conditions. This legislation was signed into law in August 2014.

Summary

It is assumed all of the above mentioned water conservation programs and efforts have contributed to the steady decrease of the average gallons per capita day (gpcd) value, which is currently 97 gpcd, as shown in **Figure I.2**. While the gpcd calculation isn't necessarily the ideal metric to measure overall system water efficiency, the 97 gpcd value compares favorably with any similarly sized utility system in the country, and this value will likely slowly decrease in the future. Furthermore, recent studies have indicated declining per capita water usage is most likely a national trend, and that utility system across the country have experienced similar decreases or flattening of demand.

At this time, CORPUD continues to provide funding for the free water conservation kits, high efficiency aerators, and high efficiency showerheads to all water customers. In order to further promote the efficiency program and improve customer access to the free fixtures, it is also planned to distribute the high efficiency showerheads and aerators to community centers within the service. The current leak detection program will also continue to be supported with staff resources and use of existing leak detecting equipment and techniques as described above.

Another critical factor in maintaining and gradually decreasing per capita consumption rates is the willingness of the system's elected leadership to adopt rate increases as prescribed by utility financial managers. To this end, the Raleigh City Council has continued to implement the recommended rate increases and is expected to support future rate increases as needed. CORPUD and the City Council have also committed to the ultimate goal of developing a "full cost of service" rate/fee structure in the future, and this goal is widely understood to not only represent responsible fiscal management, but an additional incentive to decrease water consumption as rates increase.

It is important to note that the cumulative impact of water conservation/customer water use changes, water efficiency measure and reclaimed water use are assumed to deliver 15 million gallons per day in demand savings, equivalent to one full Neuse River Basin option identified in the TRWSP. It is also important to note that if these assumed saving do not materialize in part or in whole, 4 of the 4 Neuse River options identified in the TRWSP will be required to provide for community needs.

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SECTION III. CURRENT WATER SUPPLY

Available Supply

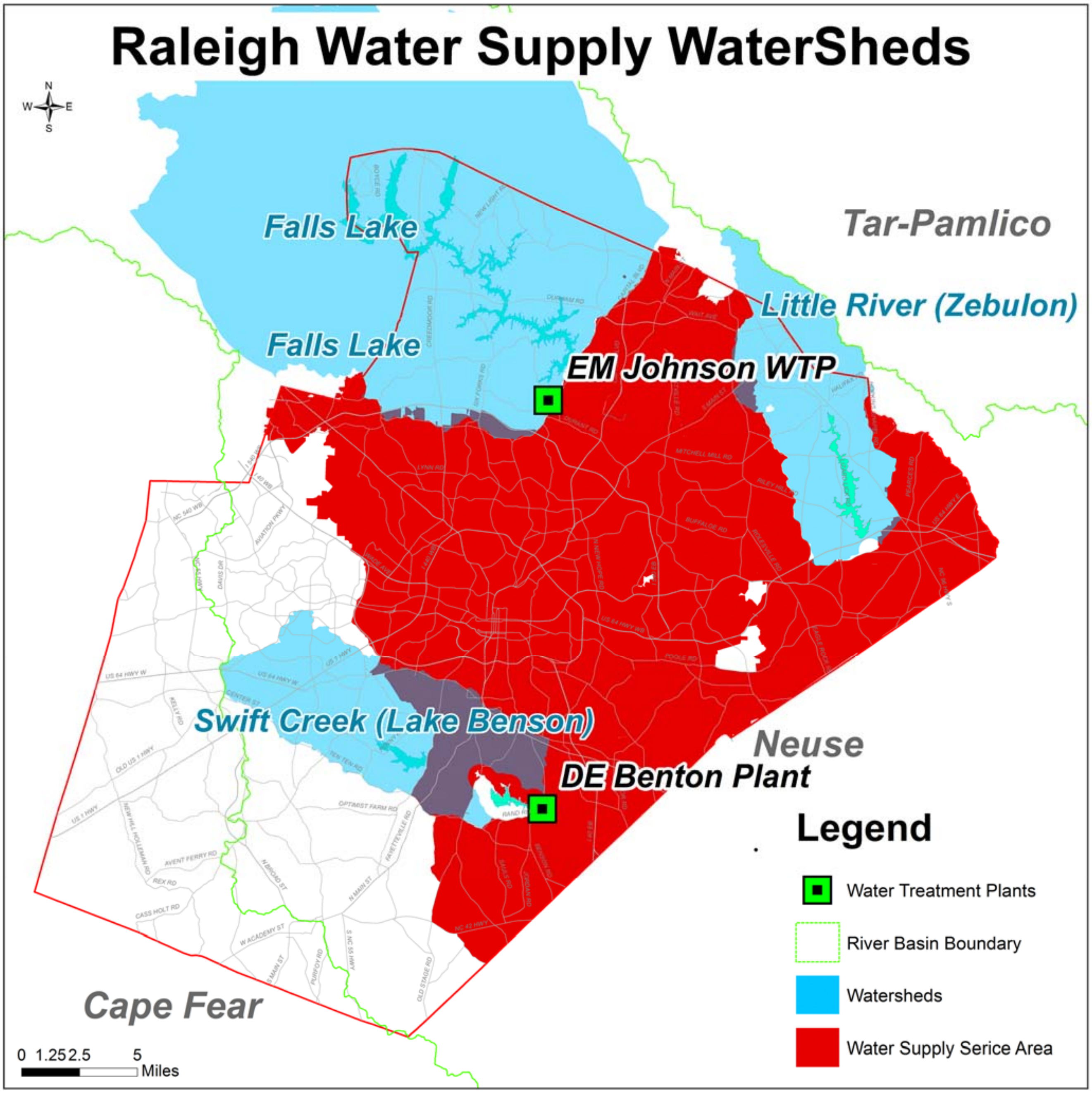

Figure III.1 – Map of Raleigh's Water Supply Sources and Water Treatment Plants

Table III.1 – Existing Source Summary, Available Supply*

Source	PWSID	SW or GW	Basin	WQ Classification	Available Supply (MGD)*
Falls Lake	03-92-010	SW	Neuse (10-1)	WS-IV, B; NSW, CA	66.1
Lake Benson & Lake Wheeler	03-92-010	SW	Neuse (10-1)	WS-III; NSW, CA	11.2

* **Hydrologic** period-of-record, 50-year yield for Falls Lake Reservoir and Lake Benson & Lake Wheeler as determined in *Little River Reservoir Draft EIS, 2012*.

Purchased Water

As noted in the Bulk Water Sales discussion in Section I – Water Demand Forecast, Raleigh is a party to several emergency sales/purchase arrangements with nearby utilities. There is also one nonemergency commitment to sell 0.75 mgd to Fuquay-Varina. Under their general terms, these agreements provide for the sale of water subject to its availability from the seller. A summary of available water via mutual agreements is as follows:

- Up to 8.5 mgd from the City of Durham
- Up to 9.5 mgd from the Town of Cary (pending completion of system modifications, mid 2015)
- Up to 1.2 mgd from the Town of Holly Springs (pending completion of system modifications, mid 2015)
- Up to 2.15 mgd from Johnston County

Water availability under these existing agreements represents only a short-term or temporary supply source for Raleigh and purchase or sales would generally be limited to times of severe drought or periods of special operational need, such as planned/unplanned infrastructure maintenance or other outages, unless a Jordan Lake allocation becomes available to the City and its Merger Partners.

SECTION IV. FUTURE WATER SUPPLY NEEDS

Table IV.1 - City of Raleigh, Existing Water Supply and Projected Water Needs

	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Demand	52.0	58.2	64.4	71.3	78.2	84.8	91.3	97.0	102.7	108.9	115.0
Supply	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3
Demand % of Supply	67%	75%	83%	92%	101%	110%	118%	126%	133%	141%	149%
Need	0.0	0.0	0.0	0.0	0.9	7.5	14.0	19.7	25.4	31.6	37.7

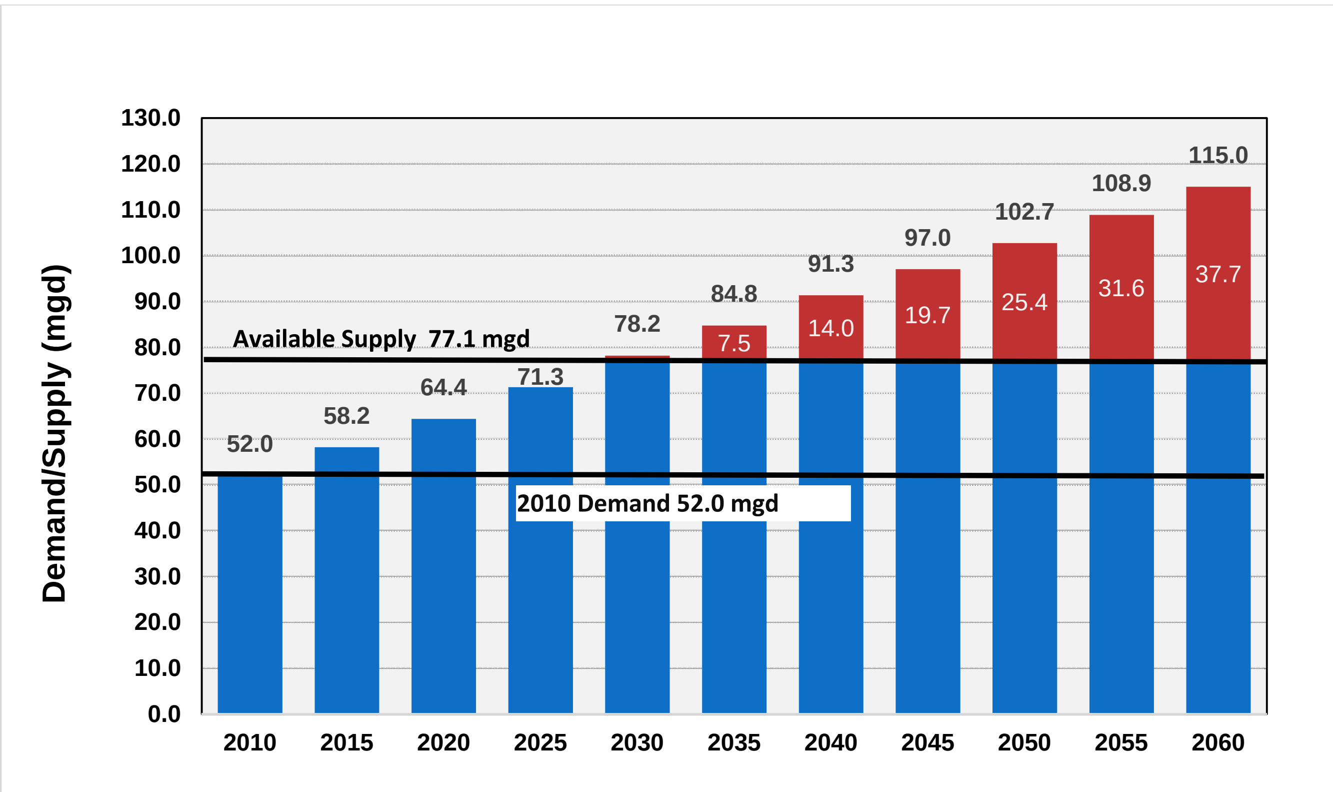

Figure IV.1 - Existing Water Supply and Projected Demands

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SECTION V. ALTERNATIVE WATER SUPPLY OPTIONS

Introduction

Raleigh has spent the last 7 years attempting to permit its next water supply expansion, which it had initially assumed would be a new reservoir on the Little River. The Little River Reservoir EIS permitting process has led the City to shift its focus away from the proposed Little River Reservoir to lower impact alternatives which, based on the "least environmentally damaging practicable alternative" (LEDPA) principle, must be pursued prior to building the Little River Reservoir. One of these alternatives, a reallocation of storage within the Falls Lake Conservation Pool to increase the City's water supply storage, has conceptual support from the applicant as well as State and Federal regulatory agencies and the City is actively pursuing this potential source (Source 1). However, there is no certainty that the lead review agency, the U.S. Army Corps of Engineers (USACE), will complete the Reallocation Study with a favorable decision that increases the City's water supply.

Several of the other potential sources identified through the Little River EIS process have been incorporated into the City's long-range water supply plan as well. The crux of the problem facing Raleigh and its Merger Partners is that there are no easy water supply expansion options that will not face significant and time intensive opposition from some set of stakeholders. As previously explained, until now the City has pursued new supply sources one at a time, in a sequential manner, but has determined it would be prudent to pursue multiple sources in parallel permitting processes given the projected need and length of modern permitting processes.

The City understands that NCDENR and the EMC are charged with balancing the needs of the region and assigning allocations from Jordan Lake in a fair and consistent manner. In turn, the City needs a clear directive regarding whether or not Jordan Lake can be considered as part of its future water supply portfolio. A decision from the EMC to not grant an allocation based on this present application, but that leaves the door open for a future allocation, would leave the City in a position of continuing uncertainty with regard to its water resource planning efforts, and will make it more difficult to develop other sources.

Source Options

There are six potential sources identified in this application which must be compiled in combinations of two to four individual sources to meet the City's projected demands for 2060. These sources, which are summarized in **Table V.1**, include the following (also see Introduction **Figure 3**):

7. Reallocation of Falls Lake Conservation Pool
8. Neuse River Intake Upstream of the Neuse River Wastewater Treatment Plant (NRWWTP)
9. Jordan Lake Allocation
10. Little River Reservoir
11. Raleigh Quarry as Off-stream Storage
12. Water Purchase Agreement

Four of the sources lie in the Neuse River Basin, and one, Jordan Lake, in the Cape Fear River Basin. The sixth source assumes the City would develop a purchase agreement with one of its neighbors and is vague in source basin assignment since the details of the arrangement have not been worked out and could potentially come from several basins in the region.

The applicant recognizes that the JLA-4 application form requests a comparison of the alternatives with regard to the environmental impacts, water quality classification, timeliness, interbasin transfer, regional partnerships, technical complexity, institutional complexity, political complexity, public benefits, and consistency with local plans. However, due to the number of sources the applicant has had to consider as part of its long-range water supply planning and the great number of permutations of those sources possible (i.e. alternatives), the applicant has chosen to describe and compare each source with respect to these criteria before delving into a comparison of the alternatives. It is hoped this will provide a more meaningful comparison with respect to the applicant's potential use of a Jordan Lake Allocation. Descriptions of the three alternatives are provided in **Tables V.2** and **V.3** below.

Note that Source 2 is divided into parts 2a and 2b. Both 2a and 2b have the same infrastructure, but distinct operational protocols.

Table V.1 – Raleigh and Merger Partners, Additional Source Water Options

Source	Type	SW or GW	Basin	WQ Classification	Development Time (yrs)	Earliest Year Online	Additional Supply (MGD)
(1) Reallocation of Falls Lake Conservation Pool	Modified Operation of Existing Reservoir	SW	Neuse (10-1)	WS-IV, B, NSW, CA	5-10	2020	14.0
(2) Neuse River intake upstream of NRWWTP							
(2a) Some Impact on Falls Lake Water Quality Pool	Stream Withdrawal	SW	Neuse (10-1)	C, NSW	5-10	2020	25.1[a]
(2b) No Impact on Falls Lake Water Quality Pool	Stream Withdrawal	SW	Neuse (10-1)	C, NSW	5-10	2020	15
(3) Jordan Lake Allocation	Storage Allocation	SW	Haw (2-1)	WS-IV, B, NSW, CA	5-10	2020	8.8
(4) Little River Reservoir	New Reservoir	SW	Neuse (10-1)	WS-II, NSW	15-30	2030	13.7
(5) Raleigh Quarry as Off-Stream Storage	Quarry Reservoir	SW	Neuse (10-1)	WS-IV, NSW	30-100	2045[b]	8 – 14.7[c]
(6) Water Purchase Agreement	Purchase	SW	unknown	Unknown	2	--	0.2 - 3.3

a – The yield potential of Source 2a is higher than indicated. However, one practical limit is that it would be built to ensure only enough supply to allow the D.E. Benton WTP to operate at a constant 40 mgd – a WTP capacity expansion which was envisioned during the design and construction of the current 20 mgd facility.

b – A 2045 on-line date is an estimate only based on a projected water supply need presented in Alternative 3. The ability to acquire the quarry by this date is a potentially prohibitively expensive proposition that is discussed herein.

c – Additional operational yield will depend on volume of quarry at the time it is converted to a water supply. The volume in turn depends on the mining rate and how long the quarry will continue to be operated as a quarry. Condemnation of the mineral rights is prohibitively expensive, therefore this option is likely to be viable only if the owner is willing to sell the quarry.

Source 1 – Reallocation of Falls Lake Conservation Pool

Description

The Falls Lake Project is a USACE dam and multifunction reservoir located in Wake, Durham, and Granville counties with storage allocated to accommodate sedimentation, water quality, the City of Raleigh's water supply, and flood control. The Falls Lake Water Quality Pool (FLWQP) and Falls Lake Water Supply Pool (FLWSP) are collectively known as the conservation pool and together impound up to 34.7 billion gallons (BG) of water at a normal pool elevation of 251.5 feet above sea level as shown in **Figure V.1**. Although USACE policy indicates permanent reallocations from the controlled flood storage pool or the sedimentation storage pool are impracticable, an exchange between the remaining storage pools does appear to be technically feasible. The City of Raleigh, through a contract with the Corps of Engineers, has exclusive rights to the water supply storage pool, which provides 45,000 Acre-Feet (14.7 billion gallons) of storage. The water supply storage pool is 42.3% of the conservation storage pool. The remaining 57.7% (61,322 acre-feet or 20 billion gallons) of the conservation storage pool is dedicated to water quality storage, which is that part of total lake storage dedicated to maintaining flows for downstream uses, including biota support, agriculture, and water supply. Inflows to the Falls Lake conservation pool are assigned in proportion to the full storage allocation for each pool. As such the FLWQP is assigned 57.7% of inflow and the FLWSP is assigned 42.3% of inflow.

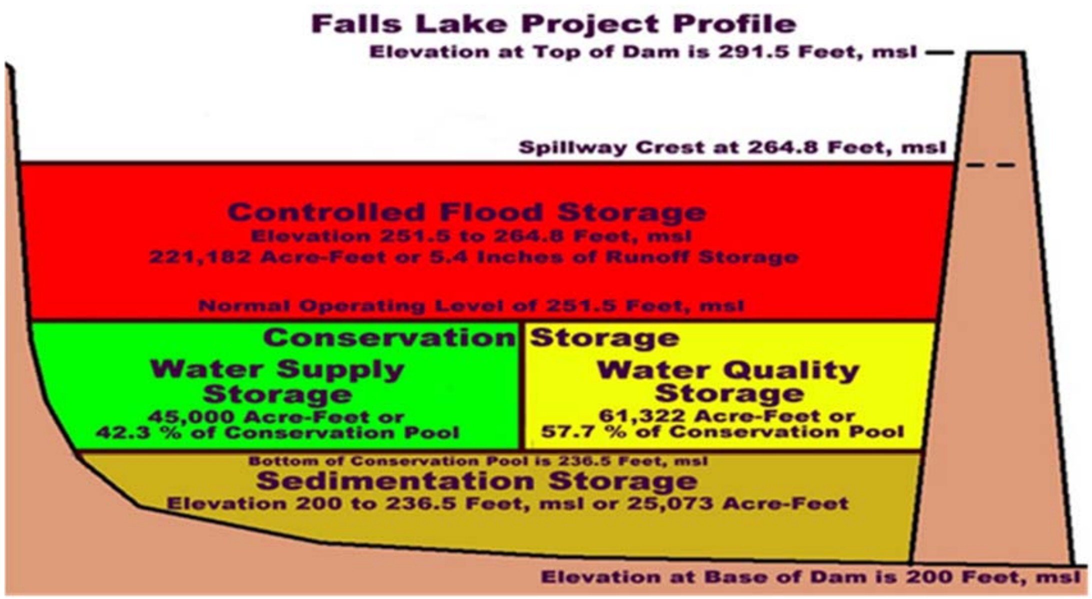

Figure V.1 – Storage profile for Falls Lake

The City withdraws water from the FLWSP, treats it at the E.M. Johnson Water Treatment Plant, delivers it to its customers, and returns over 85% of the water withdrawn to the Neuse River at the NRWWTP. The relative location of the lake, city, NRWWTP, USGS gage near Clayton, river flow direction, and withdrawal and return locations are illustrated in **Figure V.2**. The minimum release from the dam and the flow target at the Clayton gage are noted in the figure as well. It was recognized that as the City grows and water demands increase, its wastewater return at the NRWWTP will increase too. The increased return flows will reduce the burden of meeting the Clayton gage target placed on the FLWQP. Modeling using the Neuse River Basin Hydrologic Model (NRBHM) bears out the feasibility of this alternative. By reallocating 4.1 BG (11.8% of the total conservation pool volume, or 20.1% of the current FLWQP volume) from the FLWQP to the FLWSP, and adjusting the inflow assignment accordingly, the City can expect to gain 14 MGD in marginal yield. The reallocation of storage does not require the construction of a new reservoir and minimizes the need for additional infrastructure. The additional wastewater the City is expected to produce as its demand grows would mitigate for much of the lost storage in the FLWQP. Modeling shows that the smaller FLWQP would remain capable of meeting both the minimum release and the Clayton Gage target under all historical conditions. The "surplus" (i.e. minimum storage) in the FLWQP under the 2007 drought of record would decline from 25% for the current conservation pool allocation to 12% according to the NRBHM. Both of these figures assume full utilization of the FLWSP (i.e. demand levels approach 100% of the operational yield of the FLWSP), but do not factor in the benefit of wastewater derived from other sources (i.e. Lake Benson).

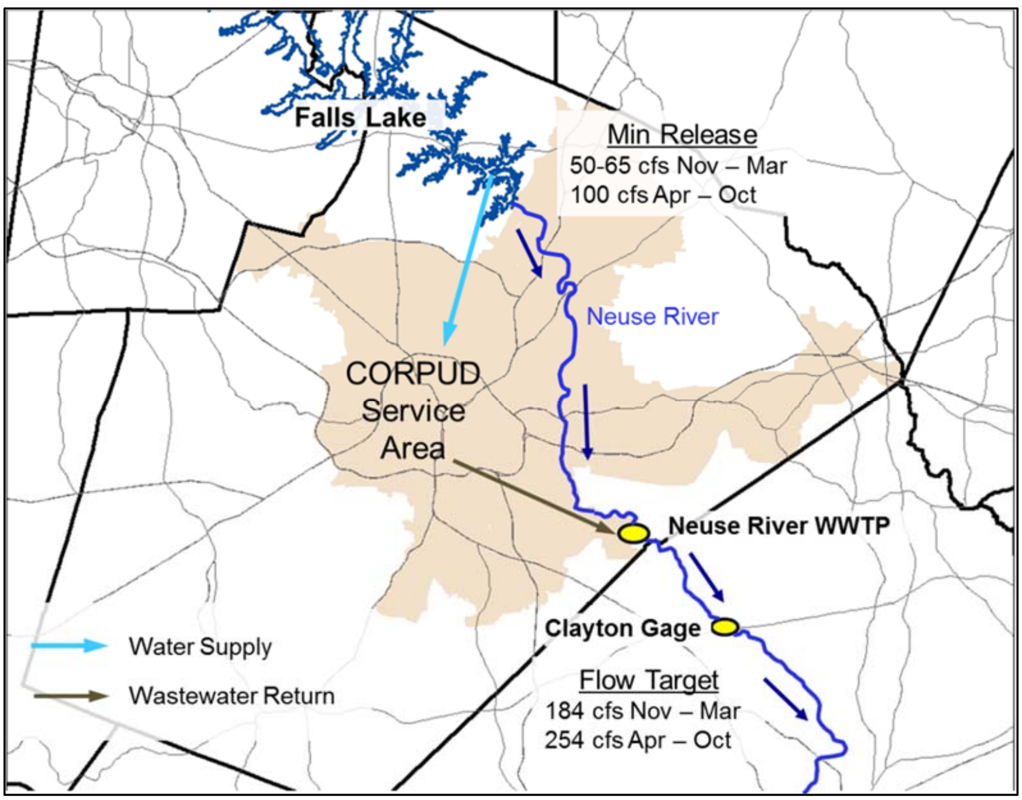

Figure V.2 – Schematic of Features between Falls Lake and Clayton, NC

The increased supply available from the FLWSP following the intended reallocation and in conjunction with anticipated demand growth would eventually necessitate a treatment capacity expansion at the E.M. Johnson WTP to 120 MGD.

Available Supply

Reallocating the Falls Lake Conservation Pool as described in the paragraphs above has been modeled using the NRBHM and would increase the operational yield of the FLWSP by 14.0 mgd.

Environmental Impacts

This source is considered to have environmental impacts that are of similar magnitude to the Jordan Lake Allocation (Source 3) and therefore are classified as '**Same As' in Table V.4**. Direct impacts to the environment from both these sources will primarily be temporary in nature and associated with the installation of new pipelines and plant expansions, and with increased withdrawals that may affect stream flow in limited reaches of the Neuse or Cape Fear rivers.

Falls Lake is designated as a nutrient –sensitive waterbody and is listed on the North Carolina Draft 2014 303(d) list for chlorophyll-a. Consequently, the City utilized NCDENR's Falls Lake Environmental Fluid Dynamics Code (EFDC) to evaluate the effects of increased water withdrawals on chlorophyll-a in Falls Lake. Modeling results indicate the impacts of the reallocation and full utilization of the expanded water supply pool on Chlorophyll-a concentrations are smaller than the margin of error of the model itself. The modeling also indicates the potential marginal impact of the reallocation on chlorophyll-a (Chl-*a*) concentrations (the main water quality parameter of interest to the model) is less than the influence of a number of other variables like reservoir inflow, wind, and cloud cover. By this measure, the project would appear to have minimal impact on water quality within the lake. Nevertheless, based on a direct comparison of the results and assuming no error in the model, the reallocation would cause a slight uptick in the 10^{th} percentile Chl-*a* exceedance concentration under the selected nutrient reduction targets (40% reduction of nitrogen, and 77% reduction of phosphorus). The compliance target is to have the Chl-*a* concentration in the lake under 40 µg/L at least 90% of the time. Because the target nutrient reductions are predicted to just meet the stated compliance criterion (see solid grey line in **Figure V.3**), any increase in Chl-*a* at the 10% exceedance threshold would push the lake into non-compliance with the stated water quality goal. Regardless, one can clearly see that the difference between the three withdrawal scenarios is insignificant when considering the accuracy of the model and other variables. More detail on the water quality modeling of this project is provided in Appendix D.

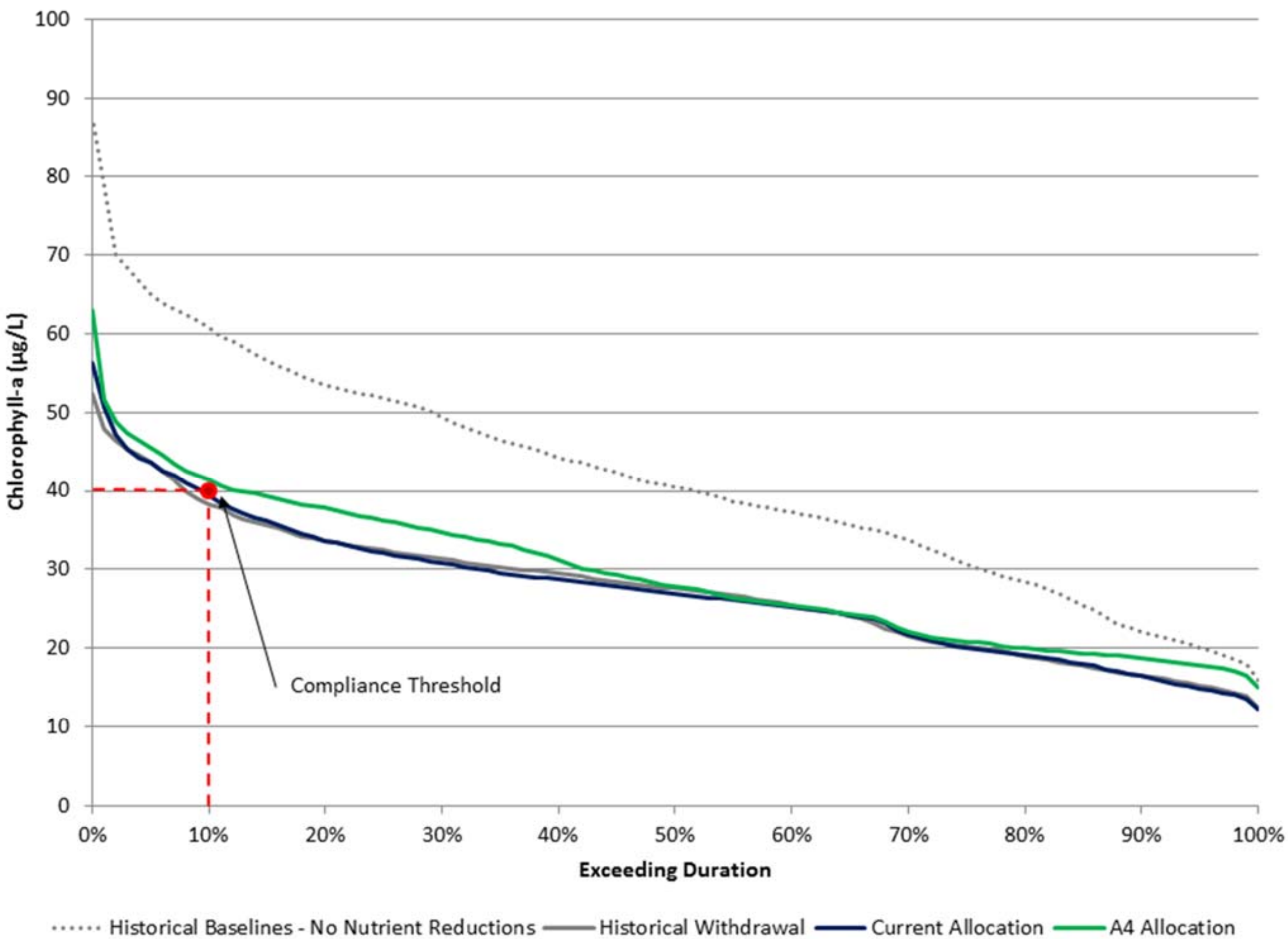

Figure V.3 – Percentile ranking Chl-*a* concentrations during 2006 with proposed nutrient reductions

While the applicant believes this source is the lowest impact water supply expansion source available, there is some concern that parties with standing in any reallocation at Falls Lake or federal 401/404 permitting process involving Neuse River options may contest any project that has potential impact on the Falls Lake Nutrient Management Strategy and Rules. This could lead to protracted and costly studies as well as expensive mitigation measures or, in the worst case, denial of the reallocation request or other Neuse River options.

The reach of the Neuse River between Falls Dam and the NRWWTP has a minimum flow regime (noted in **Figure V.2**) that would be protected, but this section of the river could experience marginally lower flows, on average, as less water is required from the FLWQP to meet the Clayton Gage target. Nevertheless, the target flows below the dam and at the Clayton Gage can be met under all historical hydrologic conditions.

The direct environmental impacts of building a new transmission line, and expanding the E.M. Johnson WTP would be largely limited to the temporary and localized construction activities needed to construct those facilities. Virtually all of these activities would occur on property already in the public domain or located within public rights-of-way. This source and the options for a new intake on the Neuse River (Source 2a or 2b) represent the sources with the least environmental impact within the array of sources being considered. A Falls Lake Reallocation would involve fewer environmental impacts than a Jordan Lake transfer (Source 3) because of its proximity to the City, resource use within the Neuse River basin, lower energy consumption for pumping, and would require the construction of many fewer miles of pipeline, especially if a wastewater discharge to the Cape Fear River Basin were required in conjunction with use of a Jordan Lake allocation.

Water Quality Classification

The water quality classification of Falls Lake is **WS-IV, NSW** and would remain unchanged with this alternative.

Timeliness

The timeliness of this source is currently projected to be **Acceptable**. Although the indicated 2020 date for the proposed reallocation should be achievable, if water quality concerns end up dominating the approval of this source it is possible the applicant will be forced to await the revised EFDC model which is not due to be available until at least 2020. The City's needs will be adequately addressed if the reallocation can be in service by 2025, though 2020 is preferable from a reliability perspective.

Interbasin Transfer

This source does not involve a surface water transfer as regulated under GS 143-215.22L.

Regional Partnerships

The City of Raleigh and its Merger Partners are a regional partnership, and as such any source the City develops provides regional benefit to all of eastern Wake County. In addition, this source is one of the four Neuse River source options identified by the City to meet its future water supply needs as part of the JLP Recommended Alternative. As previously noted, the City will need to develop at least two and probably three of the four identified Neuse River Sources to satisfy its 2060 projected need. Those Neuse Basin sources include the following: Source 1 - Falls Lake Reallocation, Source 2 - Neuse River Withdrawal Upstream of the NRWWTP, Source 4 - the Little River Reservoir, and/or Source 5 - the Raleigh Quarry.

Technical Complexity

This source is considered to be **Technically Complex**. This rating was based on the need to expand an existing water treatment plant on a limited available land footprint. However, it is well within the practical range of existing utility engineering practices and procedures. The re-assignment of storage within Falls Lake that would provide the additional water supply is **Technically Not Complex**.

Institutional Complexity

The development of this source is **Institutionally Very Complex** due to the involvement of multiple levels of government – federal, state, and local who must collaborate and reach agreement on methods for determining environmental impacts, issues of financing, and operation.

Political Complexity

This source is **Politically Very Complex** due to the institutional factors described above. In addition, the City is also member of the Upper Neuse River Basin Association (UNRBA) and is aware that members of the UNRBA could be impacted by more stringent development standards if the Falls Lake Reallocation (Source 1) cannot be conclusively cleared of the potential to adversely impact water quality within Falls Lake.

Public Benefits

This source will provide **Few Public Benefits.** The public will benefit through the economic and efficient use of an existing resource. However, it does not provide any additional recreational opportunities that do not already exist.

Consistency with Local Plans

This source is **Consistent** with the Triangle Regional Water Supply Plan as revised in 2014 that was developed through the Jordan Lake Partnership, and is consistent with City's 2013 Water Resource Assessment Plan. The proposed capacities of new treatment and transmission facilities have all been scaled to meet the future water demand projections for the City and its Merger Partners.

Source 2 – Neuse River Intake Upstream of NRWWTP

Description

This source involves siting a new intake along the Neuse River, building a raw water transmission line to the existing D.E. Benton WTP, and expanding the Benton WTP to 40 mgd. Locating a new run-of-river intake along the Neuse River just upstream of the City's Neuse River WWTP offers several advantages over other sites along the river in Wake County including the ability to utilize an additional drainage area of over 320 square miles below Falls Lake, the City owns the property at the site, and it is upstream of the City's principal wastewater discharge. **Figure V.4** illustrates the relative locations of Falls Lake, CORPUD's service area and treatment plants, as well as the intake location.

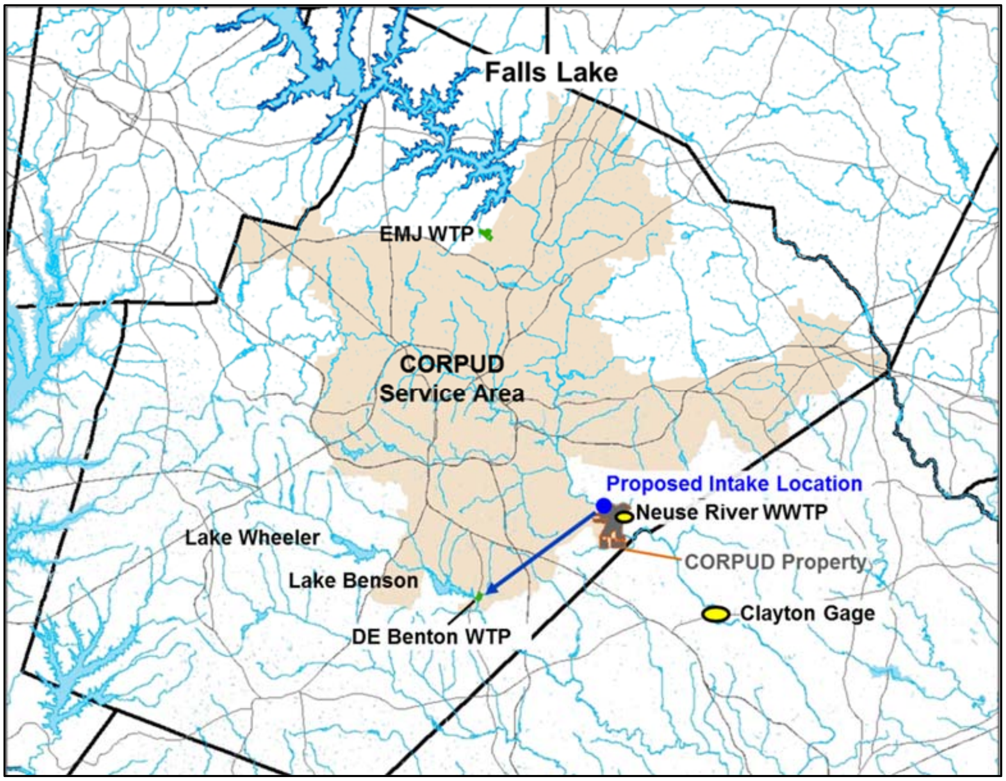

Figure V.4 – Map Indicating Proposed Downstream Neuse River Intake Location

The intake would require a new pump station and raw water transmission line to move raw water to the D.E. Benton Water Treatment Plant (WTP). The D.E. Benton WTP, currently rated at 20 mgd, provides treatment for raw water withdrawn from Lake Benson on Swift Creek. The D.E. Benton WTP would be expanded to 40 mgd. To ensure the WTP could operate at its full production capacity, the withdrawal rate would range as high as 30 mgd.

Source 2 has been divided into two parts, each with the same infrastructure but distinctly different operational protocols, dependent upon whether or not an impact on the Falls Lake Water Quality Pool will be allowed. Source 2a assumes a modest impact to the water quality pool is allowed, while 2b assumes no impacts.

Source 2a – Neuse River Intake Upstream of NRWWTP – Some impact on Falls Lake WQ Pool Allowed

Description

An assumption inherent in all of the City's Neuse River options is that the flow target at the Clayton gage would continue to be met at all times. Most of the time the minimum release from Falls Lake and the runoff from the intervening drainage area below Falls Lake (including the City's wastewater discharge) is sufficient to meet the Clayton Gage flow target. However, in dry situations, it is assumed that the USACE would release additional flow as necessary to accommodate the withdrawal from the river and still provide sufficient flow in the river to meet the Clayton flow target. The "surplus" in the FLWQP under the 2007 drought of record would decline by about 3% given the operational scenario described above though this figure varies slightly depending upon which other sources in this application are paired with this source. The small impact on the FLWQP storage and large increase in yield potential owes to the fact that that most of the time this source is fed from runoff in the intervening drainage area between Falls Lake and the intake location rather than from water released from Falls Dam.

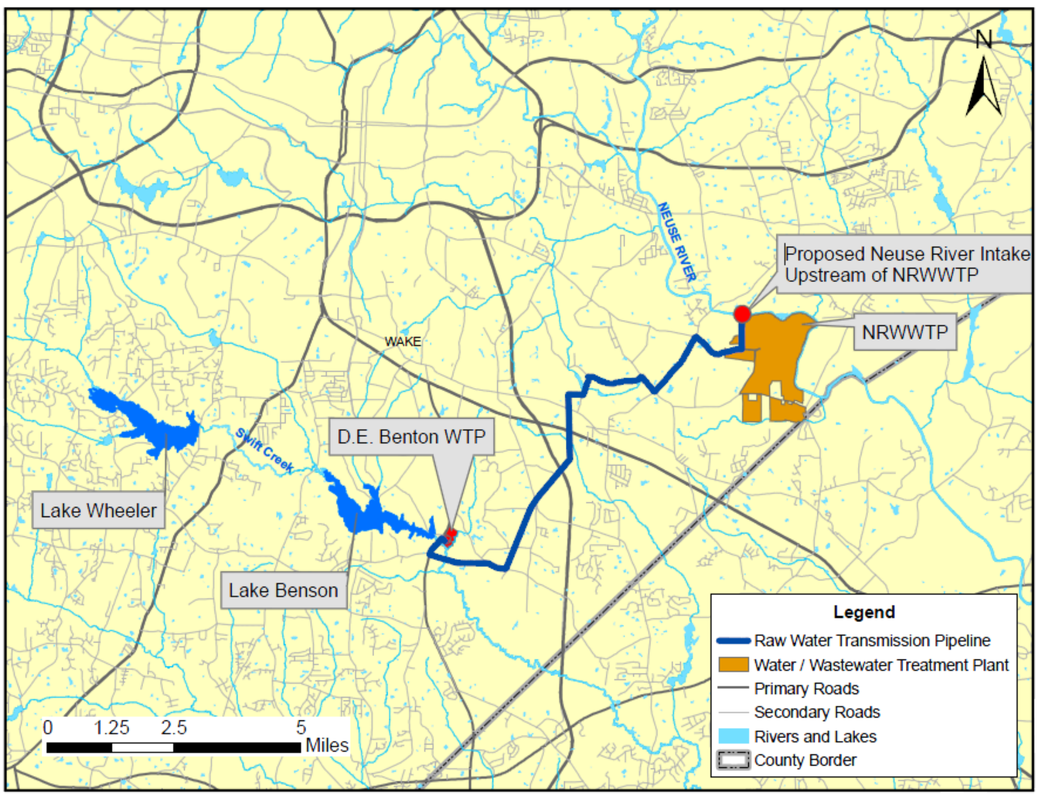

Figure V.5 – Map Indicating Potential Pipeline Route from Intake and D.E. Benton WTP

Available Supply

This source would provide up to an additional 25.1 mgd of yield, if operated as described above, even if coupled with a Falls Lake Reallocation. Based on modeling with the Neuse River Basin Hydrologic Model, the rate of withdrawal from the river could be increased beyond 30 mgd, while sustaining the Clayton Gage flow target, and without exhausting the FLWQP. However, to utilize any withdrawal over 40 mgd, the D.E. Benton WTP would need to be expanded beyond the 40 mgd capacity envisioned for the current site.

Environmental Impacts

This source is considered to have environmental impacts that are of similar magnitude to the Jordan Lake Allocation (Source 3) and therefore are classified as '**Same As' in Table V.4**. Direct impacts to the environment from both these sources will primarily be temporary in nature and associated with the installation of new pipelines and plant expansions, and with increased withdrawals that may affect stream flow in a very limited reach of the Neuse (Source 2a) or Cape Fear rivers (Source 3). This source offers a potentially very significant increase in safe yield while exacting a relatively small environmental impact. By locating the withdrawal just upstream of the NRWWTP discharge impact to streamflow below the intake will be minimized. In addition, the impact below the NRWWTP discharge will be much less than the magnitude of the raw water withdrawal. That is because the City returns 87+% (on an annual average basis, using 2009-2012 records) of the water it withdraws from all sources at the NRWWTP discharge (and 4% more at its other wastewater plants). Thus the net loss of streamflow would typically amount to less than 10% of the withdrawal rate (the Smith Creek WWTP is also upstream of the NRWWTP and adds to the wastewater return fraction in the Neuse River). Nevertheless, the return ratio is not constant across seasons and during a hot, dry month in the summer the return ratio can drop into the 60-70% range. Thus, for short periods the reduction in streamflow may amount to 30-40% of the withdrawal rate.

However, the assumed operation of this source (and all other sources too) requires adhering to the Clayton gage flow target which will minimize the impact of consumptive use during low flow periods. Furthermore, increasingly stringent conservation measures and restrictions on outdoor watering are likely to reduce the fraction of consumptive use in future decades. Because this alternative does not require the development of a new on-stream water supply impoundment, it entails none of the major environmental and social costs of a new reservoir, such as private land (and home) acquisition, road relocation, significant habitat destruction, etc. The direct environmental impacts of building a new intake on the river, transmission line, and expanding the D.E. Benton WTP would be largely limited to the temporary and localized construction activities needed to construct those facilities. The building and operation of this intake would involve fewer environmental impacts than the proposed Jordan Lake source because of its proximity to the City, resource use within the Neuse River basin, lower energy consumption for pumping, and the construction of many fewer miles of pipeline, especially if a wastewater discharge to the Cape Fear River Basin were required as part of the interbasin transfer certificate for water withdrawn from Jordan Lake. Finally, this option also depends on the same analysis of water quality impacts associated with Falls Lake, with the same earlier challenges identified herein.

Water Quality Classification

The water quality classification of this portion of the Neuse River is **C, NSW** and would require reclassification to WS-IV. Furthermore, the watershed classification would impact over a third of Raleigh, including much of downtown, a quarter of Garner, and approximately half of Knightdale as shown on **Figure V.6.** Furthermore, as shown in **Figure V.7** (income) and **Figure V.8** (racial make-up), the area impacted by the water supply watershed classification will impact the largest minority populations within CORPUD's service area. It should be noted that the communities of Knightdale and Garner have both expressed significant concerns with the perceived negative impacts on development and redevelopment potential for their respective communities. For these reasons a reclassification is anticipated to be politically and socially challenging.

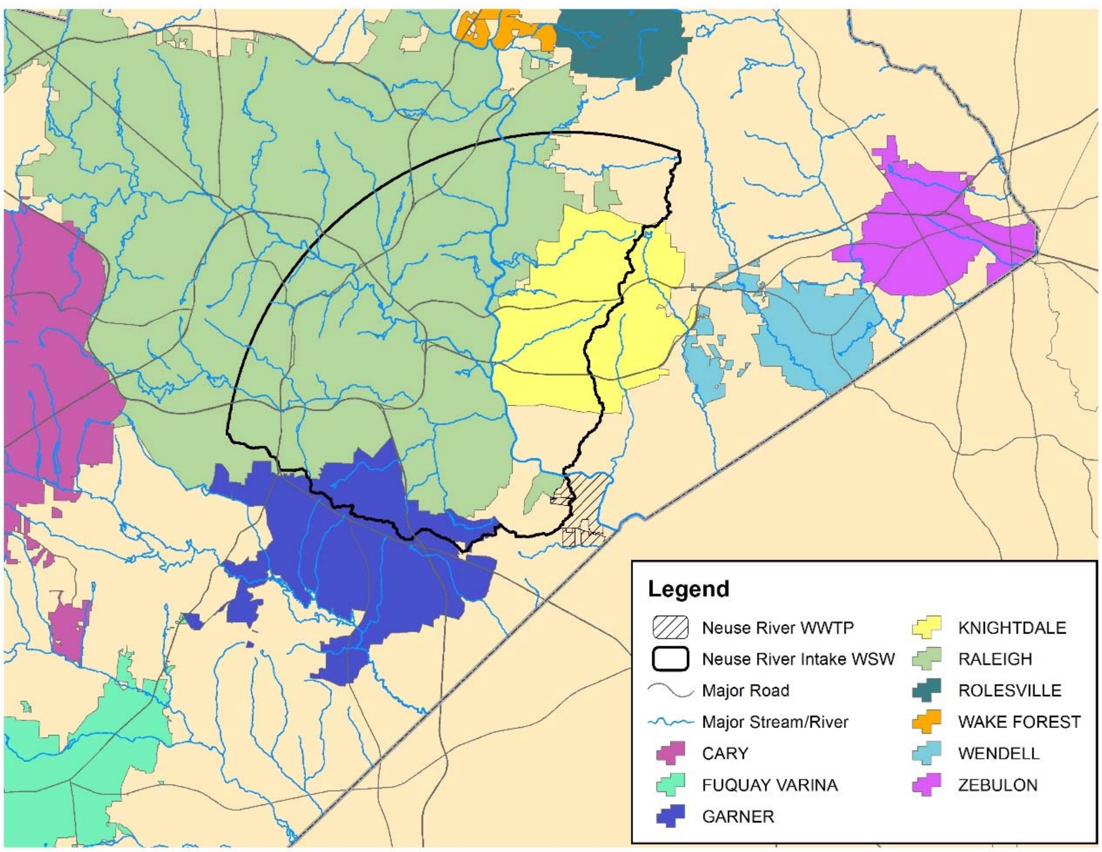

Figure V.6 – Map of Water Supply Watershed (WSW) Overlay for Neuse River Intake

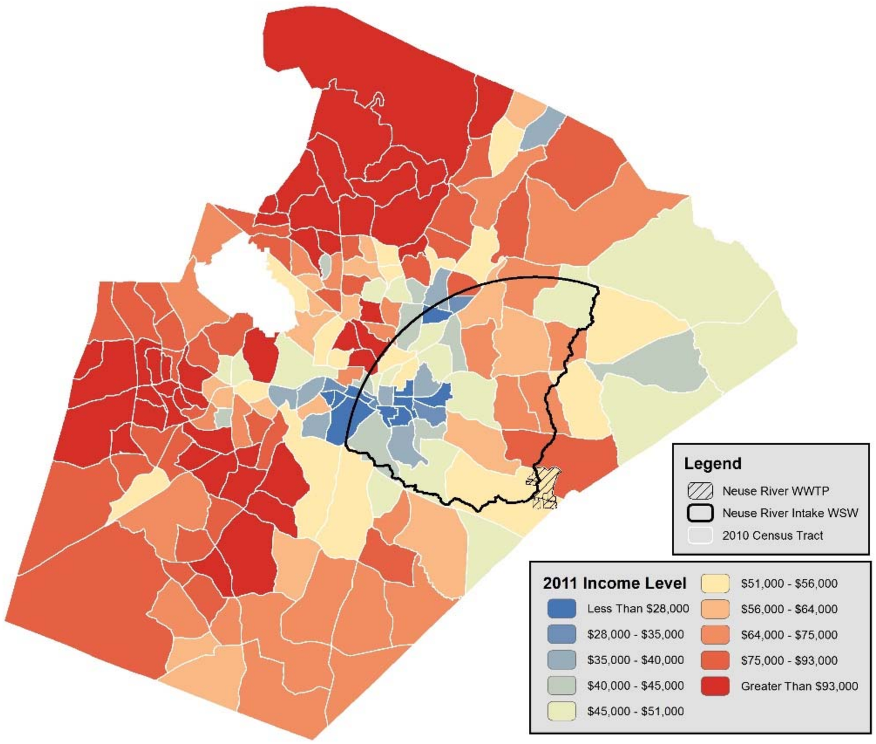

Figure V.7 – Map of Income in Wake County by 2010 Census Block

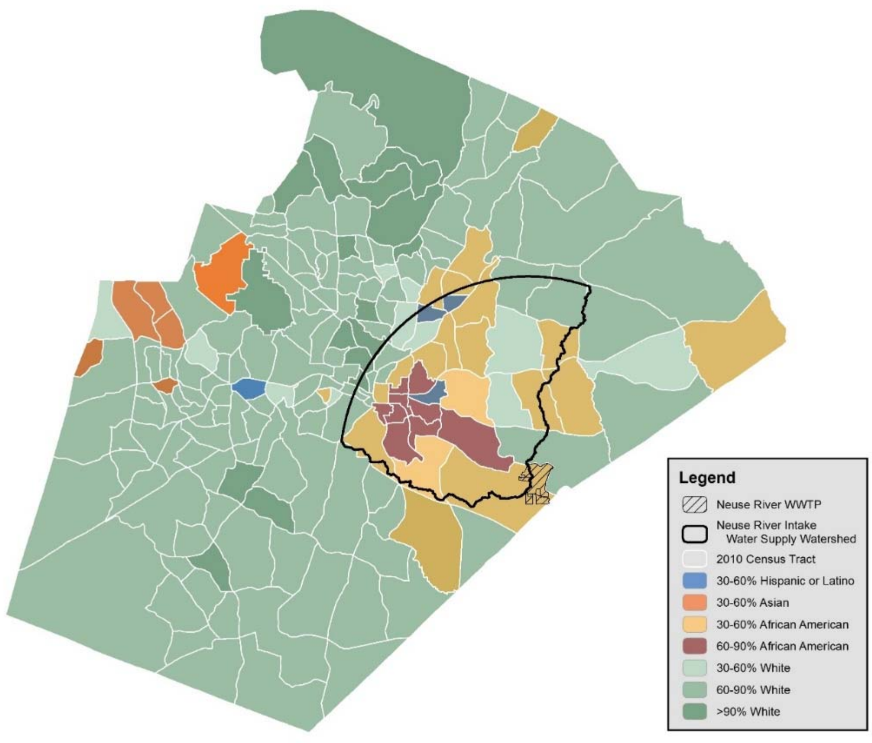

Figure V.8 – Map of Wake County Demographics by 2010 Census Block

Timeliness

The timeliness of this source is currently anticipated to be **Acceptable**. Although the indicated 2025 date for source should be achievable, if water quality concerns end up defeating the Falls Lake Reallocation, pursuit of this source may need to be accelerated. See the description of Alternative 1 for more on sequencing of this source.

Interbasin Transfer

This source does not involve a surface water transfer as regulated under GS 143-215.22L.

Regional Partnerships

The City of Raleigh and seven surrounding towns merged water utility services in 2007. Thus, the City of Raleigh and its Merger Partners are a regional partnership, and any supply the City might develop would provide a regional benefit to of the citizens of central and eastern Wake County. In addition, this source is one of the four Neuse River source options identified by the City to meet its future water supply needs as part of the JLP Recommended Alternative as presented in the TRWSP. As previously discussed the City will need to develop multiple Neuse River source options to meet its 2060 demands.

Technical Complexity

This source is considered to be **Technically Very Complex**. This rating was based on the need to construct an intake along the natural course of the river, build a pump station associated with the intake, and route a pipeline 11 miles from the intake to the D.E. Benton WTP, and expanded the D.E. Benton WTP to 40 mgd. Furthermore, the operation of releases from the FLWQP at the dam may require some additional coordination between the City and USACE to simultaneously satisfy the City's water supply needs and meet the Clayton gage flow target. Though technically very complex, these tasks are all well within the practical range of existing utility engineering practices and procedures.

Institutional Complexity

The development of this source is considered **Institutionally Very Complex** due Federal and State permitting requirements.

Political Complexity

This source would be **Politically Very Complex** due to the water supply re-classification required and the associated water supply watershed overlay shown in **Figure V.6. V.7** and **V.8**. The area within the water supply watershed overlay would be subject to more stringent stormwater management requirements and their imposition could be contested by the affected communities and neighborhoods. Furthermore, there are a number of predominantly minority communities in the overlay region which is likely to raise the issue of environmental justice. Alleviating these concerns may be possible, but could also potentially make the project more expensive for the City to pursue depending upon the extent that it must mitigate for the impact of the restrictions on these communities.

Public Benefits

This source will provide **Few Public Benefits.** The public will benefit through the economic and efficient use of an existing resource, however, it does not provide any additional recreational opportunities that do not already exist.

Consistency with Local Plans

This source is generally **Consistent** with the Triangle Regional Water Supply Plan as revised in 2014. However, the size of the intake as proposed herein is larger than that assumed in the TRWSP which was only sufficient to offset the City's demand thru 2040. However, the proposed capacities of the intake, treatment, and transmission facilities have been scaled up to meet the future water demand projections for the City and its Merger Partners over a longer time frame than was proposed in the TRWSP.

Source 2b – Neuse River Intake Upstream of NRWWTP – No impact on Falls Lake WQ Pool Allowed

Description

This source involves siting a new intake along the Neuse River, building a raw water transmission line to the existing D.E. Benton WTP, and expanding the Benton WTP to 40 mgd. The infrastructure, and many of the advantages and disadvantages, though not all, would be identical to those described for Source 2a. Please refer to the information on Source 2a and **Figures V.4**, **V.5**, **V.6**, **V.7** and **V.8** for supplementary background information on this source. The main difference between Source 2a and Source 2b is in the operation of the intake. If the relatively small impact to the Falls Lake Water Quality Pool (FLWQP) described for Source 2a were deemed unacceptable, either as a stand-alone project or cumulatively in conjunction with Source 1, the Neuse River Intake infrastructure could be operated intermittently, rather than continuously, so that no additional release would need to be made from the FLWQP to accommodate the operation of the intake while simultaneously maintaining compliance with the downstream Clayton gage flow target. During low flow periods, the withdrawal from the Neuse River Intake would be curtailed, or cease entirely. As a result, the D.E. Benton WTP would not be able to operate continuously at 40 mgd under all conditions and redundant water treatment capacity would need to be provided at the E.M. Johnson WTP or another WTP serving the City and its Merger Partners. It is also quite possible that the City's finished water distribution system would require additional upgrades as compared to Source 2a to provide the flexibility to accommodate passage of finished water that may arrive from D.E. Benton one day and another WTP the next day. The redundant WTP capacity and possible upgrades to the distribution system required to accommodate Source 2b is the one difference in infrastructure required for Source 2b as compared to Source 2a. Another option potentially available to further improve supply yield, reduce WTP production fluctuations, and complement Source 2b in general would be to provide a supplementary supply to D.E. Benton WTP or additional raw water storage to accommodate periods when the Neuse River Intake could not operate (Note: Alternatives 2 and 3 assume this latter configuration). Based on the historical hydrology in the

NRBHM, the intake would be required to shut down on about 10% of the days in the period of record, could withdraw more than 5 mgd on 89% of days, and more than 20 mgd on 83% of days while having no impact on the FLWQP storage. The operation of the Neuse River Intake in this manner, without assuming any additional off-stream storage or supplementary supply to the D.E. Benton WTP would increase the yield of the City's supply system by 15 mgd, on a 50-year operational yield basis of comparison. Any additional storage or supplementary sources would help stabilize the production rate at the Benton WTP and could increase the marginal yield of this supply source.

The "surplus" in the FLWQP under the 2007 drought of record would increase by about 7% given the operational scenario described above though this figure may vary slightly depending upon which other sources in this application Source 2b is paired. The net positive impact on the FLWQP storage and large increase in yield potential owes to the fact that this source would provide additional yield to the system, which, when utilized, will result in greater volumes of wastewater returned to the Neuse River and thereby offset some of the burden placed on the FLWQP to meet the Clayton Gage flow target.

Available Supply

A Neuse River Intake, as described in the paragraphs above, would provide an additional operational yield of 15 mgd.

Environmental Impacts

This source is considered to have environmental impacts that are **Less Than** the Jordan Lake Allocation (Source 3). Direct impacts to the environment from both these sources will primarily be temporary in nature and associated with the installation of new pipelines and plant expansions. However, operating the intake as described for Source 2b would increase, rather than decrease, the anticipated surplus storage in the FLWQP in a drought event like 2007. The net difference between operating the intake as described for Source 2a versus as described here could be on the order of an additional 10% storage remaining in the water quality pool at the worst point of a drought similar to that experienced in 2007. However, this potential benefit to the environment comes at a significant cost to the City as it will need to provide redundant treatment capacity at another facility due to the intermittent operation of the intake, or supplemental water supply(s). These additional facilities or supplies would result in additional temporary disturbances during construction.

Water Quality Classification

Same as for Source 2a.

Timeliness

Same as for Source 2a, though additional sources would be required sooner due to the reduced marginal yield provided by operating the intake without requiring a single day of increased release from the FLWQP.

Interbasin Transfer

This source does not involve a surface water transfer as regulated under GS 143-215.22L.

Regional Partnerships

The City of Raleigh and its Merger Partners are a regional partnership, and as such any source the City develops provides regional benefit to all of eastern Wake County. In addition, this source is one of the four Neuse River source options identified by the City to meet its future water supply needs as part of the JLP Recommended Alternative as presented in the TRWSP. As previously discussed the City will need to develop multiple Neuse River source options to meet its 2060 demands.

Technical Complexity

This source is considered to be **Technically Very Complex**. It is similar to the complexity described for Source 2a though the need to coordinate operation of the intake with releases from Falls Dam under Source 2b operations would be reduced. Nevertheless, the operations of the City's supply system from the perspective of its managers would become more complex during low flow periods when the Neuse River Intake would be curtailed or shut down and plant production rates across the system would have to be adjusted accordingly.

Institutional Complexity

The development of this source is considered **Institutionally Very Complex** due Federal and State permitting requirements.

Political Complexity

This source would be **Politically Very Complex**, for the same reasons described under Source 2a, with the exception that this source does not affect the FLWQP, therefore entities with standing are not likely to oppose its development.

Public Benefits

This source will provide **Few Public Benefits.** The public will benefit through the economic and efficient use of an existing resource, however, it does not provide any additional recreational opportunities that do not already exist.

Consistency with Local Plans

This source is **Consistent** with the Triangle Regional Water Supply Plan as revised in 2014. The proposed capacities of the intake, treatment, and transmission facilities have all been scaled to meet the future water demand projections for the City and its Merger Partners.

Source 3 – Jordan Lake Allocation

Description

The City of Raleigh is one of the 13 members of the Jordan Lake Partnership and has been committed to the sustainable development of water resources in the region for many years. Until now the City has not requested an allocation from the Jordan Lake Water Supply Pool and until very recently it had not planned to request an allocation. The reason for the prior position has to do with the more promising perspective it held for the potential to develop sources within the Neuse River Basin and because North Carolina's Interbasin Transfer Rule is expected to be an obstacle to the utilization of Jordan Lake water for a service area entirely within the Neuse River Basin. However, due to increasing concerns regarding obstacles facing the City's preferred future water supply sources in the Neuse Basin (Sources 1, 2, 4, and 5) the City is now seeking an allocation on Jordan Lake along a parallel development track as a contingency for the case that its preferred alternative is unable to satisfy its 2045 or 2060 projected demand.

As part of their efforts to enhance the sustainability and security of the region's water supply resources through conservation and efficiency, interconnection, and coordinated planning and development of the Jordan Lake water supply, the members of the Jordan Lake Partnership authorized Phase 2 of the Regional Interconnections Study in May 2014. Phase 1 mapped all of the existing interconnections between each of the Partners and identified potential locations for new interconnections or improvements to existing interconnections. Phase 2 will provide a model of the entire region and utilize the model to analyze flow capabilities between the partners (to include wheeling of water through multiple partners distributions systems, and identification of improvements that can increase flow transfer capabilities. The benefits of the Regional Interconnection Study include but are not limited to:

- Providing reference documentation for updating local water supply plans;
- Allow rapid development of contingency plans to isolate contamination;
- Facilitate planning for supply alternatives in response to potable water outages and shortages; and,
- Allow sharing of surplus capacity to reduce costs and defer expansions of supply sources.

If the City is successful in obtaining a Level II allocation for 4.7 mgd for Jordan Lake's Water Supply Pool, its preferred approach to developing the supply would be to work out an arrangement to purchase treated Jordan Lake water from one of the JLP members. The City of Raleigh currently has interconnections with both Durham and Cary with sufficient capacity to convey all or part of the requested allocation. While no such arrangement has been negotiated, it should be noted that the Jordan Lake Partnership Regional Interconnections Study includes $73,000 to identify improvements to facilitate transfers of up to 17 mgd to and from Cary/Apex, Durham, Holly Springs and Raleigh.

Ideally, the City would negotiate a transfer agreement with both Cary and Durham that would allow each to provide a portion of the requested allocation, thereby limiting the amount of treated water that each municipality would need to be able to provide, with an added benefit of system redundancy. Alternatively, given that the existing interconnections with each municipality are sufficient to provide the requested flow, an agreement with either Cary or Durham would suffice. Similarly, if a return flow is required as part of an Interbasin Transfer Certificate then agreements could be reached for returning wastewater flow from Raleigh's western service area (Briar Creek) to Cary and/or Durham County for treatment at the Western Wake Water Reclamation Facility and/or the Durham County Triangle Wastewater Treatment Plant, respectively. These agreements would likely be the most cost effective for the City, with the City paying their Partners for water and wastewater treatment, and a limited amount of new infrastructure to include construction of a new force main or force mains, and a new pump station or modifications to an existing pump station.

Nevertheless, since such arrangements have not yet been worked out, a conservative plan presented here assumes the City would develop a new intake across the river from the Harnett County intake (or share the cost of a capacity expansion with the County) where a water supply designation currently exists (**Figure V.9**). Arrangements would need to be made to address the need to build a supply pipeline with Harnett County. Withdrawals from the Cape Fear River would be made in coordination with an additional release from the Jordan Lake Water Supply Pool into the Cape Fear River. Treated wastewater could be discharged along the same pipeline route if required, also shown in **Figure V.9**.

Based on experience at the Cary-Apex Water Treatment Plant, Harnett County Regional WTP, Fayetteville P.O. Hoffer WTP and others, source water from Jordan Lake or the Cape Fear River can be treated conventionally to present drinking water standards. It is possible that more extensive treatment, such as granular activated carbon (GAC), may be necessary as drinking water standards become more stringent as a result of the requirements of the Safe Drinking Water Act. However, interbasin transfer considerations and future water supply allocations are likely to be the larger issues affecting the City's use of Jordan Lake water. Mitigation of the interbasin transfer from the Cape Fear River Basin to the Neuse River Basin could require that all or a portion of the water withdrawn from Jordan Lake be returned to the Cape Fear River. The concept presented here assumes the construction of an effluent transmission main from the City of Raleigh Neuse River WWTP (NRWWTP) to the Cape Fear River (See **Figure V.9**) to neutralize the IBT that would arise from the City's use of this source. The point of discharge for the effluent is near the discharge point for Harnett County's wastewater plant and would allow a common corridor to be used for much of the raw water supply line and the effluent discharge line.

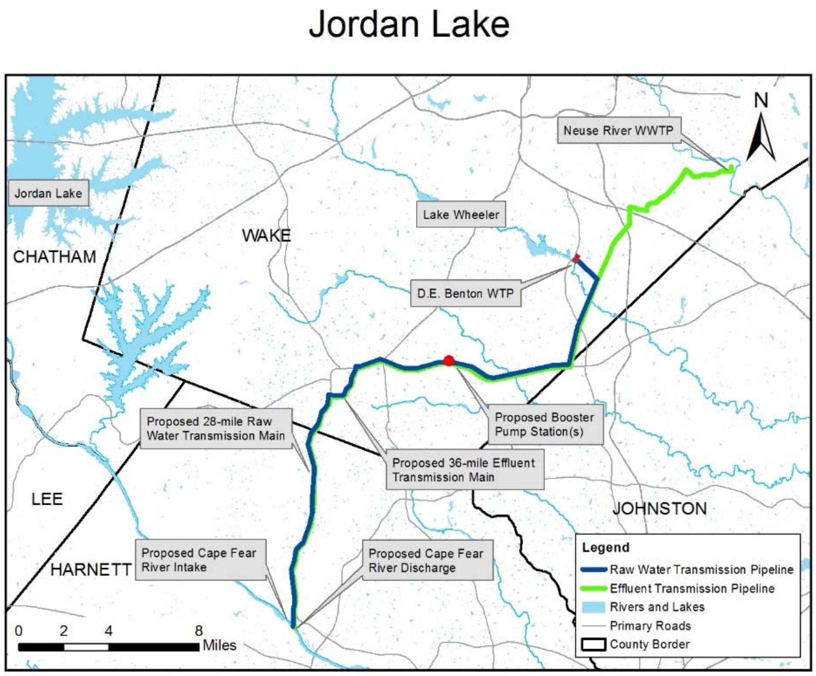

Figure V.9 – Map Indicating Potential Routes for Raw and Effluent Pipeline Associated with use of a Jordan Lake Allocation

Available Supply

A 4.7% allocation of the Jordan Lake Water Supply Pool is expected to increase the operational yield of the City's water supply system by 4.7 mgd and would be sufficient to satisfy the 2045 projected demands when implemented with one other option (assumed 2b), with no spare operational yield under Alternative 2 or 3 as presented herein. The City believes it will need at least an 8.8 mgd allocation to meet its projected 2060 demands (assuming the Neuse River Source Options discussed herein cannot have an impact on the Falls Lake Water Quality Pool).

Environmental Impacts

Environmental impacts arising from the project as proposed would owe mostly to the construction of nearly 70 miles of pipeline to bring water from the Cape Fear River to the D.E. Benton WTP, and return the wastewater from the NRWWTP back to the Cape Fear River. The withdrawal and discharge points proposed are relatively near to each other so reduced streamflow within the Cape Fear River would be minimal. There would be some potential water quality impact from withdrawing raw water and returning treated wastewater which would have a slightly different chemical composition. However, the NRWWTP is a very well run WWTP with low effluent limits and therefore the magnitude of this impact would be very slight. Provision of this water supply to the City would undoubtedly involve high unit energy costs due to the lengthy transmission routes and associated pumping requirements. If the City's preferred route for accessing this water supply via its existing interconnections with either Durham or Cary could be realized, these impacts could be significantly reduced.

Water Quality Classification

The water quality classification of Jordan Lake in the vicinity of the proposed intake is **WS-IV, NSW** and would remain unchanged with this alternative.

Timeliness

The timeliness of this source is currently projected to be **Acceptable**. The need for the Jordan Lake Allocation would begin around 2030 and would follow the development of an intake on the Neuse River (Source 2b). While it has been assumed for the purposes of this application that Source 2b will be implemented before the Jordan Lake Allocation (Source 3), it is conceivable the order of implementation for these two sources could be reversed, depending upon the ability to obtain the necessary approvals for Source 2b.

Interbasin Transfer

This source does involve a surface water transfer as regulated under GS 143-215.22L. Based on a maximum use of the allocation (8.8 mgd through 2060) and a peak month factor of 1.17 from its 2012 LWSP, the maximum month IBT would amount to 10.3 mgd. Based on the consumptive use in that peak month of 24%, and 99% use in the Neuse (10-1) Basin, 2.42 mgd would be the maximum monthly consumptive loss in Basin 10-1 and 0.025 mgd would be the peak month consumptive loss in the Contentnea Basin (10-2). It should be noted that 4.7 MGD (4.7%) is less than the 13 MGD transferred out of the Neuse to the Cape Fear River Basin up-stream of the City's primary water supply by grandfathered interbasin transfers (IBTs).

Regional Partnerships

The City of Raleigh and seven surrounding towns merged water utility services in 2007. Thus, the City of Raleigh and its Merger Partners are a regional partnership, and any supply the City might develop would provide a regional benefit to of the citizens of central and eastern Wake County. In 2009 the Jordan Lake Regional Water Supply Partnership (Jordan Lake Partnership or Partnership) was created with the primary purpose of jointly planning the expanded use of available water supply in Jordan Lake, which is located in the Cape Fear River Basin. Because the Partnership was committed to working collaboratively to enhance the sustainability and security of the region's water supply resources through conservation and efficiency, interconnection, and coordinated planning and development of the Jordan Lake water supply, the Partnership was expanded to include the City of Raleigh and its utility service area. The members of the JLP have indicated their support for the City's preferred Alternative, which does not include the use of Jordan Lake. However, in the event that the City cannot assemble sufficient sources in the Neuse River basin it would seek the support of the JLP and other regional utilities at such time as it becomes necessary to transition from the currently requested 4.7 mgd Level II allocation to a Level I allocation.

Development of this source would ideally include a regional partnership with Durham and/or Cary which would facilitate access to the City's requested allocation through existing interconnections. Alternatively, the City would seek to partner with Harnett County to share or develop a new intake (or expand their existing intake) and discharge on the Cape Fear River near Lillington.

Technical Complexity

This source is considered to be **Technically Very Complex**. This is due to the lengthy pipelines which would have to be routed through the region, and need to construct several pump stations to transport the water over relatively long distances. However, this source could be classified as **Technically Complex** if the City is able to negotiate agreements and utilize existing interconnections.

Institutional Complexity

This source is considered to be **Institutionally Very Complex**. This is due to a combination of factors including the potential need for an interbasin transfer certificate and permit lengthy raw water supply and wastewater discharge pipelines.

Political Complexity

This source would be **Politically Very Complex** due to the potential need for an interbasin transfer certificate and a perception among some stakeholders that the City would potentially be taking water away from future users within the Cape Fear River Basin. In addition, this alternative requires an encroachment into Harnett County, which will require the approval to the Harnett County Board of Commissioners. Given the timing of events, the City has not yet had an opportunity to vet the proposed alternative with Harnett County representatives.

Public Benefits

This source will provide **Few Public Benefits.** The public will benefit through the economic and efficient use of an existing resource, however, it does not provide any additional recreational opportunities that do not already exist. Similar to the Little River Reservoir (Source 4), this source benefits the public in that it provides an additional water supply source independent of the Falls Lake watershed and drainage area below the dam, thereby making the City's water supply system more robust.

Consistency with Local Plans

This source is **Consistent** with the Triangle Regional Water Supply Plan (TRWSP) as revised in 2014. At the time of the last draft of the TRWSP, the City and its Merger Partners felt there was a strong possibility that the City would be able to meet its 50 year projected needs from the source options (1, 2a, 4, and 5) within the Neuse River Basin. The additional uncertainty now cast upon sources 1 and 5, while potentially surmountable, makes it imperative to begin contingency planning for other sources. The use of a Jordan Lake Allocation, an existing water supply source for the region, is a an attractive back-up source in the event the Neuse River Basin sources are unable to be developed to produce sufficient additional yield in a timely manner.

The Recommended Regional Alternative as presented in the TRWSP does not include a Jordan Lake Allocation request for the City of Raleigh and its Merger Partners. As noted in the TRWSP, the City recognizes that its ability to meet its projected demands from source options identified in the Neuse River Basin significantly strengthen the regional supply picture, and avoid putting the City in potential conflict with other Partnership members. However, the City ultimately decided to seek an allocation from Jordan Lake given the increasing level of uncertainty in its ability to develop its preferred Neuse River Basin source water options. The TRWSP recognizes this possibility, in deference to the difficulties and uncertainties associated with the development of new water resources. As quoted from the last paragraph of page 87 of volume II of the plan:

"The recommended alternative for Raleigh is based upon several key assumptions, but represents the best available information at the present time. Given the challenges and current uncertainty as to the potential impacts of their preferred sources on water quality in Falls Lake, Raleigh may be compelled to pursue alternate, supplemental or interim sources until their Neuse River Basin sources can be developed as planned."

Therefore, the City is now making an application for a 4.7 mgd Level II Jordan Lake allocation until it can be assured that its Neuse River Basin sources can be developed as planned.

Source 4 – Little River Reservoir

Description

The City's long range water resource plan has been tied extensively to the construction of a new reservoir on the Little River. In 1971 a Wake County water and wastewater engineering study (Moore / Gardner, Edwards, Piatt and Wooten Engineers Task Force) identified the Little River as a possible site for a proposed water supply reservoir in eastern Wake County. That study's recommendation appears to have been the first time this site was identified to Wake County Board of Commissioners as a new source of water for a "regionalized" water and sewer system for the county. In 1986 an initial engineering study (Pierson & Whitman) of the potential of Little River site confirmed the 1971 study.

In 1987, the Wake County Board of Commissioners (WCBC) voted to rezone approximately 26,000 acres within the Little River Watershed. This zoning remains in effect today. In 1988 the North Carolina Environmental Management Commission voted to reclassify Little River to WS-I from its source to the bridge at NC 97. The classification was subsequently adjusted to WS-II when DWQ expanded the classification system. In 1995, Wake County began a multi-year program of acquiring property to be inundated by the proposed project. The County effort was substantially completed by 2007 and a total of approximately $15 million expended to acquire the inundated land area.

In 2006, the City of Raleigh agreed to be the lead agency in the design, permitting, construction and operation of a proposed reservoir. It retained consultants to proceed with wetlands delineation. In 2008, Raleigh entered into a Processing Agreement with the United States Army Corps of Engineers (USACE) for the preparation of an EIS for issuance of the construction permits needed to build the Little River Reservoir. From 2007 through today the City's permitting effort for the Little River Reservoir has evolved into a larger, more complex water resource planning program driven by permitting difficulties and changes in water consumption patterns. As with many federal acts, the reach and complexity of the Clean Water Act (CWA), the Endangered Species Act (ESA) and the National Environmental Policy Act (NEPA) continue to evolve as new scientific data, changing regulatory guidance, and litigation precedents shape the permitting process. It is unlikely that a new reservoir can be permitted and constructed until all other identified water sources with lower environmental impact are either implemented or shown not to be feasible (Sources 1-3, and 5). This likely places the Little River Reservoir project in a later timeline than previously reported to the public, as it appears probable that at least one other source will prove to be more feasible in terms of the "least damaging practicable alternative" criteria. Nevertheless, a delay may also leave the Little River Reservoir project in jeopardy as the U.S. Fish and Wildlife Service considers a petition to list additional aquatic species in the Little River to the ESA.

The dam and reservoir would be located near the Towns of Wendell and Zebulon, approximately fifteen (15) miles east of the City of Raleigh (see **Figure V.10)**. The normal pool elevation for the proposed reservoir is 260 feet mean sea level (MSL). The proposed reservoir would impound approximately 3.7 billion gallons and have a 50-year safe yield of approximately 13.7 mgd, adjusted for sedimentation, other losses, and minimum downstream release.

The Little River watershed above the proposed dam site encompasses approximately 52.6 square miles of predominantly rural and agricultural land. The watershed is located in the jurisdictions of Wake and Franklin Counties, and includes parts of the Towns of Rolesville and Zebulon. The reservoir would be entirely within Wake County. Regulations are currently in place in these jurisdictions governing density limits, impervious surface limits, runoff control measures, stream and impoundment buffers, retention pond maintenance responsibility, nonresidential uses permitted, and street drainage design. The current WS-II classification is a key factor that makes this site particularly suitable for water supply development.

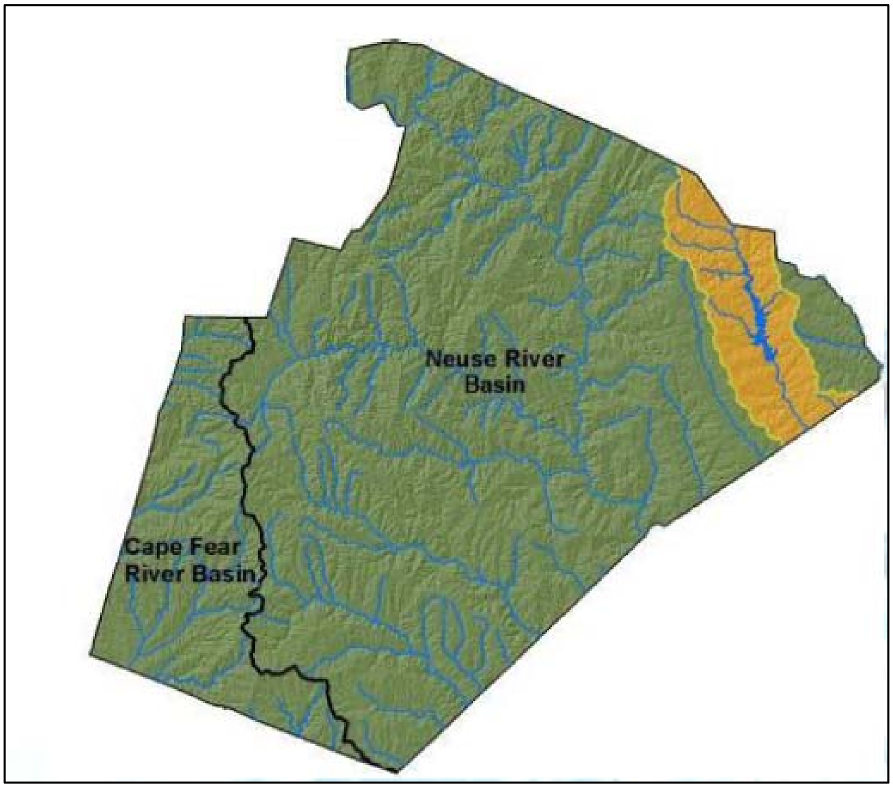

Figure V.10 – Proposed Little River Reservoir Location (Shown Highlighted)

Based on memorandum by the North Carolina Division of Water Resources (NCDWR) dated November 5, 1985, a minimum instream flow of 3.3 cfs (2.2 mgd) was recommended in order to provide for aquatic habitat. This instream flow was based on a study performed by NCDWR during 1983. It is expected that this minimum flow requirement below the dam would be updated based on more recent scientific knowledge, but there are too many variables and interests to speculate what those requirements may look like if the dam is permitted.

The project would also include a water intake, pumping station, and a water treatment plant with a capacity of 20 mgd. A finished water transmission main would convey treated water to an existing water main at N.C. 97, for distribution to the water systems of the Towns of Knightdale, Wendell and Zebulon, as well as the City of Raleigh and the other municipalities whose utility systems have been merged with the City of Raleigh utility systems.

Available Supply

The proposed Little River Reservoir, assuming a minimum release of 3.3 cfs, is expected to provide a yield of 13.7 mgd. Depending upon the results of the instream flow study and determinations by the regulatory agencies, it is possible that a higher minimum release threshold would be required, but at this stage of the evaluation it is too difficult to speculate how that minimum release structure might be arranged. A higher minimum release rate would reduce the water supply yield available from the proposed reservoir.

Environmental Impacts

The impacts of building and impounding a new reservoir for water supply will be **More Than** for the Jordan Lake Allocation (Source 3) and are significant. Of all the sources listed, this source is likely to have the greatest environmental impacts. Some of those impacts are listed below:

- Temporary increase of turbidity in the Little River during construction of the reservoir resulting from construction-related erosion. Temporary increase in noise and dust.
- Permanent loss of approximately 7.2 miles of stream and 16 acres of stream environment.
- Reduction in total streamflow from evaporation losses and depletion caused by withdrawal for drinking water.
- At the proposed normal reservoir pool elevation of 260 feet MSL, the reservoir would inundate approximately 1,150 acres. Included in this total are 507 acres of wetlands and impact to an additional 21 acres of forested wetlands at the dam site (Total wetland area impacted = 528 acres).
- Loss of terrestrial wildlife habitat in areas that are inundated.
- Inundation of areas which provide habitat for endangered or threatened species.

It is also relevant to assess the probability of preservation of these resources without reservoir construction. Without construction of the proposed reservoir, the area's designation as a water supply watershed may be lost. Land in the watershed might be used for other uses, including high-density residential, commercial, or industrial development. If this type of development occurs, and the watershed's classification as a Water Supply Watershed is removed, a valuable, high quality source of drinking water would be lost. Moreover, if development occurs, environmental impacts would be difficult to predict. Conversely, development of the proposed project allows for the permanent establishment of its use as a water supply, and maintains water supply classifications and watershed zoning regulations. With construction of the proposed reservoir, a water supply would be provided to support growth in Wake County. Mitigation efforts for losses associated with the project remain quantifiable and feasible. An aesthetically pleasing lake atmosphere would be created for observing wildlife and other permitted recreational activities.

Water Quality Classification

The water quality classification of Little River in the vicinity of the proposed reservoir is **WS-II, NSW.**

Timeliness

The timeliness of this source is currently projected to be **Acceptable** assuming one of the other sources described herein is developed first. Although the indicated 2030 first date for bringing reservoir is currently viewed as feasible, it is possible that with the development of one or two of the other sources listed in this document that the reservoir construction could be delayed until a later date. Each 10 – 15 mgd source that precedes the Little River Reservoir could delay the need to develop the Little River Reservoir by 7-10 years.

Interbasin Transfer

This source does not involve a surface water transfer as regulated under GS 143-215.22L

Regional Partnerships

The City of Raleigh and seven surrounding towns merged water utility services in 2007. Thus, the City of Raleigh and its Merger Partners are a regional partnership, and any supply the City might develop would provide a regional benefit to of the citizens of central and eastern Wake County. Furthermore, the concept for this water supply source has been developed in conjunction with Wake County over the last 4 decades. This source is one of the four Neuse River source options identified by the City to meet its future water supply needs as part of the JLP Recommended Alternative as presented in the TRWSP. As previously discussed the City will need to develop multiple Neuse River source options to meet its 2060 demands.

Technical Complexity

This source is considered to be **Technically Very Complex**. This rating was based on the need to construct a new dam in an environmentally sensitive location, build a new water treatment plant and associated transmission lines, and develop and implement an operational protocol to provide the required minimum releases.

Institutional Complexity

The development of this source is **Institutionally Very Complex** due to (1) the number of regulatory permits required and (2) the involvement of multiple units of federal, state, and local governments who must collaborate and reach agreement on methods for determining in-stream flow requirements, development buffers in the watershed, and mitigation measures.

Political Complexity

This source is **Politically Very Complex** due to the institutional factors described above.

Public Benefits

This source will provide **Many Public Benefits.** This source greatly benefits the public in that it provides an additional water supply source independent of the Falls Lake watershed and drainage area below the dam, thereby making the City's water supply system more robust. In addition, this source results in the preservation of the buffer surrounding the shoreline, and provides opportunities for recreational activities on the reservoir and on the land adjacent to the reservoir that did not previously exist.

Consistency with Local Plans

This source is **Consistent** with the Triangle Regional Water Supply Plan as revised in 2014. The proposed dam, reservoir, treatment, and transmission facilities have all been part of the City's (and now its Merger Partners) water supply plans for over two decades.

Source 5 – Raleigh Quarry as Off-stream Storage

Description

This supply expansion concept involves the construction of a new raw water intake and pumping station on the Neuse River near the Neuse River confluence with Richland Creek. The existing Raleigh Quarry is adjacent to the Neuse River and also near Richland Creek – See **Figure V.11** below.

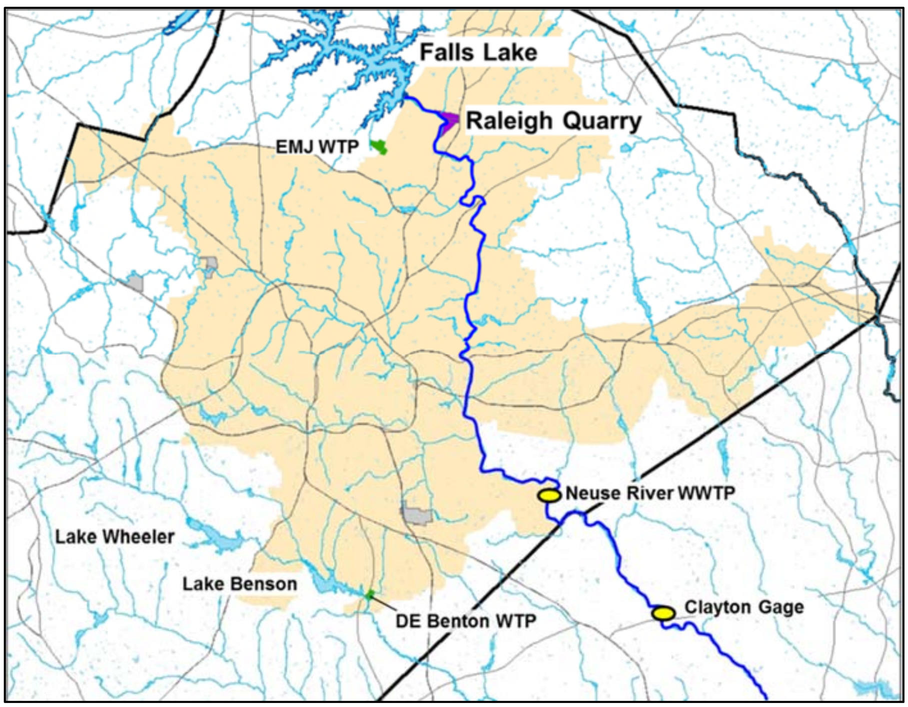

Figure V.11 – Map Locating Raleigh Quarry and Associated Features

The quarry would be filled/refilled when the Falls Lake level is above the guide curve (elevation of 251.5 feet MSL) and the USACE is releasing water from the dam at a rate exceeding the minimum release. Water would be pumped from the intake to the quarry at a rate up 50 mgd to refill the quarry. There is little intervening drainage area between the dam and the proposed intake location and it was assumed that maintaining a flow rate below the intake equivalent to the Falls Lake minimum release would be sufficient.

Utilization of the quarry's storage would involve pumping from the quarry to the E.M. Johnson WTP when the Falls Lake level is less than an elevation of 251.0 feet MSL, or 0.5 feet below the top of the conservation pool. During these conditions, raw water would be withdrawn from the quarry and pumped to the E.M. Johnson WTP at a rate of approximately 15 mgd to slow the rate of drawdown of the FLWSP. This operational arrangement assumes that if the quarry storage were depleted that no withdrawal from the river would take place.

At the current estimated usable volume of the quarry, which is about 3 billion gallons (BG), the marginal operational yield expected is on the order of 8 mgd. However, the quarry continues to be mined and the terminal volume of the pit is expected to be about 8 BG. The time frame for completion of quarrying is inexact, but under previous ownership was estimated to be 40 – 60 years. The relationship between the quarry volume and the marginal operational yield is shown below in **Figure V.12**. Estimated future and historical mining rates and their relationship to quarry volume is illustrated in **Figure V.13**, However, given the change in ownership of the quarry and the current owners' policy to extend the life of its quarries, these estimates are imprecise and subject to substantial uncertainty. The addition of adjacent land parcels could extend the life of the quarry beyond the already lengthy time horizon suggested. Another possible obstacle to utilizing this source would be the potential pursuit by Duke Energy for quarries across North Carolina for the purpose of coal ash disposal. Storage of coal ash in all or part of the Raleigh Quarry would likely render the site unsuitable for water supply purposes in perpetuity.

The utilization of this source would result in an increase in the minimum water quality pool level during drought conditions due to the higher demand (increased yield) it would support and the commensurate increase in wastewater flow return. For every 1 mgd increase in demand derived from this source, the minimum FLWQP storage would increase by 0.7% to 0.8% during a drought equivalent to the 2007 drought. This would mean that there would be more water available in the water quality pool during drought conditions to supply additional water as needed for downstream water quality or other conditions.

The increased supply available would be associated with a treatment capacity expansion at the E.M. Johnson WTP to 120 mgd.

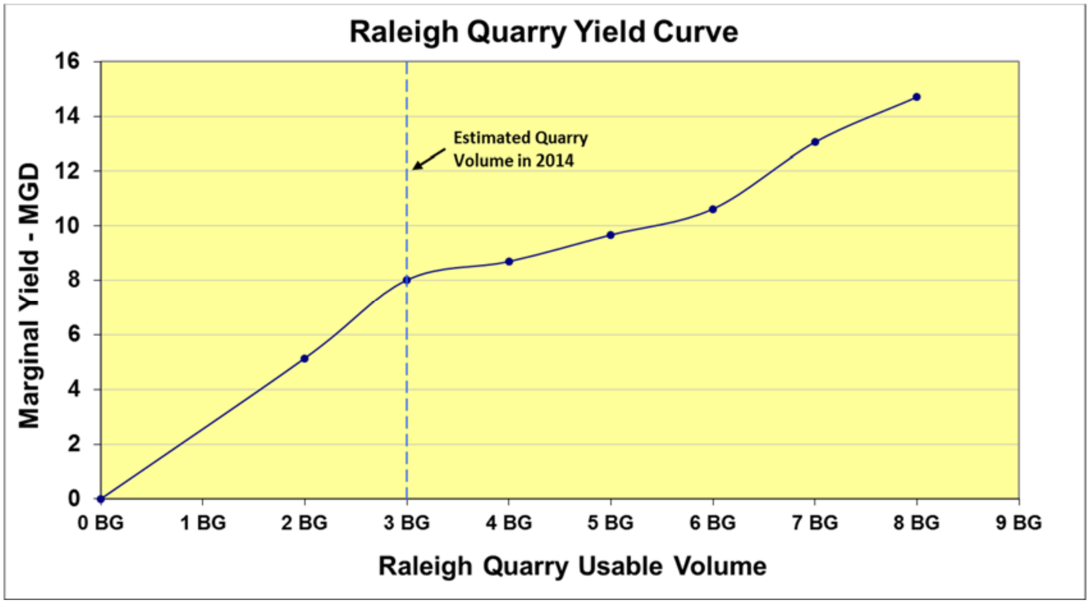

Figure V.12 – Marginal Yield of High Flow Skimming with Storage in Raleigh Quarry vs. Quarry Volume

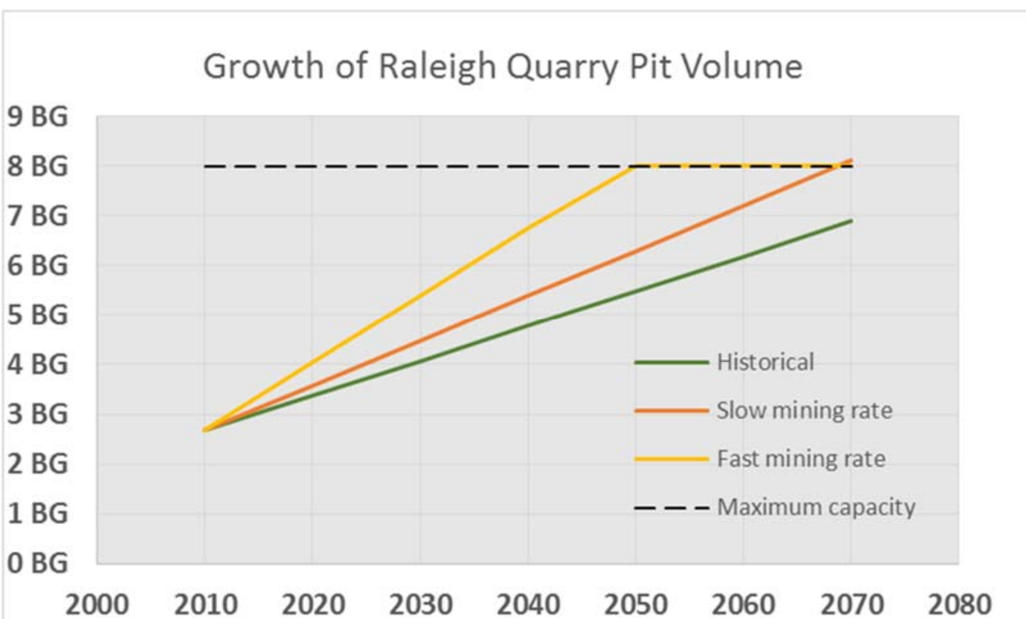

Figure V.13 – Quarry Volume vs. Year

Available Supply

Depending upon the pit volume at the point the quarry is converted to an off-line water supply, the marginal operational yield provided would be in the range of 8 - 14.7 mgd given the operational assumptions described in the preceding paragraphs.

Environmental Impacts

This source is considered to have environmental impacts that are the **Less Than** the Jordan Lake Allocation (Source 3). Direct impacts to the environment from both these sources will primarily be temporary in nature and associated with the installation of new pipelines and plant expansions. However, as with Source 2b, this source will increase the amount of water available in the FLWQP.

The operational arrangement for refilling the quarry only at high flows would protect riparian biota that depend upon the current minimum flow policy. Furthermore, the maximum withdrawal rate of 50 mgd (77 cfs) is far below the peak annual release rates in any year since the impoundment of the dam (median peak annual discharge since 1994 is over 3800 cfs) and thus the skimming operation will have negligible impact upon peak flows in the river.

Water Quality Classification

The water quality classification of Neuse River adjacent to the Raleigh Quarry is **WS-IV, NSW.**

Timeliness

The timeliness of this source is currently projected to be **Unacceptable**. Although the indicated 2045 date for this source assumes the quarry could be available within the 50 year planning timeframe, it is unlikely that this start date could be achieved easily nor without considerable expense to condemn the quarry and pay out the mineral rights to the quarry owner. Allowing the current quarry owner to mine the current site until the resources are exhausted makes the use of this source within the 50-year planning period very unlikely. The difficulties of permitting new quarry sites rival those of permitting a new reservoir and it is understood the policy response of the quarry owner is to make every effort to buy adjacent parcels with the intention of continuing mining at the site for a century or more. If an arrangement between the City and quarry owner could be negotiated to convert the current quarry pit to water supply storage while allowing the adjacent parcels to be mined this source would potentially become much more feasible within the 50-year planning window. This is being done at the American Stone Quarry outside of Carrboro, NC where a cooperative deal was negotiated between OWASA and American Stone in the year 2000. However, the owner of the Raleigh Quarry has shown no interest in establishing a similar arrangement with the City of Raleigh.

Interbasin Transfer

This source does not involve a surface water transfer as regulated under GS 143-215.22L.

Regional Partnerships

The City of Raleigh and seven surrounding towns merged water utility services in 2007. Thus, the City of Raleigh and its Merger Partners are a regional partnership, and any supply the City might develop would provide a regional benefit to of the citizens of central and eastern Wake County. Additionally, this source is one of the four Neuse River source options identified by the City to meet its future water supply needs as part of the JLP Recommended Alternative as presented in the TRWSP. As previously discussed the City will need to develop multiple Neuse River source options to meet its 2060 demands.

Technical Complexity

This source is considered to be **Technically Very Complex**. This rating was based on the need to construct a river intake, a multi-level (or adjustable level) quarry intake pump station, two new raw water transmission lines, and expand an existing water treatment plant on a limited available land footprint. The engineering of converting the quarry to a raw water storage facility is well understood and has been undertaken for at least one other utility in the region.

Institutional Complexity

The development of this source is **Institutionally Very Complex** due to the involvement of state and local governments that would participate in the permitting process for the intake and use of the quarry as an off-line water supply storage reservoir.

Political Complexity

This source would be **Politically Very Complex** due to the institutional factors described above and the possibility that downstream utilities could be concerned about the impacts of this operation on their water supplies. However, as the water supply intake on the river would only operate under higher flow scenarios, it is less likely that objections to this operational protocol would be raised by downstream users.

Public Benefits

This source will provide **Few Public Benefits.** This source benefits the public through the economic and efficient use of an existing, assuming acquisition costs are kept to a minimum. If the quarry acquisition costs are on the high side, the public benefits of this source could diminish significantly. The additional storage provides additional reliability and redundancy for the City's raw water supply to its principal water treatment plant. It does not provide any additional recreational opportunities that do not already exist.

Consistency with local plans

This alternative is **Consistent** with the Triangle Regional Water Supply Plan as revised in 2014.

Source 6 – Water Purchase Agreements

Description

Purchasing water from a neighboring utility offers one method of addressing supply scarcity in cost-effective manner as it help moderate temporal and spatial inequities in water supply. In the City's case and in the context of this application, a purchase agreement would serve to fill unmet projected demand in the combination of sources presented under Alternatives 2 and 3. While the arrangement for a purchase agreement has not been made, there is a long precedent for utilities in this region working out deals to mutually support water supply reliability standards. The City currently hopes that regularly relying on purchase agreements to meet its projected needs within the 50 year planning horizon will not be necessary. Supply availability and demand projections may change significantly over the course of the next several decades so suggestions regarding which neighboring utilities will have surplus supplies and be willing sellers is only speculation. The City of Durham, Johnston County, Town of Cary, City of Wilson, or Harnett County (via Holly Springs or Fuquay Varina) are all theoretical possibilities.

Available Supply

The projected purchase rate is 0.2 mgd for Alternative 2 and rises to 3.3 mgd for Alternative 3.

Environmental Impacts

The environmental impacts of the purchase are expected to be very minimal, but will vary depending on the source(s) that the selling utility would be required to utilize to supply its own needs as well as the contract purchase amount.

Water Quality Classification

The water quality classification of the source of any purchase agreement are unknown at present, but can be expected to fall within the WS II to WS V categories for supplies in the region.

Timeliness

The timeliness of this source is currently projected to be **Acceptable**. There are utilities in the region projecting a surplus water availability in 2045 in the range that would be needed to meet the City's outstanding demand and the interconnection capacity to move this volume of water from neighboring utilities to Raleigh or its Merger Partners either already exists or could be readily developed.

Interbasin Transfer

This source could involve a surface water transfer as regulated under GS 143-215.22L, but sources that do not involve an IBT would be preferred.

Regional Partnerships

The City of Raleigh and seven surrounding towns merged water utility services in 2007. Thus, the City of Raleigh and its Merger Partners represent a regional partnership, and any supply the City might develop would provide a regional benefit to of the citizens of central and eastern Wake County. The concept for this water supply source has been developed independently of actual inter-utility discussions to set up a purchase agreement 30+ years into the future, though a number of interlocal partnerships are already in place among the City and some of the potential sellers.

Technical Complexity

This source is considered to be **Technically Not Complex**. This rating was based on the fact there would be no need, or only a minimal need to build new facilities to provide the interconnection capacity necessary to carry out a purchase agreement of this magnitude. The exception would be if the purchase involved an IBT and required the wastewater be returned to the seller's basin.

Institutional Complexity

The development of this source is **Institutionally Not Complex** assuming the purchased water comes from within the Neuse River Basin. If an interbasin transfer were involved at a rate requiring a certificate, it would become **Institutionally Very Complex** due to the need to acquire approval for the purchase agreement.

Political Complexity

This alternative would be **Politically Not Complex** or **Politically Complex** due to the same reasons cited for the institutional factors described above.

Public Benefits

This source will provide **Few Public Benefits** other than the potentially significant benefits derived from the economic and efficient use of an existing resource.

Consistency with local plans

This alternative is **Not Consistent** with the Triangle Regional Water Supply Plan as revised in 2014, but the magnitude and type of deviation from local supply plans in place is not particularly significant. The proposed purchase arrangement would be scaled to meet the future water demand projections for the City and its Merger Partners.

Total Cost

The cost of any purchase agreement depends on the negotiated sales rate. It is not uncommon for the sale to be priced as high as the lowest tier residential consumer rate, which varies by utility but is currently in the vicinity of $3 per thousand gallons. Three dollars per thousand gallons purchased was the rate used for the cost calculations that incorporate water purchases in Alternatives 2 and 3 below.

Summary of Supply Alternatives

No single source is capable of meeting the City and its Merger Partners long term supply needs. Therefore, each alternative in this document consists of sets of a combinations of the sources described above. There are more possible combinations of sources than is practical to present here so three combinations were selected to represent what is in reality a broad spectrum of possibilities. Alternative 1 assumes the City develops the sources within the Neuse River Basin, while Alternatives 2 and 3 represent possible paths forward if particular obstacles to Alternative 1 become insurmountable. The amount of supply available from certain sources is dependent upon timing, assumed operations, and whether or not other sources are developed and used concurrently. The sources within the Neuse River Basin have been modeled in combination together so the interactions between them with respect to operational yield are generally well understood.

Table V.2 – Descriptions of Alternatives

Alternative	Description
Alternative 1	Any combination of sources 1, 2, 4, and 5 that will allow the applicant to meet its 2060 projected demand. Sources 2a and 2b are mutually exclusive and differ in terms of operation only. Source 2a assumes a new 30 mgd run-of-river intake on City owned property just upstream of the NRWWTP, expansion of D.E. Benton plant to 40 mgd, and raw water transmission facilities. The intake will be permitted to operate continuously and will have minor impacts at times on the Falls Lake WQ Pool storage. Source 2b also assumes a 30 mgd run-of-river intake with same associated facility expansions, but that the intake would only be permitted to operate intermittently such that there is no impact to Falls Lake WQ storage.
Alternative 2	Should the combinations of alternatives that can be permitted from Sources 1, 2, 4, and 5 be insufficient to meet the City's 2060 projected demand, an allocation from Jordan Lake could be instrumental to meet supply reliability standards. Although there are many potential combinations, one broad limitation that could impact Sources 1 and 2a would be that any new supply developed would be restricted from impacting the Falls Lake WQ Pool storage. In this case, an intermittently operated Neuse River Intake (Source 2b), having no negative impact on the Falls Lake WQ Pool, combined with the proposed Little River Reservoir and an 8.8 mgd Jordan Lake Allocation would nearly satisfy the expected additional need of 37.7 mgd in 2060. In addition, a small interlocal purchase of 0.2 mgd would be required.
Alternative 3	A variant of Alternative 2 assuming that, in addition to restrictions on impacting the Falls Lake WQ Pool, hurdles to permitting the Little River Reservoir are too great and that, instead, the Raleigh Quarry is acquired and put into service around 2045 when Sources 2b and 3 combined with existing supplies would be reaching their yield limit. This timing may not allow the quarry to be mined to its fullest extent. The quarry volume is assumed to be 6 billion gallons several years prior to 2050 when it must be prepared for service as a water supply and the additional yield is calculated based on the 6 BG volume. Finally, a purchase agreement for 3.3 mgd would be necessary to meet the remainder of the 2060 projected demand.

Table V.3 – Source Composition of Water Supply Alternatives (MGD)

Need and Source Options	Alternative 1	Alternative 2	Alternative 3
Total Projected Need (2045)	*19.7*	*19.7*	*19.7*
Total Projected Need (2060)	*37.7*	*37.7*	*37.7*
<u>Sources:</u>			
Falls Lake Re-Allocation (1)	14.0[a]	0.0	0.0
Neuse River Intake (2a)	23.7[a,b]	0.0	0.0
Neuse River Intake (2b)	0.0[a]	15.0	15.0
Jordan Lake Allocation - Rd 4 (3)	0.0	8.8	8.8
Little River Reservoir (4)	0.0[a]	13.7	0.0
Raleigh Quarry (5)	0.0[a]	0.0	10.6
Purchase Agreement (6)	0.0	0.2	3.3
Total New Supply (MGD)	**37.7**	**37.7**	**37.7**

a – Any combination of these Neuse River Basin alternatives that collectively provide sufficient yield to meet the projected 2060 demand would be satisfactory to the applicant.

b – The yield potential of Source 2a is higher than indicated, but is sized here for this alternative to meet 2060 demand.

Table V.4 – Summary and Ratings of Water Supply Sources

	Source 1 Falls L. Reallocation	Source 2a Neuse River Intake	Source 2b Neuse River Intake	Source 3 Jordan Lake	Source 4 Little R. Reservoir	Source 5 Raleigh Quarry
Allocation Request (% of storage)	0	0	0	8.8	0	0
Total Incremental Supply (MGD)	14.0	Up to 25.1	15.0	8.8	13.7	8-14.7
Environmental Impacts	Same as	Same as	Less Than		More Than	Less Than
Water Quality Classification	WS-IV, B, NSW, CA	C, NSW	C, NSW	WS-IV, B, NSW, CA	WS-II	WS-IV, NSW
Timeliness	Yes	Yes	Yes	Yes	Yes	No
Interbasin Transfer (MGD) [A]	None	None	None	4.7 (2045) 8.8 (2060)	None	None
Regional Partnerships	Yes	Yes	Yes	Yes	Yes	Yes
Technical Complexity	Complex	Very Complex	Very Complex	Very Complex/ Complex[D]	Very Complex	Very Complex
Institutional Complexity	Very Complex	Very Complex	Complex	Very Complex	Very Complex	Complex
Political Complexity	Very Complex	Very Complex	Very Complex	Very Complex	Very Complex	Very Complex[A]
Public Benefits	Few	Few	Few	Few	Many	Few
Consistency with local plans	Yes	Yes	Yes	Yes	Yes	Yes
Total Capital Cost ($ millions) [B]	$133M	$150M	$165M	$237M	$340M	$332M[C]
Unit Capital Cost ($M/MGD) [B]	$9.5M	$6.0M	$11.0M	$26.9M	$24.8M	$31.3M[C]

Notes:

A - *Acquisition of the quarry prior to completion of mining and exhausting mineral resources is likely to be complex. However, acquisition after completion of mining is anticipated to be "not complex".*

B – *These costs are in 2010 dollars, but have not been discounted to the date each source is to be implemented under the plans described under each alternative. The discount rate has been applied to the figures described in the paragraphs under the cost descriptions given for each alternative (i.e. combination of sources)*

C – *Assumes condemnation of the quarry in 2040 and pay out of all remaining mineral value of un-mined material in the quarry.*

D – *The technical complexity of implementing the Jordan Lake Alternative is anticipated to be reduced from very complex to complex if existing interconnections can be used, especially if no IBT certificate is required.*

Alternatives Analysis

The analysis below will rely heavily on the description of each source provided earlier in this section.

Alternative 1 – Combinations of Sources 1, 2a, 2b, 4, and/or 5

Description

Alternative 1 assumes that all of the City's water resource needs at the 2045 and 2060 planning dates are met with sources within the Neuse River Basin. As noted in the TRWSP, any combination of sources 1, 2, 4, and 5 that will allow the applicant to meet its 2060 projected demand would satisfy the City's ideal path forward. As such, there are several viable combinations that are grouped under Alternative 1. The City's other goals, beyond providing water supply reliability, in pursuing these sources is to minimize environmental disruption and to minimize cost to its users. The Falls Lake Reallocation (Source 1) and Neuse River Intake (Source 2a) are capable of providing for the City's projected need through 2060 and **Figure V.14** illustrates the ideal timing and relative impact that these sources would provide as the service area demand continues to grow over the next 45 years. The other two options available (Sources 4 and 5) in the Neuse River Basin are perceived to have significantly greater obstacles to their development. The Little River Reservoir (Source 4) has both a high price tag and high perceived environmental impacts while the Raleigh Quarry (Source 5) has a quarrying lifespan that is not compatible with water supply development within the 50-year planning horizon.

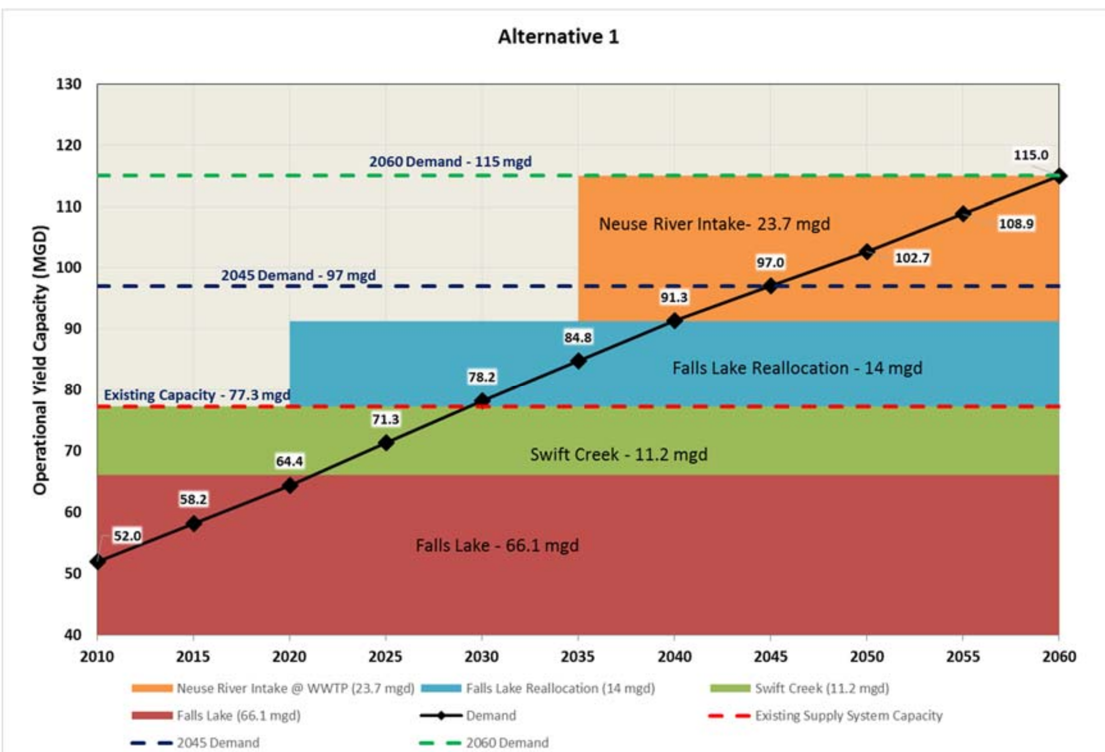

Figure V.14 –Sample timing and selection of sources for Alternative 1

Available Supply

Several combinations of sources are possible to meet the 2045 and 2060 projected demands. Sources 1 and 2a are capable of meeting the outstanding projected 2060 need of 37.7 mgd and have been modeled in conjunction with one another in such a manner that the applicant is satisfied that the two sources can function simultaneously and provide an additional 37.7 mgd of operational yield. The operation of the Raleigh Quarry (Source 5) has also been modeled in conjunction with sources 1 and 2a (or 2b) since there are interacting effects when depending on approximately the same watershed. The ultimate marginal yield of Source 5 (assuming 8 BG volume) is reduced by about 3 mgd when combined with Source 1.

Environmental Impacts

The environmental impacts will depend upon the final selection of sources used to build this alternative. Sources 1, 2 (or 2b), and 5 have relatively low environmental impacts relative to the yield improvements they would afford the City and its Merger Partners. If the Little River Reservoir (Source 4) is developed, the impacts are more significant. However, the alternative impact that would take place if the Little River Reservoir is not built is often ignored, but worthy of consideration. Please refer to the specific impacts for each source in the pages above.

Water Quality Classification

Refer to **Table V.4**. Additional description is provided in the description of some of the individual sources.

Timeliness

The timeliness of this alternative is currently projected to be **Acceptable**. As previously stated, there are several possibilities for source selection and sequencing available that all fit within he description of this alternative. The only potential problem with timeliness of this alternative would arise if Source 5 (Raleigh Quarry) were needed within the planning window.

Interbasin Transfer

This alternative would not involve a surface water transfer as regulated under GS 143-215.22L.

Regional Partnerships

The concepts for Sources 1, 2a, 4, and 5 were included as part of the JLP Recommended Alternative. However, due to potential impacts to water quality within the Falls Lake Conservation Pool for sources 1 and 2a, the City will be working with the UNRBA to address these concerns. Development of the Little River Reservoir (Source 4) has been taking place in conjunction with Wake County for the past four decades. Finally, the development of new supplies by the City of Raleigh and its Merger Partners benefit the citizens whom rely upon their existing regional partnership to reliably supply them with water and wastewater services.

Technical Complexity

Please refer to the descriptions under each individual source. All of the available combinations under the umbrella of Alternative 1 are **Technically Complex** or **Technically Very Complex**.

Institutional Complexity

Please refer to the descriptions under each individual source. All of the available combinations under the umbrella of Alternative 1 are **Institutionally Very Complex**.

Political Complexity

Please refer to the descriptions under each individual source. All of the Sources that are part of Alternative 1 are **Politically Very Complex**.

Public Benefits

This alternative will provide **Few Public Benefits.** See the description of each source under this alternative for more details.

Consistency with Local Plans

This alternative is **Consistent** with the Local Plans. See the description of each source under this alternative for more details.

Total Cost

The costs presented here have been revised from those presented in the TRWSP and reflect more detailed thinking regarding the timing that each source would be implemented and how each source would be integrated with the others. The total present worth cost estimated for this alternative, presented in 2010 dollars, is **$864 million,** which is equivalent to a unit cost of **$22.9 million** per MGD of new supply capacity. These costs include the estimated capital facilities costs of $353 million and O&M costs through 2060 of $511 million. The capital facilities figure is adjusted for the cost of financing and both the capital facilities and O&M figures are adjusted for the 1.295% discount rate. These numbers reflect a preferred set of potential sources for Alternative 1. If the Little River Reservoir or the Raleigh Quarry become part of the building blocks used in this alternative costs would rise significantly. See the description of cost under each source for an approximate comparison of cost across the set of sources that comprise this alternative. While the instructions provided in the application guidance document have been followed, salvage value and equipment replacement considerations have been omitted. This exception to the proposed cost methodology is consistent across all alternatives.

Alternative 2 – Combinations of Sources 2b, 3, 4, and 6

Description

One potential obstacle to successfully proceeding with Alternative 1 pertains to uncertainty regarding impacts to water quality in the Falls Lake Conservation Pool if Sources 1 or 2a are developed. As mentioned in the description of Source 1 (Falls Lake Reallocation), the evidence from the Falls Lake EFDC model show a very slight increase in chlorophyll-a concentration in the lake as a result of full use of the existing water supply pool or full use of an enlarged water supply brought about via reallocation compared to historical conditions from a single year – the year 2006. However, there is enough uncertainty regarding the capabilities of the current EFDC model that concerns over water quality impacts could hold up the pursuit of Source 1, and possibly Source 2a. In the worst case, Sources 1 and 2a may not be successfully developed and the City's preferred path forward would shift to Alternative 2. Under Alternative 2, the first source to be developed would be Source 2b which, like Source 2a, involves placing an intake on the Neuse River, but operating the intake assuming no streamflow augmentation from FLWQP to meet supply needs during dry periods. This arrangement provides 10 mgd less yield than operating under Source 2a assumptions, but requires the same infrastructure investment. One additional supply is needed after bringing Source 2b on-line, the City could turn to either a Jordan Lake Allocation (Source 3) or the proposed Little River Reservoir (Source 4). Both have drawbacks and would find strong critics. A Jordan Lake Allocation would have fewer marginal environmental impacts since it relies on an existing reservoir, but would involve an interbasin transfer and potentially a very costly pipeline to return an equivalent volume of wastewater to the Cape Fear Basin. Developing the Proposed Little River Reservoir would avoid the need for an interbasin transfer, but would have significant environmental impacts and carry a very high price tag. While the City cannot judge with certainty which of the two would be easier to permit, both would be needed under this path forward and we assume here that utilization of an existing source (Jordan Lake) would offer the preferred path. In either case the second project in the sequence, whether it is Source 3 or Source 4, would need to be developed and brought on-line around 2030. Assuming the second source in the Alternative is Jordan Lake, the Little River Reservoir would need to be developed and on-line around 2035, and certainly no later than 2040 to maintain supply reliability. Technically, the combination of aforementioned sources would leave a small shortfall of 0.2 mgd in 2060, so for the sake of diligence a purchase agreement (Source 6) is assumed to cover the remaining need. **Figure V.15** illustrates the timing and yield that the sources comprising this alternative offer.

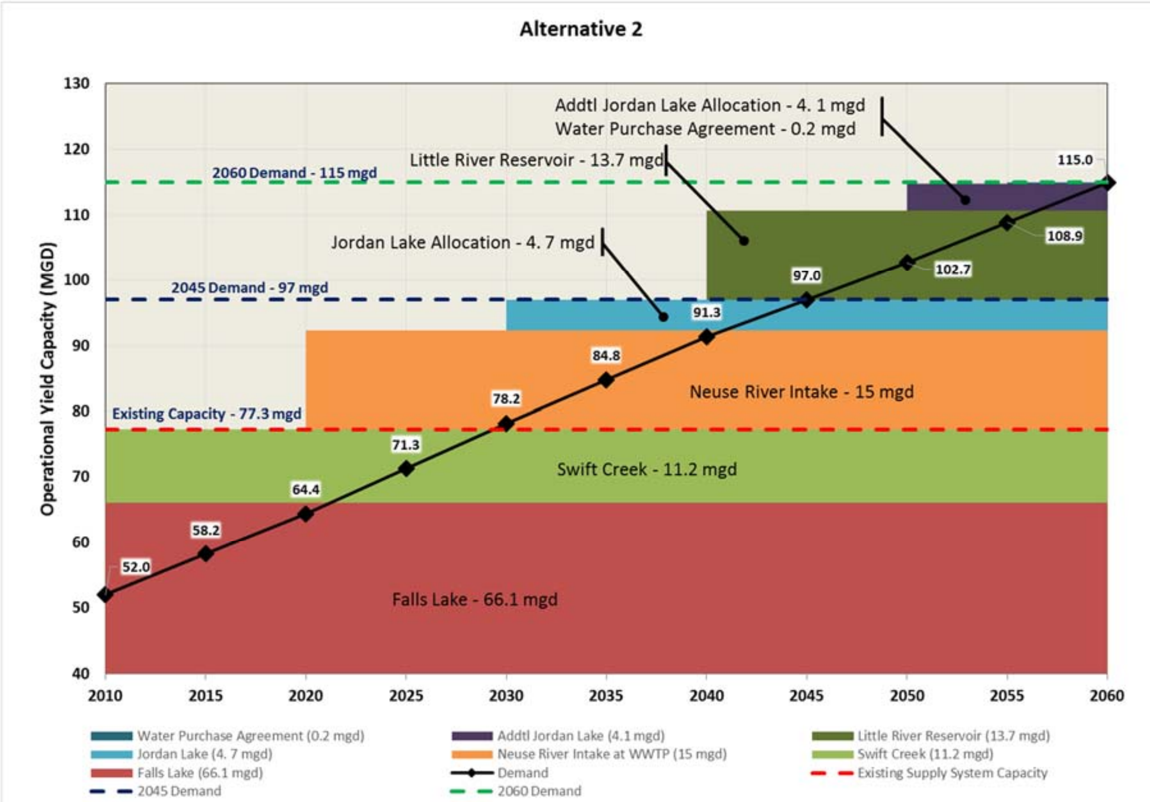

Figure V.15 –Approximate timing and selection of sources for Alternative 2

Available Supply

Outstanding need through 2045 is 19.7 mgd and that rises to 37.7 mgd in 2060. Source 2b will provide 15 mgd of additional supply and ideally be on-line by 2020, followed by Source 3 which would provide 4.7 mgd (8.8 by 2060) to satisfy projected demand through 2045. Source 3 would be brought on-line by 2030 to ensure supply reliability. Source 4 would provide 13.7 mgd of additional supply come on-line in 2040, and Source 6 will provide the remaining 0.2 mgd to meet the total 37.7 mgd of projected need through 2060.

Environmental Impacts

The environmental impacts have been laid out in greater detail under each the descriptions of each source that comprises this Alternative. The vast majority of the environmental impact under this alternative will arise from developing the Little River Reservoir. Very few of the impacts owe to the development of Source 2b. Some impacts will arise to use Source 3 (Jordan Lake Allocation) though the extent of the impacts will vary considerable depending on how the utilization of the allocation is implemented. If the City must build nearly 70 miles of new pipeline to transport water to its service area and return the discharge back to the Cape Fear, the impacts of Source 3 could rise somewhat, though a wastewater return could offset the City's interbasin transfer from the Cape Fear to utilize this source. There is hope that the impact of constructing the lengthy pipelines could be avoided through cooperation with other regional utilities by purchasing treated water through existing finished water connections and possibly paying for a smaller wastewater pump station to offset the IBT within one of our neighbor's service areas to avoid the need for the 40 mile wastewater return pipeline laid out in the concept for Source 3.

Water Quality Classification

Refer to the description provided for each individual source.

Timeliness

The timeliness of this alternative is currently projected to be **Acceptable**. See the description of each source within this alternative for additional details. The sequencing of sources is presented in the paragraphs titled **Description** and **Available Supply**, above.

Interbasin Transfer

This alternative would involve a surface water transfer as regulated under GS 143-215.22L. See the description of Source 3 (Jordan Lake Allocation) for more detail.

Regional Partnerships

The development of new supplies by the City of Raleigh and its Merger Partners benefit the citizens whom rely upon the existing regional partnership between Raleigh and its seven Merger Partners to reliably supply them with water and wastewater services. See the description of each source for additional details on other regional partnerships that pertain to each source.

Technical Complexity

Please refer to the descriptions under each individual source. Alternative 2 is **Technically Very Complex**.

Institutional Complexity

Please refer to the descriptions under each individual source. Alternative 2 is **Institutionally Very Complex**.

Political Complexity

Please refer to the descriptions under each individual source. Alternative 2 is **Politically Very Complex**.

Public Benefits

This alternative would provide **Few Public Benefits**. See the description of each source for more detail.

Consistency with Local Plans

This alternative is **Consistent** with Local Plans. See the description of each source for more detail.

Total Cost

The total present worth cost estimated for this alternative in 2010 dollars is **$1.36 billion,** which is equivalent to a unit cost of **$36 million** per MGD of additional supply capacity. These costs include the estimated capital facilities costs of $739 million, and O&M costs through 2060 of $618 million. The capital facilities figure is adjusted for the cost of financing and salvage value and both the capital facilities and O&M figures are adjusted for the 1.295% discount rate. The costs associated with this alternative would likely come down if a more ideal configuration for accessing a Jordan Lake Allocation can be arranged with other regional partners.

Alternative 3 – Combinations of Sources 2b, 3, 5, and 6

Description

This alternative covers a case similar to Alternative 2 wherein sources that could have any adverse impact to the storage in the FLWQP, or water quality in the Falls Lake conservation pool are not able to be developed. This alternative goes further and assumes that permitting a new reservoir is not possible due to perception that its environmental impacts are unacceptable. This removes Source 4 (Little River Reservoir) from consideration and assumes the City must develop the Raleigh Quarry (Source 5) and increase the amount of water purchased from neighboring utilities (Source 6). The City would look into arranging purchase agreements ahead of bringing Source 5 on-line to allow the quarry pit volume to be maximized. Even so, it would need to come on-line around 2045 to guarantee supply reliability. **Figure V.16** graphically illustrates timing and composition of this alternative.

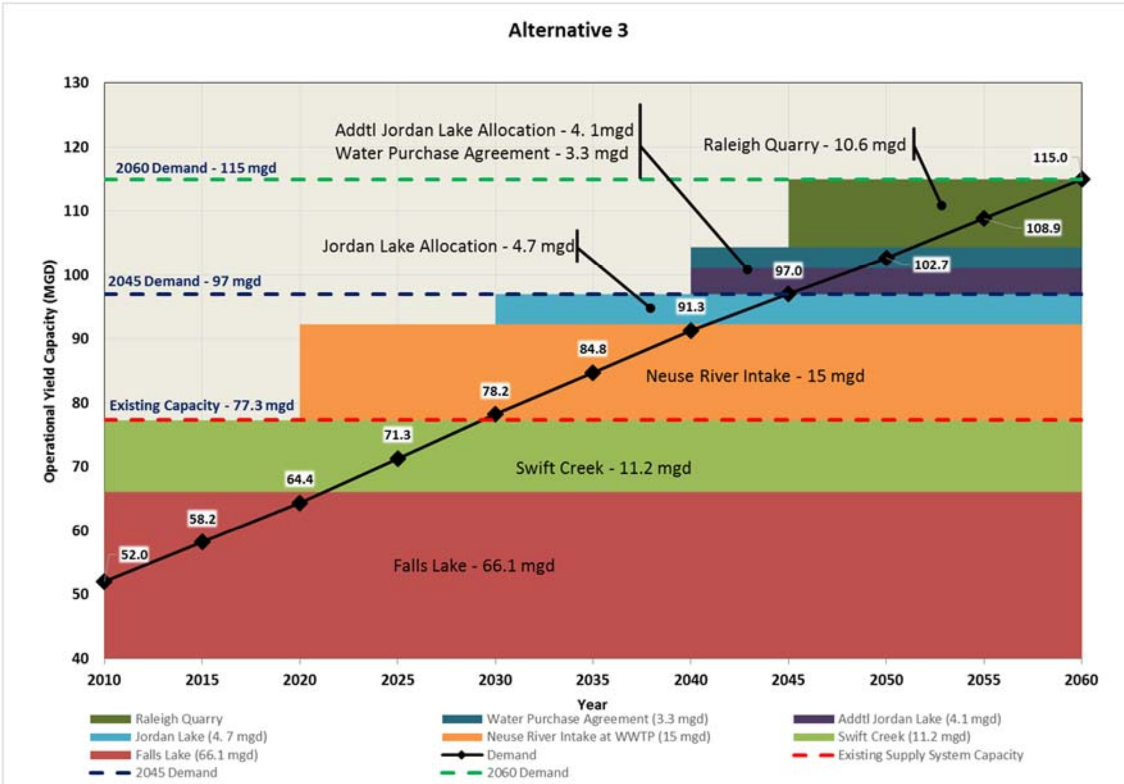

Figure V.16 –Approximate timing and selection of sources for Alternative 3

Available Supply

Outstanding need through 2045 is 19.7 mgd and that rises to 37.7 mgd in 2060. Source 2b will provide 15 mgd of additional supply and ideally be on-line by 2020, followed by Source 3 which would provide 4.7 mgd (8.8 by 2060) to satisfy projected demand through 2045. Source 3 would be brought on-line by 2030 to ensure supply reliability. Here we assume the City will make use of a modest purchase agreement (or set of agreements) to provide 3.3 mgd of supply to delay the need to bring Source 5 (Raleigh Quarry) on-line and minimize the loss in the quarry's ultimate volume (the earlier the quarry is brought on-line, the smaller its expected useable volume). The purchase agreements would need to be in place and functional by 2040, though they might not need to be "called" until a later date depending on actually hydrologic conditions. Source 5 would need to be on-line by 2045 and would provide the remaining 10.6 mgd required to meet the total 37.7 mgd of projected need through 2060.

Environmental Impacts

The environmental impacts of this alternative, as with the other two alternatives, are a summation of the impacts of the sources that comprise the alternative. Therefore, refer to the explanation provided for each source. The principal difference between Alternative 2 and Alternative 3 is the substitution of the Raleigh Quarry (Source 5) for the Little River Reservoir (Source 4). The use of the Raleigh Quarry as proposed will have fewer adverse impacts than building the Little River Reservoir, but as noted in the write up for Source 5, the management of this private quarry is making the ability to develop this source much more difficult. The result is that any reduction in environmental impacts that come from utilizing Source 5 (as compared with Source 4) may be replaced with a host of obstacles to developing the source within the 50-year planning horizon.

Water Quality Classification

Refer to the description provided for each individual source.

Timeliness

The timeliness of this alternative is currently projected to be **Unacceptable** due to the anticipated difficulty to developing Source 5 on the timeframe require to successfully implement this alternative. The sequencing of sources is presented in the paragraphs titled **Description** and **Available Supply**, above.

Interbasin Transfer

This alternative would involve a surface water transfer as regulated under GS 143-215.22L. See the description of Source 3 (Jordan Lake Allocation) for more detail.

Regional Partnerships

See the description of each source for details on regional partnerships.

Technical Complexity

Please refer to the descriptions under each individual source. Alternative 2 is **Technically Very Complex**.

Institutional Complexity

Please refer to the descriptions under each individual source. Alternative 2 is **Institutionally Very Complex**.

Political Complexity

Please refer to the descriptions under each individual source. Alternative 2 is **Politically Very Complex**.

Public Benefits

This alternative would provide **Few Public Benefits**. See the description of each source for more detail.

Consistency with local plans

This alternative is **Consistent** with the Local Plans. See the description of each source under this alternative for more details.

Total Cost

The total present worth cost estimated for this alternative in 2010 dollars is **$1.36 billion,** which in this case is equivalent to a unit cost of just over **$36 million** per MGD of additional supply capacity. These costs include the estimated capital facilities costs of $729 million, and O&M costs through 2060 of $632 million. The capital facilities figure is adjusted for the cost of financing and salvage value and both the capital facilities and O&M figures are adjusted for the 1.295% discount rate. Similarly to Alternative 2, the costs associated with this alternative would likely come down if a more ideal configuration for accessing a Jordan Lake Allocation can be arranged with other regional partners.

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SECTION VI. COMPLEXITY AND UNCERTAINTY OF RALEIGH AND ITS MERGER PARTNERS WATER SUPPLY SOURCE OPTIONS

Complexity and Uncertainties Unique to the Applicant's Water Supply Planning

The applicant, unlike other entities seeking water allocations from Jordan Lake, faces unique and unprecedented challenges associated with developing water resource alternatives. The applicant is entering the 8th year of a multi-decade process which is designed to refine and ultimately develop the water resource options identified in the Triangle Regional Water Supply Plan which include the Falls Lake Reallocation, a new Neuse River Intake upstream of the Neuse River WWTP, the Little River Reservoir, and the Raleigh Quarry. These water resource options, are themselves the refined product of an evaluation that started with 25 alternative water supply source options.

Each of the water supply source options involves difficult environmental, social and economic questions. To meet the need of our communities for the 50-year planning window, the applicant is seeking to permit four identified options in ascending order of difficultly in addition to the applicant's requested allocation from Jordan Lake. This action is taken under the prudent assumption that one or more of the identified source options will fail to be successfully developed. The Reservoir option has particular issues of note and it is unlikely that a new reservoir can be permitted and constructed until all other water supply options with lower environmental impact are either implemented or shown not to be feasible.

Complexities and Permitting Complications that Cross Source Boundaries

Several permitting complexities extend across potential sources. These complexities include water resource development guidance unique to EPA Region 4, new case law on water resource use unique to North Carolina and a potential expansion of federally listed species over the entire Southeastern United States.

EPA Guidelines on Water Efficiency Measures for Water Supply Projects in the Southeast

On June 21st, 2010, EPA Region 4 issued guidelines on water efficiency measures for water supply projects. These guidelines significantly reshaped water resource planning in the southeastern United States. The guidelines establish four sustainable water management practices that must be implemented to the "maximum extent practicable" before EPA would consider or approve new water resource alternatives. The first of those practices was defined as "effective management," which includes a description of how the utility has or will implement water consumption reduction goals, increase public understanding, involve water users in decisions and how it would use an integrated resource management approach. The second is defined as "pricing for efficiency," which is full cost pricing and conservation pricing. The third practice, "efficient water use," refers to leak detection and abatement, metering all water users, and a requirement for building codes to include the most efficient technologies, rain water harvesting, and landscaping to minimize water use. The final practice, “watershed approaches,” refers to developing water budgets on a watershed scale, seeking opportunities for wetland restoration, groundwater recharge and reuse of graywater and reclaimed water. The water conservation and efficiency assumptions and goals within the applicant’s water resource plan, as well as the tiered rate structure, were shaped or influenced by this EPA guidance document. Because of the limited record of new water resource development in Region 4, it is unknown if the applicant or any entity seeking to develop or use water resources in the Southeast United States has met the compliance threshold envisioned by EPA when implementing this guidance.

Center for Biological Diversity Litigation and Petition for Listing in the Southeastern United States

A second Federal process that may influence future water resource planning is the pending ESA listing work plan issued by the United States Fish and Wildlife Service (USFWS). As a result of litigation and subsequent settlement with WildEarth Guardians and the Center for Biological Diversity, the USFWS established a court approved multi-year work plan to review over 230 species on the 2010 threatened or endangered candidate notice for review of list; 74 of the species on the candidate list are known to exist or have existed in waters of North Carolina. Five in particular are native to the Little River and other waters of the piedmont:

Yellow lance, *Elliptio lanceolata*
Green floater, *Lasmigona subviridis*
Atlantic pigtoe, *Fusconaia masoni*
Carolina madtom, *Noturus furiosus*
Neuse River waterdog, *Necturus lewisi*

The outcome of this listing process could add additional species of concern. If this occurs, it will lead to new challenges to securing permits for projects that impact, directly or indirectly, waters those species inhabit. The process for listing a species as endangered or threatened under the Endangered Species Act (“ESA”) can be started by either the agency, or by petition from a “interested person.” A species is endangered if it is “in danger of extinction throughout all or a significant portion of its range.” A species is threatened if it “is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” The ESA requires that the Secretary “to the maximum extent practicable” decide within 90 days of receiving a petition for listing whether the petition presents “substantial scientific or commercial information” indicating that the listing of the species may be warranted. The timeline for considering the petition extends from 2015 through 2018. A listing that impacts a Source can be interjected into the permitting process at any stage, including construction. Indeed, one of the most famous listings (Snail Darter) almost led to the removal of a Tennessee Valley Authority (TVA) reservoir project that was at 95% construction completion at the time of listing. Only an act of Congress allowed the TVA reservoir project to move forward after a takings finding under the ESA.

L&S Hydro Power et Al v. Piedmont Triad Regional Water Authority

"North Carolina's law of water rights derives primarily from the common law, which provides local governments no ability based on riparian owner status, to provide citizens with drinking water. The North Carolina General Assembly has provided some relief from this common law restraint with regard to impounded waters, but the vast majority of the State's water resources are still governed by various judicial decisions interpreting eighteenth century English common law."

North Carolina is a riparian water law State. The findings of L&S Hydro Power et Al v. Piedmont Triad Regional Water Authority (PTRWA) make it clear that traditional riparian law, in North Carolina, makes no allowance for use by non-riparian users and that water supplied for the public purpose of potable water is a non-riparian use.

The Randleman Regional Reservoir was funded and constructed by PTRWA, which is a regional partnership made up of Greensboro, High Point, Randleman, Jamestown, Archdale and Randolph County. PTRWA started applying for licenses to construct and operate an impoundment in 1988 and the project was the subject of several suits reaching the North Carolina Court of Appeals before the USACE, EPA, NC-DENR and the EMC granted the PTRWA the appropriate permits, water quality certificates and water supply watershed classifications to construct the dam; including an interbasin transfer certificate allowing the transfer of water from the Deep River to the Haw River.

After construction was complete on the project, PTRWA was the subject of a new suit by seven downstream hydroelectric facilities operating on the Deep River. The hydro-electric providers argued that the dam constructed on the river to create Randleman Lake financially damaged them by reducing water flow and power generation. The Water Authority lost the case in Guilford County Superior Court and in a series of appeals that reached the state Supreme Court.
The high courts affirmed the findings of the trial court that PTRWA, with the power of condemnation, was not protected by riparian rights doctrine of reasonable use, and so had to pay for the water it "uses".

The Plaintiffs were also not required to exhaust administrative remedies (i.e., appeal the certificate for the project). The case highlights the inability of the applicant (or any potable water provider seeking to develop new water resource) to rely on permits and agency approvals as final authority to implement a new water resource project. As the basis for the judicial finding was found in the North Carolina constitution, it also implied limitations on any legislative modification of riparian rights.

Source 1- Reallocation of Falls Lake Conservation Pool – Project Uncertainties

As described in the Political Complexity section for the Reallocation (Source 1) on page 53, this source option has an uncertain future as the complexity of its permitting process leaves many open questions. As a USACE dam and multifunction reservoir, the reallocation of any storage in Falls Lake is subject to Section 6 and Section 8 of the Flood Control Act of 1944, but the primary governing legislation is the

Water Supply Act of 1958 (Act). That Act states that water supply is primarily a State and local responsibility, ensures that water supply storage is considered in new federal reservoir projects and allows for the limited reallocation of storage for water supply needs in existing reservoirs. Modification of allocations within reservoirs to meet water supply needs that would “seriously affect other authorized purposes” would require congressional authorization. The USACE developed and occasionally updated guidance to implement the Act (EP 1165-2-1 [1999], ER 1105-2-100 PGN [2000], IWR Report Policy Studies- Water Supply Database [2005]). Unfortunately, the guidance and the reallocation process was impacted by long running litigation between the States of Alabama and Florida against the State of Georgia concerning the use of Lake Lanier. In 1990, Alabama and Florida filed federal suit against the USACE to stop the USACE from giving the City of Atlanta, Georgia more water from Lake Lanier. The case was finally decided almost 24 years later in favor of the USACE (and the State of Georgia). One outcome of case was a mandated change in the guidance for reallocations under the Act. At a November 4, 2014 meeting with the USACE to discuss the Falls Lake Reallocation, the USACE informed the applicant that revised guidance was still in draft form. Relevant changes in the draft guidance included the removal of explicit thresholds in terms of acre-feet or percentage of storage that defined the term “seriously affect other authorized purposes” requiring congressional authorization. Prior to this change, the applicant’s planned reallocation request (Source 1) did not breach the threshold requiring congressional notification. However, with the removal of the explicit threshold and with the absence of applicable case law, there is some concern that parties with standing in any reallocation at Falls Lake and/or the federal 401/404 permitting process for any of the proposed Neuse River options may successfully contest the reallocation request at any stage of the process, forcing the applicant and the City to seek congressional authorization. Entities, agencies or organizations with standing could include any stakeholder regulated under the Falls Lake Nutrient Management Rules, environmental advocacy groups who establish standing under the CWA and agencies such as USFWS or the United State Environmental Protection Agency (EPA) who may regard the reallocation process as an opportunity to advance management plans for federally listed aquatic species such as the Atlantic Sturgeon. The process to acquire congressional authorization is itself complex, with individual authorization rare and omnibus authorizations occurring on a seven year interval over the last three such authorizations.

The anticipated decision making timeframe for a reallocation within Falls Lake under the Act is 36 months. If at any time in that process or as a result of litigation after the process congressional authorization becomes a requirement, up to an additional seven years may be required to secure such authorization depending upon when within the omnibus authorization cycle the requirement is initiated. A contested reallocation process can itself be delayed by the USACE until the underlying conditions leading to the contested allocation are resolved. For example, the State of Georgia recently filed suit against the USACE for failing to undertake and complete a reallocation request concerning Lake Allatoona. The reallocation request from the City of Atlanta was filed over 30 years ago in 1984.

Source 2 – Neuse River Intake Upstream of the NRWWTP - Project Uncertainties

As described in the Source 2a and 2b Political Complexity sections on pages 59 and 62, respectively, this source option has an uncertain future because of the complexity of its permitting process. First and foremost are the uncertainties associated with the required water supply watershed classification. There are concerns that the implementation of a water supply watershed classification will raise Environmental Justice concerns that could delay, detrimentally modify, or make impractical the development of Source 2. To understand this concern, one must understand the complexity of the interrelated regulation.

§ N.C.G.S. 130A-320 requires the EMC to adopt rules governing the sanitation of watersheds from which public drinking water supplies are obtained. 15A NCAC 18C.0202 requires that any surface water which is to receive treatment for removal of dissolved matter or suspended matter in order to be used for a public water system must be obtained from a source which meets the Water Supply Watershed (WS) stream classification standards of WS-I, WS-II, WS-III, WS-IV or WS-V, established by the EMC and codified in 15A NCAC 2B. Since the stream reach in the vicinity of the suggested withdrawal point for Source 2 does not currently carry a WS designation, one would need to be applied. Those standards include land use regulations and impervious surface limitations; regulation designed to address stormwater discharges, with potential pollution loads, to WS waters.

The development of Source 2 will also require 404/401 permitting under the Clean Water Act (installation of an intake and waterway crossing of any raw water transmission mains) as well as compliance with the Nation Environmental Policy Act (NEPA) [note that compliance with the State Environmental Policy Act (SEPA) is also required but assumed to be satisfied by the NEPA process]. In the NEPA process, Environmental Justice issues must be identified and addressed. *Environmental Justice* is defined by Executive Order 12898 (February 1994) to be the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.
The EPA Office of General Counsel memo titled *EPA Statutory and Regulatory Authorities Under Which Environmental Justice Issues May Be Addressed in Permitting* (December 1, 2000) notes that “the broadest potential authority to consider environmental justice concerns [within the] CWA section 404 program rests with the Corps of Engineers, which conducts a broad "public interest review" in determining whether to issue a section 404 permit. In evaluating the "probable impacts . . . of the proposed activity and its intended use on the public interest," the Corps is authorized to consider, among other things, aesthetics, general environmental concerns, safety, and the needs and welfare of the people. 33 CFR § 320.4(a).”

EPA's *Final Guidance for Incorporating Environmental Justice Concerns in EPA's NEPA Compliance Analyses* (April 1998) notes that the White House Council for Environmental Quality (CEQ) regulations require that environmental justice concerns to be identified during the screening analysis or during the development of an EA or EIS with the potential interrelated socioeconomic impacts to both the total affected population (or a "control" population) and to the low-income and/or minority communities of concern evaluated, to the maximum extent practicable. It further notes that cultural or social impact assessments should be evaluated through standard socioeconomic models employed to predict shifts and changes in particular socioeconomic indicators such as employment, income levels, and housing quality.

As demonstrated in **Figure V.7** (income) and **Figure V.8** (demographics), the area impacted by a water supply watershed classification required by 15A NCAC 18C.0202 pursuant to § N.C.G.S. 130A-320 will impact the largest minority populations within CORPUD's service area. Furthermore, the watershed classification would impact the communities of Knightdale and Garner, both of which have expressed significant concerns with the perceived negative impacts on development and redevelopment potential for each community.

Source 3 – Jordan Lake Allocation – Project Uncertainties

Inherently this source option has an uncertain future as it is ultimately up to the EMC to determine whether the City has demonstrated a sufficient need for a Jordan Lake Allocation as compared with other applicants, and that the requested allocation constitutes the best use of this existing surface water resource and serves the best interest of those in the region.

The need for an interbasin transfer certificate, as regulated under North Carolina G.S. § 143-215.22L, and as described in Section V, Interbasin Transfer on page 66, is perceived to be the biggest obstacle to implementation of this source option.

Subsection (t) of North Carolina G.S. § 143-215.22L lays out the guiding policy of the state with regard to surface water transfers and reads as follows: "(t) Statement of Policy - It is the public policy of the State to maintain, protect, and enhance water quality within North Carolina. It is the public policy of this State that the reasonably foreseeable future water needs of a public water system with its service area located primarily in the receiving river basin are subordinate to the reasonably foreseeable future water needs of a public water system with its service area located primarily in the source river basin. Further, it is the public policy of the State that the cumulative impact of transfers from a source river basin shall not result in a violation of the antidegradation policy set out in 40 Code of Federal Regulations § 131.12 (1 July 2006 Edition) and the statewide antidegradation policy adopted pursuant thereto."

This guiding policy could be interpreted to advise against allocations from Jordan Lake to water providers whose service area lie wholly in another regulatory basin if there is any possibility that such allocation and transfer could impact water systems located in the source (donor) basin. Such allocations have often been incorrectly equated with IBT requests, which have been very difficult to complete because of political opposition. Indeed, only three IBT certificates have been issued by the EMC since the process was available in the early 1990s and no IBT certificates have been issued under the newer legislation and rules issued after the settlement of litigation between North Carolina and South Carolina over an IBT certificate to Concord and Kannapolis in the mid-2000s.

It is worth noting the City of Durham, is currently removing an average of approximately 13 mgd from the Neuse River Basin upstream of the City's primary water supply (Falls Lake) and discharging to the Cape Fear Basin. Further, Durham is grandfathered for an interbasin transfer of up to 45.4 mgd, and that if Durham increases its transfer amounts as it is allowed to do, this would serve to diminish the safe yield of Falls Lake, further increasing the City's need for a reliable water source.

In any event, as previously noted, the City of Raleigh and its Merger Partners require an atemporal response to this allocation request so that as it pursues other sources the City and other stakeholders have a clear understanding of its future ability to rely on Jordan Lake to meet a portion of its future supply need. A decision from the EMC to not grant an allocation, but that leaves the door open for a future allocation, would leave the City in a position of continuing uncertainty with regard to its water resource planning efforts, and will make it more difficult to develop other sources.

Source 4 – Little River Reservoir – Project Uncertainties

As described in Section V, Environmental Impacts, page 71, this source option has an uncertain future because of the complexity of its permitting process; a process that assumes that all river impoundments take a heavy environmental toll in the form of compromised landscapes, ecosystems and fisheries. Under the Clean Water Act, a federal permit is required from the USACE for reservoir construction. An environmental impact statement (EIS) is required as a part of the application for this permit in order to comply with the National Environmental Policy Act (NEPA).

The area currently reserved for the Little River Reservoir would be converted from predominantly undeveloped rural land use (agricultural and forested land) for use as raw water storage. The main concrete portion of the dam would have a crest length of about 800 feet and a height of about 39 feet above the existing stream bed. Including the embankment sections, the dam would have an overall length of about 2,400 feet.

Total area impacted would be approximately 1,840 acres, including 1,150 acres inundated, 70 acres in the dam and spillway area, and 620 in the buffer area. Included in this are a total are 507 acres of wetlands and impact to an additional 21 acres of forested wetlands at the dam site (total wetland area impacted = 528 acres). Impounding the Little River would also result in the permanent loss of approximately 7.2 miles of stream and 16 acres of stream environment, the loss of terrestrial wildlife habitat in areas that are inundated, which could provide habitat for endangered or threatened species. Finally, one or more roads would have to be abandoned or raised and/or relocated for proposed reservoir.

The Clean Water Act requires mitigation of stream and wetland impacts through the 404 and 401 permitting process. Because dams can change riverine habitat and large mainstream reservoirs can impede fish passage and change biota downstream through flow and temperature changes, extensive studies of downstream habitat and flow characteristics are also required. The Little River has been a focus of anadromous fish habitat restoration by State, federal, and private entities. These partnerships were instrumental in the removal of the first three dams on the river (Cherry Hospital, Raines Mill Dam, and Lowell Mill Dam). Removal of the dams has allowed anadromous species, including American shad, striped bass, and river herring, to reenter the river and begin using spawning and nursery habitats which had been blocked for decades (Burdick, S.M. and J.E. Hightower. 2006). The Little River also historically harbored the "…single largest extant population of the Carolina madtom known within the entire Neuse drainage" (page 70; Burr, B.M., B.R. Duhajda, W.W. Dimmmick and J.M. Grady. 1989. Distribution, Biology, and Conservation Status of the Carolina Madtom, *Noturus furiosus*, an Endemic North Carolina catfish. Brimleyana 15:57-86). This small species of catfish is state-listed as threatened, and the Little River has been identified as a site for augmentation / restoration of the Carolina madtom (Midway, S.R. 2008. Habitat Ecology of the Carolina Madtom, *Notorus furiosus*, an Imperiled Endemic Stream Fish. (MS Thesis, North Carolina State University, Raleigh. 74 pp.).

The North Carolina Wildlife Action Plan does not specifically mention the Little River, but it does mention that the Middle Neuse River and tributaries are priority areas for habitat protection, and it has the Little River watershed highlighted on Map 5B.12b as a priority area for freshwater conservation.

Two federally listed species, the Dwarf Wedge Mussel and the Tar Spiny Mussel, have existing small populations downstream of the proposed Little River Reservoir. Therefore, consultation with the USFWS is required under the Endangered Species Act. Although the Tar Spiny Mussel was not known to be present in the Little River at the time the revised Tar Spiny Mussel Recovery Plan was developed, the Little River is considered essential by the USFWS to the recovery of the species and essential to the survival of the species, especially given that the species may now be extirpated from the mainstem of the Tar River and extremely rare to extirpated in Tar River tributaries such as Shocco Creek, Swift creek, Little Fishing Creek and Fishing Creek. Consequently, the USFWS has provided a preliminary decision that the Little River ecosystem represents an aquatic resource of national importance (ARNI) and may be "unmitigable".

For these reasons it is unlikely the Little River Reservoir can be permitted and constructed until all other water supply options with lower environmental impacts are either implemented or shown not to be feasible. It is even conceivable that additions to the lists could preclude or otherwise end the project altogether.

Source 5 – Raleigh Quarry as Off-stream Storage – Project Uncertainties

As described in Section V, Timeliness, page 76, this source option has an uncertain future due to the timing of the completion of quarrying operations. If waiting for the completion of quarrying becomes untenable, the cost of paying out the mineral rights in the condemnation process could be prohibitive. Currently the quarry is relatively small compared to its anticipated build-out volume which makes acquisition in the near term both expensive and less than ideal from the perspective of optimizing its value for water supply storage.

The owner of the Raleigh Quarry, Heidelburg Cement Group (HCG), is a multinational firm that is the largest aggregate producer and third largest cement producer in the world. HCG representatives have communicated the company's intention to continue mining operationswell beyond the 30-50 year window regional utilities use for long-range water supply planning. HCG has shown no interest in a voluntary sale of the quarry or arrangement to allow the City to use the existing pit while a new adjacent pit is developed for continued mining. Although the applicant does possess the powers of eminent domain, the City would owe the owner damages from condemnation of the quarry that include compensation for lost mining revenues (mineral rights). Previously estimated figures of the remaining mineral value in 2020 ranged between $350M and $970M, depending on the final litigation findings and determination of value for the lost mineral rights. While the remaining mineral value would be smaller by 2040 (the time at which the City would need to take over the Quarry to have it ready by 2045 as suggested in Alternative 3), if HCG acquires additional adjacent parcels, the size of the quarry and total mineral content may actually increase from present estimations. If the City can develop other water supply sources sufficient to meet its needs over the 50-year planning horizon, it would be preferable as it will; 1) maximize the supply value of the quarry, 2) minimize the acquisition cost, and 3) avoid an undesirable situation where the right of eminent domain might need be applied.

Source 6 – Water Purchase Agreements – Project Uncertainties

As with any water transfer agreement there is no guarantee that City's neighbors will have excess water available to augment the City's water supplies, and even if they do there is no guarantee they would be willing to sell it to the City. In addition, it's not known from which basin water would be available, so there is a potential an interbasin transfer certificate would be required for this source under Alternative 3.

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SECTION VII. PLANS TO USE JORDAN LAKE

As indicated in the description of the alternatives in Section V, the City of Raleigh and its Merger Partners are pursuing a Level II allocation of 4.7 mgd. If the City's allocation request is approved, it will immediately begin working with its fellow members of the JLP, or other utilities if necessary, to develop an agreement to purchase treated water and make use of existing or newly developed interconnections to transfer the allocated flow into their system.

If the City is unable to negotiate an agreement they will pursue more costly methods, such as the proposed intake in Harnett County to convey its allocation from the Cape Fear River. It should be noted that no one water source is sufficient to meet Raleigh's projected demands, therefore the City will concurrently work to develop one or more of the Neuse River Basin sources to include Source 1 – Falls Lake Reallocation, Source 2 – Neuse River Intake, and Source 4 – Little River Reservoir. Source 5 – Raleigh Quarry, is not a feasible source in the short term, therefore pursuit of this source will most likely be postponed, allowing the quarry volume to be increased and thereby increasing its potential yield. If and when one or more of these pursuits are successful, and the City can demonstrate its ability to satisfy its projected needs from sources within the Neuse River Basin, the City would expect NCDENR would rescind its Jordan Lake allocation. Conversely, if one or more of the Neuse River Basin sources are unable to be permitted the City may seek to convert the Jordan Lake Level II allocation to a Level I sooner rather than later.

If the sources are approved as proposed in Alternative 2 or 3 as proposed herein, the City would need to have the ability to utilize their 4.7 mgd Jordan Lake allocation by 2030 in order to guarantee supply reliability. An additional 4.1 mgd allocation would be requested and be first used between 2040 and 2050 depending upon the sequencing of the Little River Reservoir and water purchase agreements. Infrastructure would be built to handle a total allocation of 8.8 mgd in order to meet the 2060 projected demand of 37.7 mgd.

The City understands that NCDENR and the EMC are charged with balancing the needs of the region and assigning allocations from Jordan Lake in a fair and consistent manner. The City, in making this application for an allocation, is attempting to inject some certainty into its water resource planning efforts. As such, it is critical that the City receive a definitive and atemporal response to this allocation request so that as it pursues other sources the City and other stakeholders have a clear understanding of its future ability to rely on Jordan Lake to meet a portion of its future supply need. A decision from the EMC to not grant an allocation, but that leaves the door open for a future allocation, would leave the City in a position of continuing uncertainty with regard to its water resource planning efforts, and will make it more difficult to develop other sources.

Estimate of Costs

Please refer to the costs described under the Jordan Lake source (Source 3) for a description of the estimated costs for the City to utilize a Jordan Lake allocation. The Jordan Lake allocation is integrated with other supply sources into the cost estimates for Alternative 2 and Alternative 3, which include costs for all the water supply sources that comprise these respective alternatives. It should be noted that the cost presented herein represents a worst case scenario, as it assumes the City would need to obtain their Jordan Lake allocation via a new intake on the Cape Fear River near Lillington. If the allocation is granted, the City would first pursue the much more economical approach of an agreement with one or more of its neighbors and utilize existing interconnections, in lieu of developing extensive new infrastructure.

SECTION VIII. REFERENCES

City of Raleigh, 2013*. Water Resource Assessment and Plan,* 2013.

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Appendix A - Jordan Lake Allocation Round 4 Workbook

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City of Raleigh and its Merger Partners Jordan Lake Allocation Round 4 Workbook

Provide a description of the groups of customers included in each use sector or sub-sector

Use Sector	Use Sub-sector	Description
Residential		Includes all single family, residential irrigation use.
Commercial		Includes all commercial users (non-industrial), and multi-family residential*
Industrial		Includes all industrial users
Institutional		Includes all institutional users (i.e. Universities, Schools, Hospitals, etc.)
Non-Revenue	Water Treatment Plant Process Water	Calculated as ~0.25% of total water demand for 2010 and carried forward to future projection years.
	Distribution System Process Water	Includes line flushing and hydrant testing. Calculated as ~4.75% of total water demand for 2010 and carried forward to future projection years.
	Other	Includes unbilled water, construction, waterline breaks, street cleaning, and Fire Department use. Calculated as ~9% of total water demand for 2010 and carried forward to future projection years.
Unique		

*The City of Raleigh has recently recoded its billing system and moved multi-family accounts into the residential category.
Long range projections were made based on the 2010 billing data, therefore multi-family accounts were included in the commercial category for this analysis.

Local Water Supply Plan supplemental information for Jordan Lake Allocation Application

Applicant	City of Raleigh & Merger Partners
Date	14-Nov-14

Projections

Type of Population to be Served		2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Year-round population		485,219	561,882	638,500	718,843	799,100	879,441	963,200	1,048,700	1,134,200	1,225,200	1,316,200
Seasonal Population (if applicable)												
Indicate months of seasonal use												
	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec

Type of Use (Average Daily Service Area Demand in Million Gallons per Day (MGD) Do not include sales to other systems)		2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
(1) Residential		29.43	32.94	36.45	40.35	44.26	47.97	51.67	54.91	58.12	61.61	65.08
Metered Irrigation												
(2) Commercial		11.42	12.78	14.17	15.66	17.16	18.61	20.09	21.31	22.56	23.91	25.26
Metered Irrigation												
(3) Industrial		1.30	1.45	1.61	1.78	1.96	2.12	2.28	2.43	2.57	2.72	2.88
Metered Irrigation												
(4) Institutional		3.40	3.81	4.19	4.66	5.08	5.54	5.93	6.34	6.72	7.12	7.52
Metered Irrigation												
Sub-total		45.55	50.98	56.42	62.45	68.46	74.25	79.97	84.99	89.97	95.35	100.74
(5) System Processes % as Decimal	0.05	2.29	2.56	2.84	3.14	3.44	3.73	4.02	4.27	4.52	4.79	5.06
(6) Unaccounted-for Water % as Decimal	0.09	4.16	4.66	5.15	5.70	6.25	6.78	7.30	7.76	8.22	8.71	9.20
(7) Total Service Area Demand		52.0	58.2	64.4	71.3	78.2	84.8	91.3	97.0	102.7	108.9	115.0

Sales Commitments		**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Existing Sales Contracts (list buyer and years covered by contract)												
Fuquay-Varina		0.75	0.75	0.75								
Existing commitments for additional Future Sales (list buyer)												
Total Sales Contracts		0.75	0.75	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total System Demand		52.8	58.9	65.2	71.3	78.2	84.8	91.3	97.0	102.7	108.9	115.0
		2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**

Future Supplies List all new supplies or facilities which were under development as of July 1, 2012							
Source or Facility Name	PWSID	SW or GW	Sub-Basin	Wat Qual Classification	Expected Supply	Development Time	Year Online
Falls Lake (Existing WS Pool)	03-92-010	SW	10-1	WS-IV, NSW	66.1	-	1983
Swift Creek	03-92-010	SW	10-1		11.2	-	2010
Falls Lake (4.1 BG Reallocation from FLWQP)	(03-92-010)	SW	10-1	WS-IV, NSW	14	5	2020
Neuse River Intake near NR WWTP	(03-92-010)	SW	10-1	C , NSW	25	5	2030
Jordan Lake	(03-92-010)	SW	2-3	WS-IV, NSW	8.8	10	2030
Little River Reservoir	(03-92-010)	SW	10-1	WS-II, NSW	13.7	15	2040
High Flow Skimming of Neuse River with Off-stream Storage in Raleigh Quarry	(03-92-010)	SW	10-1	WS-IV, NSW	8 - 14.7	10	2045

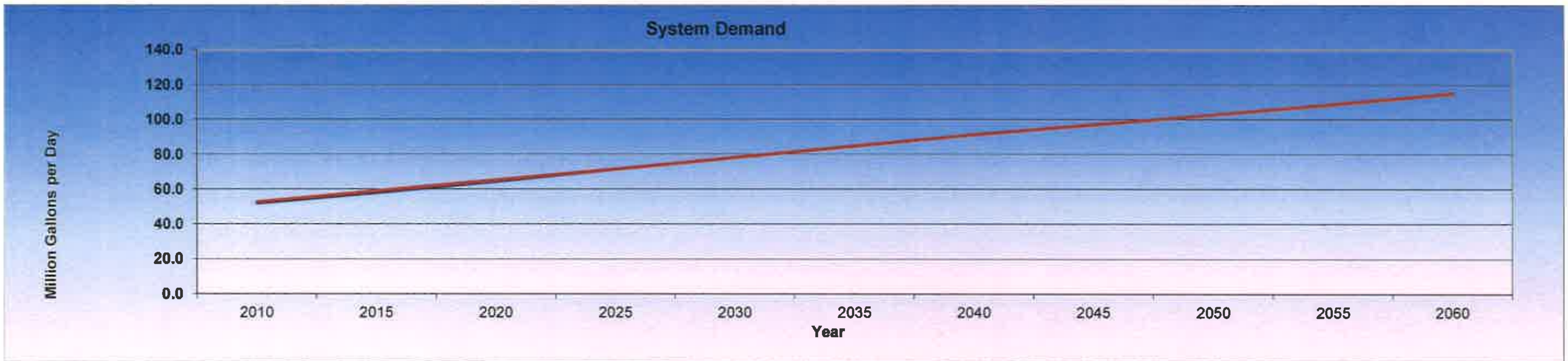
Demand - Supply Comparison (Show all quantities in Million Gallons per Day)											
Available Supply , MGD	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
(1) Existing Surface Water Supply	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3
(2) Existing Ground Water Supply											
(3) Existing Purchase Contracts											
(4) Future Supplies											
(5) Total Available Supply	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3
(6) Service Area Demand	52.0	58.2	64.4	71.3	78.2	84.8	91.3	97.0	102.7	108.9	115.0
(7) Existing Sales Contracts	0.75	0.75	0.75								
(8) Contracts for Future Sales											
(9) Total Average Daily Demand	52.8	58.9	65.2	71.3	78.2	84.8	91.3	97.0	102.7	108.9	115.0
(10) Demand as Percent of Supply		76%	84%	92%	101%	110%	118%	126%	133%	141%	149%
Additional Information for J.L. Allocation											
(12) Sales Under Existing Contracts											
(13) Expected Sales Under Future Contracts											
(14) Demand in Each Planning Period	52.0	58.2	64.4	71.3	78.2	84.8	91.3	97.0	102.7	108.9	115.0
(15) Supply Deficit (Demand minus Supply)	(25.3)	(19.1)	(12.9)	(6.0)	0.9	7.5	14.0	19.7	25.4	31.6	37.7
Peak Day Demand	73	81	90	100	109	119	128	136	144	152	161
Assumed Peak Day to Annual Average Day factor	1.4										

Supply Utilization in Basin 10-1	99%
Supply Utilization in Basin 10-2	1%

2009-2012 average return to Basin 10-1 — 90.2%

2009-2012 average re Smith Creek — 1.3% — 2.6%

NR WWTP — 87.6%



System Demand
Million Gallons per Day
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
2060
Year

City of Raleigh & Merger Partners	Applicant
14-Nov-14	Date

Future Supply Alternative 1
List the Components of each alternative scenario including the expected period when each component will come online. Show all water volumes in millions of gallons per day

	(label the alternative presented in this table)										
	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
(1) Line (15) From Demand - Supply Comparison Table	25.3	19.1	12.9	6.0	(0.9)	(7.5)	(14.0)	(19.7)	(25.4)	(31.6)	(37.7)
Source 1 (Falls lake Reallocation)			14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Source 2a (Neuse River Intake)						23.7	23.7	23.7	23.7	23.7	23.7
(3) Supply Available for future needs	**25.3**	**19.1**	**26.9**	**20.0**	**13.1**	**30.2**	**23.7**	**18.0**	**12.3**	**6.1**	**(0.0)**
(4) Total discharge to Source Basin	47.6	53.1	58.8	64.3	70.5	76.4	82.3	87.5	92.6	98.2	103.7
(5) Consumptive Use in Source Basin	4.4	5.0	5.5	6.0	6.6	7.1	7.7	8.2	8.7	9.2	9.7
(6) Total discharge to Receiving Basin	0.7	0.8	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.4	1.5
(7) Consumptive Use in Receiving Basin	0.04	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.10
(8) Amount NOT returned to Source Basin	**0.7**	**0.8**	**0.9**	**1.0**	**1.1**	**1.2**	**1.3**	**1.4**	**1.4**	**1.5**	**1.6**
(9) Total Average Daily Demand	**52.8**	**58.9**	**65.2**	**71.3**	**78.2**	**84.8**	**91.3**	**97.0**	**102.7**	**108.9**	**115.0**
Peak Day Demand	**73**	**81**	**90**	**100**	**109**	**119**	**128**	**136**	**144**	**152**	**161**
E.M. Johnson WTP Capacity *	86	86	86	100	100	100	120	120	120	120	120
D.E. Benton WTP Capacity *	20	20	20	20	20	40	40	40	40	40	40
Peak Day Demand as % of WTP Capacity *	69%	77%	85%	83%	91%	85%	80%	85%	90%	95%	101%

* - timing of facility expansions done so as to keep peak day demand <= 85% of WTP Capacity except at the run out of the planning horizon

List details of the future supply options included in this alternative scenario

Future Source	PWSID	SW or GW	GS 143-215.22G Basin	Wat. Qual Classification	Additional Supply mgd	Development Time (years)	Year Online
Falls Lake	03-92-010	SW	2-3	WS-IV, B; NS	14	5	2020
Neuse River Intake	03-92-010	SW	10-1	C; NSW	23.7	5	2030

City of Raleigh & Merger Partners	Applicant
14-Nov-14	Date

Future Supply Alternative 2

List the Components of each alternative scenario including the expected period when each component will come online. Show all water volumes in millions of gallons per day

	(label the alternative presented in this table)										
	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
(1) Line (15) From Demand - Supply Comparison Table	25.3	19.1	12.9	6.0	(0.9)	(7.5)	(14.0)	(19.7)	(25.4)	(31.6)	(37.7)
Source 2b(Neuse River Intake)			15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Source 3 (Jordan Lake Allocation)					4.7	4.7	4.7	4.7	8.8	8.8	8.8
Source 4 (Little River Reservoir)							13.7	13.7	13.7	13.7	13.7
Source 6 (Water Purchase Agreement)										0.2	0.2
(3) Supply Available for future needs	**25.3**	**19.1**	**27.9**	**21.0**	**18.8**	**12.2**	**19.4**	**13.7**	**12.1**	**6.1**	**(0.0)**
(4) Total discharge to Source Basin	47.6	53.1	58.8	64.3	66.2	72.2	78.1	83.2	84.7	90.2	95.8
(5) Consumptive Use in Source Basin	4.4	5.0	5.5	6.0	6.2	6.7	7.3	7.8	7.9	8.4	9.0
(6) Total discharge to Receiving Basin	0.7	0.8	0.9	0.9	5.3	5.4	5.5	5.6	9.4	9.5	9.6
(7) Consumptive Use in Receiving Basin	0.04	0.05	0.06	0.06	0.46	0.47	0.47	0.48	0.83	0.83	0.84
(8) Amount NOT returned to Source Basin	**0.7**	**0.8**	**0.9**	**1.0**	**5.8**	**5.9**	**6.0**	**6.1**	**10.2**	**10.3**	**10.4**
(9) Total Average Daily Demand	**52.8**	**58.9**	**65.2**	**71.3**	**78.2**	**84.8**	**91.3**	**97.0**	**102.7**	**108.9**	**115.0**
Peak Day Demand	**73**	**81**	**90**	**100**	**109**	**119**	**128**	**136**	**144**	**152**	**161**
E.M. Johnson WTP Capacity *	86	86	86	86	100	100	100	100	100	100	100
D.E. Benton WTP Capacity *	20	20	40	40	40	40	40	40	50	50	50
Zebulon (LRR) WTP *							20	20	20	20	20
Peak Day Demand as % of WTP Capacity *	69%	77%	72%	79%	78%	85%	80%	85%	85%	89%	95%

* - timing of facility expansions done so as to keep peak day demand <= 85% of WTP Capacity except at the run out of the planning horizon

List details of the future supply options included in this alternative scenario

Future Source	PWSID	SW or GW	GS 143-215.22G Basin	Wat. Qual Classification	Additional Supply mgd	Development Time (years)	Year Online
Neuse River Intake	03-92-010	SW	10-1	C; NSW	23.7	5	2030
Jordan Lake	03-92-010	SW	2-3	WS-IV; CA	8.8	10	2030
Little River Reservoir	03-92-010	SW	10-1	WS-II; HQW,	13.7	15	2040

City of Raleigh & Merger Partners	Applicant
14-Nov-14	Date

Future Supply Alternative 3

List the Components of each alternative scenario including the expected period when each component will come online. Show all water volumes in millions of gallons per day

	(label the alternative presented in this table)										
	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
(1) Line (15) From Demand - Supply Comparison Table	25.3	19.1	12.9	6.0	(0.9)	(7.5)	(14.0)	(19.7)	(25.4)	(31.6)	(37.7)
Source 2b (Neuse river Intake)			15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Source 3 (Jordan Lake Allocation)					4.7	4.7	8.8	8.8	8.8	8.8	8.8
Source 6 (Water Purchase Agreement)							3.3	3.3	3.3	3.3	3.3
Source 5 (Quarry)								10.6	10.6	10.6	10.6
(3) Supply Available for future needs	**25.3**	**19.1**	**27.9**	**21.0**	**18.8**	**12.2**	**13.1**	**18.0**	**12.3**	**6.1**	**(0.0)**
(4) Total discharge to Source Basin	47.6	53.1	58.8	64.3	66.2	72.2	74.4	79.5	84.7	90.2	95.8
(5) Consumptive Use in Source Basin	4.4	5.0	5.5	6.0	6.2	6.7	7.0	7.4	7.9	8.4	9.0
(6) Total discharge to Receiving Basin	0.7	0.8	0.9	0.9	5.3	5.4	9.3	9.3	9.4	9.5	9.6
(7) Consumptive Use in Receiving Basin	0.04	0.05	0.06	0.06	0.46	0.47	0.47	0.48	0.83	0.83	0.84
(8) Amount NOT returned to Source Basin	**0.7**	**0.8**	**0.9**	**1.0**	**5.8**	**5.9**	**9.7**	**9.8**	**10.2**	**10.3**	**10.4**
(9) Total Average Daily Demand	**52.8**	**58.9**	**65.2**	**71.3**	**78.2**	**84.8**	**91.3**	**97.0**	**102.7**	**108.9**	**115.0**
Peak Day Demand	**73**	**81**	**90**	**100**	**109**	**119**	**128**	**136**	**144**	**152**	**161**
E.M. Johnson WTP Capacity *	86	86	86	100	100	100	100	120	120	120	120
D.E. Benton WTP Capacity *	20	20	20	20	40	40	40	40	50	50	50
Peak Day Demand as % of WTP Capacity *	69%	77%	85%	83%	78%	85%	88%	83%	82%	87%	92%

* - timing of facility expansions done so as to keep peak day demand <= 85% of WTP Capacity except at the run out of the planning horizon

List details of the future supply options included in this alternative scenario

Future Source	PWSID	SW or GW	GS 143-215.22G Basin	Wat. Qual Classification	Additional Supply mgd	Development Time (years)	Year Online
Neuse River Intake	03-92-010	SW	10-1	C; NSW	23.7	5	2020
Jordan Lake	03-92-010	SW	2-3	WS-IV; CA	8.8	10	2030
Water Purchase Agreement - Cary	03-92-010	SW	2-3	WS-IV; CA	3.3	2	2040
Neuse River Intake - Raleigh Quarry	03-92-010	SW	10-1	WS-IV; NSW	10.6	10	2045

Applicant	City of Raleigh
Date	13-Nov-14

Alternatives	Summary Description
Alternative 1	Any combination of sources 1, 2, 4, and 5 that will allow the applicant to meet its 2060 projected demand. Sources 2a and 2b are mutually exclusive and differ in terms of operation only. Source 2a assumes a new 30 mgd run-of-river intake on City owned property just upstream of the NRWWTP, expansion of D.E. Benton plant to 40 mgd, and raw water transmission facilities. The intake will be permitted to operate continuously and will have minor impacts at times on the Falls Lake WQ Pool storage. Source 2b also assumes a 30 mgd run-of-river intake with same associated facility expansions, but that the intake would only be permitted to operate intermittently such that there is no impact to Falls Lake WQ storage. We have assumed Source 1 (Falls Lake Reallocation) and 2a (Neuse River Intake) are implemented, as these two sources together could meet the City's 2060 demands.
Alternative 2	Should the combinations of alternatives that can be permitted from Sources 1, 2, 4, and 5 be insufficient to meet the City's 2060 projected demand, an allocation from Jordan Lake could be instrumental to meet supply reliability standards. Although there are many potential combinations, one broad limitation that could impact Sources 1 and 2a would be that any new supply developed would be restricted from impacting the Falls Lake WQ Pool storage. In this case, an intermittently operated Neuse River Intake (Source 2b), having no negative impact on the Falls Lake WQ Pool, combined with the proposed Little River Reservoir and an 8.8 mgd Jordan Lake Allocation would nearly satisfy the expected additional need of 37.7 mgd in 2060. In addition, a small interlocal purchase of 0.2 mgd would be required.
Alternative 3	A variant of Alternative 2 assuming that, in addition to restrictions on impacting the Falls Lake WQ Pool, hurdles to permitting the Little River Reservoir are too great and that, instead, the Raleigh Quarry is acquired and put into service around 2045 when Sources 2b and 3 combined with existing supplies would be reaching their yield limit. This timing may not allow the quarry to be mined to its fullest extent. The quarry volume is assumed to be 6 billion gallons several years prior to 2050 when it must be prepared for service as a water supply and the additional yield is calculated based on the 6 BG volume. Finally, a purchase agreement for 3.3 mgd would be necessary to meet the remainder of the 2060 projected demand.

	Alternative 1	Alternative 2	Alternative 3
Allocation Request (% of storage)	0%	4.7%	4.7%
Total Supply (MGD)	37.7 mgd	37.7 mgd	37.7 mgd
Environmental Impacts	See Table V.4 of the application	See Table V.4 of the application	See Table V.4 of the application
Water Quality Classification	WS-IV (Source 1), C (Source 2a)	C (Source 2b), WS-IV (Source 3), & WS-II (Source 4)	C (Source 2b), & WS-IV (Sources 3 & 5)
Interbasin Transfer (MGD)	None	4.7	4.7
Regional Partnerships	UNRBA and JLP	UNRBA and JLP	UNRBA and JLP
Technical Complexity	Complex to Very Complex	Very Complex	Complex
Institutional Complexity	Very Complex	Very Complex	Very Complex
Political Complexity	Very Complex	Very Complex	Very Complex
Public Benefits	Few	Many	Few
Consistency with local plans	Yes	Yes	Yes
Total Cost ($ millions)	864	1357	1361

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Appendix B - 2012 Local Water Supply Plan

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Raleigh

2012

The Division of Water Resources (DWR) provides the data contained within this Local Water Supply Plan (LWSP) as a courtesy and service to our customers. DWR staff does not field verify data. Neither DWR, nor any other party involved in the preparation of this LWSP attests that the data is completely free of errors and omissions. Furthermore, data users are cautioned that LWSPs labeled **PROVISIONAL** have yet to be reviewed by DWR staff. Subsequent review may result in significant revision. Questions regarding the accuracy or limitations of usage of this data should be directed to the water system and/or DWR.

1. System Information

Contact Information

Water System Name:	Raleigh	PWSID:	03-92-010
Mailing Address:	P.O. Box 590 Raleigh, NC 27602	Ownership:	Municipality
Contact Person:	Leigh Ann Hammerbacher	Title:	Water Conservation Specialist
Phone:	919-996-3468	Fax:	919-996-4545
Secondary Contact:	Ed Buchan	Phone:	919-996-3471
Mailing Address:	, NC	Fax:	- -

Distribution System

Line Type	Size Range (Inches)	Estimated % of lines
Asbestos Cement	6-8	2.00 %
Cast Iron	4-12	6.00 %
Ductile Iron	3-54	75.00 %
Galvanized Iron	1-4	1.00 %
Polyvinyl Chloride	2-12	16.00 %

What are the estimated total miles of distribution system lines? 2,507 Miles

How many feet of distribution lines were replaced during 2012? 7,356 Feet

How many feet of new water mains were added during 2012? 68,848 Feet

How many meters were replaced in 2012? 9,154

How old are the oldest meters in this system? 6 Year(s)

How many meters for outdoor water use, such as irrigation, are not billed for sewer services? 8,622

What is this system's finished water storage capacity? 54.200 Million Gallons

Has water pressure been inadequate in any part of the system since last update? No

Programs

Does this system have a program to work or flush hydrants? Yes, Annually

Does this system have a valve exercise program? Yes, Annually

Does this system have a cross-connection program? Yes

Does this system have a program to replace meters? Yes

Does this system have a plumbing retrofit program? Yes

Does this system have an active water conservation public education program? Yes

Does this system have a leak detection program? Yes

Dedicated leak detection crews use specialized audio equipment to locate and repair leaks throughout the distribution system. Leak Detection is done in tandem with the Valve Maintenance program, on a daily basis, inside Raleigh, by two crews (of two to four employees). In an emergency situation, we are called to investigate a leak by dispatchers and it will be verified and prioritized.

The work is based off the grid and conducted street by street. The crew supervisors are in charge of the daily operation and how they are to move through the grids.

Various equipment is used to detect leaks, such as permaloggers. Permaloggers are small devices that attach to the water system at multiple points for a timeframe and listens/ logs the usage. These are used to survey a wider range of the water system at one time. Afterwards, the information is uploaded and any anomalies are highlighted by the specific devices that logged the information. Any red flags raised by the Permaloggers are further investigated by staff utilizing a GROUND Microphone and Correlating System. Correlating System consists of two radio outstations that communicate back to a receiver. The receiver plots the footage between the two points and allows for the leak to be pin-pointed within feet, if not within inches.

The toilet rebate program ($100 rebate for each older model toilet replaced with a new Water Sense labeled toilet) and showerhead exchange program continue to be funded through FY 13.

Water Conservation

What type of rate structure is used? Increasing Block

How much reclaimed water does this system use? 0.400 MGD For how many connections? 27

Does this system have an interconnection with another system capable of providing water in an emergency? Yes

Emergency connections have been established with Durham, Cary, Fuquay Varina, and a connection with Johnston County is planned.

2. Water Use Information

Service Area

Sub-Basin(s)	% of Service Population	County(s)	% of Service Population
Neuse River (10-1)	99 %	Wake	100 %
Contentnea Creek (10-2)	1 %		

What was the year-round population served in 2012? 497,000

Has this system acquired another system since last report? No

Water Use by Type

Type of Use	Metered Connections	Metered Average Use (MGD)	Non-Metered Connections	Non-Metered Estimated Use (MGD)
Residential	159,693	19.990	5	0.000
Commercial	19,870	16.420	3	0.000
Industrial	186	2.000	0	0.000
Institutional	900	3.280	0	0.000

How much water was used for system processes (backwash, line cleaning, flushing, etc.)? 0.601 MGD

There has been an ongoing improvement in Raleigh's accounts database and billing software since November 2011. During this significant update, which remains ongoing, a tremendous amount of account and premise data was reconciled and/or deleted altogether. As a result, many, many commercial/industrial/institutional customers which were incorrectly coded as "residential" (based on the meter size) were changed into their proper category. This would explain the unusual reduction in residential volume since the 2011 Plan.

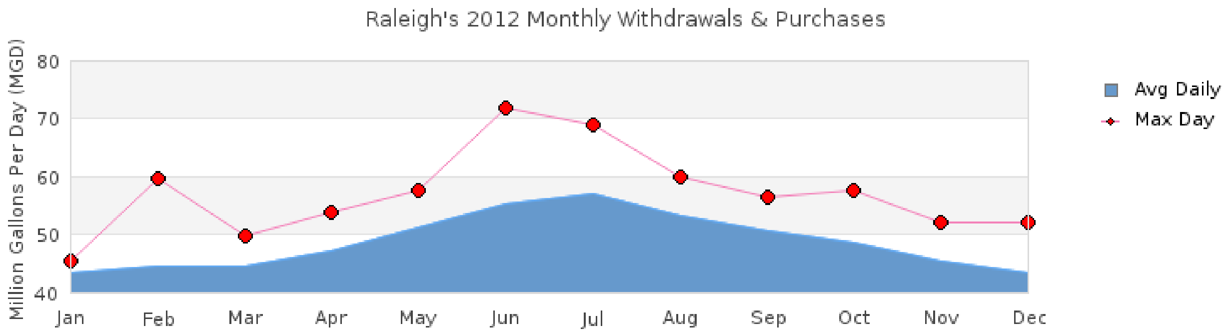
Water Sales

Purchaser	PWSID	Average Daily Sold (MGD)	Days Used	Contract MGD	Contract Expiration	Contract Recurring	Required to comply with water use restrictions?	Pipe Size(s) (Inches)	Use Type
Cary	03-92-020	0.000	0	0.000	2032	Yes	No	24	Emergency
Fuquay-Varina	03-92-055	0.001	365	0.750	2021	No	Yes	16	Regular
Holly Springs	03-92-050	0.000	0	1.200	2029	No	Yes		Emergency
Johnston County	03-51-070	0.000	0	2.150	2028	No	No	16	Emergency

3. Water Supply Sources

Monthly Withdrawals & Purchases

	Average Daily Use (MGD)	Max Day Use (MGD)		Average Daily Use (MGD)	Max Day Use (MGD)		Average Daily Use (MGD)	Max Day Use (MGD)
Jan	43.290	45.460	May	51.080	57.560	Sep	50.610	56.380
Feb	44.420	59.750	Jun	55.160	71.830	Oct	48.440	57.540
Mar	44.650	49.880	Jul	57.080	68.930	Nov	45.300	52.060
Apr	47.060	53.950	Aug	53.240	59.830	Dec	43.260	52.020



Surface Water Sources

Stream	Reservoir	Average Daily Withdrawal		Maximum Day Withdrawal (MGD)	Available Raw Water Supply		Usable On-Stream Raw Water Supply Storage (MG)
		MGD	Days Used		MGD	* Qualifier	
Neuse River	Falls Lake	40.580	365	59.600	67.000	SY50	14,600.000
Swift Creek	Lake Benson	8.050	365	13.490	11.200	SY50	2,085.000

* Qualifier: C=Contract Amount, SY20=20-year Safe Yield, SY50=50-year Safe Yield, F=20% of 7Q10 or other instream flow requirement, CUA=Capacity Use Area Permit

Surface Water Sources (continued)

Stream	Reservoir	Drainage Area (sq mi)	Metered?	Sub-Basin	County	Year Offline	Use Type
Neuse River	Falls Lake	772	Yes	Neuse River (10-1)	Wake		Regular
Swift Creek	Lake Benson	36	Yes	Neuse River (10-1)	Wake		Regular

What is this system's off-stream raw water supply storage capacity? 150 Million gallons

Are surface water sources monitored? Yes, Daily

Are you required to maintain minimum flows downstream of its intake or dam? Yes

Does this system anticipate transferring surface water between river basins? No

Water Purchases From Other Systems

Seller	PWSID	Average Daily Purchased (MGD)	Days Used	Contract			Required to comply with water use restrictions?	Pipe Size(s) (Inches)	Use Type
				MGD	Expiration	Recurring			
Cary	03-92-020	0.000	0				No	30	Emergency
Durham	03-32-010	0.000	0				No	24	Emergency
Johnston County	03-51-070	0.000	0	0.000	2028	No	Yes	16	Emergency

Water Treatment Plants

Plant Name	Permitted Capacity (MGD)	Is Raw Water Metered?	Is Finished Water Ouput Metered?	Source
Dempsey E. Benton WTP	20.000	Yes	Yes	Lake Benson
E.M. Johnson WTP	86.000	Yes	Yes	Falls Lake

Did average daily water production exceed 80% of approved plant capacity for five consecutive days during 2012? No

If yes, was any water conservation implemented?

Did average daily water production exceed 90% of approved plant capacity for five consecutive days during 2012? No

If yes, was any water conservation implemented?

Are peak day demands expected to exceed the water treatment plant capacity in the next 10 years? No

4. Wastewater Information

Monthly Discharges

	Average Daily Discharge (MGD)		Average Daily Discharge (MGD)		Average Daily Discharge (MGD)
Jan	43.014	May	43.323	Sep	46.555

Feb	43.477	Jun	42.139	Oct	44.340
Mar	46.339	Jul	43.490	Nov	42.764
Apr	43.874	Aug	44.389	Dec	42.570

How many sewer connections does this system have? 166,826

How many water service connections with septic systems does this system have? 4,668

Are there plans to build or expand wastewater treatment facilities in the next 10 years? Yes

Will expand Neuse Waste Water Facility to 75 MGD and Little River Waste Water Facility to 4 MGD

Wastewater Permits

Permit Number	Permitted Capacity (MGD)	Design Capacity (MGD)	Average Annual Daily Discharge (MGD)	Maximum Day Discharge (MGD)	Receiving Stream	Receiving Basin
NC0007528	0.000	0.000	0.000		Smith Creek	Neuse River (10-1)
NC0029033	75.000	60.000	41.907	56.640	Neuse River	Neuse River (10-1)
NC0030759	6.000	3.000	1.326	1.845	Neuse River	Neuse River (10-1)
NC0079316	2.200	1.850	0.625	1.490	Little Creek	Contentnea Creek (10-2)
NC0082376	0.000	0.000	0.000	0.000	Unnamed trib. to Honeycutt Crk	Neuse River (10-1)

Wastewater Interconnections

Water System	PWSID	Type	Average Daily Amount		Contract Maximum (MGD)
			MGD	Days Used	
Apex	03-92-045	Receiving	0.000	0	1.000
Clayton	03-51-020	Receiving	0.000	0	1.000
Johnston County	03-51-070	Receiving	0.000	0	1.000
Middlesex	04-64-050	Receiving	0.080	365	0.190

5. Planning

Projections

	2012	2020	2030	2040	2050	2060
Year-Round Population	497,000	683,300	844,500	995,700	1,225,700	1,508,800
Seasonal Population	0	0	0	0	0	0
Residential	19.990	36.450	44.260	51.670	58.120	65.080
Commercial	16.420	15.360	18.100	20.280	22.560	25.260
Industrial	2.000	1.750	2.060	2.310	2.570	2.880
Institutional	3.280	4.570	5.390	6.040	6.720	7.520
System Process	0.601	3.070	3.630	4.060	4.460	5.060
Unaccounted-for	6.205	5.590	6.590	7.380	8.220	9.200

Projection numbers are based on 2010 population and use estimates. The projected use for industrial numbers fall below the measured use in 2012. The City will revisit these numbers and provide new projected data in the 2014 Plan.

Future Supply Sources

Source Name	PWSID	Source Type	Additional Supply	Year Online	Year Offline	Type
Falls Lake	03-92-010	Surface	13.700	2017		Regular
Little River Reservoir	03-92-010	Surface	13.100	2025		Regular

The City has updated the annual Water Resources Assessment and Plan. The plan considers three additional new water resource options in addition to the Little River Reservoir, and the City is currently pursuing reallocation of the Falls Lake conservation pool to provide additional water storage.

Demand v/s Percent of Supply

2012	2020	2030	2040	2050	2060

Surface Water Supply	78.200	78.200	78.200	78.200	78.200	78.200
Ground Water Supply	0.000	0.000	0.000	0.000	0.000	0.000
Purchases	0.000	0.000	0.000	0.000	0.000	0.000
Future Supplies		13.700	26.800	26.800	26.800	26.800
Total Available Supply (MGD)	78.200	91.900	105.000	105.000	105.000	105.000
Service Area Demand	48.496	66.790	80.030	91.740	102.650	115.000
Sales	0.001	0.750	0.000	0.000	0.000	0.000
Future Sales		0.000	0.000	0.000	0.000	0.000
Total Demand (MGD)	48.497	67.540	80.030	91.740	102.650	115.000
Demand as Percent of Supply	62%	73%	76%	**87%**	**98%**	**110%**

The purpose of the above chart is to show a general indication of how the long-term per capita water demand changes over time. The per capita water demand may actually be different than indicated due to seasonal populations and the accuracy of data submitted. Water systems that have calculated long-term per capita water demand based on a methodology that produces different results may submit their information in the notes field.

Your long-term water demand is 40 gallons per capita per day. What demand management practices do you plan to implement to reduce the per capita water demand (i.e. conduct regular water audits, implement a plumbing retrofit program, employ practices such as rainwater harvesting or reclaimed water)? If these practices are covered elsewhere in your plan, indicate where the practices are discussed here.

Are there other demand management practices you will implement to reduce your future supply needs? Much of our previous demand management has focused on education regarding water conservation and efficiency. However, natural economic trends and consistently improving water fixture efficiency has depressed drinking water demands such that our pumpage has decreased every year since 2008. Our recent AWWA water audit has indicated that our unbilled water percentage is well within industry standards, and our current gallons per capita day (98 gpcd) is within the lowest 5% of the entire country. In addition, recent water utility studies have indicated this is national trend, and will most likely continue for the foreseeable future. While adding additional customers will increase overall demand over time, it is believed this will be a slow process.

What supplies other than the ones listed in future supplies are being considered to meet your future supply needs? Through the Little River Reservoir Environmental Impact Study process, local quarries have been identified as possible side stream storage options and a reallocation of the water quality pool in Falls Lake has also been evaluated.

How does the water system intend to implement the demand management and supply planning components above? Water effieciency practices will continue to be encouraged through either rebate programs or educational outreach programs. In addition, the residential tiered rate system will remain in place, which has had a significant impact on reducing demand.

The Little River Reservoir planning project will continue to move forward and additional alternatives will be evaluated through this process.

Additional Information

Has this system participated in regional water supply or water use planning? No

What major water supply reports or studies were used for planning? Studies were conducted by Hazen and Sawyer.

Please describe any other needs or issues regarding your water supply sources, any water system deficiencies or needed improvements (storage, treatment, etc.) or your ability to meet present and future water needs. Include both quantity and quality considerations, as well as financial, technical, managerial, permitting, and compliance issues: .

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Appendix C - Alternatives Cost Analysis

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HAZEN AND SAWYER
Environmental Engineers & Scientists

Summary of Variables and Constants
City of Raleigh Jordan Lake Round Four Allocation Application
Conceptual-Level Project Cost Estimates
Draft Dated 11/14/2014

Source	Source Water Alternatives	Effective Yield
S1	Falls Lake Conservation Pool Reallocation	14.0
S2A	Neuse River Intake at N. R. Wastewater Treatment Plant	25.1
S2B	Neuse River Intake at N. R. Wastewater Treatment Plant/No Falls Lake Impact*	15.0
S3	Jordan Lake	8.8
S4	Little River Reservoir	13.7
S5	Raleigh Quarry	10.6
S6A	Water Purchase Agreement	0.2
S6B	Water Purchase Agreement	3.3
SS	Supplemental EM Johnson Facility Expansion as required to meet Peak Capacity Requirements	3.3

Source	Element	Water Supply Alternatives	Year Implemented	Capacity (mgd) Avg. Day/ Yield	Maximum Day Facility Total	Maximum Day Net Increment	Maximum Day Assigned Increment
		ALTERNATIVE 1					
S1		**Falls Lake Conservation Pool Reallocation**		**14.0**	**20.0**		**20.0**
	a	Expand EMJohnson to 100 MGD, including Raw Water facilities improvements	2020		100.0	14.0	10.0
	b	Expand EMJ to 120 MGD, including Raw Water facilities improvements	2040		120.0	64.0	10.0
SS		**Supplemental EM Johnson Facility Expansion**					
	a	Expand EMJohnson to 100 MGD	2020		100.0	14.0	4.0
	b	Expand EMJ to 120 MGD	2040		120.0	20.0	10.0
S2A		**Neuse River Intake at Neuse River Wastewater Treatment Plant**	**2035**	**23.7**	**30.0**		**30.0**
	a	New Intake & PS in Neuse River	2035		30.0		30.0
	b	New Pipeline from Intake to DEB	2035		30.0		30.0
	c	Expand D.E. Benton to 40 MGD	2035		40.0		20.0
		TOTAL:		**37.7**			
		ALTERNATIVE 2					
S2B		**Neuse River Intake at N. R. Wastewater Treatment Plant/No Falls Lake Impact***		**15.0**	**15.0**		**15.0**
	a	Expand D.E. Benton to 40 MGD	2020		40.0		15.0
	b	New Intake & PS in Neuse River	2020		30.0		30.0
	c	New Pipeline from Intake to DEB	2020		30.0		30.0
	d	Expand D.E. Benton to 50 MGD	2050		50.0		5.0
SS		**Supplemental EM Johnson Facility Expansion**					
	a	Expand EMJohnson to 100 MGD, including Raw Water facilities improvements	2030		100.0	14.0	14.0
S3		**Jordan Lake**		**8.8**	**13.0**		**13.0**
	a	Round 4 Level II Allocation	2020		4.7		4.7
	b	Convert Level II to Level I Allocation	2030		4.7		4.7
	c	RW Water Facilities	2030		13.0		13.0
	d	RW Transmission & Booster PS	2030		13.0		13.0
	e	Expand D.E. Benton to 40 MGD	2020		40.0		5.0
	f	Effluent PS	2030		13.0		13.0
	g	Effluent transmission line, Booster PS, and Outlet Structure	2030		13.0		13.0
	h	Round X Level II Allocation	2030		4.1		4.1
	i	Convert Level II to Level I Allocation	2050		4.1		4.1
	j	Expand D.E. Benton to 50 MGD	2050		50.0		5.0
S4		**Little River Reservoir**		**13.7**			
	a	Dam, related facilitates and	2040				
	b	Intake, transmission main, Eastern Wake WTP	2040		20.0		20.0
S6A		**Water Purchase Agreement**	2055	**0.2**	0.2		0.2
		TOTAL:		**37.7**			
		ALTERNATIVE 3					
S2B		**Neuse River Intake at N. R. Wastewater Treatment Plant/No Falls Lake Impact***	**2020**	**15.0**	**15.0**		**15.0**
	a	Expand D.E. Benton to 40 MGD	2020		40.0		15.0
	b	New Intake & PS in Neuse River	2020		30.0		30.0
	c	New Pipeline from Intake to DEB	2020		30.0		30.0
	d	Expand D.E. Benton to 50 MGD	2050		50.0		2.0
SS		**Supplemental EM Johnson Facility Expansion**					
	a	Expand EMJohnson to 100 MGD, including Raw Water facilities improvements	2025		100.0	14.0	14.0
	b	Expand EMJohnson to 120 MGD, including Raw Water facilities improvements	2045		120.0	20.0	5.0
S3		**Jordan Lake**	**2030**	**8.8**	**13.0**		**13.0**
	a	Round 4 Level II Allocation	2020		4.7		4.7
	b	Round 4 Level I Allocation Purchase	2030		4.7		4.7
	c	Round X Level II Allocation	2030		4.1		4.1
	d	RW Intake & Piping	2030		13.0		13.0
	e	RW Transmission & Booster PS	2030		13.0		13.0
	f	Expand D.E. Benton to 40 MGD	2020		40.0		5.0
	g	Effluent PS	2030		13.0		13.0
	h	Effluent transmission line, Booster PS, and Outlet Structure	2030		13.0		13.0
	i	Round X Level I Allocation Purchase	2040		4.1		4.1
	j	Expand D.E. Benton to 50 MGD	2050		50.0		8.0
S5		**Raleigh Quarry**		**10.6**	**15.0**		**15.0**
		Quarry Purchase	2040				
	a	River Intake, PS, Piping to the quarry***	2045		50.0		50.0
	b	Quarry PS, and transmission line to EMJ	2045		15.0		15.0
	c	Expand EMJ to 120 mgd	2045		120.0		15.0
S6B		**Water Purchase Agreement**	2040	**3.3**	3.3		3.3
		TOTAL:		**37.7**			

Notes:
* No impact on Falls Lake Water Quality Pool permitted
** Expansion at EM Johnson will take place even without an increase in water supply due to need to meet peak day demand

*** Capacity required to achieve effective yield

Capital and life cycle costs are presented in 2010 dollars and were developed in compliance with the NCDENR, Division of Water Resources, Jordan Lake Water Storage Allocation Application Guidelines, Round Four, June 4, 2013.

Costs include construction, contractor profit and overhead, engineering, legal and permitting expenses, and an overall 10% contingency.

Variables and Constants

Description	Value	Units	Notes
General			
Current ENR CCI (average for 2010):	8802		
Project Cost Start Date:	2010		
Project Cost Begin Capital Finance:	2015		
Project Cost Complete Initial WTP Construction:	2020		
Project Cost Complete WTP Expansion:	2040		
Project Cost End Date:	2060		
Project Cost Lifespan:	50	years	
Calculation of Capital Costs			
Contractor Mobilization, Overhead, and Profit:	15%		
Engineering Studies, Design, and Construction Services:	15%		
Land Acquisition and Easements:	Project Specific		
Legal Fees, Permits, and Approvals:	5%		
Contingency:	10%		
Raw and Finished Water Main - Rural:	$9.00	per inch-diameter/ft	
Raw and Finished Water Main - Urban:	$15.00	per inch-diameter/ft	

Pipeline Sizing LOOKUP

Pipe Diam.	Next Largest
4	6
6	8
8	10
10	12
12	14
14	16
16	18
18	20
20	24
24	30
30	36
36	42
42	48
48	54
54	60
60	66
66	72
72	78
78	84

Calculation of Water Treatment Plant Construction Costs (Greenfield Site)

Updated EPA Cost Curves (2010, ENR CCI 8802) for Water Treatment Facilities - Refer to Cost Backup Documentation

Includes Ozone, UV, GAC, and Residuals

Does Not Include Land, Contractor Profit & Overhead, Engineering, Legal Costs, or contingencies

		Capacity (mgd)	Construction Cost (2010 $)	Cost/gal
Cost = a*(Q+1)^b				
R^2 = 0.99958		5	$23,216,000	$4.643
a =	3097698.29	25	$80,109,000	$3.204
b =	0.844652129	100	$252,044,000	$2.520
Allowance for greenfields/other	65%			

Calculation of Water Treatment Plant Expansion Costs

Updated EPA Cost Curves (2010, ENR CCI 8802) for Water Treatment Facilities - Refer to Cost Backup Documentation

Includes Ozone, UV and GAC

Does Not Include Land, Contractor Profit & Overhead, Engineering, Legal Costs, or Contingencies

		Capacity (mgd)	Construction Cost (2010 $)	Cost/gal
Cost = a*Q + b				
R^2 = 0.999882		5	$22,997,000	$4.599
a =	884746.1589	30	$71,658,000	$2.389
b =	6029467.063	100	$207,909,000	$2.079
Cost Added:	120%			

EM Johnson WTP Expansion Costs, Including WTP & Raw Water Facilities

From supporting information Sep 2012 Falls Lake Final WQ Evaluation & Impacts to Drinking Water Treatment

Facility Capacity:	100 mgd	1 mgd	Year
Capital Costs for Baseline+UV+GAC:	$ 360,700,000	$ 3,607,000	2,010
Deduct 52% for cont., eng. & Contractor OH	$ 237,300,000	$ 2,373,000	2,010
Estimated salvage value existing facilities:	$ 200,000,000	$ 2,000,000	2,010
Subtotal Capital Costs (2010$):	$ 437,300,000	$ 4,373,000	2,010
O&M Costs			
		1 mgd	
Annual O&M Costs (Baseline+UV+GAC):		$ 515,000	2,010

Calculation of Life Cycle Costs			
Discount Rate:	1.295%		
Capital /Rehabilitation and Replacement Costs			
Issuing Expense:	0.0%		
Capital Recovery Interest Rate:	3.225%		
Financing Term (Years):	25	years	
Equipment Lifespan:	25	years	
Pipelines/Structures Lifespan:	50	years	
Equipment Replacement as % of Total Construction Cost:	15%		
Number of Years Replacement Equipment Defrayed Over:	5	years	
Operation and Maintenance Costs			
Annual O&M Costs as Percent of Construction Costs:	10%		
Fixed O&M Costs as % of Total O&M Costs:	70%		
Variable O&M Costs as % of Total O&M Costs:	30%		
Variable O&M Cost Constant (mgd, 70% eff, Kw-hr/yr):	2,195		
Energy Cost:	$0.082	per kW-hr electrical energy	
Level I Allocation Costs	Jordan Lake		Falls Lake* -NEED TO CONFIRM
Total Purchase Cost:	$91,041.00	per mgd	$100,000 per mgd
Annual Cost for Subsequent Years (aso Level II Annual Cost):	$2,220.00	per mgd/yr	2500 per mgd/yr
Additional Fixed Administration Cost (annual):	$250		$250
Finished Water Purchase Costs			
Annual Purchase Cost: @ $3.00/1,000 gals	$1,095,000.00	per mgd	

Capital Cost Recovery Interest Rate, ic:	3.2250%
Discount Rate, i:	1.2950%
Capital Cost Financing term:	25
Present Year:	2015

Year Implemented	2020	2025	2030	2035	2040	2045	2050	2055
Number of years from Present Year to Implementation Year, n1	5	10	15	20	25	30	35	40
Effective Capital Recovery Term (Nc): 25 yrs or implementation year to 2060 if less	25	25	25	25	20	15	10	5
Number of years from Implementation Year to 2060	40	35	30	25	20	15	10	5
Present Worth Factor from Implementation Year to Present Year	0.9377	0.8793	0.8245	0.7731	0.7249	0.6798	0.6374	0.5977
Factor for Present Worth of Capital Cost Financing	1.1727	1.0996	1.0311	0.9668	0.7478	0.5425	0.3499	0.1693
Present Worth Factor for Annual O&M Costs	29.1303	24.6187	20.3881	16.4211	12.7014	9.2134	5.9427	2.8758

Source	Source Water Alternatives	Effective Yield
S1	Falls Lake Conservation Pool Reallocation	14.0
S2A	Neuse River Intake at N. R. Wastewater Treatment Plant/No Falls Lake Impact*	15.0
S2B	Neuse River Intake at N. R. Wastewater Treatment Plant	25.1
S3	Jordan Lake	8.8
S4	Little River Reservoir	13.7
S5	Raleigh Quarry	10.6
S6A	Water Purchase Agreement	0.2
S6B	Water Purchase Agreement	3.3
SS	Supplemental EM Johnson Facility Expansion as required to meet Peak Capacity Requiremen	3.3

Summary of Alternative 1 Costs

Increase in Average Day Water Supply: 37.7 mgd

Capital Costs (2010 Dollars)

Source	Description	Year Implemented 2020	2025	2030	2035	2040	2045	2050	2055	Total	$/MGD
	Total Capital Costs by Year Implemented[1]										
S1	Falls Lake Conservation Pool Reallocation	$67,677,250				$65,255,000				132932250.00	
S2B	Neuse River Intake at N. R. Wastewater Treatment Plant				$150,280,000					$150,280,000	
SS	Supplemental EM Johnson Facility Expansion	$26,132,000				$65,255,000					
	Total Capital Costs	**$93,800,000**			**$150,300,000**	**$130,500,000**				**$374,600,000**	**$9,900,000**
	O&M and Present Worth Costs										
	Annual O&M Costs[2]										
S1	Falls Lake Conservation Pool Reallocation	$5,200,000				$5,150,000					
S2B	Neuse River Intake at N. R. Wastewater Treatment Plant				$10,300,000						
SS	Supplemental EM Johnson Facility Expansion	$2,060,000				$5,150,000					
		$7,260,000			**$10,300,000**	**$10,300,000**				**$27,860,000**	**$700,000**
	Present Worth of Capital Cost Financing	$110,000,000			$145,310,000	$97,590,000				**$352,900,000**	
	Present Worth of O&M Costs	$211,490,000			$169,140,000	$130,820,000				**$511,450,000**	
	Total PW Costs	**$321,490,000**			**$314,450,000**	**$228,410,000**				**$864,350,000**	**$22,900,000**

Summary of Alternative 2 Costs

Increase in Average Day Water Supply: 37.7 mgd

Capital Costs (2010 Dollars)

Source	Description	Year Implemented 2020	2025	2030	2035	2040	2045	2050	2055	Total	$/MGD
	Total Capital Costs by Year Implemented[1]										
S2B	Neuse River Intake at N. R. Wastewater Treatment Plant	$129,440,000						$35,250,000		**$164,690,000**	
SS	Supplemental EM Johnson Facility Expansion			$92,910,000						**$92,910,000**	
S3	Jordan Lake	$34,340,270		$167,593,764				$35,040,810		**$236,974,845**	
S4	Little River Reservoir					$339,740,000				**$339,740,000**	
S6A	Water Purchase Agreement									**$0**	
	Total Capital Costs	**$163,780,270**		**$260,503,764**		**$339,740,000**		**$70,290,810**		**$834,314,845**	**$22,100,000**
	O&M and Present Worth Costs										
	Annual O&M Costs[2]										
S2B	Neuse River Intake at N. R. Wastewater Treatment Plant	$7,725,000						$2,575,000			
SS	Supplemental EM Johnson Facility Expansion			$7,210,000							
S3	Jordan Lake	$2,585,684		$429,352				$2,575,000			
S4	Little River Reservoir					$10,300,000					
S6A	Water Purchase Agreement								$220,000		
	Total Annual O&M Costs:	**$10,310,684**		**$7,639,352**	**$0**	**$10,300,000**		**$5,150,000**	**$220,000**	**$33,620,036**	**$900,000**
	Present Worth of Capital Cost Financing	$192,060,000		$268,600,000		$254,060,000		$24,590,000	$0	**$739,310,000**	
	Present Worth of O&M Costs	$300,350,000		$155,750,000		$130,820,000		$30,600,000	$630,000	**$618,150,000**	
	Total PW Costs	**$492,410,000**		**$424,350,000**		**$384,880,000**		**$55,190,000**	**$630,000**	**$1,357,460,000**	**$36,000,000**

Summary of Alternative 3 Costs

Increase in Average Day Water Supply: 37.7 mgd

Capital Costs (2010 Dollars)

Source	Description	Year Implemented 2020	2025	2030	2035	2040	2045	2050	2055	Total	$/MGD
	Total Capital Costs by Year Implemented[1]										
S2B	Neuse River Intake at N. R. Wastewater Treatment Plant	$129,440,000						$35,250,000		**$164,690,000**	
SS	Supplemental EM Johnson Facility Expansion		$92,910,000				$33,260,000				
S3	Jordan Lake	$34,340,270		$167,593,764				$49,199,807		**$251,133,841**	
S5	Raleigh Quarry					$168,630,000	$163,390,000			**$332,020,000**	
S6B	Water Purchase Agreement									**$0**	
	Total Capital Costs	**$163,780,270**	**$92,910,000**	**$167,593,764**		**$168,630,000**	**$196,650,000**	**$84,449,807**		**$747,843,841**	**$19,800,000**
	O&M and Present Worth Costs										
	Annual O&M Costs[2]										
S2B	Neuse River Intake at N. R. Wastewater Treatment Plant	$7,725,000						$2,575,000			
SS	Supplemental EM Johnson Facility Expansion		$7,210,000				$2,575,000				
S3	Jordan Lake	$2,585,684		$429,352				$4,120,000			
S5	Raleigh Quarry						$7,725,000				
S6B	Water Purchase Agreement								$3,610,000		
	Total Annual O&M Costs:	**$10,310,684**	**$7,210,000**	**$429,352**			**$10,300,000**	**$6,695,000**	**$3,610,000**	**$38,555,036**	**$1,000,000**
	Present Worth of Capital Cost Financing	$192,060,000	$102,160,000	$172,800,000		$126,100,000	$106,670,000	$29,550,000	$0	**$729,340,000**	
	Present Worth of O&M Costs	$300,350,000	$177,500,000	$8,750,000		$0	$94,900,000	$39,790,000	$10,380,000	**$631,670,000**	
	Total PW Costs	**$492,410,000**	**$279,660,000**	**$181,550,000**		**$126,100,000**	**$201,570,000**	**$69,340,000**	**$10,380,000**	**$1,361,010,000**	**$36,100,000**

The initial capital costs shown are the total projected costs (in 2010 Dollars) for the initial construction and are assumed to be financed, for simplicity, in the year of implementation.
Capital costs shown for subsequent years are marginal/incremental costs for facility expansions and are assumed to be financed in the indicated year.
Similarly, the initial annual O&M costs shown are assumed to occur in the year of implementation and to be repeated annually thereafter. Costs shown for subsequent years are marginal costs associated with facility expansions.
Annual costs are based on actual O&M costs for Raleigh's EM Johnson WTP and RW facilities. Costs for Source 3, Jordan Lake, include O&M costs for transmission facilities associated with the return of treated wastewater effluent to the Cape Fear Basin.
Because of the operational complexity of the various source components, O&M costs are not adjusted for variations in water production rates from year to year.

Appendix D - Falls Lake EFDC Model Analysis

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Technical Memorandum

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PREPARED FOR: City of Raleigh

FROM: Hazen and Sawyer

PREPARED BY: Matthew Jones and Reed Palmer

DATE: November 4, 2014

SUBJECT: Falls Lake EFDC Model
Evaluation of Alternative Reservoir Withdrawals
H&S Project 31089-001

Introduction

In order to address projected water supply deficits as the population and water demand of the Raleigh service area continue to grow, the City of Raleigh and its consultants are evaluating a number of water supply alternatives. Some of these alternatives, which are being evaluated in the context of the Environmental Impact Statement (EIS) for the proposed Little River Reservoir, involve altering withdrawals from Falls Lake, the primary source of raw water for the City. The most promising of these alternatives, Alternative A.4, involves permanently reallocating part of the water quality pool within Falls Lake to the water supply pool. This alternative would make it possible to withdraw water at a higher rate and greater overall volume from the reservoir in order to meet water supply needs. Details of this alternative allocation are discussed later in this memo and elsewhere.

One concern that has been raised regarding Alternative A.4 is the potential impact of increased withdrawals upon water quality within the reservoir. Falls Lake is designated as a nutrient-sensitive waterbody and is listed on the North Carolina Draft 2012 303(d) list for chlorophyll-*a* (Chl-a) and turbidity impairments. The North Carolina Department of Environment and Natural Resources (NCDENR) has developed a nutrient management strategy to address this impairment. There is a concern that modified withdrawals from the reservoir could degrade water quality within Falls Lake. If this were the case, these withdrawals would exacerbate water quality concerns, hinder water quality improvement efforts, and generally downgrade the feasibility of Alternative A.4.

In order to assist in developing the nutrient management strategy for the Falls Lake Watershed, the NCDENR Division of Water Resources (DWR) Modeling & TMDL Unit developed a nutrient response model for Falls Lake. This effort was completed in 2009 utilizing the Environmental Fluid Dynamics Code (EFDC) model framework, and was developed under the guidance of the Falls Lake Technical Advisory Committee. Discussion of the model inputs, assumptions, calibration, and validation can be found within the Falls Lake Nutrient Response Model Final Report, published by the NCDENR DWR Modeling & TMDL Unit on November 30th, 2009 (2009 NCDENR Report).

A key purpose of the EFDC model was to simulate Chl-a concentrations within the reservoir. Because Chl-a in the water is associated with photosynthesizing algae, it serves as an indicator of eutrophication.

North Carolina has established a Chl-a standard of 40 µg/L, which applies to Falls Lake. A goal established by DWQ statewide indicates that this standard should be exceeded with a frequency of less than 10%. The objective of the existing EFDC model was to predict chlorophyll-*a* concentrations within the lake in response to reductions in nutrient loading from the various tributaries, in support of developing a nutrient management strategy for Falls Lake.

As the EFDC model is the best available simulation of water quality within Falls Lake, the model was utilized to analyze the effect of alternative withdrawals on Chl-a concentrations to demonstrate whether or not there will be negative impacts on water quality resulting from re-allocation. Because alternative withdrawal scenarios were not considered during the original development of the EFDC model for Falls Lake, results may not provide a definitive assessment of expected reservoir water quality for different withdrawal scenarios; however, the EFDC model provides the only effective means of evaluating potential water quality impacts at this time. Due to understood model constraints, these analyses are expected to provide a comparative indication of changes in water quality response within the lake as a result of the alternative withdrawal scenarios. If consistent and substantial changes in Chl-a concentrations are evident, further analyses may be needed to understand the contributing factors and potential impacts on overall water quality within Falls Lake.

EFDC Model Background

The Falls Lake EFDC model contains 21 inflow locations, 1 outflow location, and 519 total computational grids distributed across the lake (Figure 1). The EFDC model was setup to cover the period from March 2005 through October 2007, with inflow and outflow model inputs developed from historical data. The model was calibrated with data from 2005 and 2006, and validated using 2007 data. Analyses for development of the nutrient management plan focused predominantly upon 2006 simulations, as 2005 and 2007 were both affected by drought conditions and more data was available for 2006. Consequently, simulations of withdrawal alternatives focused on 2006 data.

The EFDC model simulates numerous aspects of water quantity and quality within the lake across four vertical layers at each of the model grid locations. Although the model provides output information on a variety of water quality parameters, information on Chl-a was of particular interest for development of the nutrient management plan and assessment of compliance with water quality goals. For the nutrient management plan, compliance with the Chl-a target of 40 µg/l specifically focused on the NEU013B monitoring site, which is located approximately 1 mile southeast of Interstate 85 (Figure 1). Based upon model outputs, it is possible to evaluate the Chl-a concentration averaged over the photic zone depth at the compliance point and other locations continuously throughout the duration of simulations.

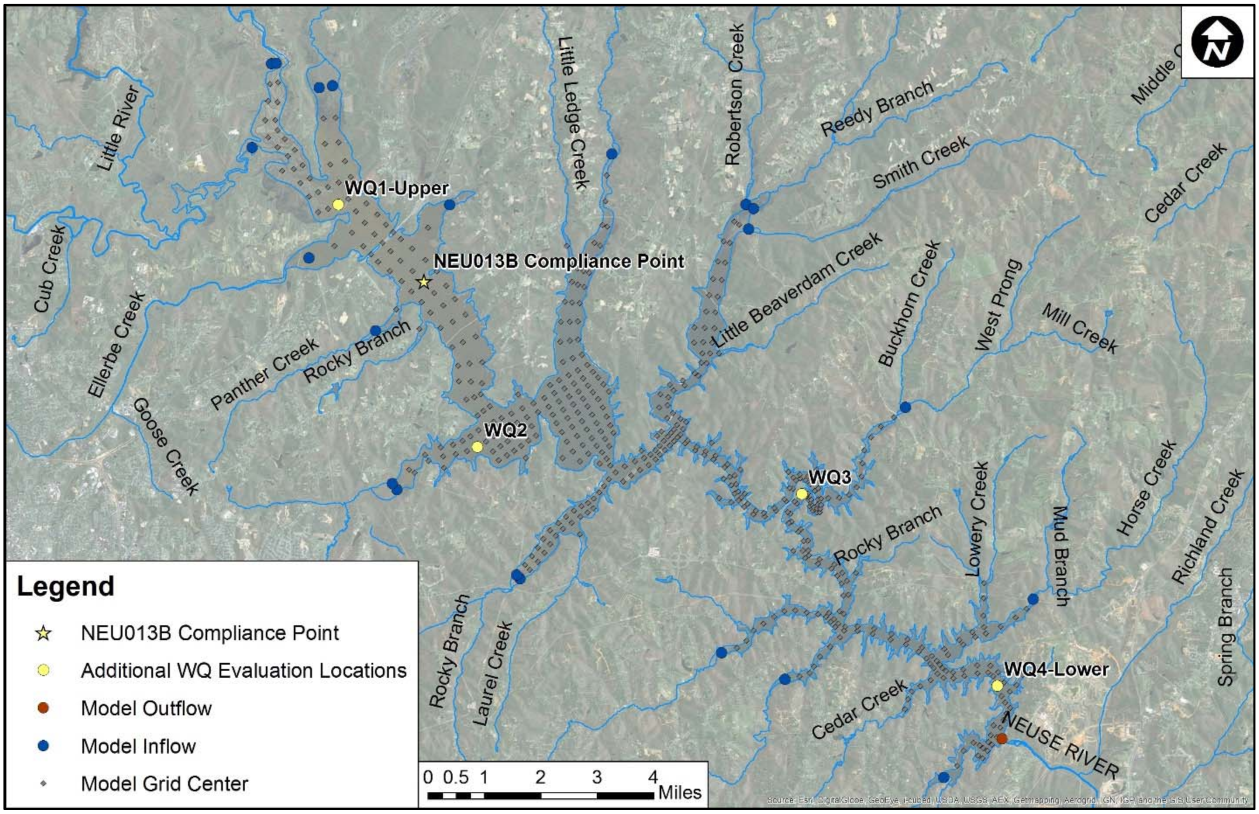

Figure 1: Geographic layout of Falls Lake EFDC model

Approach

Hazen and Sawyer obtained a copy of the EFDC model developed for Falls Lake from NCDENR in May 2012. Before evaluating any alternatives, the model was run utilizing existing input files for 2005, 2006, and 2007. These simulations are hereinafter referred to as the historical model, since they were intended to replicate historical conditions and did not reflect any changes in nutrient inputs to the reservoir or reservoir withdrawals. Results from these simulations were in agreement with those published in the 2009 NCDENR Report, confirming that the model was operating as intended.

Hydrologic Modeling to Simulate Outflow

In order to utilize the EFDC model to evaluate potential impacts from alternative withdrawals, it was necessary to modify the outflow time series utilized in EFDC. Water quality evaluations considered three hydrologic scenarios: historical withdrawals, maximum possible withdrawals under the current allocation, and maximum possible withdrawals under the A.4 allocation. The existing EFDC model utilizes a single outflow time series, located at the face of the dam, to simulate both releases and water supply withdrawals. After evaluation of several hydrologic modeling alternatives, the preferred approach to simulate reservoir outflow involved direct changes to the outflow time series, informed by historical records, withdrawal and release targets, and the Neuse River Basin Model (NRBM).

The single outflow time series within EFDC actually consists of three components: the water supply withdrawal, low flow release, and storm release, all of which are impacted when simulating an increased water supply withdrawal. Hydrologic simulations for the current allocation and A.4 allocation were both based on modifications to the historical 2006 outflow time series used in the existing EFDC model, using historical withdrawal, release, and water surface elevation records combined with reservoir operation rules to partition the singular outflow in the model into its three constituent components.

For all of the hydrologic revisions, the water supply withdrawal was provided as a time series from NRBM simulations. For the current allocation scenario, this meant creating a theoretical high water supply demand, such that the Falls Lake Water Supply Pool (FLWSP) would be exhausted (but not cause a shortage) in the most severe historical hydrologic conditions (2007). The water supply withdrawal for the A.4 scenario was developed in a similar fashion, with the size of the FLSWSP increased to provide a target yield of 80.1 mgd from Falls Lake, supporting City of Raleigh's projected 2040 demand (91.3 mgd total 2040 demand = 11.2 mgd from Lake Benson and 80.1 mgd from Falls Lake). The A.4 allocation transfers 4.1 BG of volume from the Falls Lake Water Quality Pool (FLWQP) to the FLWSP. Additional assumptions utilized in NRBM simulations and a discussion of hydrologic modeling for low flow and storm releases can be found in Appendix B.

Construction of Nutrient Load Input Files

In addition to specified withdrawal scenarios, simulations were conducted for scenarios representing different nutrient inflow loads, specifically implementation of nutrient reductions anticipated under the Falls Lake Nutrient Management Strategy. Upon full implementation, the Falls Lake Nutrient Management Strategy calls for a 40% and 77% reduction in the annual mass load of nitrogen and phosphorous, respectively, delivered to the lake. Through coordination with NCDENR, this was implemented within the model by applying a 30% and 70% reduction to influent nitrogen and phosphorus loads for the 5 major upstream basins to reflect reductions from controllable sources. These nutrient reductions were implemented within the model by modifying the wqpsl.inp input file. Nutrient reduction scenarios were simulated to evaluate whether changes in reservoir withdrawals would negatively affect compliance with the Chl-a standard after implementation of the Nutrient Management Strategy.

In total, there were 6 base simulation scenarios evaluated using EFDC (Figure 2). Analyses focused predominantly on simulated Chl-a concentrations, which were averaged over the photic zone, represented by the top two model layers for most locations presented herein.

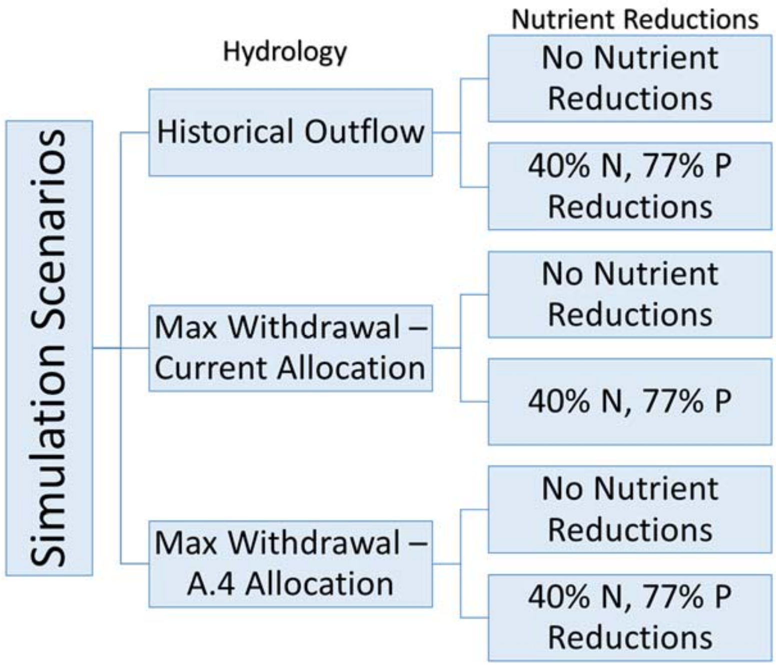

Figure 2: Breakdown of base EFDC simulation scenarios

Results and Analysis

Reservoir Hydrology

As expected, total reservoir outflows were generally highest for the A.4 allocation and lowest for the historical outflow scenario (Figure 3). It is worth noting that cumulative annual outflow was nearly equivalent for all three hydrologic scenarios. Increases in withdrawals provides more storage within the lake for storm events, reducing storm releases and causing cumulative outflows among the three hydrologic scenarios to converge during those events. This effect can be observed during 2006 for storm events in late June and mid-November.

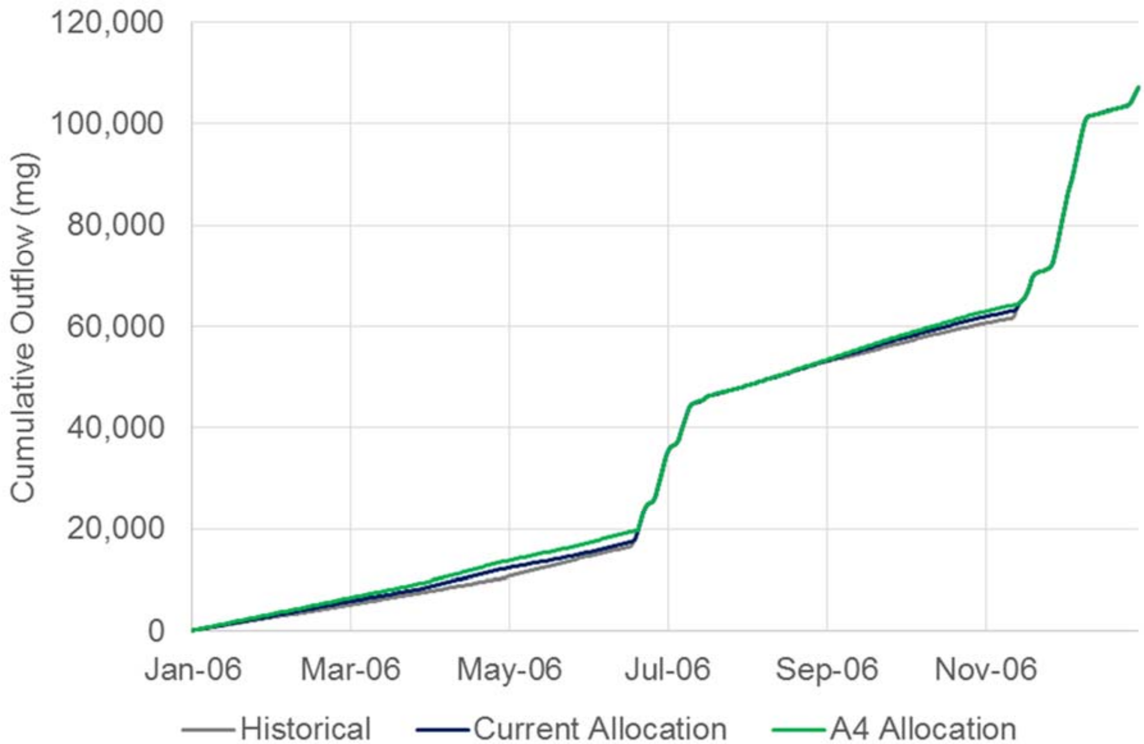

Figure 3: Cumulative reservoir outflow for the three hydrologic scenarios

Simulated water surface elevations (WSEs) exhibited similar trends, diverging during periods of dry weather and converging for large storm events (Figure 4). The largest difference between historical water surface elevations and the A4 allocation scenario was 10 inches and took place in April. When comparing the two maximum withdrawal scenarios, the water surface elevation for the A4 allocation was never more than 6.5 inches below the result for the current allocation.

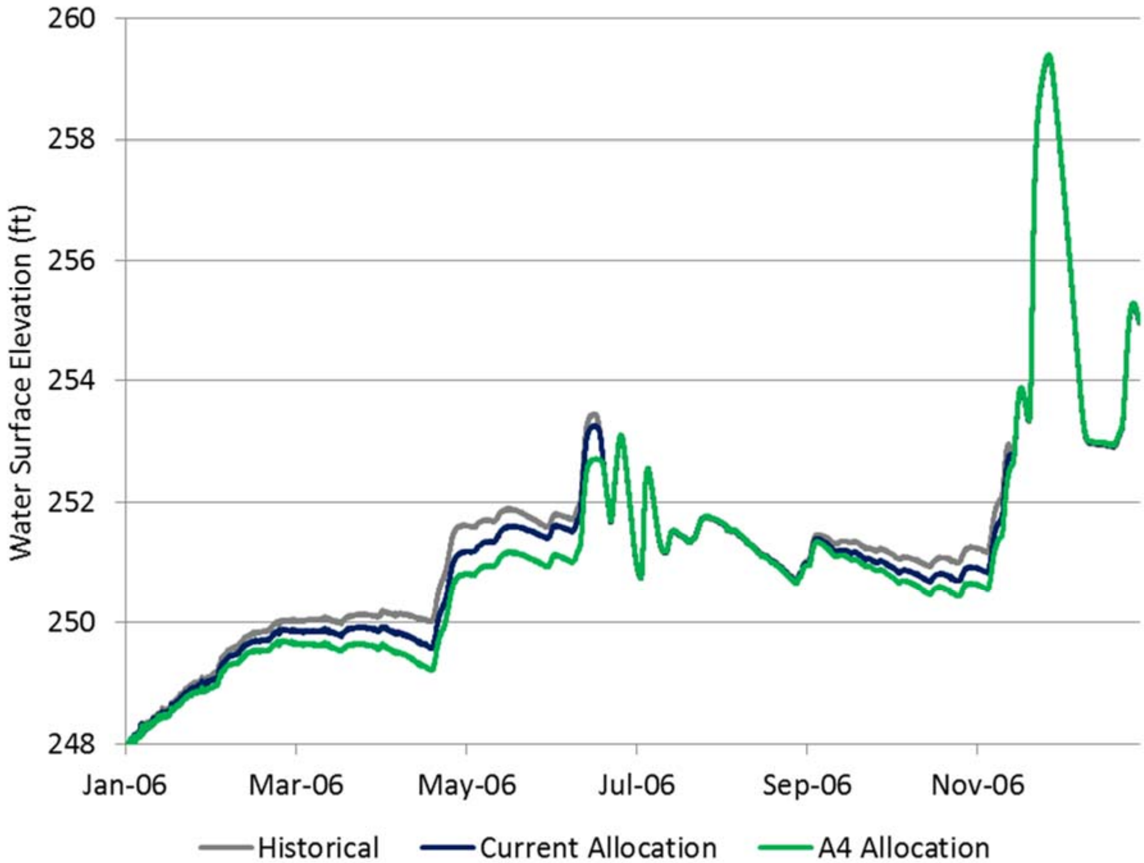

Figure 4: Simulated water surface elevations within EFDC and OASIS for specified withdrawal scenarios

In order to provide further context for the hydrologic changes associated with re-allocation, the NRBM was utilized to compare inflows to withdrawals from Falls Lake over the period from 1930 through 2012. Inflow was based upon historical records with water supply withdrawals, low flow releases, and storm releases established using the NRBM for three scenarios: historical 2006 demand pattern, maximum water supply withdrawal under the current allocation, and maximum water supply withdrawal under the A.4 allocation. Results of these simulations demonstrate that changes in outflow due to re-allocation are minimal when compared to natural changes in lake hydrology from inflow variability. While total inflow varied by more than 300 BG on an annual basis, the A4 allocation never increased the combination of water supply withdrawals and low flow releases by more than 12 BG (Figure 5). It should also be noted that hydrologic and water quality simulations presented herein for the current allocation and A.4 allocation assume that the maximum possible water supply withdrawal is utilized consistently throughout the entire year as a worst case scenario. At **no point** in the history of operating the reservoir has the maximum water supply withdrawal been used to this extent.

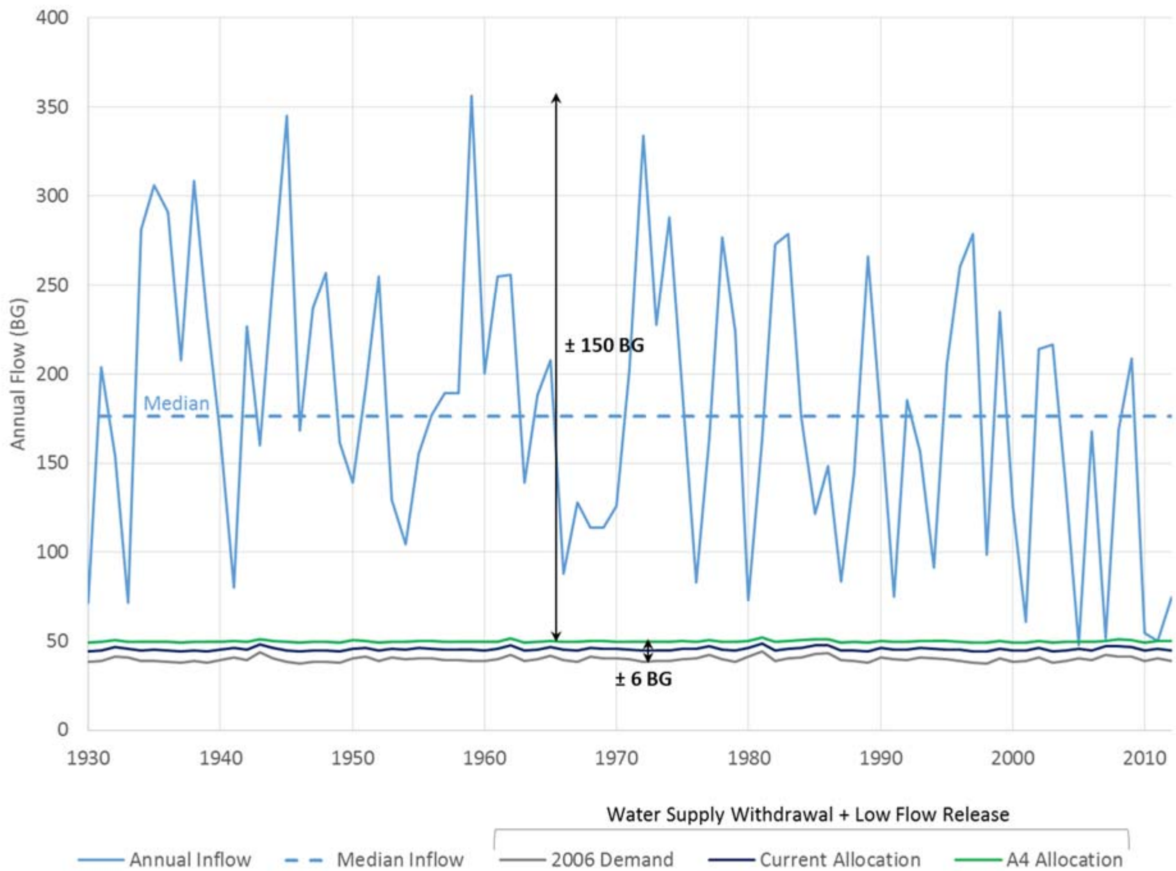

Figure 5: Total annual inflow compared to annual water supply withdrawals and low flow releases for specified withdrawal scenarios

Water Quality – No Nutrient Reductions, Unmodified Chl-a Concentrations

Chl-a concentrations within Falls Lake varied substantially throughout the year under all of the hydrologic scenarios considered (Figure 6). Sharp increases in Chl-a concentrations appear to generally coincide with storm events, which is likely due to nutrients and Chl-a delivered from the various tributaries within the model. These trends are evident when evaluating the Chl-a concentrations spatially within the reservoir over time, with concentrations frequently highest near points of substantial inflow. If increased withdrawals are associated with water quality impacts, the combination of extended periods of low inflow combined with several large storm events in 2006 presents a conservative evaluation of those potential impacts. It is important to note that there are many complex and competing factors within the model affecting Chl-a concentrations, making it difficult to definitively identify singular factors responsible for concentration changes.

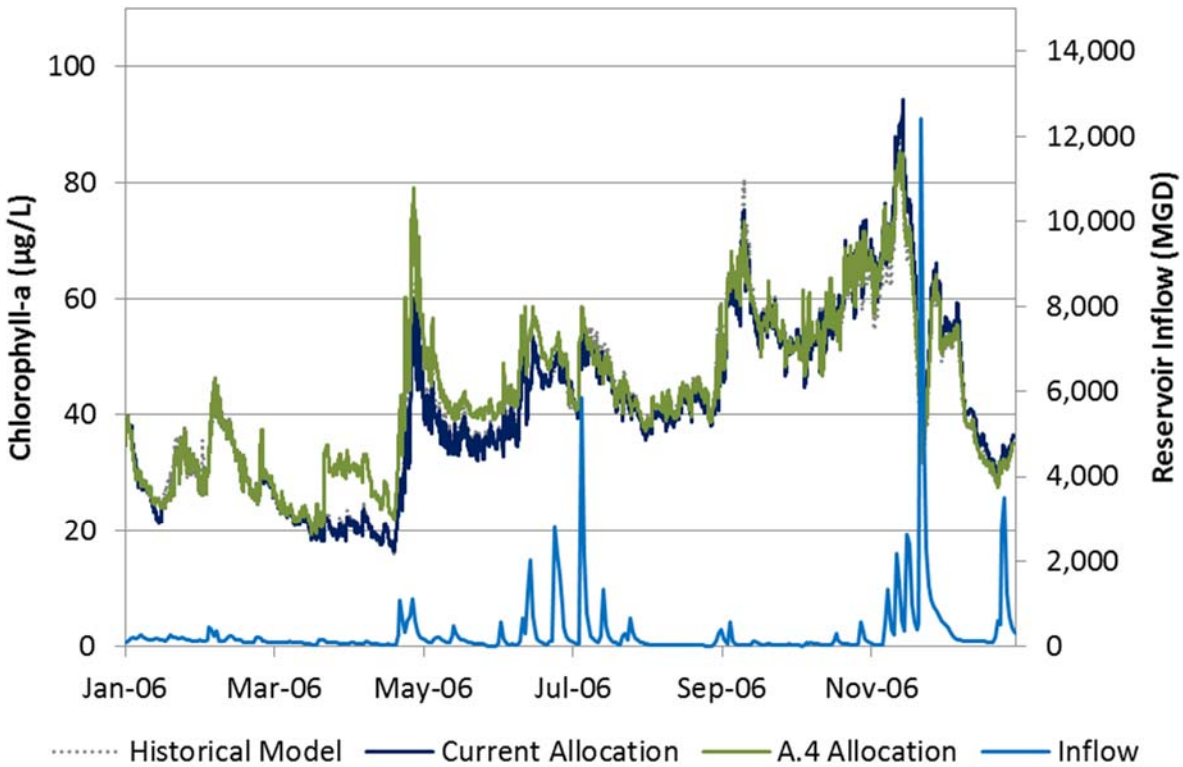

Figure 6: Simulated Chl-a concentrations at the NEU013B compliance point without nutrient reductions or inflow Chl-a concentration modifications

Simulations results did not present a clear or consistent increase in Chl-a concentrations for any of the hydrologic scenarios considered. When compared to the current allocation, Chl-a concentrations simulated for A.4 were higher from late March through June, but were generally similar or lower during other parts of the year. If there was a simple relationship between increased withdrawals or lower water surface elevations and Chl-a concentrations, consistent Chl-a differences would be expected during the periods of March through June and September through October. The most noticeable difference in Chl-a concentration appeared in late March, with no apparent influencing factor, and increased in late April in response to a substantial storm event (Figure 7).

Figure 7: Difference between A.4 allocation Chl-a concentrations and those simulated for the current allocation at the NEU013B compliance point

Water Quality – 40/77 Nutrient Reductions, Unmodified Chl-a Concentrations

Overall trends in Chl-a results with nutrient reductions in place were similar to those scenarios without nutrient reductions (Figure 8). Although Chl-a concentrations were lower, due to reduced nutrient inputs, none of the allocation scenarios were consistently better or worse than the others. Examining the portion of simulated time when specified Chl-a thresholds are exceeded demonstrates the improvements in water quality that result from implementing the nutrient management strategy, but indicates minimal differences in overall water quality between the current and A4 allocations (Figure 9). Simulations suggest that under the current allocation, the 40 µg/L Chl-a target is met 91% of the time, and met 88% of the time under the A.4 allocation. Upon implementing the nutrient reduction strategy, the annual average Chl-a concentration at NEU013B was 14 µg/L lower than existing conditions for the current allocation and 12 µg/L lower for the A4 allocation.

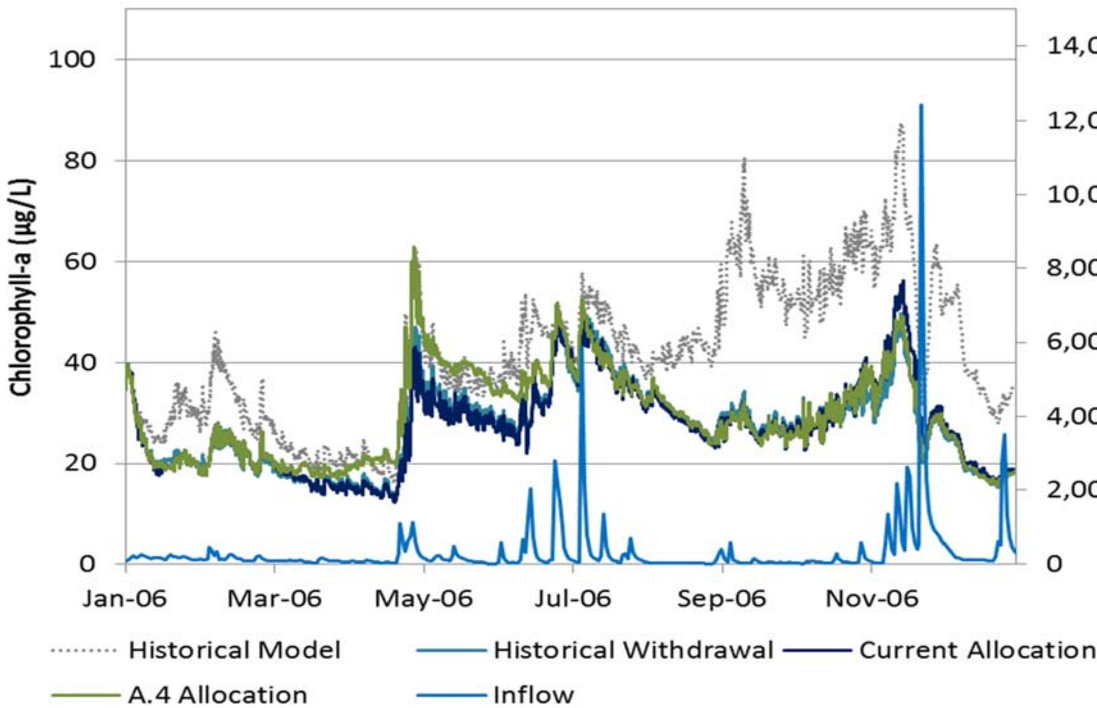

Figure 8: Simulated Chl-a concentrations at the NEU013B compliance point with 40/77 nutrient reductions and no inflow Chl-a concentration modifications

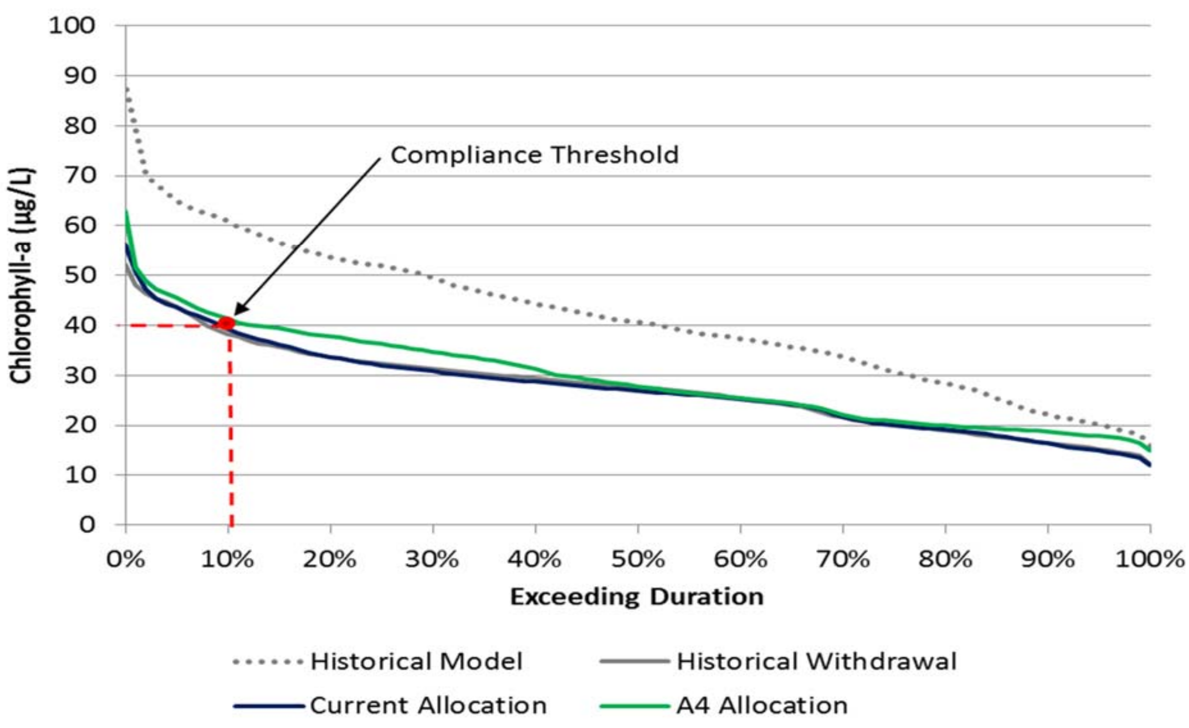

Figure 9: Percentile ranking of period specified Chl-a concentrations are exceeded at NEU013B

Sensitivity Analyses

Because Chl-a concentrations in a water body are subject to complex physical, chemical, and biological processes, it can be difficult to model Chl-a with a high degree of accuracy and precision. As such, understanding the error and uncertainty of modeling efforts is important to ensure modeling results are interpreted in the appropriate context, especially when considering whether observed changes in Chl-a constitute a significant difference. One basis for establishing this context is to examine the error of the model, or its ability to replicate historical observations. As discussed within DENR's Falls Lake Nutrient Response Model Final Report, the model agreed reasonably well with Chl-a observations, representing the same order of magnitude and capturing spatial trends; however, it is clear that changes in Chl-a resulting from re-allocation as compared to the historical case are smaller in magnitude than the margin of error within the model in replicating observed conditions (Figure 10).

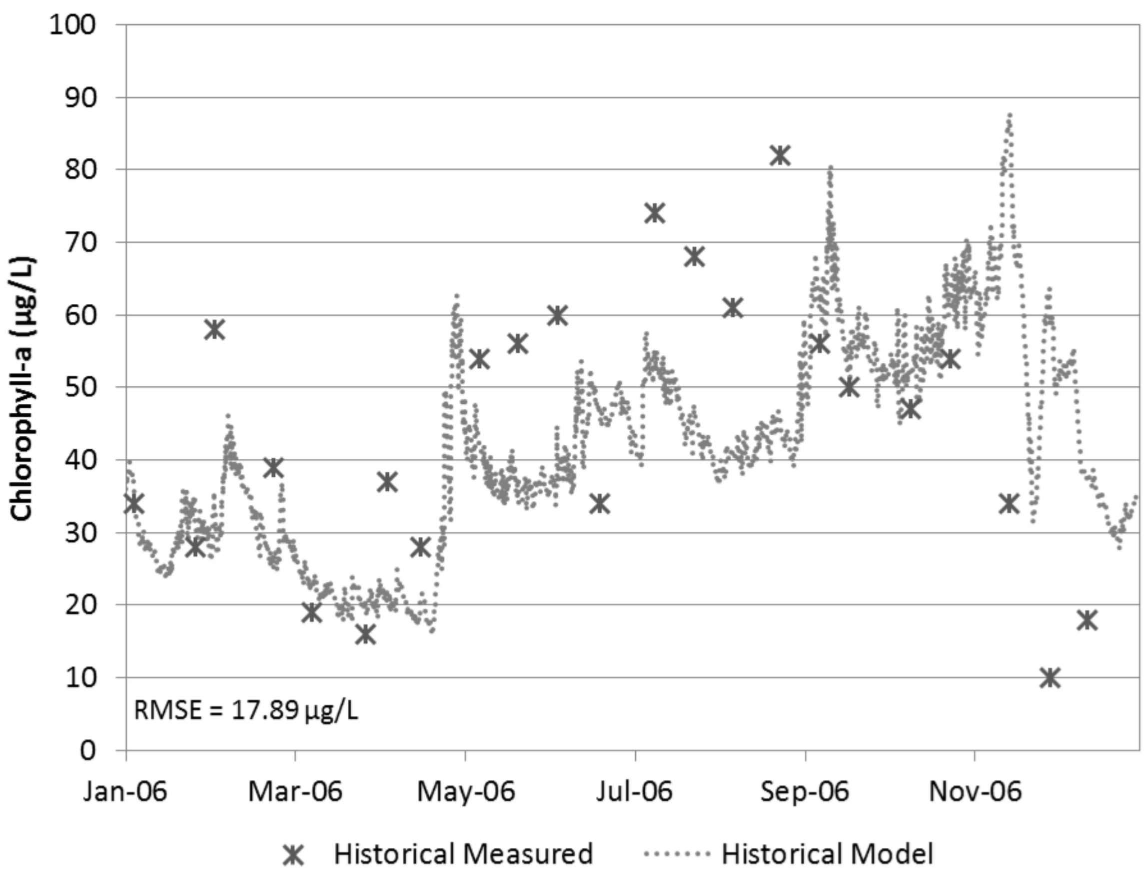

Figure 10: Simulated historical Chl-a concentrations at NEU013B compared with 2006 Chl-a observations

In addition to an evaluation of model error, several sensitivity analyses were conducted to provide context for observed differences in Chl-a concentrations between the various hydrologic scenarios. These sensitivity analyses focused on inflow Chl-a concentrations specified within the model and uncontrollable weather parameters such as wind and cloud cover.

Water Quality – 40/77 Nutrient Reductions, 10 µg/L Inflow Chl-a Concentration

Through coordination with the Upper Neuse River Basin Association (UNRBA) and their consultant, Cardno-Entrix, it was identified that inflow Chl-a concentrations specified within the model may not be representative of actual stream inflow. According to their analysis, inflow Chl-a concentrations specified within the model were based upon monitoring data collected within Falls Lake and not directly within the tributaries. As such, influent Chl-a concentrations for a set of simulations were specified at a constant 10 µg/L based on coordination with Cardno-Entrix to examine the sensitivity of this input. It is important to note that the model was not recalibrated after changing these influent concentrations. Some recalibration would be required to reproduce historical observations after influent Chl-a values were modified; however, such efforts were beyond the scope of this evaluation. As such, these modified Chl-a scenarios were intended to evaluate relative differences and whether changes to some model input assumptions could influence the effect of alternative withdrawals.

Simulations indicated that model results are sensitive to the inflow Chl-a concentration, with overall Chl-a simulations lower than those simulated previously. However, differences in Chl-a between hydrologic scenarios were generally less evident when inflow Chl-a concentrations were set at a constant 10 µg/L (Figure 11). When examining the portion of simulated time when specified Chl-a thresholds are exceeded, Chl-a differences between the hydrologic scenarios are almost imperceptible (Figure 12). Simulated Chl-a never exceeded 40 µg/L. This analysis suggests that the EFDC model is sensitive to Chl-a inflow concentrations; however, adjustments to Chl-a inflow concentrations would need to be paired with other model adjustments and calibration activities in order to use these lower Chl-a inflow concentrations for an assessment of Chl-a threshold compliance.

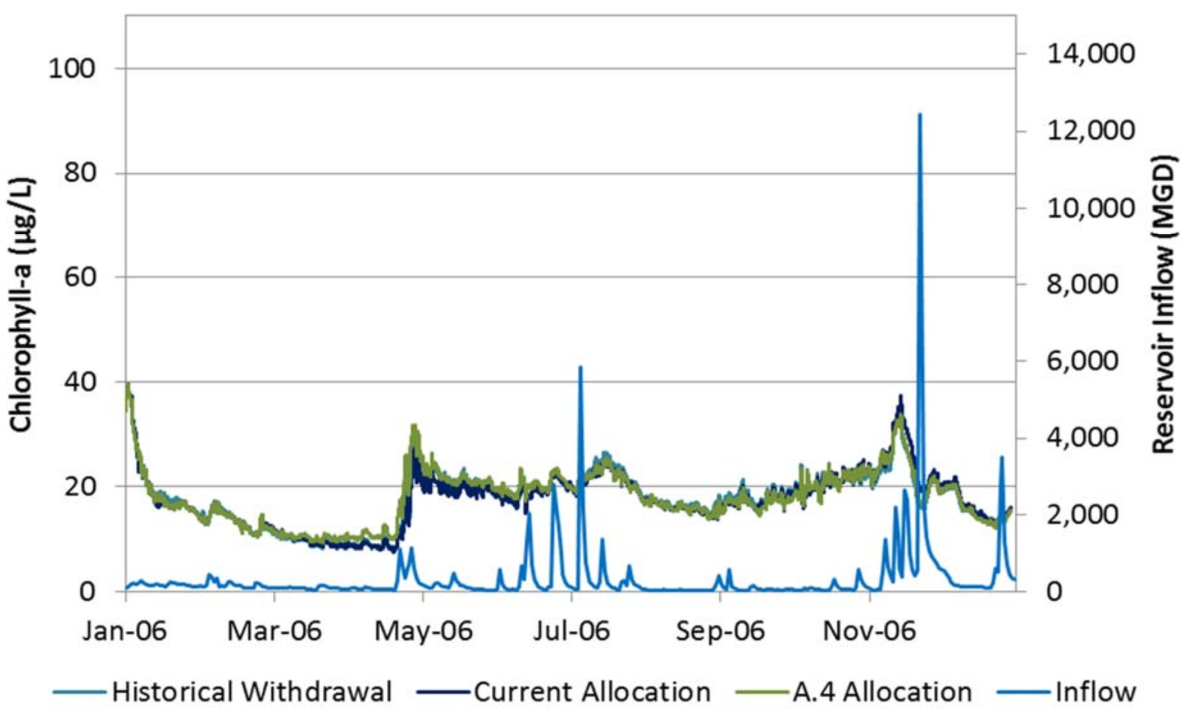

Figure 11: Simulated Chl-a concentrations at the NEU013B compliance point with 40/77 nutrient reductions and Chl-a inflow a constant 10 µg/L

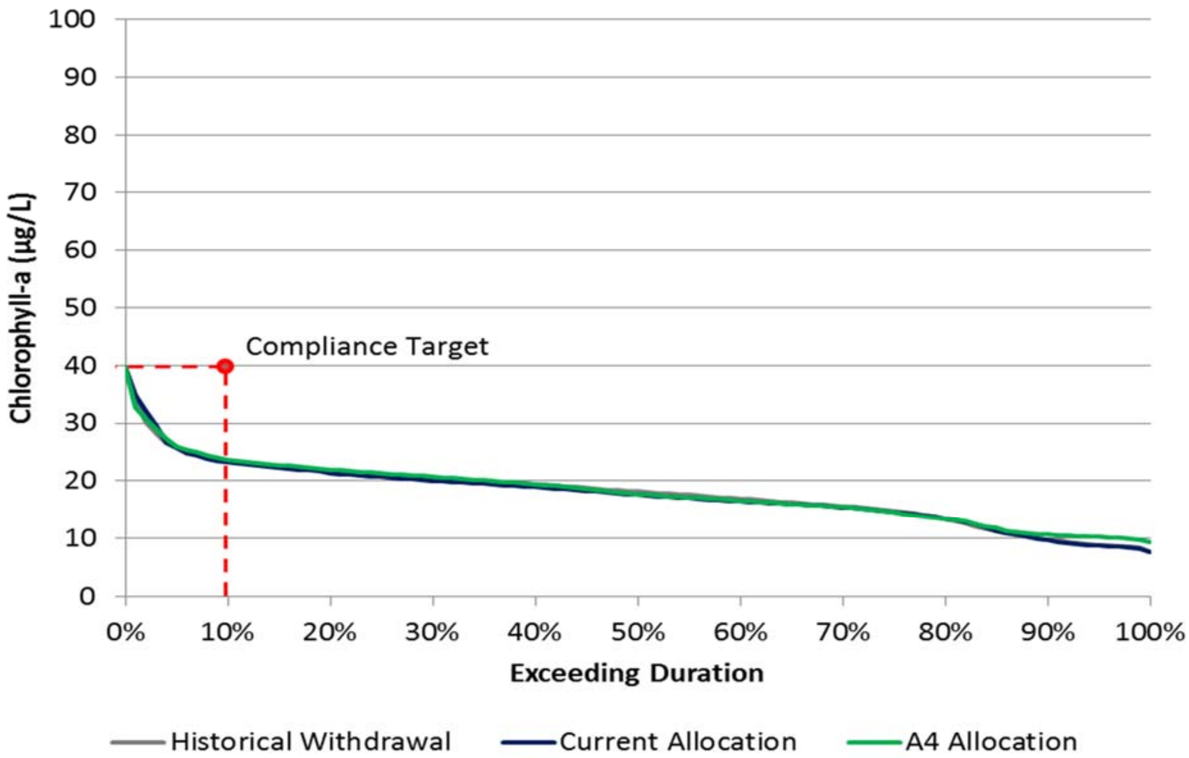

Figure 12: Percentile ranking of period specified Chl-a concentrations are exceeded at NEU013B with 40/77 nutrient reductions and Chl-a inflow a constant 10 µg/L

Water Quality – 40/77 Nutrient Reductions, ± 20% Cloud Cover

A sensitivity analysis was conducted by modifying the model input for cloud cover to determine how uncontrollable weather variables independent of nutrient inputs affect Chl-a concentrations. Cloud cover was selected as a model input for analysis because it exhibits uncontrollable fluctuations, has no direct connection to nutrient inputs or other aspects of the nutrient management strategy, and should impact Chl-a concentrations by affecting the amount of solar radiation available for algal growth. Cloud cover was uniformly increased and decreased by 20% throughout the year for simulations of the current allocation and A4 allocation with nutrient reductions in place. This 20% adjustment was generally representative of differences in annual average cloud cover measured at RDU airport over the period from 1997 through 2013.

Contrary to expectations, changes in cloud cover did not have a consistent impact on Chl-a concentrations. A decrease in cloud cover was expected to increase the amount of solar radiation to support algal growth and increase Chl-a concentrations; however, the opposite effect was observed, with either an increase or decrease in cloud cover reducing Chl-a concentrations for the A4 allocation (Figure 13). Simulation results indicate that under the A4 scenario, Chl-a complied with the 40 µg/L compliance target 90% of the time when cloud cover was increased by 20% and 89% of the time when cloud cover was decreased by 20%, compared to 88% compliance with no cloud cover adjustments (Figure 14). Similar effects were observed when unilaterally increasing or decreasing wind speeds by 20%.

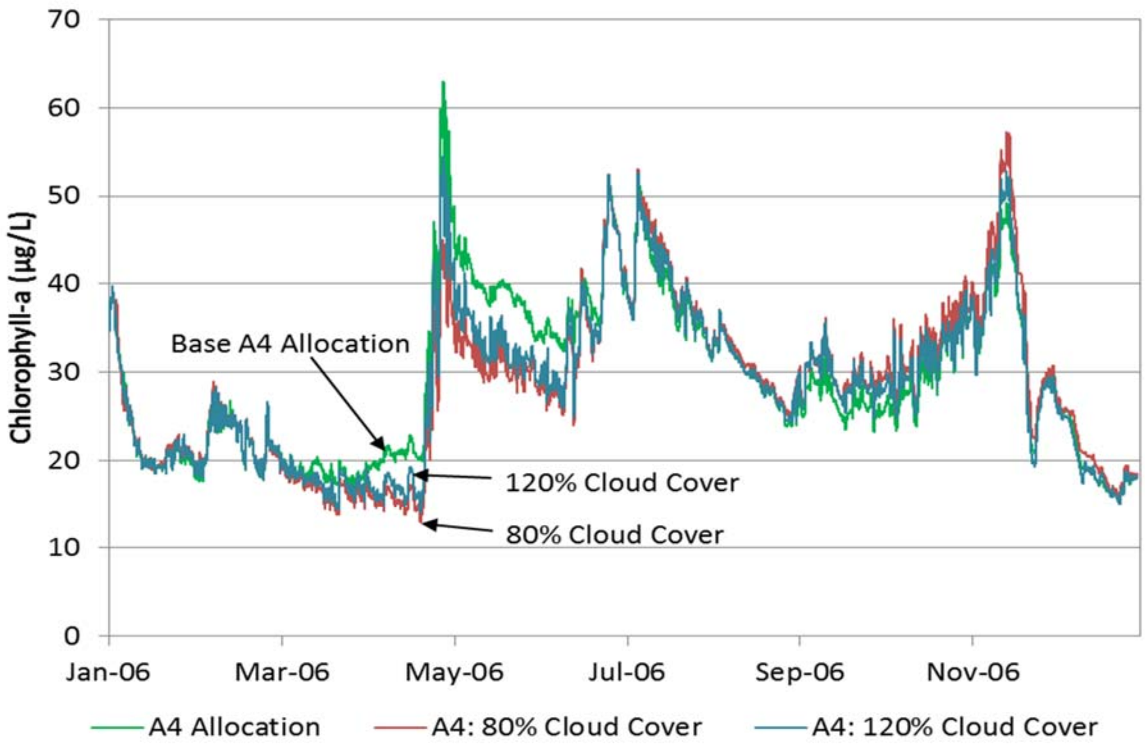

Figure 13: Simulated Chl-a concentrations at the NEU013B compliance point with 40/77 nutrient reductions for the A4 allocation and cloud cover unilaterally increased or decreased by 20%

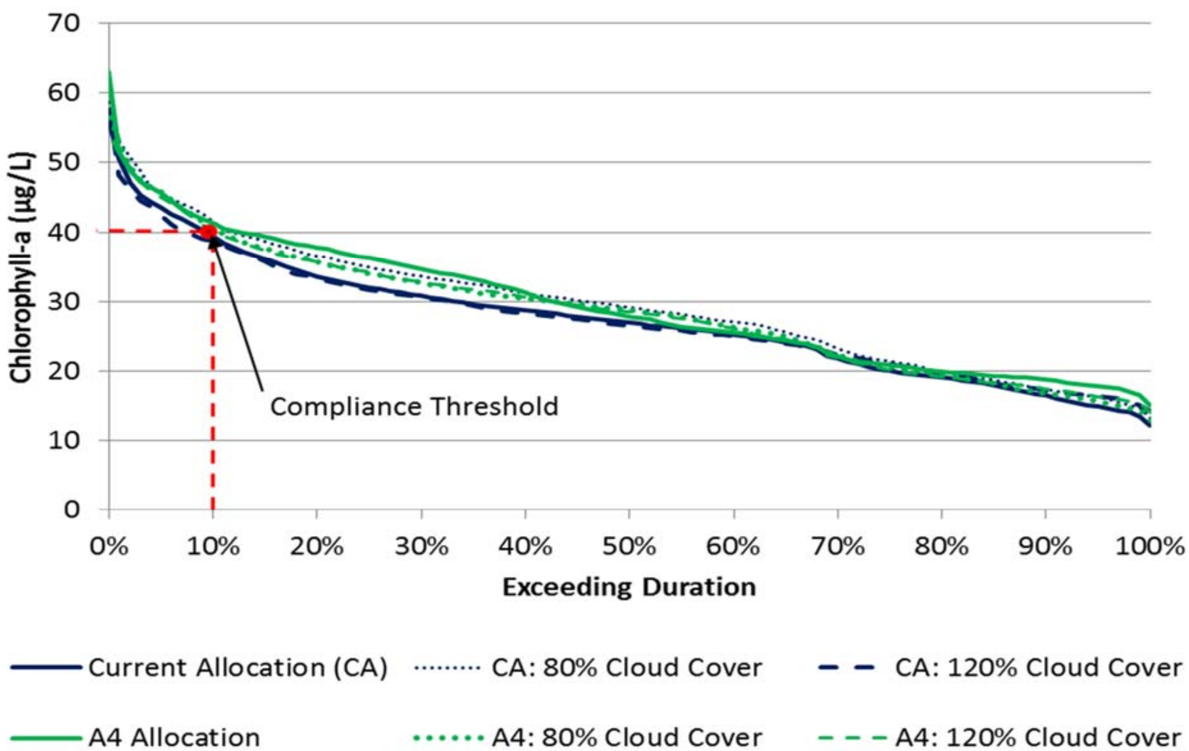

Figure 14: Percentile ranking of period specified Chl-a concentrations are exceeded at NEU013B for cloud cover sensitivity analyses

Water Quality – 40/77 Nutrient Reductions, ± 20% Wind Speed

Similar to the analyses conducted for cloud cover, a sensitivity analysis was conducted with wind speed to evaluate the impact of natural variation in uncontrollable weather parameters on Chl-a within the model. Wind speed was uniformly increased and decreased by 20% throughout the year for simulations of the A4 allocation with nutrient reductions in place. Results were generally similar to those for cloud cover, with either an increase or decrease in wind speed reducing Chl-a concentrations through a substantial portion of the year (Figure 15). When evaluating exceedance durations, increasing wind speed by 20% resulted in higher Chl-a concentrations compared to the base A4 allocation scenario, due predominantly to an increase in Chl-a concentrations during the fall months (Figure 16).

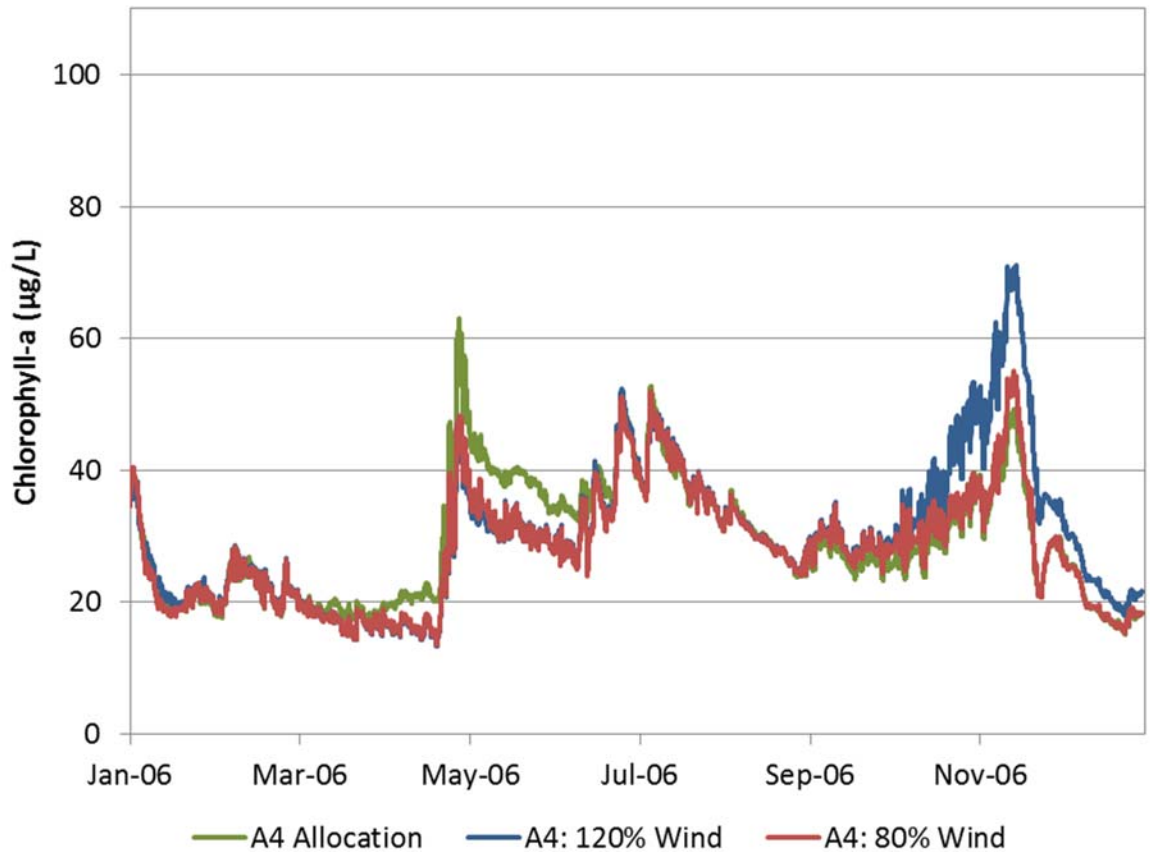

Figure 15: Simulated Chl-a concentrations at the NEU013B compliance point with 40/77 nutrient reductions for the A4 allocation and wind speed unilaterally increased or decreased by 20%

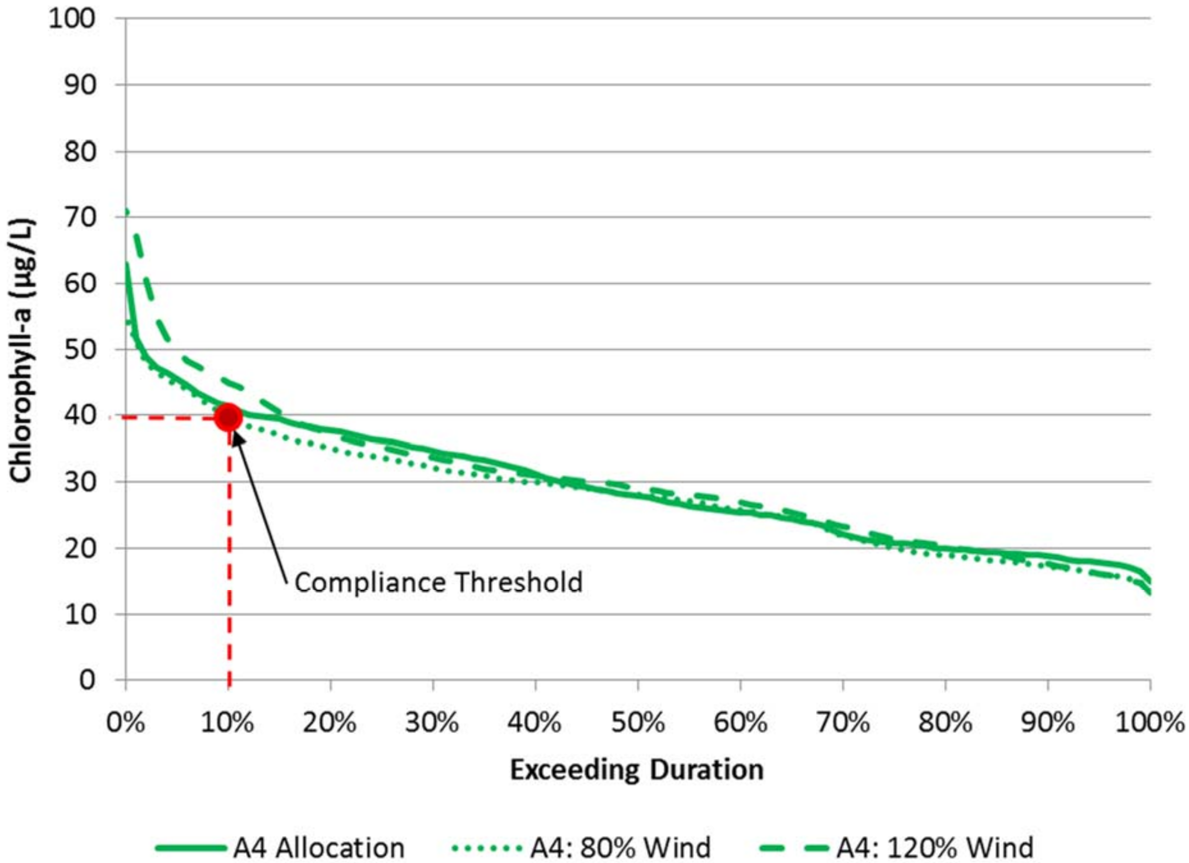

Figure 16: Percentile ranking of period specified Chl-a concentrations are exceeded at NEU013B for wind speed sensitivity analyses

Water Quality – Additional Evaluation Locations

Although water quality evaluations focused on the NEU013B compliance point, additional locations throughout Falls Lake were evaluated to confirm findings and identify any spatial trends. Refer to Figure 1 for the location of additional evaluation locations within the Lake. Results discussed herein reflect the scenario with nutrient management in place and no modifications to inflow Chl-a concentrations, with results for modified Chl-a inflows contained in Appendix A.

Chl-a concentrations at the most downstream location, WQ4-Lower, were lower than those observed at upstream locations and exhibited minimal differences between historical conditions and the two withdrawal scenarios for much of the year. The negligible differences between the allocation scenarios for this location during dry weather periods suggests that the direct action of withdrawing water from the reservoir has minimal impacts on water quality (Figure 17).

Although there were some exceptions, Chl-a concentrations generally decreased as evaluation locations moved further downstream (Figure 18). The largest differences between the A.4 and current allocation were observed at WQ2, near the Little Lick Creek tributary.

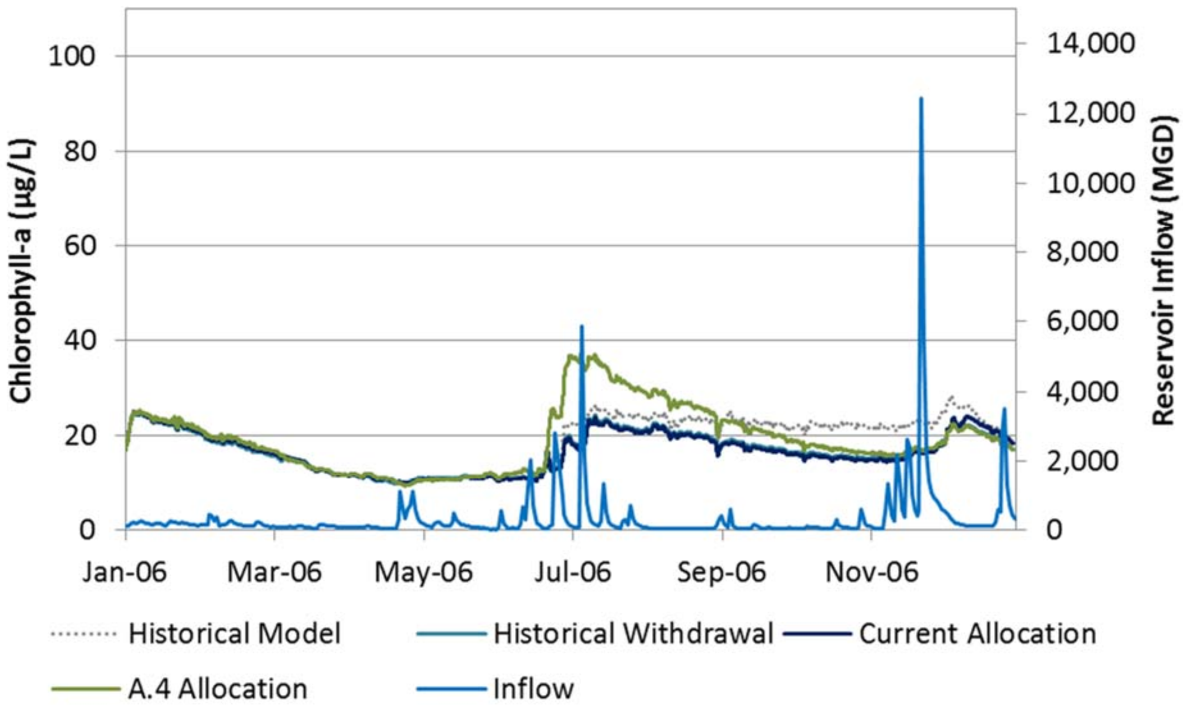

Figure 17: Simulated Chl-a concentrations at the WQ4-Lower location with nutrient reductions and unmodified inflow Chl-a concentrations

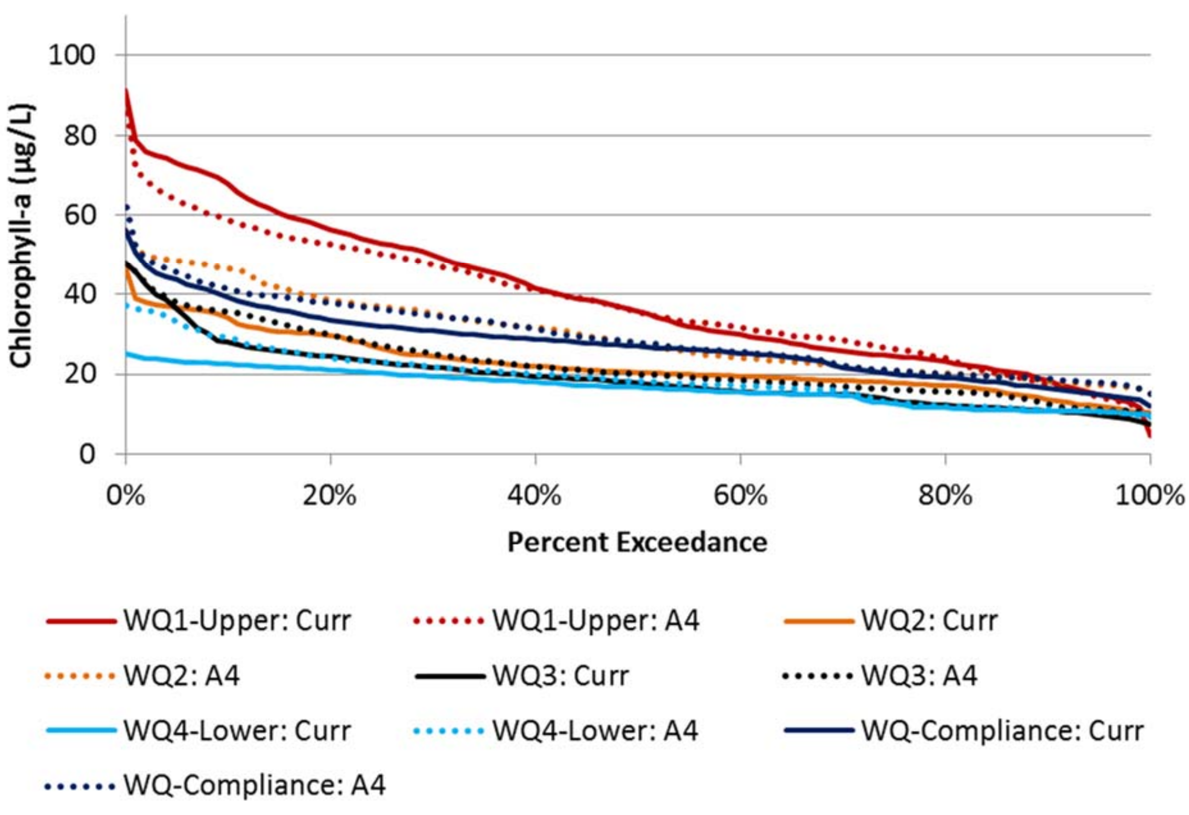

Figure 18: Percentile ranking of period specified Chl-a concentrations are exceeded at specified locations

Conclusions

For the withdrawal scenarios evaluated herein, EFDC modeling efforts do not provide defensible nor conclusive evidence that increases in reservoir withdrawals from re-allocation increase Chl-a concentrations.

Due to the numerous complex and competing factors within the model, it is difficult to isolate any specific mechanisms through which increased water withdrawals influence reservoir water quality or to identify the driving factors behind the rather modest changes observed. This complexity is best illustrated by the unpredictable response of simulated Chl-a concentrations to modified withdrawals and other uncontrollable factors like cloud cover and wind speed. While simulating implementation of the nutrient management strategy produced clear and consistent reductions in Chl-a, an increase in reservoir withdrawals produced Chl-a impacts similar or smaller in magnitude than those observed through sensitivity analyses of other model parameters. These water quality results are combined with the observation that any connections between reservoir hydrology and water quality are much more likely to be associated with large fluctuations in reservoir inflow, which are orders of magnitude larger than the relatively minor changes in reservoir outflow resulting from re-allocation (Figure 5).

While results of this modeling effort cannot definitively conclude that changes in reservoir withdrawals and an increase in the volume of the water supply pool could not have a negative impact on reservoir Chl-a concentrations, neither is there clear evidence that such negative impacts would occur.

Therefore the conclusions of this analysis are that simulations utilizing the best currently available model of water quality for Falls Lake do not show that increasing the size of the water supply pool to meet area water demands will result in water quality degradation within the lake.

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Appendix A

EFDC Simulation Results

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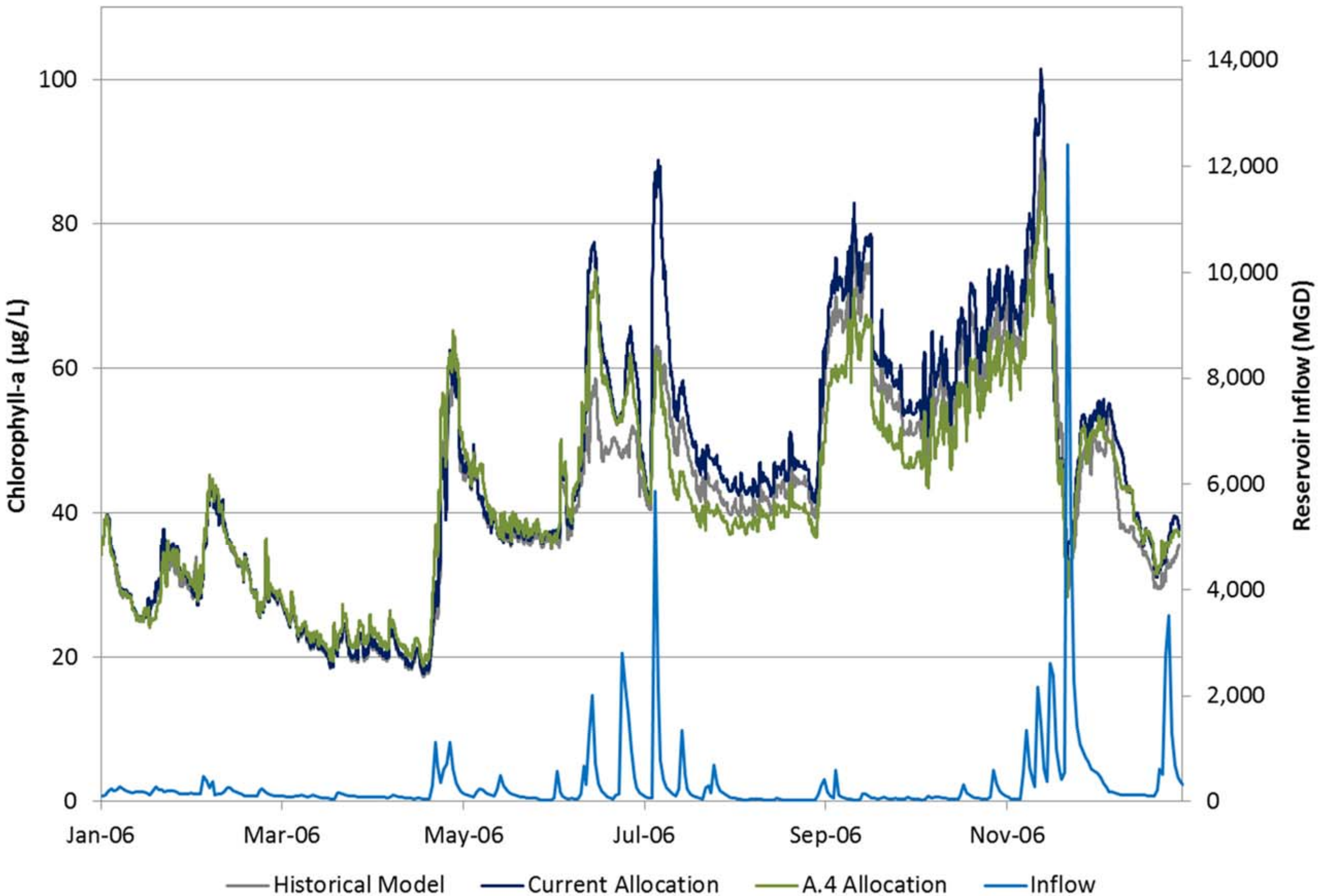

Figure A.1: Simulated 2006 NEU013B Chl-a concentrations for scenario with no nutrient reductions and no influent Chl-a modifications

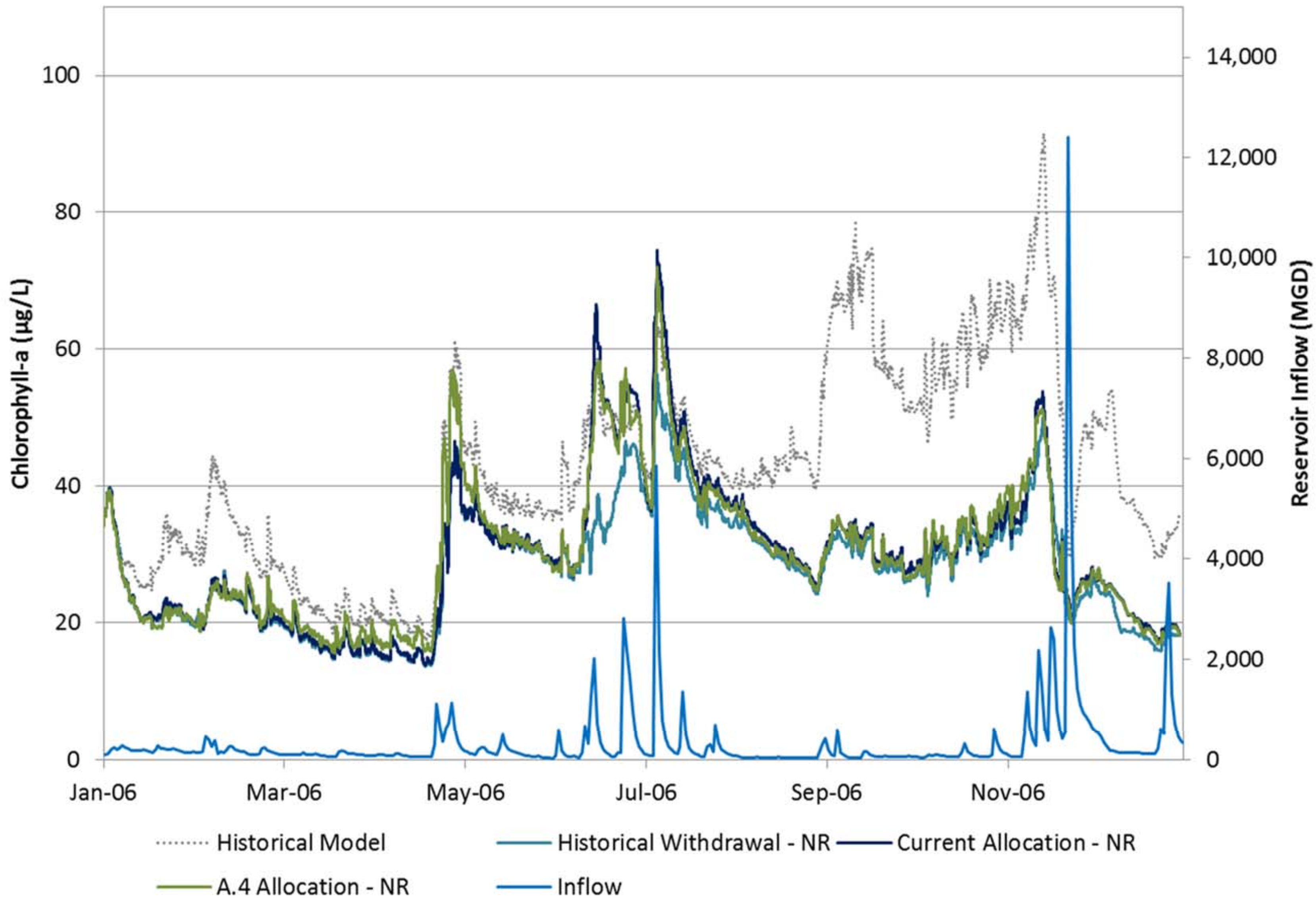

Figure A.2: Simulated 2006 NEU013B Chl-a concentrations for scenario with nutrient reductions and no influent Chl-a modifications

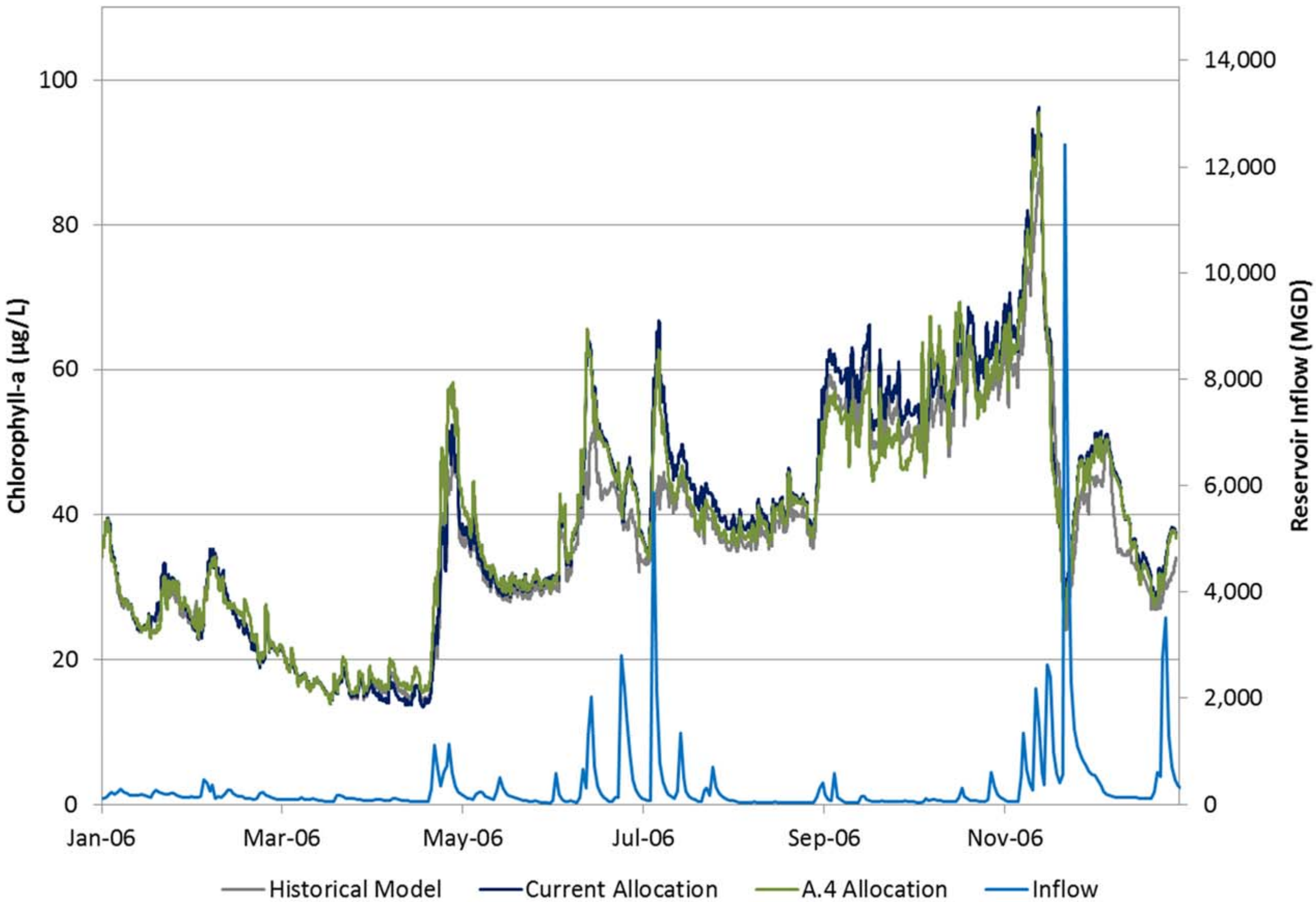

Figure A.3: Simulated 2006 NEU013B Chl-a concentrations for scenario with influent Chl-a modifications and no nutrient reductions

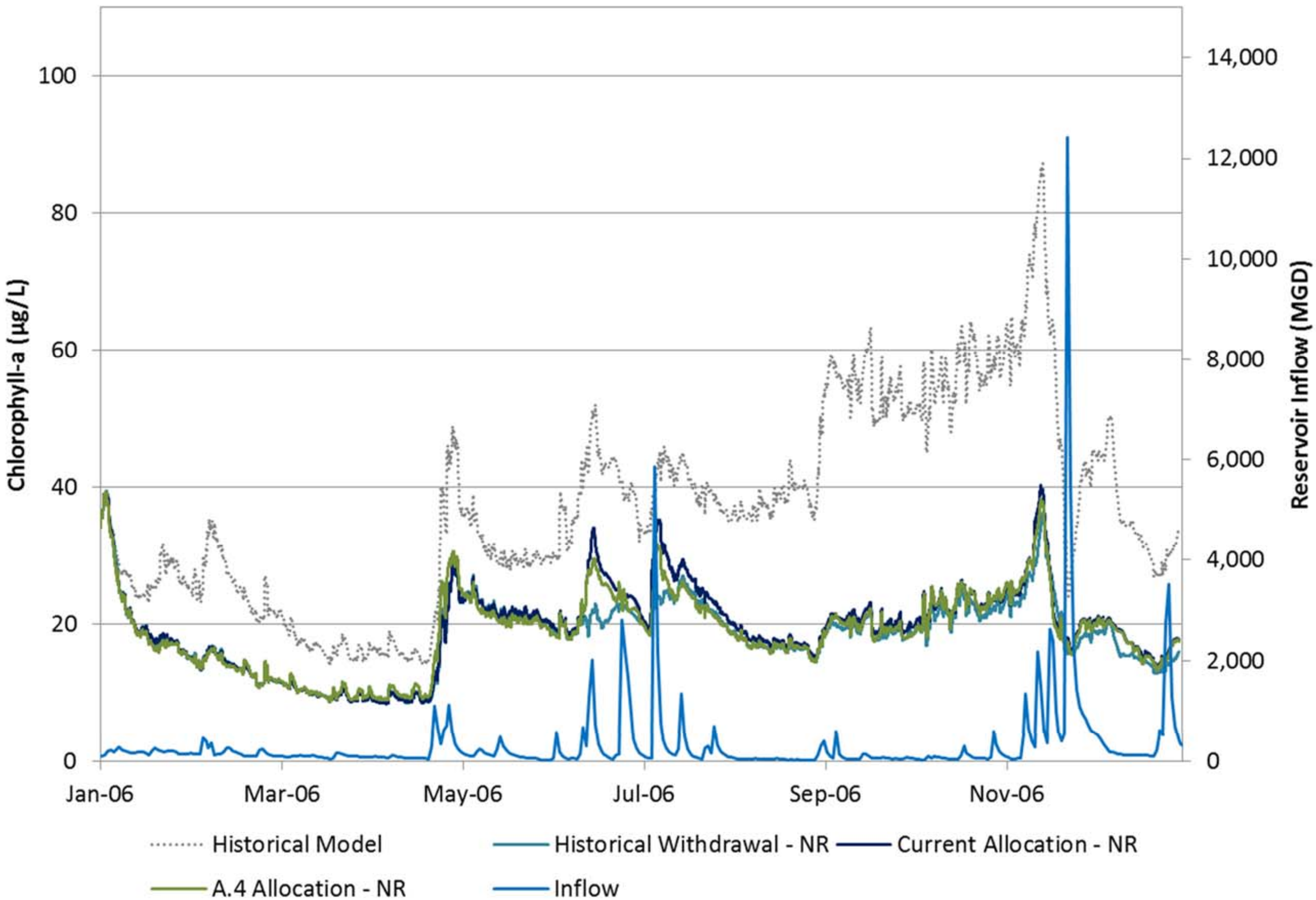

Figure A.4: Simulated 2006 NEU013B Chl-a concentrations for scenario with nutrient reductions and influent Chl-a modifications

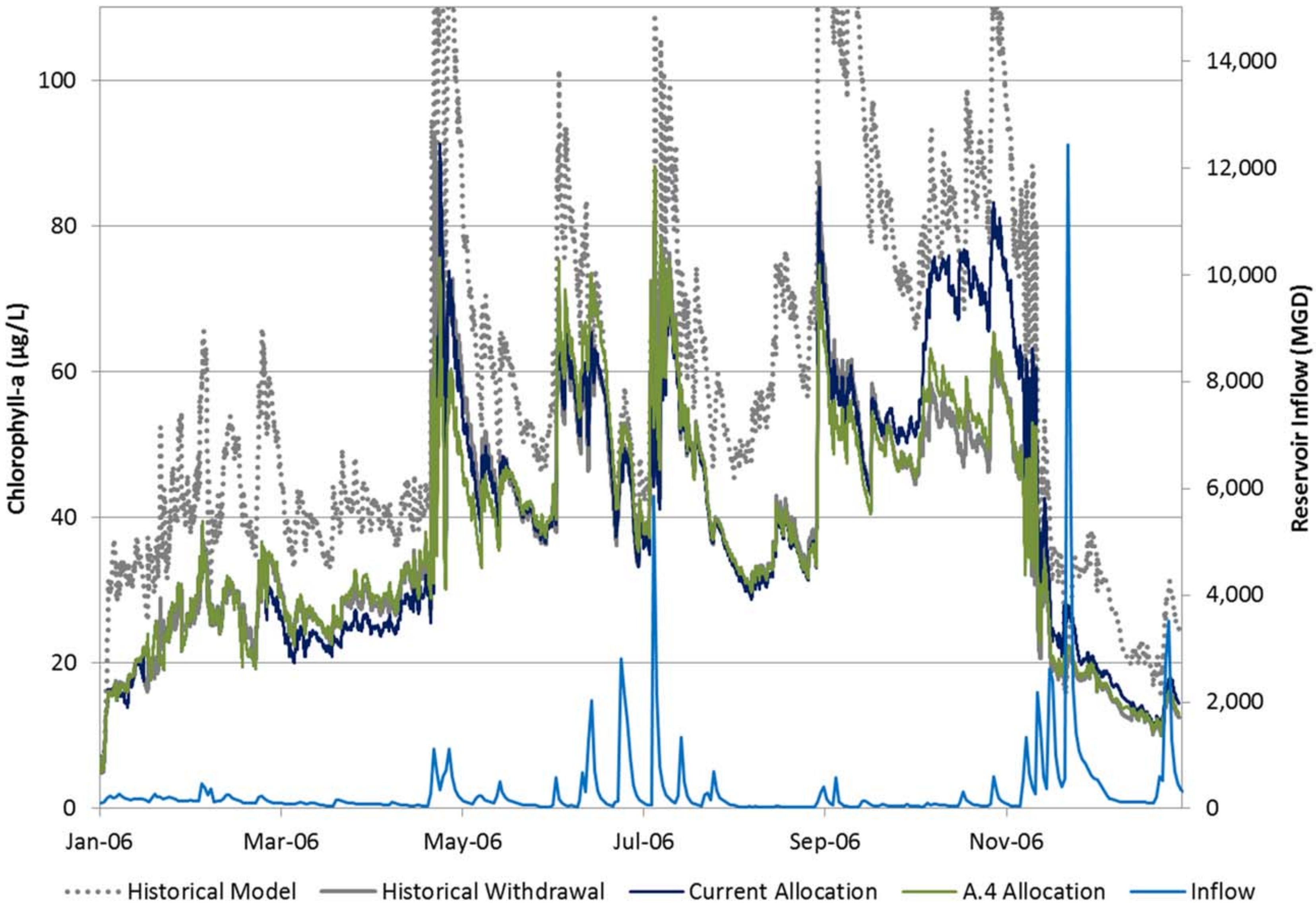

Figure A.5: Simulated 2006 WQ1-Upper Chl-a concentrations for scenario with nutrient reductions and no influent Chl-a modifications

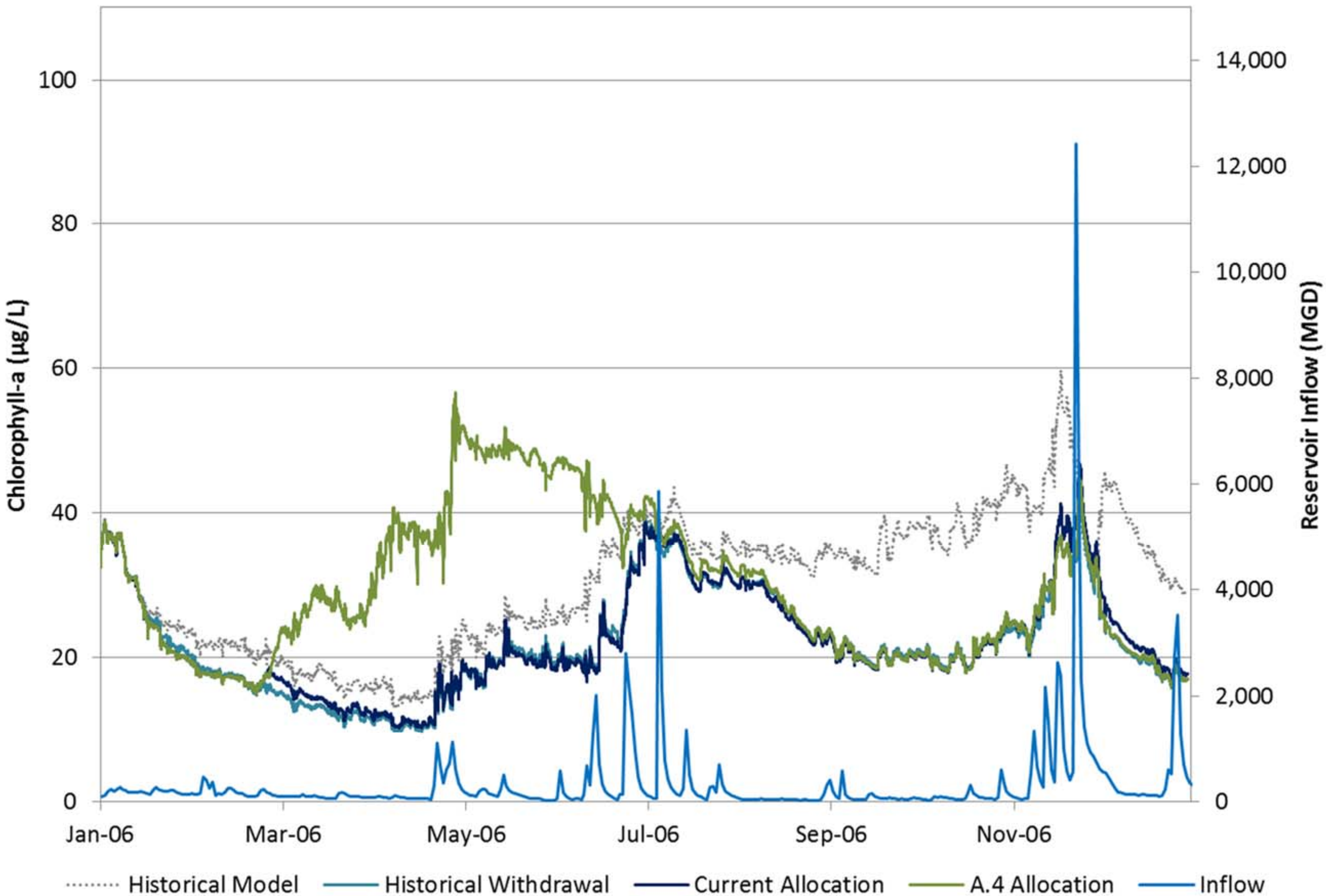

Figure A.6: Simulated 2006 WQ2 Chl-a concentrations for scenario with nutrient reductions and no influent Chl-a modifications

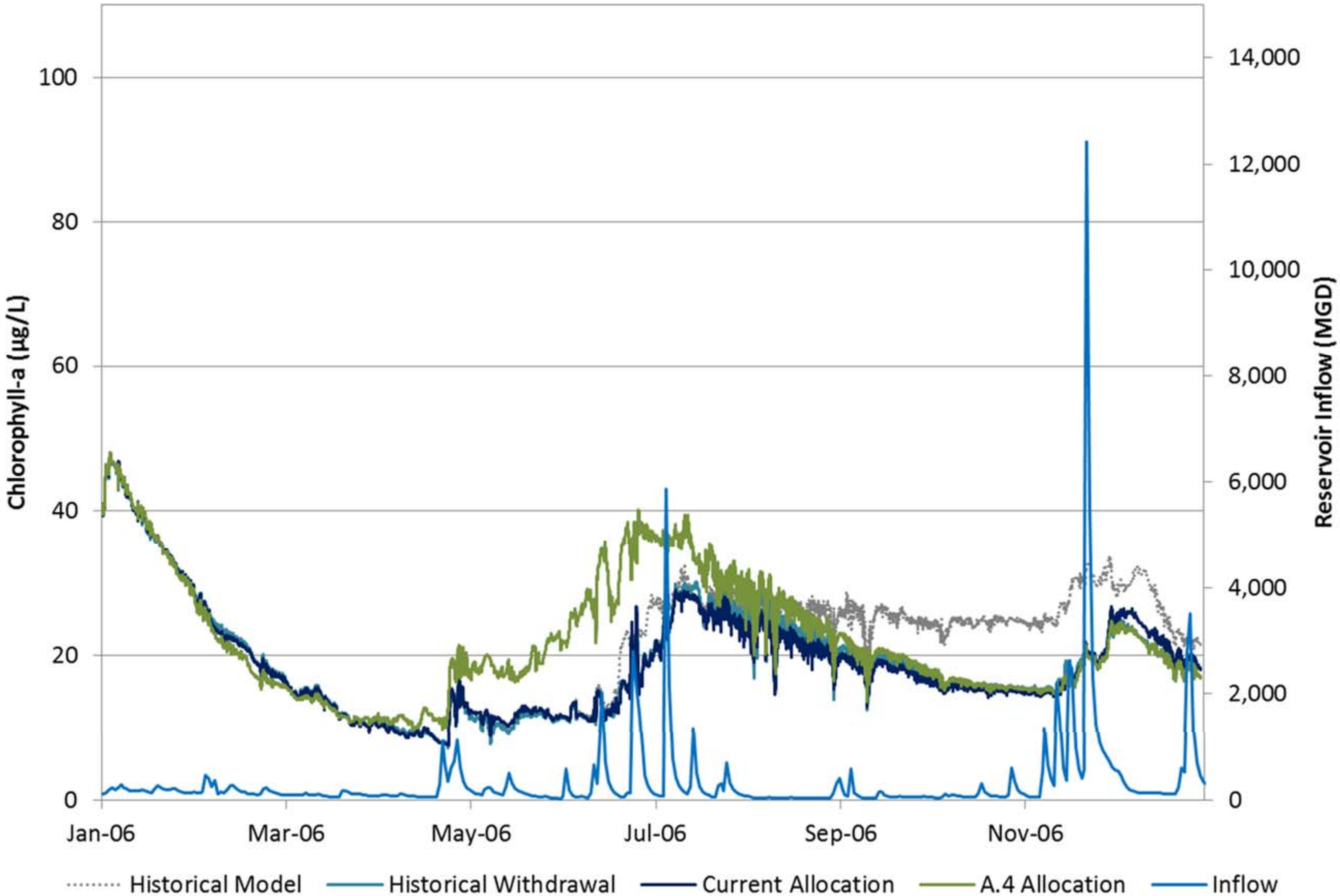

Figure A.7: Simulated 2006 WQ3 Chl-a concentrations for scenario with nutrient reductions and no influent Chl-a modifications

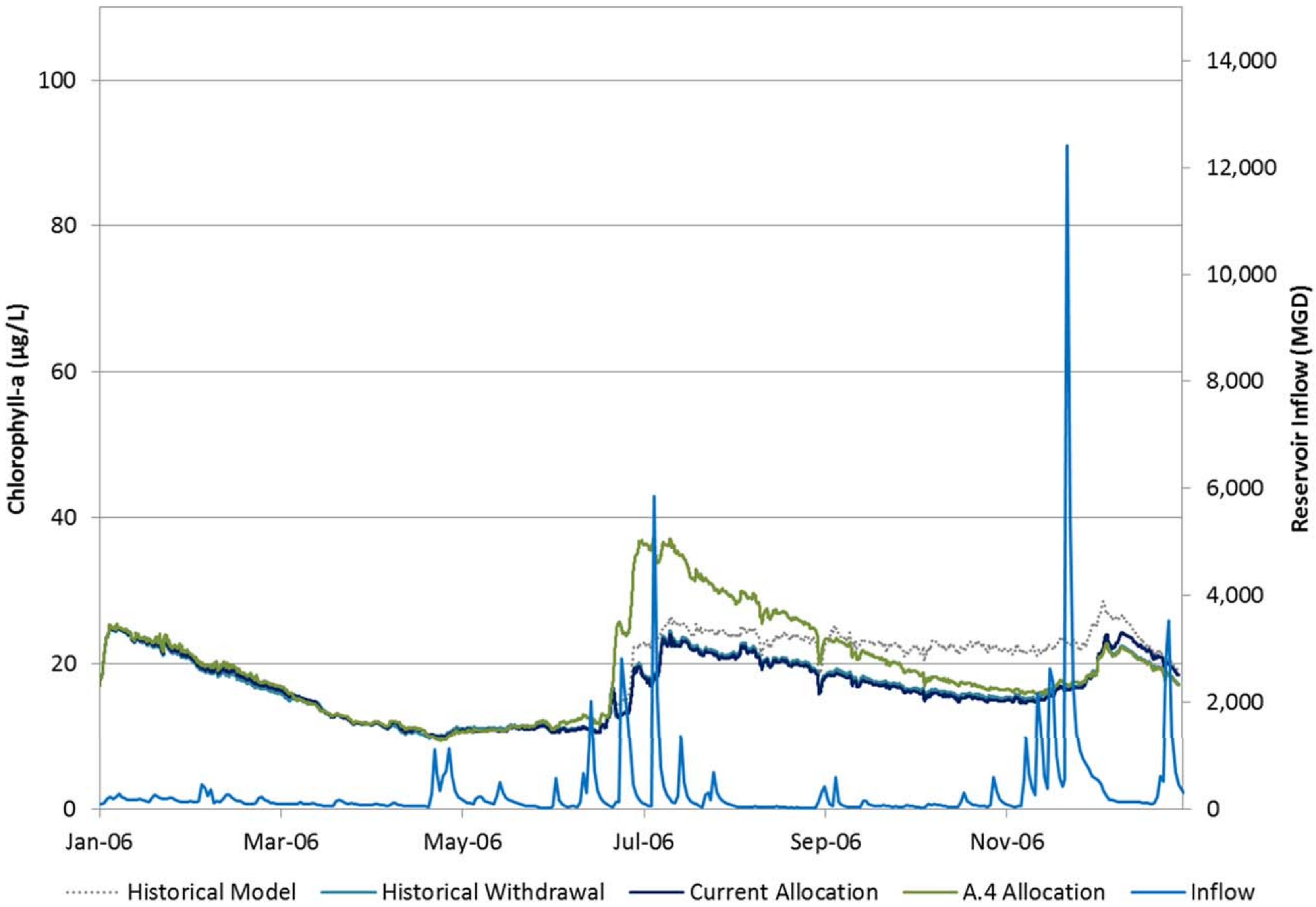

Figure A.8: Simulated 2006 WQ4-Lower Chl-a concentrations for scenario with nutrient reductions and no influent Chl-a modifications

Appendix B

OASIS Hydrologic Simulation Assumptions

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OASIS Modeling Assumptions

1. The City's annual demand pattern was changed from the 2004 pattern to the 2005 pattern. The 2005 pattern is more representative of a drought year and produces a lower (thus more conservative) estimate of yield.
2. The City's wastewater return pattern was also changed to the 2005 pattern. This keeps the withdrawal and return patterns coordinated and also represents a wastewater return pattern for a hot, dry year when residential customers are irrigating lawns and landscaping more heavily. Increased irrigation during hot, dry periods tends to coincide with a lower fraction of the water withdrawn from Falls Lake being returned to the Neuse River. In turn this leads to somewhat greater reliance on the FLWQP to meet the Clayton gage flow target.
3. The initial lake level conditions were changed to those matching the historical conditions for the starting date of the particular EFDC run (1/1/2006).
4. The simulation was modified to allow for a variable volume of water to be moved from the FLWQP to the FLWSP. It was determined that 4.1 BG of volume needed to be transferred to the FLWSP for Raleigh to meet its 2040 demand target.
5. It was assumed that inflow to the conservation pool would be apportioned according to the total volume assigned to each pool. For example, the current allocation volume of the FLWQP (including Beaver Dam volume) is 61322 acre-feet (af) of a total conservation storage volume of 106322 acre-feet (af), or 57.7% of the total. When the conservation pool is not full, the same ratio is applied to apportion inflow received by the lake - 57.7% of the lake's inflow is allocated to the FLWQP and the remaining 42.3% is assigned to the FLWSP. For modeling of the conservation pool reallocation scenario, we assumed 45.8% (48740 af / 106322 af) of lake inflow would be apportioned to the FLWQP and 54.2% (57582 af / 106322 af) would be allotted to the FLWSP.
6. The demand for the City of Durham was revised upward from 27 mgd in the DWR baserun to 31 mgd. This was done to reflect an expected increase in demand from Lake Michie and Little River Reservoir. However, Durham will need other sources to meet its future needs and predicted what those sources will be is beyond the scope of modeling at this point. Durham's Teer Quarry was not considered to be a water supply source for these simulations.

Hydrologic Modeling Procedure for Low Flow and Storm Releases

Low flow releases are subject to a minimum allowable release from the reservoir itself and a flow target at Clayton. The minimum allowable release at the dam is 60 cfs from November through March and 100 cfs for the remainder of the year. The flow target at Clayton, which is achieved through a combination of Falls Lake releases, discharges from the Neuse River wastewater treatment plant (WWTP), and other river inflows, is 184 cfs from November through March and 254 cfs for the remainder of the year. Because increases in water supply withdrawals deliver more water to the Neuse River WWTP and therefore support compliance with the Clayton flow target, it is possible for low flow releases from Falls Lake to be reduced in accordance with increased withdrawals, provided the 60 and 100 cfs minimum releases are satisfied. The amount of water from withdrawals returned to the Neuse River was adjusted by a monthly correction to address losses within the service area. These corrections or return ratios varied from 0.72 to 1.08 based on flow records from 2006.

For the current allocation and A.4 allocation maximum withdrawal scenarios, historical storm releases were reduced according to the storage made available within the reservoir through increased outflows. Essentially, the overall increase in outflow from withdrawals and low flow releases was tracked cumulatively over time to create a storm storage deficit within the lake. Storm releases from the historical scenario had to first satisfy this storm storage deficit before registering as a storm release under the revised hydrologic scenarios. Revised water supply withdrawals, low flow releases, and storm releases were added together for the current allocation and A.4 allocation and used to replace the outflow time series within the EFDC model.