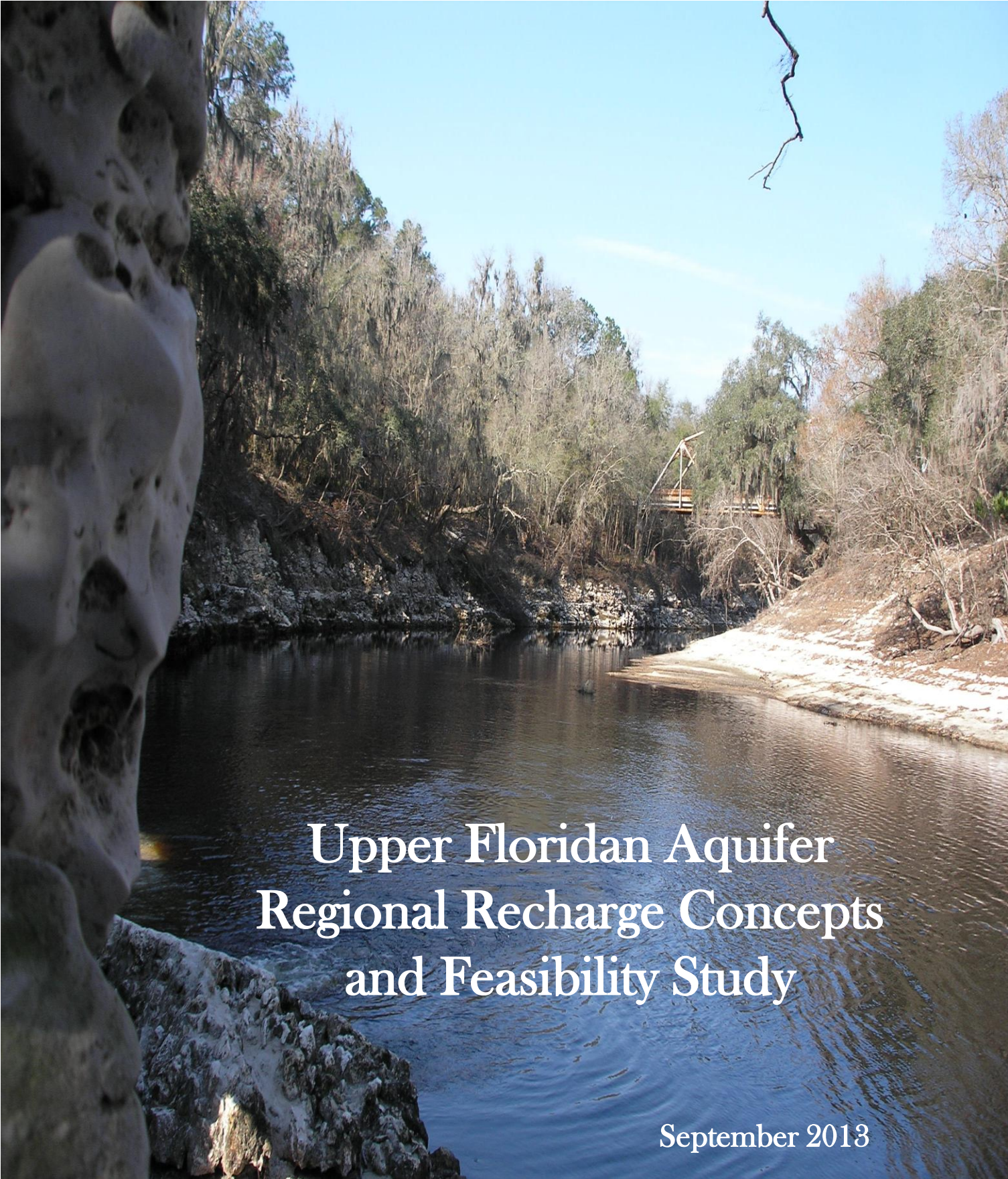




Upper Floridan Aquifer Regional Recharge Concepts and Feasibility Study

September 2013



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Executive Summary

The Suwannee River Water Management District (SRWMD), St. Johns River Water Management District (SJRWMD), and the Florida Department of Environmental Protection (FDEP) are participating in the North Florida Aquifer Replenishment Initiative (NFARI); a cooperative effort to protect, maintain, or restore regional aquifer water levels by recharging the Upper Floridan Aquifer (UFA) at strategic locations. Anticipated benefits of the initiative include increases in river baseflow and spring flow and an overall increase in the potentiometric surface of the UFA, both of which are important to development of a sustainable water supply for the region. The SRWMD and SJRWMD (Districts) contracted with Atkins North America, Inc. (Atkins) in July 2012 to develop conceptual aquifer recharge concepts and associated planning-level capital cost opinions for selected projects, which are presented in this report and supported by two technical memoranda. This report specifically addresses:

- Hydrologic and hydrogeologic data review,
- Source water identification,
- Regulatory and treatment requirements,
- Treatment processes and options for source waters prior to recharge,
- Groundwater flow modeling and identification of hydrogeologic features in areas suitable for recharge,
- Recommendations for recharge concepts,
- Conceptual engineering design for recharge water intake, treatment, pumping and transmission lines and for recommended concepts, and
- Planning level cost estimates and project completion schedules.

The study area includes portions of the upper Suwannee River and upper and lower Santa Fe River basins in the SRWMD, and the St. Marys River, Black Creek, St. Johns River, and Ocklawaha River basins in the SJRWMD. Four aquifer recharge concepts were evaluated by Atkins after selection by the SRWMD and SJRWMD.

1. Recharge Concept 1: the treatment of reclaimed water from northeast Florida for recharge into the UFA in the study area.
2. Recharge Concept 2: the capture and storage of surface waters from the upper Suwannee River for treatment and direct recharge into the UFA.
3. Recharge Concept 3: the capture of flood waters within the floodplain along the upper Suwannee River for storage and indirect recharge into the UFA.
4. Recharge Concept 4: the capture and storage of surface water from within the SJRWMD for treatment and recharge into the UFA.

Five surface water sources in the study area were evaluated as sources for aquifer recharge:

- St. Marys River along the Florida–Georgia border,
- Rodman Reservoir on the Ocklawaha River,

- St. Johns River upstream of the confluence with the Ocklawaha River within the study area,
- Black Creek, a tributary of the St. Johns River located in Clay County, and
- Upper Suwannee River from the Florida-Georgia border to its confluence with the Alapaha River.

Hydrologic and Hydrogeologic Data

Surface water quality of the source waters is critical to selection of treatment and disinfection processes and compliance with drinking water standards. Water quality treatment for the five source waters would be required prior to being used to recharge the UFA due to:

- Black Creek: Elevated total coliforms, total organic carbon (TOC), total suspended solids (TSS), fecal coliform, total dissolved solids (TDS), and chloride,
- Lower St. Johns River: Elevated TOC, TSS, fecal and total coliform, and chloride,
- Rodman Reservoir/ Ocklawaha River: Elevated TOC, TSS, and fecal coliforms. Total coliform data not available,
- St. Marys River: Elevated TOC, TSS, fecal coliforms, and total coliforms, and
- Upper Suwannee River: Elevated TOC, TSS, total nitrogen (TN), fecal coliforms, and total coliforms.

A regional hydrogeologic framework, as identified in “Simulation of Ground-Water Flow in the Intermediate and Floridan Aquifer Systems in Peninsular Florida” (USGS WRI 02-4009, 2002) , combined with input from SRWMD and SJRWMD staff, was used to evaluate areas for indirect and direct recharge under the four recharge concepts. Digital data for the Floridan Aquifer System (FAS) were compiled from the U.S. Geological Survey (USGS) Regional Aquifer-System Analysis (RASA) Program in the 1980s and were used to:

- Define the extent of confinement between the surficial aquifer system (SAS) and the UFA,
- Select the primary aquifer characteristics necessary for assessing the aquifer recharge options,
- Select the SAS characteristics essential for surface recharge system siting, and
- Define UFA issues essential for siting and conceptually designing an UFA recharge system.

Regulatory and Treatment Requirements

The application of direct and indirect aquifer recharge regulations are predicated on the classification of the receiving groundwater by the state of Florida. Groundwater classifications and designated uses are defined under FDEP Chapter 62-520, Florida Administrative Code (F.A.C.) and differentiated primarily on the basis of TDS concentrations of the aquifer. Within the study area, the TDS concentrations of the SAS and UFA are less than 10,000 milligrams per liter (mg/L) based on data presented in the

Florida Geological Survey - Special Publication No. 34 (1992) and correspond to a G-II groundwater classification for both aquifers.

Direct aquifer recharge can be achieved by the recharge of surface water or reclaimed water through recharge wells or aquifer storage and recovery (ASR) wells, under evaluation as Recharge Concepts 1 and 2. Recharge and ASR wells are regulated under FDEP Chapter 62-528, F.A.C., also known as the Underground Injection Control (UIC) rule. Aquifer recharge using reclaimed water is further regulated under FDEP Chapters 62-600, F.A.C., (Domestic Wastewater Facilities) and 62-610, F.A.C. (Reuse of Reclaimed Water and Land Application) which include additional treatment, disinfection, and monitoring requirements.

Indirect aquifer recharge can be achieved by the use of natural features such as sinkholes, floodplains, and wetlands, or artificial features such as reservoirs, mine pits, and rapid infiltration basins (RIB), using either surface water or reclaimed water, which are under evaluation as Recharge Concepts 3 and 4. A RIB is an earthen basin designed to rapidly percolate water through the soil and to the groundwater. The use of RIBs with reclaimed water is regulated under FDEP Rules 62-610.500 to 62-610.525, F.A.C. These rules require that the reclaimed water be treated to at least secondary treatment standards (for wastewater treatment) and basic disinfection levels prior to the RIB application and also require additional treatment depending on the location of the RIB, subsurface drainage, and hydraulic loading rate.

Current FDEP regulations have no specific water treatment regulations concerning indirect recharge using surface water. However, FDEP may implement water quality restrictions depending on: (1) the type of recharge - natural (sinkholes, floodplains, and wetlands) versus artificial (reservoirs, mine pits, and RIBs), (2) proximity of the source water to the receiving groundwater, (3) quality of the source water and receiving groundwater, and (4) special conditions identified in an Environmental Resource Permit (ERP).

Treatment Processes and Options

Five treatment options were developed for the direct (Recharge Concepts 1 and 2) and indirect recharge (Recharge Concepts 3 and 4) of surface and reclaimed water. The options are listed below.

1. Direct recharge of surface waters via recharge well or ASR well to groundwater
2. Direct recharge of reclaimed water that has TDS concentrations less than 3,000 mg/L: ASR to groundwater if reclaimed water has TDS between 1,000 and 3,000 mg/L and is not being discharged to a current or anticipated public water supply
3. Direct recharge of reclaimed water that has TDS concentrations less than 3,000 mg/L: ASR or recharge well to groundwater with reclaimed water that meets full water quality treatment and disinfection criteria
4. Indirect recharge of surface water
5. Indirect recharge of reclaimed water

The types of treatment processes necessary to achieve regulatory compliance of the recharge water quality requirements for the five treatment options described above may include:

- Intake screens,
- pH control,
- Coagulation/flocculation,
- Clarification/sedimentation,
- Filtration,
- Activated carbon adsorption, and
- Final disinfection.

Water Supply Availability

Minimum flows and levels (MFLs) have not been established for the source waters evaluated. Therefore, flow constraints were developed as proxies for MFLs, based on results of those that have been previously established, to provide conservative estimates of available yields from the source waters. Withdrawal scenarios of 0, 5, 10, 15, and 20 percent were used for initial evaluation of available water volumes, and 5 percent reductions were used for further evaluation. Any newly designated MFL criteria would take precedent over the 5 percent flow constraint. Withdrawals that may have already impacted historic flows were not addressed. Five potential surface water sources in addition to reclaimed water were initially developed for the four aquifer recharge concepts, and then refined to include two for further analysis:

- Rodman Reservoir/Ocklawaha River, and
- Upper Suwannee River from Benton to Ellaville.

Flows in the Rodman Reservoir were relatively uniform and may offer opportunity for water capture throughout the year, and a withdrawal of 30 million gallons per day (mgd) was selected for evaluation. Seasonal variation in flows in the upper Suwannee River is higher and water would likely be available during high wet season flows, but significantly less during low dry season flows. Therefore a 40 mgd withdrawal scenario was selected for evaluation.

Hydrogeologic Assessment of Potential Recharge Project Locations

Hydrogeological conditions in the study area are critical to selecting sites for direct recharge (under Recharge Concepts 1 and 2) and indirect recharge (under Recharge Concepts 3 and 4) projects. The data from the USGS MegaModel (USGS 2002) was used to assist in identifying areas with suitable hydrogeologic conditions. A total of 18 separate sites were assessed as potential aquifer recharge sites (some sites were evaluated for both Recharge Concepts 2 and 3). Another site, PCS Phosphate land, was added under Recharge Concept 3 due to its size and location relative to the upper Suwannee River.

Recharge Concept 1 - The treatment of reclaimed water from northeast Florida for recharge into the UFA in the study area. Projects with reclaimed water from wastewater treatment facilities (WWTFs), with capacities greater than 10 mgd were considered and four facilities were identified: Buckman Street, Southwest, District II, and Arlington East. Only direct aquifer recharge at the WWTF sites provides an opportunity to improve aquifer water levels without costs of pumping and piping to remote locations.

Recharge Concept 2 - The capture and storage of surface water from the upper Suwannee River for treatment and direct recharge into the UFA. Nine sites were initially evaluated for direct recharge into the UFA, including sinkholes and swallets with direct connection to the UFA. Locations with an overlying confining bed to contain the recharged water and an aquifer transmissivity with sufficient transmissivity were examined and considered important. Three sites were further evaluated:

- White Sulphur Springs (Recharge Concept Site 2-1),
- Suwannee Springs, (Recharge Concept Site 2-2), and
- Falling Creek Falls Park (Recharge Concept Site 2-3).

Recharge Concept 3 - The capture of flood waters within the floodplain along the upper Suwannee River for storage and indirect recharge of the UFA. Ten Locations were initially evaluated for indirect recharge into the UFA. Sufficient hydraulic head difference between SAS and UFA, limited or no confining beds below the SAS, and an adequate storage feature (e.g., wetland, RIB), were considered important, and evaluated under Recharge Concept 3. Three sites were further evaluated:

- Eleven Ponds (Recharge Concept Site 3-1),
- Phosphate mined lands north of the Suwannee River (Recharge Concept Site 3-2), and
- Mattair Springs (Recharge Concept Site 3-3).

Recharge Concept 4 - The capture and storage of surface water from the SJRWMD for treatment and recharge into the UFA. Both indirect and direct recharge and the availability of surface water from rivers and streams in the SJRWMD were examined, although water availability and water quality reduced the potential project locations from four to one. The Rodman Reservoir on the Ocklawaha River, approximately 26 miles from Keystone Heights (the recharge area) was selected for further evaluation. Keystone Heights is an area where surface water and groundwater declines have been dramatic, yet it is also an UFA potentiometric high. Direct aquifer recharge would improve regional groundwater levels and assist in lake water level recovery. Indirect recharge is anticipated via the lakes (Brooklyn and Geneva) to the UFA from downward leakage. Additional water quality analyses will likely be required to address water quality impairments in Lake Geneva.

Groundwater Modeling Analysis for Potential Recharge Sites

Groundwater modeling was conducted using the revised USGS MegaModel to evaluate UFA benefits of potential project locations identified in Recharge Concepts 2 and 3, and to compare the modeled benefits between sites. Groundwater flow modeling for Recharge Concepts 1 and 4 could be completed by the SJRWMD; results are not available. Potential recharge sites for Recharge Concepts 2 and 3 were evaluated for both 20 and 40 mgd recharge rates. The groundwater modeling was used to compare the increases in the potentiometric surface of the UFA, and increased spring discharge and/or river baseflows at selected locations along the upper Suwannee River, Ichetucknee River, and Santa Fe River for each of the simulated sites. The Falling Creek Falls Park site was selected for further evaluation due to greater regional benefits and designated as Recharge Concept 2. PCS Phosphate land was selected for further evaluation due to greater regional benefits, and designated as Recharge Concept 3.

Conceptual Design of Selected Aquifer Recharge Concepts

Basic engineering criteria were established for the selected aquifer recharge concepts and design and treatment schematics were developed for the selected aquifer recharge concepts/projects. The next phase of work would include site-specific data collection and analysis for preliminary design of aquifer recharge concepts.

Recharge Concept 1. Direct recharge of reclaimed water from Buckman Street WWTF and Southwest WWTF into UFA. Up to 30 mgd of reclaimed water from the Buckman Street WWTF and 10 mgd from the Southwest WWTF may be available for direct aquifer recharge via recharge wells on the WWTF properties. The conceptual design includes supplemental treatment of reclaimed water, pumping and yard piping, six recharge wells for the Buckman WWTF site, and two recharge wells for the Southwest WWTF.

Recharge Concept 2. Direct recharge of water from Suwannee River into Falling Creek Falls Park. Up to 40 mgd of water from the Suwannee River may be available for treatment and aquifer recharge at District-owned land in Falling Creek Falls Park. The conceptual design includes a raw water intake structure near White Sulphur Springs, transmission piping, and a new WTP and recharge wells at Falling Creek Falls Park.

Recharge Concept 3. Indirect recharge of water from the upper Suwannee River to clay settling area (CSA) reservoir on PCS Phosphate lands. Up to a maximum daily capacity of 40 mgd of water may be pumped from the upper Suwannee River to a CSA reservoir, then to a phosphate mining sand tailing area for filtration and aquifer recharge, or back to the upper Suwannee River during periods of low flow. Conceptual design elements include a raw water intake structure on the upper Suwannee River, transmission and distribution piping, and modification of the CSA for water storage. Additional water treatment is not anticipated.

Recharge Concept 4. Indirect recharge of water from the Rodman Reservoir to Lake Brooklyn and Lake Geneva. Up to 30 mgd of water from the Rodman Reservoir may be pumped to Lake Brooklyn and Lake Geneva in Keystone Heights, with up to 10 mgd treated and discharged into Lake Geneva and the remainder discharged to Lake Brooklyn. Conceptual design elements include a raw water intake structure on Rodman Reservoir, transmission piping, and a new WTP at Lake Geneva.

Planning Level Cost Estimates and Implementation Schedule

Opinion of probable costs for each of the four aquifer recharge concepts were developed (Table ES-1) and include capital costs, annual operating and maintenance (O&M) cost, and annual project cost. Annual project cost provides an annualized cost (capital and O&M) over 20 years and a production cost per 1,000 gallons.

Table ES-1: Summary of Costs

Aquifer Recharge Concept	Total Capital Cost	Annual O&M Cost	Annualized Capital Cost (20 years @ 3.75%)	Total Unit Production Cost (\$/1000 gallons)*
1	\$182,455,391	\$7,872,007	\$21,001,880	\$1.44
2-3	\$303,823,830	\$7,766,829	\$29,630,629	\$2.03
3-2	\$173,693,169	\$7,105,458	\$19,604,783	\$1.34
4	\$278,972,563	\$3,915,766	\$23,991,217	\$2.19

**Total unit production costs assumed design flow, 24 hours/day, 365 days/year.*

Estimated time frames for Recharge Concepts 1, 2, and 3 are 9 years, and 8 years for Recharge Concept 4, exclusive of the system expansion phase. The similar estimates reflects funding availability, permit and regulatory rule changes, contracting difficulties, work sequencing and contractor performance. The implementation schedule also includes annual project costs to execute the five project phases.

Conclusions

The 18 initial aquifer recharge project sites were evaluated based on several criteria (below) and the final selection of the four aquifer recharge concepts are summarized in Table ES-2. The final choice of the preferred recharge project should include site specific data collection and field testing.

- Site availability – suitable land area available for construction,
- Source water quality – water quality acceptable for aquifer recharge with minimal treatment,
- Source water availability – sufficient to justify implementation of the recharge concept,

- Appropriate hydrogeological conditions – hydrogeology suitable for aquifer recharge project,
- Site logistics – site is suitable for construction of an aquifer recharge project, and
- Regional water resource benefits – proposed aquifer recharge project will increase in the potentiometric surface of the UFA at a regional level.

Table ES-2: Recharge Concept Benefits and Issues/Constraints

SELECTED RECHARGE CONCEPT	REGULATORY : RULES AND PERMITS	ENVIRONMENTAL : SOURCE AVAILABILITY AND MODELING RESULTS	TECHNICAL : WATER TREATMENT	ECONOMICS : COST
1. BUCKMAN/ SOUTHWEST WWTF	- Recharge well permitting - Reclaimed water regulations - WWTF operating permit	- Available source water - Limited source water piping - Anticipated regional benefits to potentiometric surface	- Additional reclaimed water treatment required - Existing onsite infrastructure utilized	- Capital - \$182,455,391 \$/1000 gal - \$1.44 - O&M - \$7,872,007
2. FALLING CREEK FALLS PARK	- Recharge well permitting - Surface water diversion permitting - Pipeline transmission permitting	- Available source water - Significant source water piping - Regional benefits to spring and river flow	- Significant engineering required - Significant water treatment required	- Capital - \$303,823,830 \$/1000 gal - \$2.03 - O&M - \$7,766,829
3. PCS PHOSPHATE LAND	- Reservoir permitting - Surface water diversion permitting - Water quality regulations	- Available source water - Moderate source water piping - Regional benefits to spring and river flow	- Significant engineering required - No additional water treatment required	- Capital \$173,693,169 \$/1000 gal - \$1.34 - O&M - \$7,105,458
4. OCKLAWAHA RIVER/RODMAN RESERVOIR	- Surface water diversion permitting - Water quality regulations - Pipeline transmission permitting	- Available source water - Significant source water piping - Anticipated regional benefits to potentiometric surface	- Significant engineering required - Minimal water treatment required	- Capital - \$278,972,563 \$/1000 gal - \$2.19 - O&M - \$3,915,766

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1.0 INTRODUCTION

The Suwannee River Water Management District (SRWMD), St. Johns River Water Management District (SJRWMD), and the Florida Department of Environmental Protection (FDEP) have entered into an agreement that formalizes the coordination of water resource management and planning in north Florida. These two water management districts (Districts) are participating in the North Florida Aquifer Replenishment Initiative (NFARI); a cooperative effort to protect, maintain, or restore regional aquifer water levels by recharging the Upper Floridan aquifer (UFA) at strategic locations. Anticipated benefits of the initiative include hydrological and ecological improvements to local surface water features such as lakes, springs, and rivers, and development of a sustainable water supply for the region. As part of the NFARI, the Districts contracted with Atkins North America, Inc. (Atkins) in July 2012 to perform a study to develop conceptual approaches for recharging the UFA. The study is intended to identify key project components and associated planning-level capital cost opinions for selected aquifer recharge concepts. The study area is shown in Figure 1-1 and includes portions of the upper Suwannee River basin, the Alapaha River basin, and the upper and lower Santa Fe River basins in the SRWMD, and the St. Marys River basin, Black Creek basin, St. Johns River basin and Ocklawaha River basins in the SJRWMD.

This report presents the conceptual approaches to recharging the UFA based on the methods, results, conclusions, and recommendations developed and detailed in two technical memoranda (TM-1 and TM-2) prepared under the same contract with the SRWMD, briefly described below.

- TM-1 included identification and evaluation of four aquifer recharge concepts with respect to source water availability, water quality, required treatment levels, and regulatory permitting constraints, and
- TM-2 included an evaluation of hydrologic and hydrogeologic data collected under TM-1, groundwater flow modeling to identify optimum locations for aquifer recharge facilities and effectiveness of conceptual designs for applicable recharge concepts, and preliminary feasibility analysis of collection, storage, treatment, transmission, and recharge locations, and narrowed the focus of the study to three areas: the upper Suwannee River watershed, Santa Fe River watersheds, and the Keystone Heights potentiometric high. TM-2 also included planning level cost estimates and scheduling.

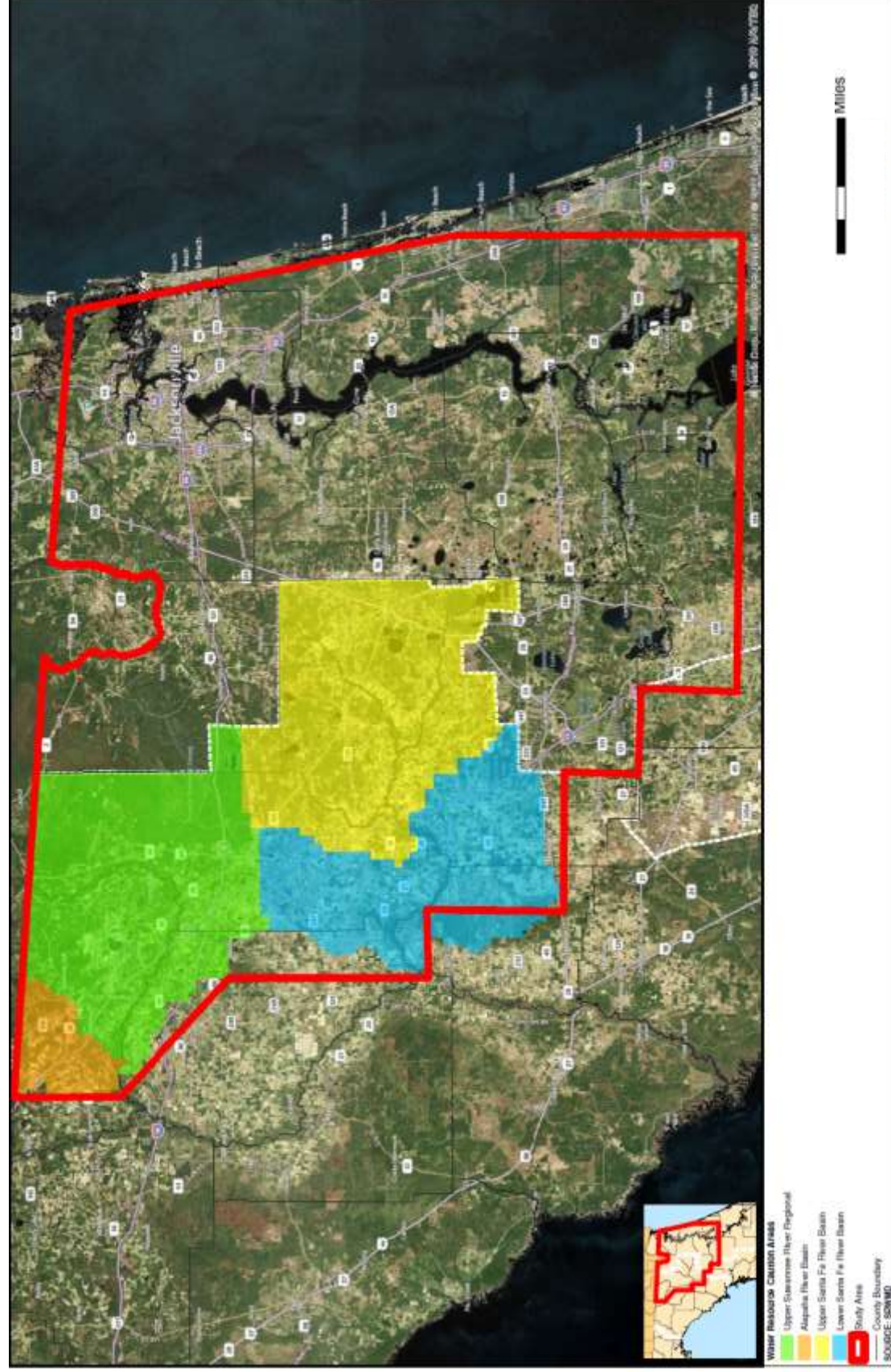


Figure 1-1: Aquifer Recharge Concepts Proposed Study Area

The four aquifer recharge concepts developed for this study are summarized below:

- Recharge Concept 1: the treatment of reclaimed water from northeast Florida for recharge into the UFA in the study area,
- Recharge Concept 2: the capture and storage of surface waters from the upper Suwannee River for treatment and direct recharge into the UFA,
- Recharge Concept 3: the capture of flood waters within the floodplain along the upper Suwannee River for storage and indirect recharge into the UFA, and
- Recharge Concept 4: the capture and storage of surface water from within the SJRWMD for treatment and recharge into the UFA.

In addition to evaluating locations of potential source waters and recharge locations for the various concepts, the means of recharge, i.e. direct or indirect, under each concept was also evaluated. Direct and indirect recharge were evaluated as part of the recharge concepts due to collection, treatment, transport, and cost considerations. Direct aquifer recharge is referred to in this report as the recharge of source water through recharge wells or natural features, such as sinkholes, that have a direct pathway to the UFA. Indirect aquifer recharge is referred to as the recharge of source water involving natural features such as floodplains, wetlands, and sinkholes that are not directly connected to the UFA, or artificial features such as mine pits, sand tailings and rapid infiltration basins (RIB).

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2.0 HYDROLOGIC AND HYDROGEOLOGIC DATA

Five surface water sources have been identified in the study area for the potential aquifer recharge projects:

- St. Marys River along the Florida–Georgia border,
- Rodman Reservoir on the Ocklawaha River,
- Lower St. Johns River upstream of the confluence with the Ocklawaha River within the study area,
- Black Creek, a tributary of the St. Johns River located in Clay County, and
- Upper Suwannee River from the Florida-Georgia border to the confluence with the Alapaha River.

Available data were reviewed for relevance to the proposed recharge concepts and to determine data gaps that prevent proper assessment of the recharge concepts. The results of the data review and inventory indicated that the available data were adequate for this planning level feasibility study. However, additional data may be necessary for preliminary design engineering and permitting of the preferred project. Relevant water quality, hydrology, and ecological data that are available for these source waters are summarized below with respect to permitting the proposed recharge projects. The data compiled for the five surface water sources are summarized in Table 2-1.

2.1 Surface Water Quality

Florida's surface water quality standards have been developed to maintain healthy surface water bodies, as set forth primarily in Chapter 62-302 of the F.A.C. Under this regulation, surface water discharged to another surface water (wetland or river) must not violate surface water quality standards. Rule 62-302.530, F.A.C. sets forth for all waters of the state that "in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna." Florida also has an "anti-degradation" water quality standard (Rule 62-302.300, F.A.C.) that is a public interest test and requires an evaluation of the water quality impacts of a discharge to assure that water quality criteria are not violated, i.e. that the use or action is consistent with (benefits) the public interest. Florida's groundwater standards are the same as the state's drinking water standards, and are addressed specifically in Section 3.0 *Regulatory and Treatment Requirements* of this report.

Characterizing the water quality of the source waters is important for identifying water treatment processes that may be necessary prior to recharging surface waters and/or groundwater. The source water quality was evaluated with respect to regulatory standards, including Total Maximum Daily Loads (TMDL), impaired water bodies, and FDEP water body classifications. TMDL and Basin Management Action Plan (BMAP) reports are not available for the St. Marys River or the Ocklawaha River/Rodman Reservoir, although this is not considered a critical data gap since surface waters will not be discharged into these rivers under any of the recharge concepts examined for this study.

Table 2-1: Summary of Available Data Relevant to the Recharge Concepts under Evaluation

Data Topic	St. Marys River	Ocklawaha River/ Rodman Reservoir	Lower St. Johns River	Black Creek	Upper Suwannee River	Source
Hydrology	Satellite Imagery/Aerial Photography	X	X	X	X	LABINS, SJRWMD
	Topography	X	X	X	X	USGS
	Government-Owned Parks, WMAs	X	X	X	X	FGDL
	Existing, Ongoing Watershed Studies	X	X	X	X	SJRWMD, SRWMD
	Existing Water Supply Plans	X	X	X	X	SJRWMD, SRWMD
	Rainfall Stations and Data	X	X	X	X	USGS, SJRWMD, SRWMD
	Stream Flow Stations and Data	X	X	X	X	USGS, SJRWMD, SRWMD
	Water Stage Recorders and Data	X	X	X	X	USGS, SJRWMD, SRWMD
	Finalized MFL	NA	NA	NA	2013	SRWMD, SJRWMD
	MFL Information (Schedule, Map, Reports)	X	X	X	X	SRWMD, SJRWMD
Biology/Ecology	Floodplain	X	X	X	X	FGDL, SRWMD, FEMA
	Springs Reports	X	X	X	X	SJRWMD, SRWMD
	Geology/Soils	X	X	X	X	NRCS
	Land Use/Land Cover	X	X	X	X	FGDL, SJRWMD, SRWMD
	Sensitive/Unique Habitats	X	X	X	X	FGDL, SHCA
	Threatened/Endangered Species	X	X	X	X	FGDL, FNAL, FFWCC
	Recorded Cultural Resources Sites	X	X	X	X	FGDL
	National Wetland Inventory	X	X	X	X	USFWS
	Primary and Secondary DWS	X	X	X	X	FDEP
	Class III Water Standards	X	X	X	X	FDEP
Water Quality	Surface Water Quality Data	X	X	X	X	SRWMD, SJRWMD, USGS, FDEP
	TMDL/BMAP Reports	NA	NA	X	X	FDEP
	Reclaimed Water Quality Characterization	X	X	X	X	SRWMD, SJRWMD, FDEP
	WBID Boundary	X	X	X	X	FDEP
	WBID Impairment Status	X	X	X	X	FDEP
	Supplemental Reports	X	X	X	X	SJRWMD, SRWMD, USGS, ATKINS, FDEP

DWS = Drinking Water Standard; NRCS= National Resources Conservation Service; FEMA =Federal Emergency Management Agency; FGDL= Florida Geographic Data Library; SHCA= Strategic Habitat Conservation Areas; TMDL= Total Maximum Daily Load; BMAP= Basin Management Action Plan; WBID= Water Body Identification number; X=Available; NA=Not Available

Water quality data from the Impaired Water Rule (IWR) database (compiled by the State of Florida from the United States Environmental Protection Agency [EPA] Data Warehouse [STORET], and the U.S. Geological Survey [USGS]) were used to evaluate the water quality of the source waters. A preliminary review of the IWR database indicates data are available for the source waters being considered (Table 2-1).

Water quality statistics for selected parameters that affect the selection of treatment and disinfection processes for meeting drinking water standards were determined for the five source waters under evaluation. Data were downloaded from <http://www.dep.state.fl.us/water/basin411/download.htm>, the FDEP IWR Run46 database. Polygons associated with these are mapped in Figure 2-1. Minimum, mean, median, and maximum values were generated for January 2002 through May 2012 for chloride, fecal coliforms, total coliforms, total dissolved solids (TDS), total nitrogen (TN), total organic carbon (TOC), and total suspended solids (TSS) for comparison with relevant drinking water standards. Surface water quality for the five raw water sources is summarized in Table 2-2 and includes values for water quality parameters important to determining treatment requirements.

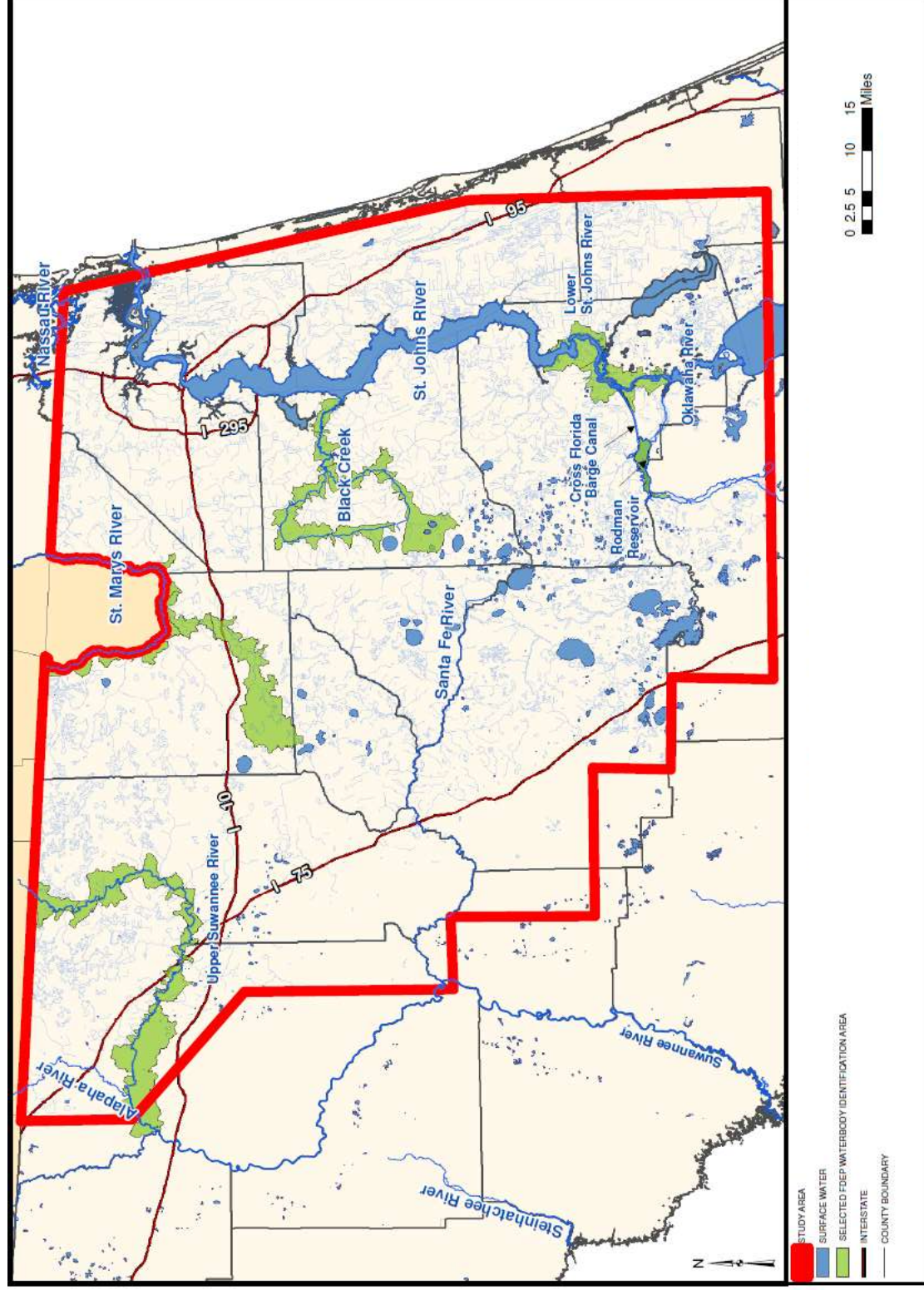


Figure 2-1: Source Waters for which Water Quality Data Were Compiled for Evaluation of Groundwater Recharge Concepts

**Table 2-2: Summary of Surface Water Quality
for the Five Proposed Raw Water Sources**

Water Source	Parameter	Unit	Criteria	N	Min	Mean	Median	Max
St. Marys River	Chloride	mg/L	250	137	3	9	8	39
	Fecal Coliforms	#/100mL	200	36	3	135	45	2600
	Total Coliforms	#/100mL	200	15	85	259	232	460
	Total Dissolved Solids	mg/L	3000	101	43	103	101	212
	Total Nitrogen	mg/L	10	164	0.4	1.2	1.2	2.7
	Total Organic Carbon	mg/L	3	122	1.5	48.1	50.3	95.0
	Total Suspended Solids	mg/L	5	103	1.0	5.0	5.0	16.0
Ocklawaha River/ Rodman Reservoir	Chloride	mg/L	250	60	15	42.0	35.0	111
	Fecal Coliforms	#/100mL	200	1	460	460	460	460
	Total Dissolved Solids	mg/L	3000	54	199	315	310	407
	Total Nitrogen	mg/L	10	1177	0.1	0.8	0.7	5.9
	Total Organic Carbon	mg/L	3	63	1.0	9.6	8.2	21.3
	Total Suspended Solids	mg/L	5	63	1.4	6.0	5.0	58.0
Lower St. Johns River	Chloride	mg/L	250	617	44	209	200	369
	Fecal Coliforms	#/100mL	200	123	1	39	18	380
	Total Coliforms	#/100mL	200	97	8	193	116	2460
	Total Dissolved Solids	mg/L	3000	554	273	557	540	1340
	Total Nitrogen	mg/L	10	696	0.7	1.3	1.2	3.3
	Total Organic Carbon	mg/L	3	527	7.3	16.6	16.5	30.7
	Total Suspended Solids	mg/L	5	690	2.0	11.7	10.0	98.0
Black Creek	Chloride	mg/L	250	398	4	244	11	4600
	Fecal Coliforms	#/100mL	200	104	3	106	25	1300
	Total Coliforms	#/100mL	200	11	300	1133	668	6000
	Total Dissolved Solids	mg/L	3000	387	5	511	90	7570
	Total Nitrogen	mg/L	10	425	0.1	0.7	0.6	2.1
	Total Organic Carbon	mg/L	3	419	4.6	18.8	16.0	57.5
	Total Suspended Solids	mg/L	5	407	1.4	6.2	5.0	73.0
Upper Suwannee River	Chloride	mg/L	250	453	2	7	7	15
	Fecal Coliforms	#/100mL	200	226	0	108	20	2100
	Total Coliforms	#/100mL	200	56	40	943	255	7800
	Total Dissolved Solids	mg/L	3000	295	5	115	112	277
	Total Nitrogen	mg/L	10	473	0.2	1.5	1.4	28.3
	Total Organic Carbon	mg/L	3	478	0.5	50.3	51.9	100.0
	Total Suspended Solids	mg/L	5	200	0.0	5.4	4.0	116.0

#= colony forming units (CFU); N= number of samples

Note: Parameters listed will be used to determine treatment requirements.

Note: The criteria are applicable to surface water quality and not drinking water standards.

Results of the surface water quality data review indicate that, based on the elevated concentrations for each of the source waters, additional treatment may be necessary to satisfy drinking water standards if using these source waters.

- St. Marys River. Data from the St. Marys River indicate elevated mean TOC and maximum TSS, and fecal and total coliform concentrations,
- Rodman Reservoir. Mean fecal coliforms, TOC and TSS concentrations were elevated. Total coliform data were not available within the Rodman Reservoir,
- Lower St. Johns River. Water quality in the lower St. Johns River downstream of its confluence with the Ocklawaha River indicate elevated mean TOC and TSS, as well as elevated maximum fecal and total coliform concentrations. Similar to Black Creek, chloride concentrations were elevated,
- Black Creek. Values for mean total coliforms, TOC and TSS concentrations, plus maximum concentrations for fecal coliform and TDS, were elevated. In addition, elevated chloride concentrations were observed in the downstream portions of the selected river systems, and
- The upper Suwannee River water quality data included elevated mean TOC and TSS, and maximum TN, fecal, and total coliform concentrations.

Table 2-2 summarizes the water quality data for these source waters.

The Suwannee River is classified as a Class III water body and as such, water quality must support designated uses for recreation, plus the propagation and maintenance of a healthy, well-balanced population of fish and wildlife. Water released from storage back into the Suwannee River under Recharge Concept 3 must meet Class III water quality standards based on the conditions of human and aquatic life, and expressed as concentrations, levels, or narrative descriptions of impacts. Surface water diversion, storage, and subsequent natural groundwater recharge in the Suwannee River floodplain (Recharge Concept 3) are unlikely to violate water quality standards, but would require a joint application for an Environmental Resource Permit (ERP)/ Authorization to use Sovereign Submerged Lands/ Federal Dredge and Fill Permit from FDEP. A permit from the United States Army Corps of Engineers (USACE) for the surface water diversion structures would also be required. The ERP would address dredge and fill activities and associated water quality regulations (e.g. Federal Clean Water Act [CWA] and the National Pollutant Discharge Elimination System [NPDES] regulations). The IWR (Chapters 62-302 and 62-303, F.A.C.) describes the water quality standards and methods used to determine water quality conditions for specified designated use categories.

Water bodies presently designated as “impaired” by the State of Florida will be identified with respect to discharging (returning) stored water to impaired/unimpaired surface waters. At this time, the Suwannee and Santa Fe rivers have TMDLs that address dissolved oxygen (DO) and nutrients.

Nitrate-nitrogen (N) concentrations in spring waters in the SJRWMD and the Suwannee River have increased substantially over the past several years (Hornsby et al. 2002, Katz et

al. 1999). Numerous domestic and monitor wells have yielded water with nitrate-N concentrations that exceed 10 milligrams per Liter (mg/L) which is the maximum contaminant level set by the EPA for infant health reasons. Consequently, groundwater recharge projects must be considered with respect to their contribution of additional nutrients into these water systems.

2.2 Surface Water Hydrology

Surface water hydrology data are available from rainfall stations, stream flow stations, and water stage recorders for the five potential water sources. Federal Emergency Management Agency (FEMA) flood data are also available for these watersheds. Information related to MFLs is available, although MFLs have not yet been designated for any of the five potential water sources selected (the SRWMD is expected to set an MFL for the upper Suwannee River and the SJRWMD for the Ocklawaha River in the near future). The lack of established MFLs is considered a substantial data gap with respect to evaluating the source water volumes that are available for aquifer recharge.

MFLs provide the limit at which water cannot be removed from the system without causing significant harm. Therefore, the volume of water that may be available from a particular water body for aquifer recharge is dependent on the MFL for that water source. Available source water could be identified from water bodies with established MFLs by comparing MFLs with USGS discharge data and permitted water withdrawals. For example, the adopted MFL for the lower Suwannee River below the Wilcox gauge requires a minimum of 6,600 cubic feet per second (cfs) for a flow duration frequency of 50 percent for the period May 1 through October 31. Based on this information, surface water withdrawals at the Wilcox gauge cannot reduce discharges below 6,600 cfs over the identified time period. Flows available after meeting any established MFL may provide a source of water for a recharge project.

Portions of the Suwannee River watershed have adopted MFLs (e.g., the lower Suwannee River and springs, and the upper Santa Fe River) while MFLs for other portions of the watershed will be established in the near future (e.g., the lower Santa Fe River, the Ichetucknee River and associated springs, and the upper Suwannee River). MFLs for several segments of the St. Johns River have already been established.

2.3 Hydrogeology

Hydrogeologic conditions within the study area have been documented since the inception of the various data collecting organizations. Both the USGS (started in 1879), and the Florida Geological Survey (started in 1907) have conducted numerous hydrogeological studies in north Florida in the past. In more recent years, scientific studies conducted by other state agencies and private organizations have resulted in a hydrogeologic understanding of the study area. The culmination of this historical data collection and data interpretation has been detailed in the report titled: *Simulation of Ground-Water Flow in the Intermediate and Floridan Aquifer Systems in Peninsular Florida*, prepared by the USGS in 2002. Based on discussions with the SRWMD and SJRWMD staff during the kick-off

meeting, it was decided that the hydrogeologic framework as established by the above referenced study is appropriate to use as the basis for evaluations in this study. It is noted that the study area for that document encompasses all of this study. This study focused mainly on how the hydrogeology influences the implementation of the four recharge concepts. In general, a recharge concept using a surface application of available water will require certain hydrogeologic conditions to be successful. Conversely, a recharge concept applying direct aquifer recharge will require significantly different hydrogeologic conditions to be successful.

Hydrogeologic data and reports provided by the SRWMD and SJRWMD in support of the project include the following:

- Geologic cross sections within the study area,
- Potentiometric surface maps representing typical high and low groundwater levels,
- Potentiometric surface maps representing drought, flooding, predevelopment, and pre-1972 conditions,
- Geophysical logs of wells deeper than 500 feet,
- The location and results of aquifer performance tests (APTs),
- The location and use of consumptive use permits (CUPs) equal to or greater than one mgd,
- The location and use of all surface water withdrawals from the Suwannee and Santa Fe rivers,
- Karst features maps (closed depressions and fracture traces),
- Locations and discharges of springs within the study area,
- Location and acreage of state and public lands,
- Location of solid waste and SUPERFUND sites,
- Geologic maps showing spatial location, structural top, and thickness of various geologic and hydrogeologic units,
- Aerial photography with land surface elevation contours,
- Location, type, and recharge capacity of permitted injection or aquifer recharge wells, and
- Permitted wastewater and reclaimed water treatment facilities in the study area including information on flow and effluent water quality.

In addition to the data and reports provided by SRWMD and SJRWMD, information from the USGS was obtained to establish the hydrogeologic framework as referenced in the 2002 groundwater flow modeling report. This information was available from the USGS website as a series of Geographic Information System (GIS) database figures and was generated in support of the groundwater flow modeling project (Bellino 2011). A digital dataset for the Floridan Aquifer System (FAS) in Florida and in parts of Georgia, Alabama, and South Carolina was developed from selected reports published as a part of the USGS Regional Aquifer-System Analysis (RASA) Program in the 1980s. These reports contain maps and data depicting the extent and elevation of both time-stratigraphic and hydrogeologic units of which the FAS is composed, as well as data on hydrology, meteorology, and aquifer properties. Maps and data of particular interest for aquifer recharge projects include thickness and transmissivity of the SAS, depth to and thickness

of the upper confining unit, transmissivity and thickness of the UFA, and any lower confinement of the UFA.

Finally, the FDEP maintains a GIS database that is used to predict the vulnerability of Florida's aquifer systems to surface sources of contamination. The Florida Aquifer Vulnerability Assessment (FAVA) was developed to identify areas of relative aquifer vulnerability based on the local hydrogeologic setting. Therefore, relative hydrogeologic maps have been generated for this study. These maps and data are used to support identifying potential aquifer recharge sites.

Atkins generated a series of figures to assist in the assessment of potential recharge facility locations in the study area. The figures include:

- Figure 2-2 Predevelopment Potentiometric Surface of the UFA within the Study Area,
- Figure 2-3 May 2010 Potentiometric Surface of the UFA, Representing Average Groundwater Levels,
- Figure 2-4 Springs, Sinkholes, Mines, and District Owned Lands Within the Study Area, and
- Figure 2-5 Confinement of the UFA within the Study Area.

The data assessment supported the work elements listed below, which were used in the analysis and selection of the preferred recharge concepts.

- Defining the extent of confinement between the SAS and the UFA,
- Selecting the primary aquifer characteristics necessary for assessing the aquifer recharge options,
- Selecting the SAS characteristics that are essential for surface recharge system siting, and
- Defining the UFA issues that are essential for siting and conceptually designing a UFA recharge system.

Review of the data provided by the SRWMD, SJRWMD, as well as the hydrogeologic databases obtained from the USGS and FDEP, indicated adequate and sufficient data for the evaluations undertaken for this study.

As described in the introduction, two fundamental means of recharge were evaluated:

1. Indirect recharge using surface applications such as reservoirs, RIBS, sand tailings, ponds, and wetland storage, and
2. Direct underground recharge using wells or natural features that are directly connected to the UFA.

The feasibility of each recharge concept was not determined solely by the availability of source water. The quality of the source water will, however, directly impact the treatment

requirements prior to being recharged, as well as the transportation costs. The success of each recharge concept is dependent on the quantity and quality of available water, the cost, and the hydrogeological conditions that allow storage and conveyance of the available water. The location and quality of the available water significantly affects the transportation and treatment costs. This study includes an assessment of the hydrogeological conditions required for each recharge concept.

Indirect, surface application of available water may rely on RIBS and/or wetlands to store and subsequently recharge the aquifer with the available water. For those concepts designed to recharge water into the surficial aquifer system (SAS) or the UFA and then replenish baseflow of springs and rivers, a formation with sufficiently high hydraulic conductivity is necessary for the recharged water to travel to the point of discharge. These recharge concepts require little or no confining bed conditions above or within the formations used for recharge. Surface applications require a relatively thick unsaturated zone to provide sufficient storage capacity within that formation. The preferred hydrogeologic conditions for surface recharge applications would include the hydrogeologic characteristics outlined below:

- The lack of, or limited, confining beds below the SAS to allow vertical aquifer recharge, and
- A formation of sufficient thickness to provide adequate water storage volume.

Indirect surface applications to a river for flow considerations may include the use of an offstream reservoir or wetland to store available water adjacent to a river. The favored locations will be in the hydraulic flow pattern that is upgradient to the spring and river reaches so that the groundwater hydraulic flow is toward the potential recharge point. In these cases, hydrogeologic conditions that are favorable for water storage include:

- A minimal unsaturated zone that restricts groundwater recharge so maximum storage is contained in the reservoir for controlled releases, and
- The existence of confining beds that prevents groundwater recharge to underlying formations.

Aquifer recharge has the benefits of raising the hydraulic head in the UFA for sustainable spring discharge and river baseflow, altering the hydraulic head patterns, shifting local or regional groundwater basin boundaries, and replenishing groundwater supplies. Specific hydrogeologic conditions are preferred to accomplish these results. The receiving aquifer should be characterized by the conditions listed below:

- Sufficient hydraulic conductivity and storage characteristics to accept water recharge, and then provide sufficient natural groundwater flow to influence spring discharge and river baseflow,
- An upper confining bed to contain the recharged water resulting in rising potentiometric levels that generates flow to specific discharge locations such as springs and providing aquifer recharge to locations at some functional distance

- from the point of discharge, and
- A hydraulic head flow path that will result in groundwater flow toward the preferred location (such as springs or river discharge points).

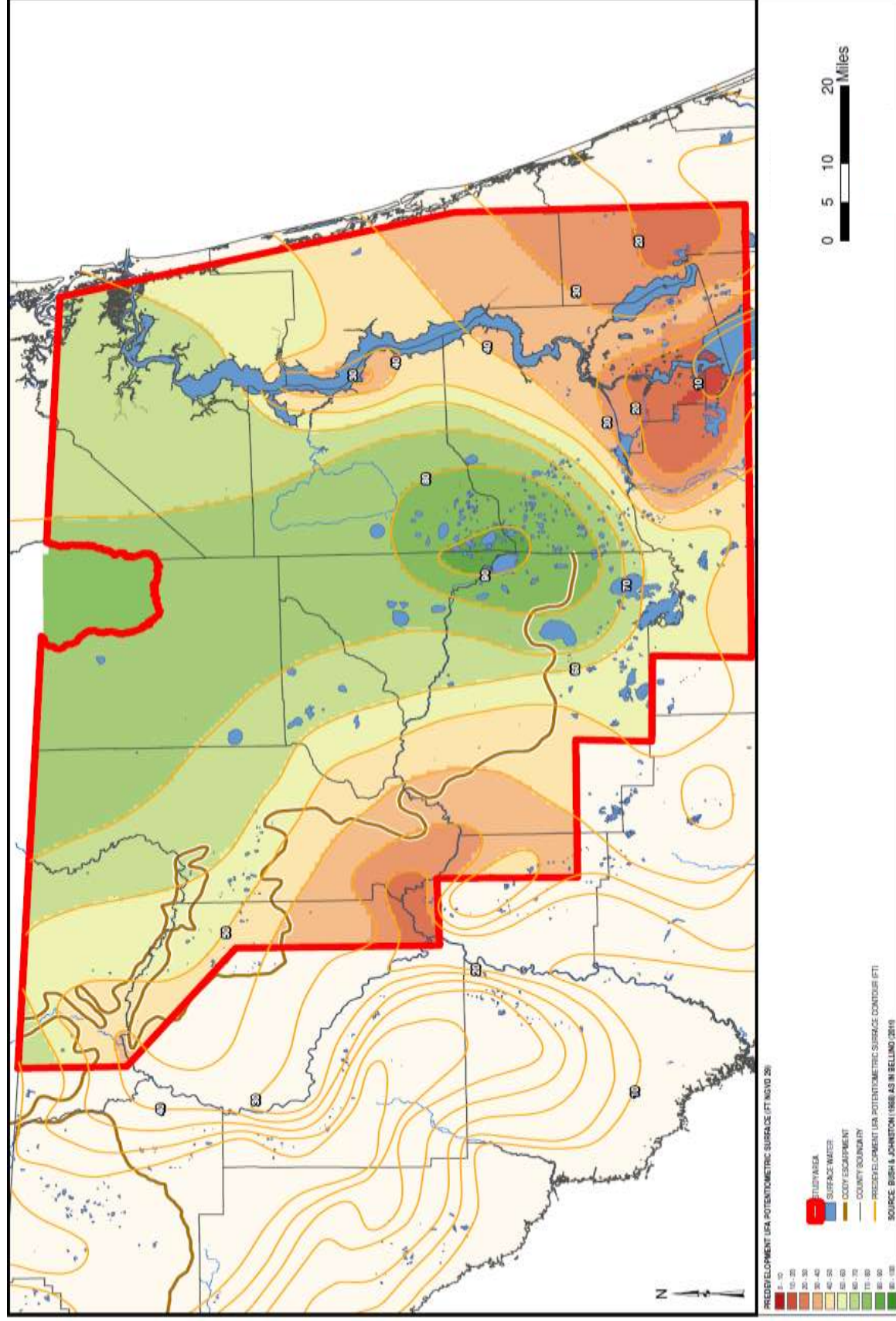


Figure 2-2: Predevelopment Potentiometric Surface of the Upper Floridan Aquifer within the Study Area

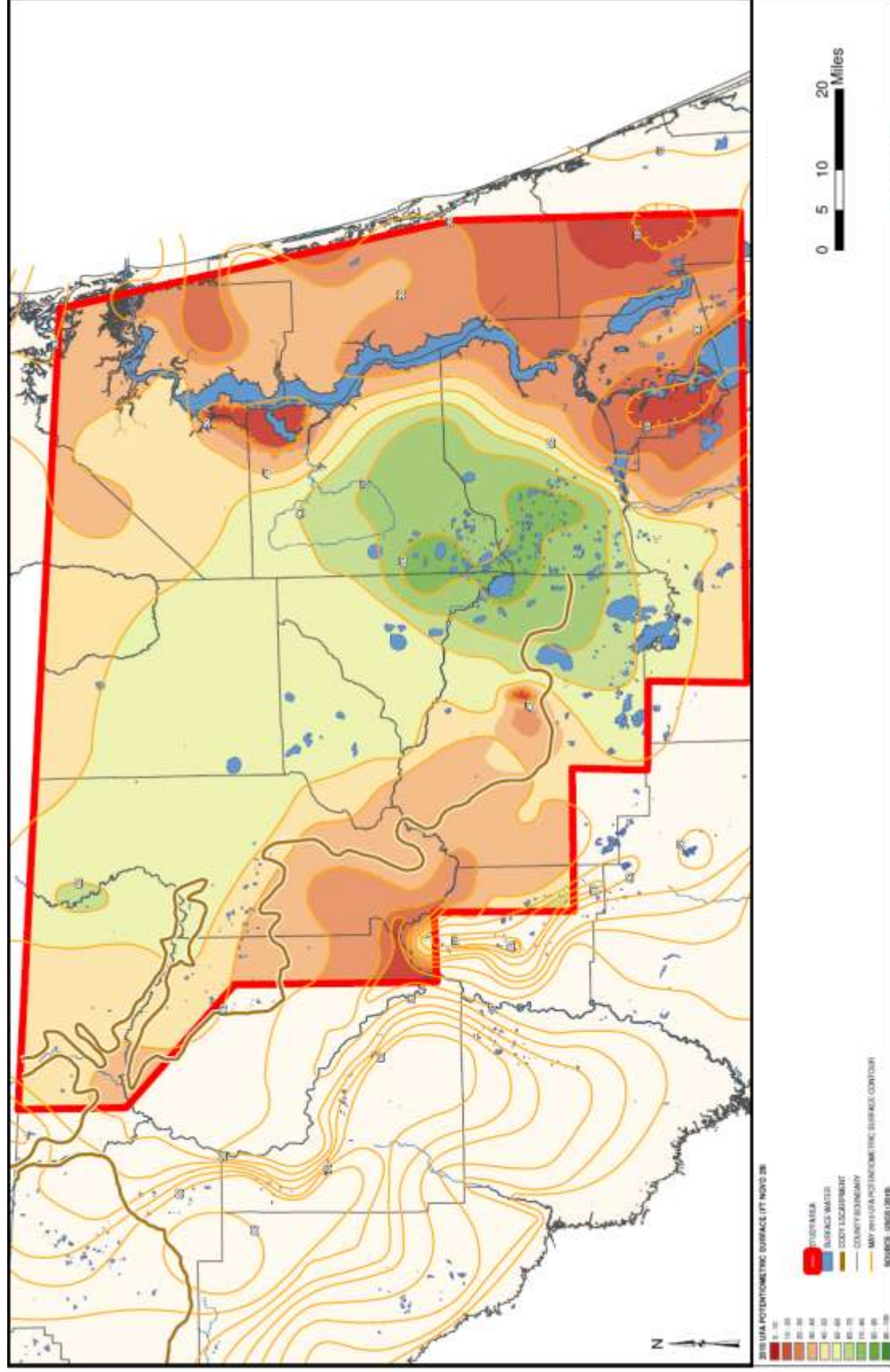


Figure 2-3: May 2010 Potentiometric Surface of the Upper Floridan Aquifer, Representing Average Groundwater Levels

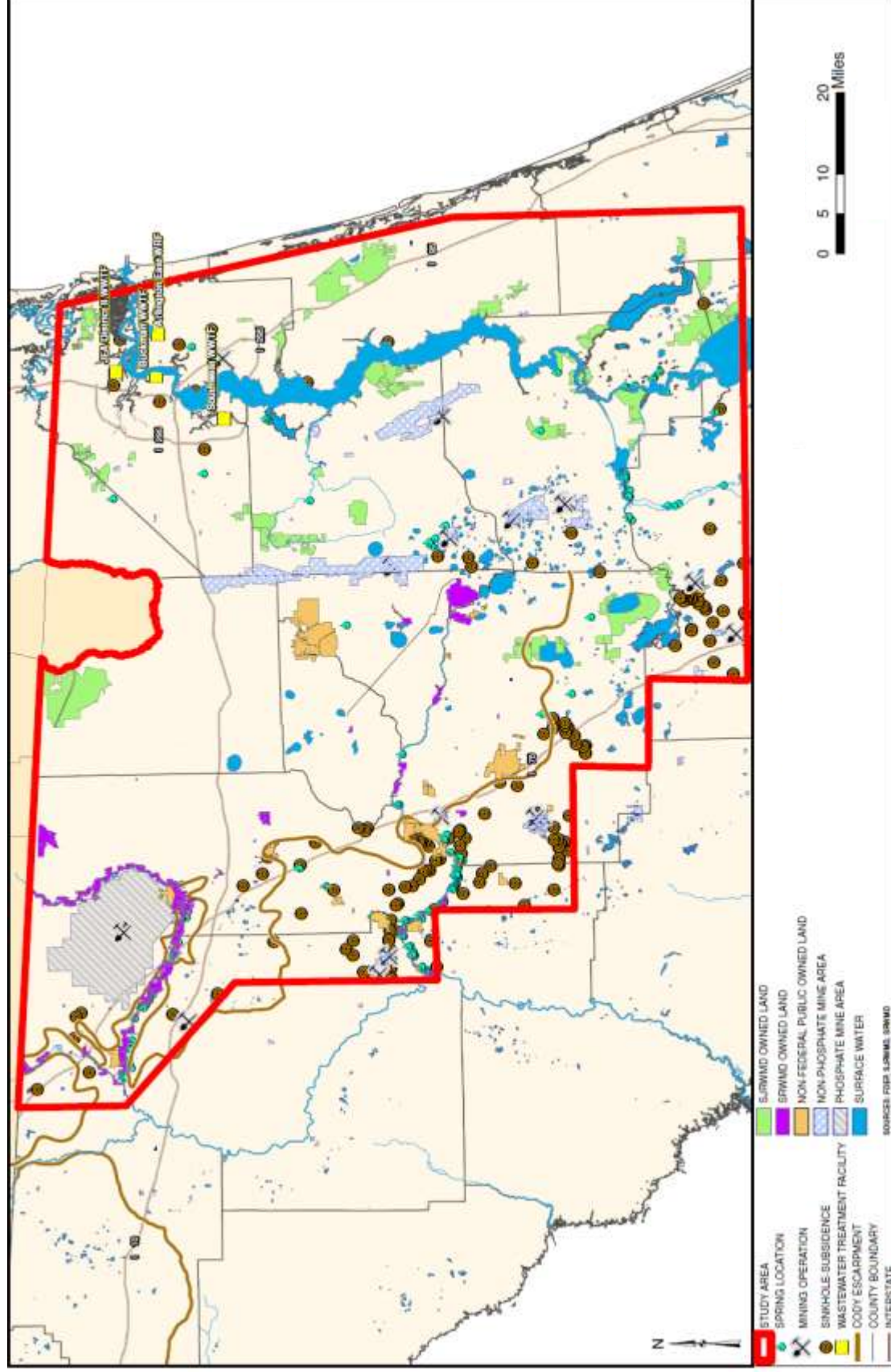


Figure 2-4: Springs, Sinkholes, Mines, and District Owned Lands within the Study Area

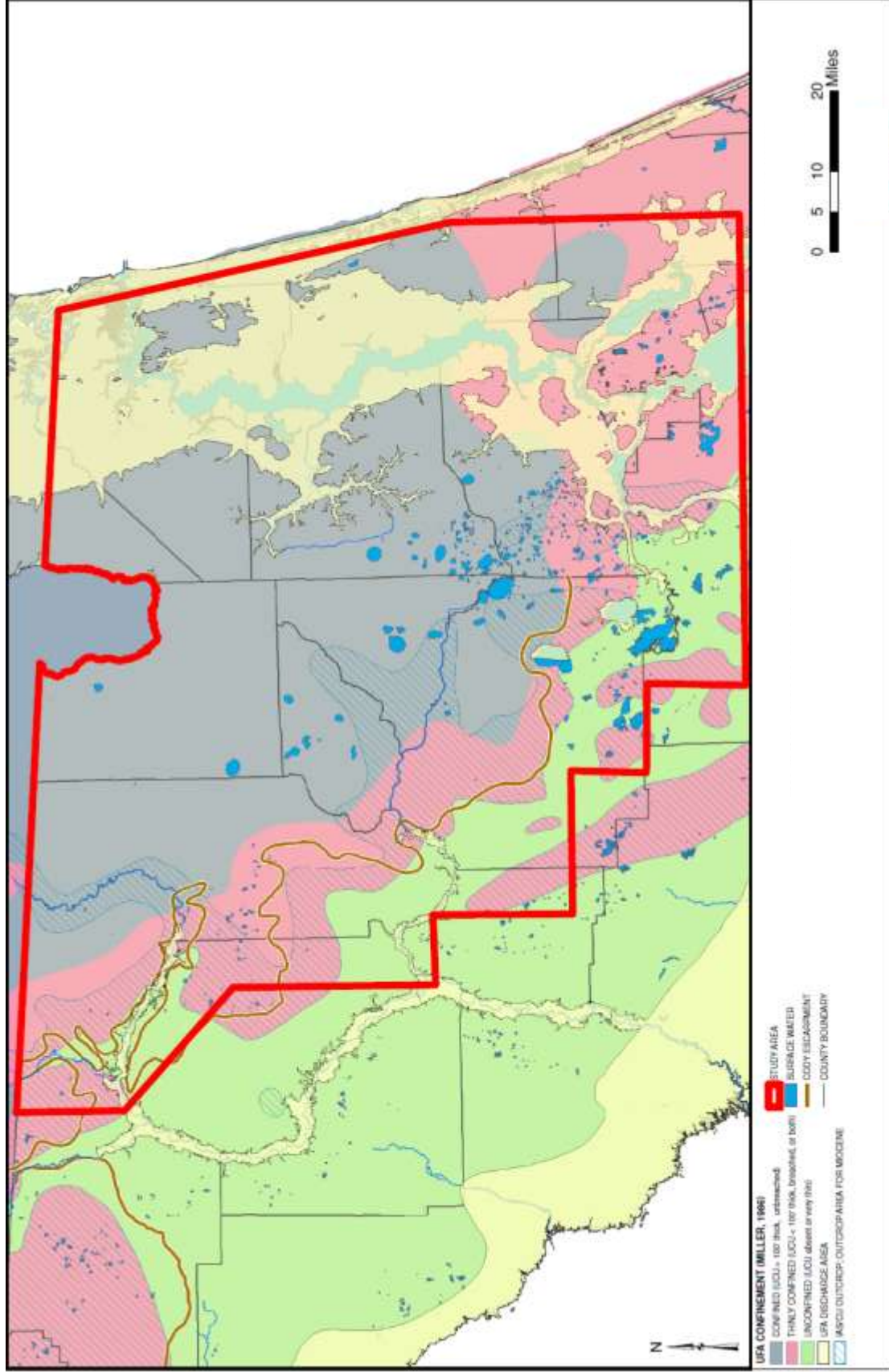


Figure 2-5: Confinement of the Upper Floridan Aquifer within the Study Area

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3.0 REGULATORY AND TREATMENT REQUIREMENTS

The application of direct and indirect aquifer recharge regulations are predicated on the classification of the receiving groundwater by the State of Florida. Groundwater classifications and designated uses are defined under FDEP Chapter 62-520, F.A.C. The groundwater classifications (F-1, G-I, G-II, G-III and G-IV) are primarily differentiated on the basis of TDS concentrations of the aquifer. Within the study area, the TDS concentrations of the SAS and UFA are less than 10,000 mg/L based on data presented in the Florida Geological Survey - Special Publication No. 34 (1992) and correspond to a G-II groundwater classification for both aquifers. For the purpose of this study, any evaluations of aquifer recharge regulatory and water quality treatment requirements will therefore be based on a G-II groundwater classification.

3.1 Direct Aquifer Recharge and Applicable Rules

Direct aquifer recharge can be achieved by the recharge of surface water or reclaimed water through recharge wells or ASR wells, which are under evaluation as Recharge Concepts 1 and 2. Recharge wells refer to wells that only convey water to the aquifer, while ASR wells involve both the introduction and recovery of water to and from the aquifer.

Recharge and ASR wells are regulated under FDEP Chapter 62-528, F.A.C., also known as the Underground Injection Control (UIC) rule. The purpose of the UIC rule is to protect the State's underground sources of drinking water (USDW) and prevent the degradation of the quality of other aquifers adjacent to the recharge storage zone (Rule 62-528.100(1), F.A.C.). The USDW is designated as groundwater having less than 10,000 mg/L of TDS.

Aquifer recharge using reclaimed water is further regulated under FDEP Chapters 62-600, F.A.C., (Domestic Wastewater Facilities) and 62-610, F.A.C., (Reuse of Reclaimed Water and Land Application). These Chapters include additional treatment, disinfection, and monitoring requirements in addition to those listed in the UIC rule. The requirements for what constitutes a public water supply in conjunction with receiving groundwater (TDS levels between 1,000 and 3,000 mg/L) of an aquifer storage and recovery (ASR) project are listed in Rule 62-610.466(9), F.A.C., which limits the public water supply to within 1,000 feet radially from the ASR well or located within the radial extent of the extended zone of discharge (area of well influence) plus an additional 500 feet radially in the horizontal direction.

3.2 Indirect Aquifer Recharge and Applicable Rules

Indirect aquifer recharge can be achieved by the use of natural features such as sinkholes, floodplains, and wetlands, or artificial features such as reservoirs, mine pits, and RIBs, using either surface water or reclaimed water, which are under evaluation as Recharge Concepts 3 and 4. A RIB is an earthen basin designed to rapidly percolate water through the soil and to the groundwater. The use of RIBs with reclaimed water is regulated under FDEP Rules 62-610.500 to 62-610.525, F.A.C. These rules require that the reclaimed water be treated to at least secondary treatment standards (for wastewater treatment) and basic

disinfection levels prior to the RIB application, but also requires additional treatment depending on the location of the RIB, subsurface drainage, and hydraulic loading rate.

Current FDEP regulations have no specific water treatment regulations concerning indirect recharge using surface water. However, FDEP may implement water quality restrictions depending on: (1) the type of recharge - natural (sinkholes, floodplains, and wetlands) versus artificial (reservoirs, mine pits, and RIBs), (2) proximity of the source water to the receiving groundwater, (3) quality of the source water and receiving groundwater, and (4) special conditions identified in an ERP. For the purpose of this evaluation, the following are assumed:

- Indirect natural aquifer recharge systems with raw surface water of similar or better quality to the receiving groundwater or surface water will not require water treatment, and
- All other indirect aquifer recharge systems using surface water will require compliance with the primary and secondary drinking water standards (DWS). This is the same treatment requirements for direct aquifer recharge using surface water.

Based on review of the existing applicable rules and discussions with FDEP, treatment and disinfection requirements for direct and indirect aquifer recharge, for surface and reclaimed water, to Class G-II groundwater are summarized in Tables 3-1 and 3-2, respectively.

Table 3-1: Treatment and Disinfection Requirements for Direct Aquifer Recharge

Source of Recharge Water/Type of Recharge System	Applicable Rules and Required Treatment	Comments
Surface Water/ Recharge Well or ASR Well to Groundwater	FDEP Rule 62-528.610(1), F.A.C. All Class V wells shall be used or operated in such a manner that they do not present a hazard to an underground source of drinking water.	
	FDEP Rule 62-520.310(8)(a), F.A.C. Surface water for aquifer recharge well or ASR shall be of comparable quality of the receiving groundwater.	The receiving groundwater is classified as G-II which is for potable water use. Therefore, the surface water will need to meet primary and secondary DWS (or subsequent secondary WQCE).
Reclaimed Water/ ASR Well to Groundwater (1,000 - 3,000 mg/L TDS) <i>Only applies if receiving groundwater is not currently used as a source of public water supply.</i>	FDEP Rule 62-610.466(9)(b)1, F.A.C. Reclaimed water shall meet the principal treatment disinfection requirements contained in FDEP Rule 62-610.563, F.A.C. except for modification described in FDEP Rules 62-610.466(9)(b)1a to 62-610.466(9)(b)1.d., F.A.C.	FDEP Rule 62-610.466(12)(b)1, F.A.C. Water recovered from the ASR shall be monitored for Carbonaceous biochemical oxygen demand (CBOD5), TSS, and fecal coliform and shall meet the limits established in FDEP Chapter 62-610 Part III, F.A.C.
	FDEP Rule 62-610.563(2)(a), F.A.C. Secondary Treatment High-Level Disinfection TSS: 5 mg/L maximum before application of disinfectant	The fecal coliform limitations associated with high-level disinfection does not apply.
	FDEP Rule 62-610.563(2)(b), F.A.C. Filtration	
	FDEP Rule 62-610.563(3)(b), F.A.C. Primary DWS	The parameters listed as primary DWS shall be applied as maximum single sample permit limitations. The primary DWS for asbestos and sodium does not apply.

Source of Recharge Fluid/Type of Recharge System	Applicable Rules and Required Treatment	Comments
Reclaimed Water/ Direct Recharge to Groundwater <3,000 mg/L Total Dissolved Solids (TDS)	FDEP Rule 62-610.560(2), F.A.C. Reclaimed water to groundwater containing 3,000 mg/L or less TDS for recharge shall meet the full treatment disinfection requirements contained in FDEP Rule 62-610.563, F.A.C.	
	FDEP Rule 62-610.563(2)(a), F.A.C. Secondary Treatment High-Level Disinfection Total Suspended Solids (TSS): 5 mg/L maximum before application of disinfectant	
	FDEP Rule 62-610.563(2)(b), F.A.C. Filtration	
	FDEP Rule 62-610.563(2)(c), F.A.C. Total Nitrogen (TN): 10 mg/L maximum annual average	
	FDEP Rule 62-610.563(3)(b), F.A.C. Primary and Secondary DWS	
	FDEP Rule 62-610.563(3)(c), F.A.C. Additional reductions of pollutants which otherwise would be discharged in quantities which would reasonably be anticipated to pose risk to public health because of acute or chronic toxicity shall be required.	
	FDEP Rule 62-610.563(3)(d), F.A.C. Total Organic Carbon (TOC): 3 mg/L - monthly average and 5 mg/L - max single sample	Alternative TOC limitations can be granted if conditions in 62-610.563(6)(a) to 62-610.563(6)(d) are met.
	FDEP Rule 62-610.563(3)(e), F.A.C. Total Organic Halogen (TOX): 0.2 mg/L - monthly average and 0.3 mg/L - max single sample	Alternative TOX limitations can be granted if conditions in 62-610.563(6)(a) to 62-610.563(6)(d) are met.
	FDEP Rule 62-610.563(3)(f), F.A.C. The treatment process shall include processes which serve as multiple barriers for control of organic compounds and pathogens.	The multiple barrier approach is a concept that relies on more than one treatment technology to treat water. An example is filtration and UV for the control of pathogens.

	FDEP Rule 62-610.564, F.A.C. Pilot testing for one (1) year - including mutagenicity testing approved by the FDEP.	Possible reduction in the duration or scope of the pilot testing program if conditions in 62-610.564(5)(a) and 62-610.564(5)(b) are met.
Source of Recharge Fluid/Type of Recharge System	Applicable Rules and Required Treatment	Comments
Reclaimed Water/ ASR to Groundwater <3,000 mg/L TDS	FDEP Rule 62-610.466(9)(a)1, F.A.C. Reclaimed water to groundwater containing 3,000 mg/L or less TDS for ASR shall meet the full treatment disinfection requirements contained in FDEP Rule 62-610.563, F.A.C.	FDEP Rule 62-610.466(12)(b)2, F.A.C. Water recovered from the ASR shall be monitored for fecal coliform and shall meet the limits established in FDEP Chapter 62-610 Part III, F.A.C.
	FDEP Rule 62-610.563(2)(a), F.A.C. Secondary Treatment High-Level Disinfection TSS: 5 mg/L maximum before application of disinfectant	
	FDEP Rule 62-610.563(2)(b), F.A.C. Filtration	
	FDEP Rule 62-610.563(2)(c), F.A.C. TN: 10 mg/L maximum annual average	
	FDEP Rule 62-610.563(3)(b), F.A.C. Primary and Secondary DWS	
	FDEP Rule 62-610.563(3)(c), F.A.C. Additional reductions of pollutants which otherwise would be discharged in quantities which would reasonably be anticipated to pose risk to public health because of acute or chronic toxicity shall be required.	
	FDEP Rule 62-610.563(3)(d), F.A.C. TOC: 3 mg/L - monthly average and 5 mg/L - max single sample	Alternative TOC limitations can be granted if conditions in FDEP Rules 62-610.563 (6)(a) to 62-610.563(6)(d), F.A.C. are met.

	FDEP Rule 62-610.563(3)(e), F.A.C. TOX: 0.2 mg/L - monthly average and 0.3 mg/L - max single sample	Alternative TOX limitations can be granted if conditions in FDEP Rules 62-610.563 (6)(a) to 62-610.563(6)(d), F.A.C. are met.
	FDEP Rule 62-610.563(3)(f), F.A.C. The treatment process shall include processes which serve as multiple barriers for control of organic compounds and pathogens.	The multiple barrier approach is a concept that relies on more than one treatment technology to treat water. An example is filtration and disinfection for the control of pathogens.
	FDEP Rule 62-610.564, F.A.C. Pilot testing for one (1) year - including mutagenicity testing approved by the FDEP.	Possible reduction in the duration or scope of the pilot testing program if conditions in 62-610.564(5)(a) and 62-610.564(5)(b) are met.

Table 3-2: Treatment and Disinfection Requirements for Indirect Aquifer Recharge

Source of Recharge Water/Type of Recharge System	Applicable Rules and Required Treatment	Comments
Surface Water/ Indirect natural aquifer recharge with surface water that is (1) in close proximity to the recharge location and (2) of similar quality to the receiving groundwater	No additional treatment needed	Assumed*
Surface Water/ Indirect aquifer recharge (not included above)	Primary and Secondary DWS (or subsequent secondary WQCE)	Assumed* (This is the same treatment requirements for direct recharge using surface water.)
Reclaimed Water/ Indirect (natural or artificial) aquifer recharge	FDEP Rule 62-610.525(1)(a), F.A.C. Additional levels of preapplication are required for the projects over ground waters in aquifers used for public water supply, which are unconfined, and have high permeable soil types	
	FDEP Rule 62-610.525(5), F.A.C. Secondary Treatment High-Level Disinfection TSS: 5 mg/L maximum before application of disinfectant	
	FDEP Rule 62-610.525(6), F.A.C. Filtration	
	FDEP Rule 62-610.525(7), F.A.C. TN: 10 mg/L maximum annual average	

	FDEP Rule 62-610.525(8)(a), F.A.C.	
	Primary and Secondary DWS	The parameters listed as primary DWS shall be applied as maximum single sample permit limitations. The primary DWS for asbestos and bacteriological parameters do not apply. Bacteriological parameters listed in the primary DWS include: Legionella, Heterotrophic Plate Count, Mycobacteria, and Total Coliforms.

** **Note:** According to current FDEP regulations there are no specific water treatment regulations concerning the use of RIBs, storage ponds or reservoirs, and wetlands using surface water. However, FDEP may implement water quality restrictions depending on: (1) the type of recharge, natural vs. artificial, (2) proximity of the source water to the receiving groundwater, (3) quality of the source water and receiving groundwater, and (4) special conditions identified in an ERP issued by the FDEP.*

4.0 TREATMENT PROCESSES AND OPTIONS

Water quality of reclaimed and surface water sources was first characterized to assess the quality of the water available for recharge. Once this step was completed, water treatment options were developed to address water quality requirements for the direct and indirect aquifer recharge of both surface and reclaimed water.

4.1 Quality of Reclaimed Water Source

Based on the results of the kickoff meeting, only wastewater treatment facilities (WWTFs) with a capacity of greater than 10 mgd were considered for evaluation. Monthly discharge monitoring reports (DMRs) from the Jacksonville Electric Authority (JEA)-Buckman WWTF, JEA-Arlington East WWTF, JEA-District II WWTF, and JEA-District II WWTF for the period of July 2009 to June 2012 were reviewed to assess the quality of reclaimed water available for recharge in the study area. Reclaimed water quality data for TSS, total nitrogen (TN), fecal coliform, and carbonaceous biochemical oxygen demand (CBOD5) are listed in Table 4-1.

Table 4-1: Reclaimed Water Quality Data for Total Suspended Solids, Total Nitrogen, Fecal Coliform, and Carbonaceous Biochemical Oxygen Demand

Parameter	Buckman Street WWTF	Southwest WWTF	District II WWTF	Arlington East WWTF
TSS (month average)	2.5 to 10.6	4.3 to 21.4	3 to 8.2	3 to 11.8
TSS (weekly average)	3.1 to 21	5 to 29.4	3 to 11.9	3.1 to 20.5
TSS (max month single sample)	5 to 85	7 to 38	5 to 40	5 to 41
TN (annual average 07/11 to 06/12)	6.29	5.27	11.06	5.73
TN (month average)	3.03 to 11.05	4.42 to 9.41	8.82 to 12.62	3.33 to 9.6
TN (month max single sample)	6.38 to 20.26	5.51 to 20.16	12.13 to 17.87	4.14 to 17.93
Fecal Coliform (monthly average)	2 to 18.08	2 to 21	2 to 20	2 to 4
Fecal Coliform (mo. max single sample)	4 to 2600	7 to 1200	2 to 120	2 to 880
CBOD5 (month average)	2 to 3.97	2 to 8.8	2 to 7.4	2 to 5
CBOD5 (weekly average)	2 to 9.57	3 to 14	2 to 13.4	2 to 6.9
CBOD5 (max month single sample)	2 to 16	3 to 20	3 to 19	3 to 19

** All values in mg/L except for Fecal Coliform which is in Coliform Forming Units (CFU) per 100mL*

From the reviewed DMRs, the following wastewater treatment assumptions were made to determine the necessary treatment processes to achieve the treatment conditions described in Section 3.0:

- Existing WWTF effluent meets secondary treatment as defined by FDEP Rule 62-600.420(1)(a), F.A.C., which requires annual averages of 20 mg/L TSS and 20 mg/L CBOD5. No additional treatment is required to achieve secondary treatment,
- FDEP Rule 62-600.440(5)(f)2, F.A.C., requires fecal coliform values from facilities with high level disinfection to be below 25 CFU/100 milliliters (mL) for all samples. From the data above, this requirement is not being met. Additional treatment will be needed if high level disinfection is required,
- FDEP Rule 62-600.440(5)(f)3, F.A.C., requires TSS values for all samples to be below 5 mg/L before high level disinfection. From the data above, this requirement is not being met. Additional filtration will be needed to reduce the TSS to less than 5 mg/L,
- Three of the four facilities had a TN annual average of less than 10 mg/L. It shall be assumed that no additional treatment will be necessary if a TN effluent limit of 10 mg/L is required. Reclaimed water from District II WWTF, which has a TN annual average of over 10 mg/L, may be blended with water from the other WRFs to lower the TN value. Consequently, the nitrate annual average (as N) is also less than 10 mg/L, and
- WQCEs may be obtained to waive any secondary DWSs not reliably met in the recharge water.

4.2 Quality of Surface Water Source

Surface water quality data from St. Marys, Rodman Reservoir, , the lower St. Johns River, Black Creek, , and upper Suwannee River for the period from January 2002 to May 2012 were reviewed to assess the quality of surface water available for recharge in the study area. Surface water quality data for chloride, total coliform, TDS, TN, TOC, and TSS are listed in Table 4-2.

Based on the data in Table 4-2, the following assumptions were made to determine the necessary treatment processes to achieve the treatment levels described in Section 3.0:

- The available surface water quality generally meets the secondary DWS for chloride except for Black Creek and portions of the lower St. Johns River,
- To meet the primary DWS for total coliform, the surface water from all potential sources must undergo high level disinfection. FDEP Rule 62-600.440(5)(f)3, F.A.C., requires TSS values for all samples to be below 5 mg/L before high level disinfection. From the data above, this requirement is not being met,
- The TDS concentrations of the surface water sources are comparable to that of the receiving groundwater and no additional treatment is likely to be required,
- Elevated TOC levels in the surface water sources are likely due to decaying natural organic matter and not from synthetic sources such as detergents, pesticides, fertilizers, and herbicides. Therefore, TOC reduction or treatment is not required for indirect recharge using surface water due to the natural source of TOC. If it is found that the elevated TOC levels are from synthetic sources that may cause violations to the primary DWS, treatment targeting these organics (such as granular

activated carbon as described in Options 1A and 4A or Ultrafiltration (UF) filters in Options 1B and 4B) may be required, and

- WQCEs may be obtained to waive any secondary DWS not reliably met in the surface water.

Table 4-2: Surface Water Quality Data for Chloride, Total Coliform, Total Dissolved Solids, Total Nitrogen, Total Organic Carbon, and Total Suspended Solids

Parameter	Black Creek	Lower St. Johns	Ocklawaha River/ Rodman Reservoir	St. Marys	Upper Suwannee
Chloride (Min - Max)	4 to 4600	44 to 369	15 to 111	3 to 39	2 to 15
Chloride (Average)	244	209	42	9	7
Total Coliform (Min - Max)	300 to 6000	8 to 2460	No Data	85 to 460	40 to 7800
Total Coliform (Average)	1133	193	No Data	259	943
TSS (Min - Max)	1.4 to 73	2 to 98	1.4 to 58	1 to 16	0 to 116
TSS (Average)	6.2	11.7	6.0	5.0	5.4
TDS (Min - Max)	5.3 to 7570	273 to 1340	199 to 407	43 to 212	5 to 277
TDS (Average)	511	557	315	103	115
TN (Min - Max)	0.15 to 2.11	0.70 to 3.27	0.13 to 5.90	0.35 to 2.66	0.2 to 23.8
TN (Average)	0.73	1.29	0.8	1.2	1.5
TOC (Min - Max)	4.6 to 57.5	7.3 to 30.7	1 to 21.3	1.5 to 95	0.5 to 100
TOC (Average)	18.8	16.6	9.6	48.1	50.3

** All values in mg/L except for Total Coliform which is in CFU per 100 mL
Source - FDEP. 2012. IWR WBID Run46 database. Watershed Assessment Program
<http://www.dep.state.fl.us/water/basin411/download.htm>. August 2012*

4.3 Treatment Options for Reclaimed and Surface Water Sources

Five treatment options were developed for the direct (Recharge Concepts 1 and 2) and indirect recharge (Recharge Concepts 3 and 4) of surface and reclaimed water. The options are listed below and detailed descriptions follow:

1. Direct recharge of surface waters via recharge well or ASR well to groundwater,
2. Direct recharge of reclaimed water that has TDS concentrations less than 3,000 mg/L: ASR to groundwater if reclaimed water has TDS between 1,000 and 3,000 mg/L and is not being discharged to a current or anticipated public water supply,
3. Direct recharge of reclaimed water that has TDS concentrations less than 3,000 mg/L: ASR or recharge well to groundwater with reclaimed water that meets full water quality treatment and disinfection criteria,
4. Indirect recharge of surface water, and
5. Indirect recharge of reclaimed water.

4.3.1 Direct Recharge of Surface Water to Groundwater – Recharge Well or Aquifer Storage and Recovery Well

FDEP Chapter 62-528, F.A.C., requires that surface water used to directly recharge an aquifer (whether through recharge or ASR wells) shall meet primary and secondary DWS. Based on the raw surface water quality data that Atkins reviewed for the potential water sources (Table 4-2), two treatment options for direct surface water recharge are proposed. All options are described from initial to final treatment.

Option 1A

- Intake Screens – Intake screens are used to remove objects such as plants, logs, and other debris that could damage downstream process equipment,
- pH control – Lime is added to adjust the pH of the water to a level that will be optimal for subsequent treatment processes,
- Coagulation/Flocculation – After the pH has been adjusted, a coagulant is injected and rapidly mixed with the water. The purpose of the coagulant is to cause colloidal particles to destabilize and form larger particles referred to as floc. Coagulation/flocculation results in the reduction of TSS, TOC, color, turbidity, algae, pathogens, Cryptosporidium, iron, manganese, and arsenic,
- Clarification/Sedimentation – Flocs that are formed are allowed to settle out and are removed from the water as residuals. The residuals are then thickened and dewatered prior to offsite disposal,
- Deep Bed Filtration – The water undergoes deep bed filtration to reduce TSS levels to less than 5 mg/L. The typical filtering medium is sand or anthracite with downward or upward flow through the media. In addition to TSS removal, deep bed filtration can remove phosphorus, protozoan cysts, and oocysts. Deep bed filtration equipment includes backwash facilities to flush out accumulated debris and particles from the filters,
- Activated Carbon Adsorption (see note after Option 1B)* – This physical process removes organic compounds including pesticides and other chemicals that may be found in surface waters. Activated carbon filtration equipment includes backwash facilities to flush out accumulated debris and particles from the filters, and
- Final disinfection – Ultraviolet (UV) disinfection is performed to inactivate bacteria and viruses in the water including Cryptosporidium and Giardia. UV equipment shall be sized to deliver the dosage required to meet the removal/inactivation requirements found in the Surface Water Treatment Rule (SWTR) for Giardia and viruses and the Long-term 1 and 2 Enhanced Surface Water Treatment Rules (LT1ESWTR and LT2ESWTR) for Cryptosporidium. The location of the UV system should be at the wellhead site.

Option 1B

- Intake Screens – See description in Option 1A,
- pH control – See description in Option 1A,

- Coagulation/Flocculation – See description in Option 1A,
- Clarification/Sedimentation – See description in Option 1A,
- Screen Filters (see note below)* – The purpose of the 300-micron screen filters is to remove solids that can damage or prematurely clog the UF filters,
- UF filters (see note below)* – The UF filters operate at a range of between 0.005 to 0.2 microns. The UF filters remove biodegradable organics, priority organic pollutants, TSS, bacteria, protozoan cysts, oocysts, helminth ova, and bacteria. The UF filters also produce consistently low turbidity regardless of feed water quality and quantity. Similar to the activated carbon filters in Option 1, the UF equipment includes backwash facilities to flush out accumulated debris and particles, and
- Final disinfection - See description in Option 1A.

* Note – For the purpose of this study, it is assumed that activated carbon adsorption and screen and UF filters are only required if it is found that organic compounds from synthetic sources are causing violations to the primary DWS. If the elevated TOC levels are from natural sources, FDEP may not require treatment targeting these organic compounds.

4.3.2 Direct Recharge of Reclaimed Water to Groundwater – Aquifer Storage and Recovery to Groundwater (1,000 – 3,000 mg/L TDS) and Not A Source for Public Water Supply within the Study Area

This option is for reclaimed water that will directly recharge into an aquifer with TDS concentrations between 1,000 and 3,000 mg/L and not a source for public water supply. The requirements for what constitutes a public water supply in conjunction with receiving groundwater are listed in Rule 62-610.466 (9), F.A.C., which limits the public water supply to within 1,000 feet radially from the ASR well or located within the radial extent of the extended zone of discharge (area of well influence) plus an additional 500 feet radially in the horizontal direction. Treatment conditions for this option include:

- Secondary treatment and filtration,
- High level disinfection,
- Primary DWS, and
- TSS: 5 mg/L maximum before application of disinfectant.

An option for the treatment of reclaimed water to reach these treatment conditions includes:

Option 2

- Deep Bed Filtration – Secondary treated effluent from the WWTF will undergo deep bed filtration to reduce TSS levels to less than 5 mg/L. Typical filtering medium is sand or anthracite with flow being downward or upward. Aside from TSSs, deep bed filtration can remove phosphorus, protozoan cysts, and oocysts. Deep bed filtration equipment includes backwash facilities to flush out accumulated debris and particles from the filters,

- Activated Carbon Adsorption – The necessity of the activated carbon adsorption process will depend on whether the requirements of the primary DWS can be met with secondary treatment, deep bed filtration, and final UV disinfection. Activated carbon adsorption removes organic compounds, including pesticides, which are regulated under the DWS, and
- Final disinfection – UV disinfection is performed to inactivate bacteria and viruses in the water including *Cryptosporidium* and *Giardia*. UV equipment shall be sized to deliver the dosage required to meet high level disinfection as defined in FDEP Rule 62-600.440(5), F.A.C. The location of the UV system should be at the wellhead site.

Further evaluations will need to be conducted the preliminary design phase to refine the TDS levels in the study area and identify locations if TDS levels are between 1,000 and 3,000 mg/L.

4.3.3 Direct Recharge of Reclaimed Water to Groundwater – Recharge Well or Aquifer Storage and Recovery Well to Groundwater with <3,000 mg/L TDS

According to FDEP Chapters 62-600 and 62-610, F.A.C., reclaimed water that is to be used to directly recharge (recharge wells or ASR wells) an aquifer with less than 3,000 mg/L TDS shall meet the following:

- Secondary treatment and filtration,
- High level disinfection,
- Primary and Secondary DWS,
- TSS: 5 mg/L maximum before application of disinfectant,
- TOC: 3 mg/L – monthly average and 5 mg/L - max single sample,
- TOX: 0.2 mg/L – monthly average and 0.3 mg/L - max single sample, and
- TN: 10 mg/L maximum annual average.

In addition to meeting the above requirements, reclaimed water directly recharging an aquifer with less than 3,000 mg/L TDS will consist of two potential treatment options based on the finished reclaimed water quality in the study area:

Option 3A

- Deep Bed Filtration – Secondary treated effluent from the WWTF undergoes deep bed filtration to reduce TSS levels to less than 5 mg/L. The typical filtering medium is sand or anthracite with downward or upward flow through the media. In addition to TSS removal, deep bed filtration can remove phosphorus, protozoan cysts, and oocysts. Deep bed filtration equipment includes backwash facilities to flush out accumulated debris and particles from the filters,
- Activated Carbon Adsorption – The purpose of activated carbon adsorption is to reduce TOC and TOX levels to the required effluent limits. In addition, organic compounds regulated under the DWS, including pesticides, may be removed through activated carbon adsorption. Activated carbon adsorption equipment includes backwash facilities to flush out accumulated debris and particles from the

filters. FDEP Rule 62-600.540(3)(d), F.A.C., requires the use of activated carbon adsorption or a FDEP approved alternative technology prior to the direct aquifer recharge with reclaimed water, and

- Final disinfection – UV disinfection is performed to inactivate bacteria and viruses in the water including *Cryptosporidium* and *Giardia*. UV equipment shall be sized to deliver the dosage required to meet high level disinfection as defined in FDEP Rule 62-660.440(5), F.A.C. The location of the UV system should be at the wellhead site.

Option 3B

Option 3B involves the use of reverse osmosis (RO). From discussions with RO manufacturers, it was assumed that: (1) the reclaimed water has a silt density index (SDI) of greater than 5, so RO pre-treatment of the feed water is required, (2) microfiltration will be the only RO pre-treatment needed and (3) that other RO pre-treatment technologies such as chlorination, activated carbon adsorption, and chemical coagulation are not required. It should be noted that, prior to design of the RO system, a complete water analysis must be performed to assess the source water quality. Parameters to be assessed include, but are not limited to, TOC, TSS, salinity (chloride), barium, pH, temperature, and turbidity. A list of the minimum required water quality analyses are listed in Table 4-3.

- Deep Bed Filtration – The purpose of deep bed filtration is to reduce the TSS to less than 5 mg/L and to remove solids that can damage or prematurely clog the microfiltration (MF) filters. See additional description in Option 3A,
- MF filters – The MF filters operate at a range of between 0.08 to 2.0 microns. The MF filters remove turbidity, residual suspended solids, protozoan cysts, oocysts, helminth ova, and bacteria. The MF filters also produce consistently low turbidity regardless of feed water quality and quantity. Similar to the deep bed filtration equipment, the MF equipment will include backwash facilities to flush out accumulated debris and particles. MF filtration is a RO pre-treatment step that minimizes fouling, scaling, and degradation of the RO membranes,
- Reverse Osmosis – The RO filters operate at a range of between 0.0001 to 0.001 microns. The RO filters remove TOC, biodegradable organics, hardness, heavy metals, nitrate, priority organic pollutants, synthetic organic compounds, TDS, bacteria, protozoan cysts, oocysts, helminth ova, and viruses. Similar to other filtration equipment, the RO equipment will include backwash facilities to flush out accumulated debris and particles, and
- Final disinfection – UV disinfection is performed to inactivate bacteria and viruses in the water including *Cryptosporidium* and *Giardia*. UV equipment shall be sized to deliver the dosage required to meet high level disinfection as defined in FDEP Rule 62-600.440(5), F.A.C. The location of the UV system should be at the wellhead site.

Further evaluations will need to be conducted during preliminary design phase to refine the TDS levels in the study area and identify locations if TDS levels are between 1,000 and 3,000 mg/L.

**Table 4-3: Minimum Required Water Quality Analyses
for Reverse Osmosis Pretreatment**

Aluminum*	Potassium
Ammonia	Selenium
Arsenic	Silica Colloidal (as SiO ₂)
Bacteriological (coliform)	Silica Soluble (as SiO ₂)
Bacteriological (Total)	Silver
Barium*	Sodium
Bicarbonate	Strontium*
Cadmium	Sulfate
Calcium	Total Alkalinity (m value)
Carbonate	Total Dissolved Solids
Carbonate Alkalinity (p value)	Total Hardness
Chloride	Total Iron*
Chlorine	Total Organic Carbon
Chromium	Total Phosphate
Color	Total Suspended Solids
Conductivity	Turbidity (NTU)
Copper	Zinc
Dissolved Iron*	
Fluoride	Primary and Secondary Maximum Contaminant Levels
Free Chlorine	
Lead	
Magnesium	On Site Measurements
Manganese	Temperature
Nickel	pH
Nitrate	Carbon Dioxide
Orthophosphate	Hydrogen Sulfide

* Recommended to be measured in µg/L

Note: From Table 1. Pretreatment for Membrane Processes. American Membrane Technology Association (www.amta.org)

4.3.4 Indirect Recharge of Surface Water to Groundwater

As stated in Section 3.0, current FDEP regulations do not define specific water treatment regulations concerning indirect recharge using surface water. However, FDEP may implement water quality restrictions depending on: (1) the type of recharge such as natural (sinkholes, floodplains, and wetlands) versus artificial (reservoirs, mine pits, and RIBs), (2) proximity of the source water to the receiving groundwater, (3) quality of the source water and receiving groundwater, and (4) special conditions identified in an ERP. For the purpose of this study, the following are assumed:

- Indirect natural aquifer recharge systems with surface water (1) in close proximity to the recharge location and (2) of similar quality to the receiving groundwater will not require water treatment, and

- All other indirect aquifer recharge systems using surface water will require compliance with the primary DWS or subsequent secondary WQCE. This is the same treatment requirements for direct aquifer recharge using surface water.

No treatment options for indirect aquifer recharge systems using surface water in close proximity to the recharge location and of similar quality to the receiving groundwater are presented since it is assumed that no additional treatment is needed.

Two (2) options for the treatment of surface water for all other indirect aquifer recharge systems are included below.

Option 4A

- Intake Screens – Intake screens are used to remove objects such as plants, logs, and other debris that could damage downstream process equipment,
- pH control – Lime is added to adjust the pH of the water to a level that will be optimal for subsequent treatment processes,
- Coagulation/Flocculation – After the pH has been adjusted, a coagulant is injected and rapidly mixed with the water. The purpose of the coagulant is to cause colloidal particles to destabilize and form larger particles referred to as floc. Coagulation/flocculation results in the reduction of TSS, TOC, color, turbidity, algae, pathogens, Cryptosporidium, iron, manganese, and arsenic,
- Clarification/Sedimentation – Flocs that are formed are allowed to settle out and are removed from the water as residuals. The residuals are then thickened and dewatered prior to offsite disposal,
- Deep Bed Filtration – The water undergoes deep bed filtration to reduce TSS levels to less than 5 mg/L. The typical filtering medium is sand or anthracite with downward or upward flow through the media. In addition to TSS removal, deep bed filtration can remove phosphorus, protozoan cysts, and oocysts. Deep bed filtration equipment includes backwash facilities to flush out accumulated debris and particles from the filters,
- Activated Carbon Adsorption (see note after Option 4B)* – This physical process removes organic compounds including pesticides and other chemicals that may be found in surface waters. Activated carbon filtration equipment includes backwash facilities to flush out accumulated debris and particles from the filters, and
- Final disinfection – UV disinfection is performed to inactivate bacteria and viruses in the water including Cryptosporidium and Giardia. Size UV equipment to deliver the dosage required to meet the removal/inactivation requirements found in the SWTR for Giardia and viruses and the LT1ESWTR and LT2ESWTR for Cryptosporidium. The location of the UV system should be at the wellhead site. Chloramination may be an option here in lieu of UV disinfection. Chloramination involves the injection of chlorine and ammonia in the water to form chloramines, a long lasting disinfectant. However, it is important to note that chloramination may not be as effective as UV at inactivating certain potentially harmful organisms including Cryptosporidium and

that additional monitoring, testing, and treatment for these organisms may be required.

Option 4B

- Intake Screens – See description in Option 4A,
- pH control – See description in Option 4A,
- Coagulation/Flocculation – See description in Option 4A,
- Clarification/Sedimentation – See description in Option 4A,
- Screen Filters (see note below)* – The purpose of the 300-micron screen filters is to remove solids that can damage or prematurely clog the UF filters,
- UF filters (see note below)* – The UF filters operate at a range of between 0.005 to 0.2 microns. The UF filters remove biodegradable organics, priority organic pollutants, TSS, bacteria, protozoan cysts, oocysts, helminth ova, and bacteria. The UF filters also produce consistently low turbidity regardless of feed water quality and quantity. Similar to the activated carbon filters in Option 1, the UF equipment includes backwash facilities to flush out accumulated debris and particles, and
- Final disinfection - See description in Option 4A.

* Note – For the purpose of this study, it is assumed that activated carbon adsorption and screen filters and UF filters are only required if it is found that organic compounds from synthetic sources are causing violations to the primary DWS. If the elevated TOC levels are from natural sources, FDEP may not require treatment targeting these organic compounds.

4.3.5 Indirect Recharge of Reclaimed Water to Groundwater– Indirect (Natural or Artificial) Aquifer Recharge

FDEP Chapter 62-610, F.A.C., requires that reclaimed water used to indirectly recharge an aquifer shall meet the following treatment conditions:

- Secondary treatment and filtration,
- High level disinfection,
- Primary and secondary DWS,
- TSS: 5 mg/L maximum before application of disinfectant, and
- TN: 10 mg/L maximum annual average.

In addition to meeting the above requirements, reclaimed water indirectly recharging an aquifer shall consist of the following potential treatment option based on the finished reclaimed water quality.

Option 5

- Deep Bed Filtration – Secondary treated effluent from the WWTF undergoes deep bed filtration to reduce TSS levels to less than 5 mg/L. The typical filtering medium is sand or anthracite with downward or upward flow through the media. In addition to TSS removal, deep bed filtration can remove phosphorus, protozoan cysts, and oocysts. Deep bed filtration equipment includes backwash facilities to flush out accumulated debris and particles from the filters,
- Activated Carbon Adsorption – Activated carbon adsorption follows deep bed filtration. The purpose of activated carbon adsorption is to remove organic compounds regulated under the DWS, such as pesticides. Activated carbon adsorption equipment includes backwash facilities to flush out accumulated debris and particles from the filters, and
- Final disinfection – UV disinfection is performed to inactivate bacteria and viruses in the water including Cryptosporidium and Giardia. Size UV equipment to deliver the dosage required to meet high level disinfection as defined in FDEP Rule 62-660.440(5), F.A.C. The location of the UV system should be at the wellhead site.

A summary of required additional treatment processes is provided in Table 4-4.

Table 4-4: Treatment and Disinfection Requirements for Aquifer Recharge

Source of Recharge Water / Type of Recharge System	Additional Treatment Required
Surface Water/Direct - Recharge well or Aquifer storage and recovery well <i>* For the purpose of this study, it is assumed that activated carbon adsorption and screen and UF filters are only required if it is found that organic compounds from synthetic sources are causing violations to the primary DWS. If the elevated TOC levels are from natural sources, FDEP may not require treatment targeting these organic compounds.</i>	Option 1A • Intake Screens • pH Control • Coagulation/Flocculation • Clarification/Sedimentation • Deep Bed Filtration • Activated Carbon Adsorption* • Final Disinfection Option 1B • Intake Screens • pH Control • Coagulation/Flocculation • Clarification/Sedimentation • Screen Filters* • Ultrafiltration* • Final Disinfection
Reclaimed Water/Direct - Aquifer storage and recovery well to groundwater (1,000 – 3,000 mg/L TDS) <i>Only applies if receiving groundwater is not currently used as a source of public water supply nor is reasonably expected to be used as one in the future. The requirements for what constitutes a public water supply in conjunction with receiving groundwater (TDS levels between 1,000 and 3,000 mg/L) of an ASR project are listed in Rule 62-610.466(9), F.A.C., which limits the public water supply to within 1,000 feet radially from the ASR well or located within the radial extent of the extended zone of discharge (area of well influence) plus an additional 500 feet radially in the horizontal direction.</i>	Option 2 • Deep Bed Filtration • Activated Carbon Adsorption • Final Disinfection

Source of Recharge Water / Type of Recharge System	Additional Treatment Required
Direct recharge of Reclaimed Water/ Recharge well or Aquifer storage and recovery to groundwater (<3,000 mg/L TDS)	Option 3A • Deep Bed Filtration • Activated Carbon Adsorption • Final Disinfection Option 3B • Deep Bed Filtration • Microfiltration • Reverse Osmosis • Final Disinfection
Indirect recharge of Surface Water/ Indirect natural aquifer recharge with surface water that is (1) in close proximity to the recharge location and (2) of similar quality to the receiving groundwater will not require water treatment <i>* According to current FDEP regulations there are no specific water treatment regulations concerning indirect recharge using surface water. However, FDEP may implement water quality restrictions depending on: (1) the type of recharge, natural (sinkholes, floodplains, and wetlands) versus artificial (reservoirs, mine pits, and RIBs), (2) proximity of the source water to the receiving groundwater, (3) quality of the source water and receiving groundwater, and (4) special conditions identified in an ERP.</i>	No additional treatment needed.

Source of Recharge Water / Type of Recharge System	Additional Treatment Required
Indirect recharge of Surface Water/ Indirect aquifer recharge (not included in other groups) <i>* According to current FDEP regulations there are no specific water treatment regulations concerning indirect recharge using surface water. However, FDEP may implement water quality restrictions depending on: (1) the type of recharge, natural (sinkholes, floodplains, and wetlands) versus artificial (reservoirs, mine pits, and RIBs), (2) proximity of the source water to the receiving groundwater, (3) quality of the source water and receiving groundwater, and (4) special conditions identified in an ERP.</i> <i>** For the purpose of this study, it is assumed that activated carbon adsorption and screen and UF filters are only required if it is found that organic compounds from synthetic sources are causing violations to the primary DWS. If the elevated TOC levels are from natural sources, FDEP may not require treatment targeting these organic compounds.</i>	Option 4A • Intake Screens • pH Control • Coagulation/Flocculation • Clarification/Sedimentation • Deep Bed Filtration • Activated Carbon Adsorption** • Final Disinfection Option 4B • Intake Screens • pH Control • Coagulation/Flocculation • Clarification/Sedimentation • Screen Filters • Ultrafiltration** • Final Disinfection
Indirect recharge of Reclaimed Water/ Indirect (natural or artificial) aquifer recharge	Option 5 • Deep Bed Filtration • Activated Carbon Adsorption • Final Disinfection

Note: From review of reclaimed water and surface water quality data, the following assumptions were made: (1) existing WWTF effluent meets secondary treatment levels. (2) The TSS of existing WWTF effluent and surface water are greater than 5 mg/L. (3) Existing WWTF effluent and surface water do not meet high level disinfection requirements. (4) The TN and Nitrate (as N) of existing WWTF effluent are less than 10 mg/L. (5) The TDS of the surface water is comparable to that of the receiving groundwater (6) The surface water meets the secondary DWS for chloride. (7) Elevated TOC levels in surface water are due to decaying natural organic matter and not from synthetic sources such as detergents, pesticides, fertilizers, and herbicides. Therefore, TOC reduction or treatment is not required for indirect recharge using surface water due to the natural source of TOC. If it is found that the elevated TOC levels are from synthetic sources that may cause violations to the primary DWS, treatment targeting these organics (such as granular activated carbon as described in Option 4A or UF filters in Option 4B) may be required. (8) WQCE may be obtained to waive any secondary DWSs not reliably met in the recharge water.

5.0 WATER SUPPLY AVAILABILITY

The five potential source waters (presented previously in Section 1 and detailed in TM-2) were evaluated for potential yield after the water quality analysis. Established constraints, such as MFLs, were taken into account during the evaluation. The five source waters considered for the potential aquifer recharge concepts are listed below:

1. St. Marys River along the Florida–Georgia border,
2. Rodman Reservoir on the Ocklawaha River,
3. Lower St. Johns River upstream of the confluence with the Ocklawaha River, within the designated study area,
4. Black Creek, a tributary into the St. Johns River in Clay County, Florida, and
5. Upper Suwannee River from the Florida-Georgia border to the confluence with the Alapaha River.

Available flow data and MFL criteria were reviewed for relevance to the proposed source waters and developing potential yields from the source waters. None of the evaluated water sources evaluated in the study area have established MFLs, however, the SJRWMD is in the process of establishing MFLs for the Ocklawaha River in 2014-2015. Consequently, flow constraints were developed as proxies for MFLs. The methods used to develop the flow constraints are based on results of previously established MFLs and provide conservative estimates of potentially available yields from the analyzed water bodies. Once adopted, MFLs determine the available yield from the respective water bodies and supersede any preliminary estimates provided in this study.

5.1 Application of Suwannee River Water Management District and St. Johns River Water Management District Minimum Flows and Levels Criteria to Potential Surface Water Withdrawal Scenarios

The SRWMD and SJRWMD both include numerous rivers and springs and have historically relied upon different methods to develop and implement MFLs. SRWMD uses a multiple parameter approach to develop percent of flow reductions in establishing MFLs, similar to that developed and implemented by the Southwest Florida Water Management District (SWFWMD). The SJRWMD MFL evaluation process includes ranges of flow requirements with unique values for water level (i.e. frequent high, frequent low), duration (period of time), and interval (frequency of recurrence). However, an Interagency Agreement executed among the SRWMD, SJRWMD, and FDEP, requires coordination between the Districts in the development of MFL strategies when withdrawals in one District contribute to water resource impacts in another (see <http://northfloridawater.com/pdfs/2013/01-23/agendapacket.pdf>). Consequently, MFLs were reviewed for the three Districts.

Atkins reviewed and compared MFL criteria (flow reductions under established MFLs) with flows and potential flow reduction scenarios for source waters. Several MFL flow reductions for rivers and spring runs developed by the SRWMD and the SWFWMD are listed in Table 5-1. Percent flow reductions range from a low of 3 percent (Homosassa River) to no more than 18 percent (Anclote River), but typically range from 10 to 15

percent. Based on these ranges, 0, 5, 10, 15, and 20 percent withdrawal scenarios were considered appropriate for initial comparison with annual flows from potential source waters.

Table 5-1: Percent Flow Reductions Identified in Minimum Flows and Levels Development for Rivers and Spring Runs in the Suwannee River Water Management District and Southwest Florida Water Management District

River/Spring Run	Date of Development	Established Flow Reductions
Upper Santa Fe River	Proposed 2007	15% flow reduction at flows > 2.3 cfs, 0% < 2.3 cfs
Manatee and Fanning/ Little Fanning Springs (on the lower Suwannee River)	2005	10% flow reductions
Madison Blue Springs	2004	70 cfs
Waccasassa River	2006	12.5% reduction in the baseline flow duration curve
Homosassa River	Final 2012	3% reduction
Gum Slough	Draft 2011	9% reduction
Upper Hillsborough River	2007	8-10% reduction at low flows, 8-13% for high flows, 11% for medium flows, or 0% if flows less than 52 cfs (5-year median)
Alafia River	2005	10% low flow reduction, 8-13% high flows, 15% medium flows
Withlacoochee River	Draft 2010	11-13% low flow reductions, 7-17% medium and high flow reduction
Anclothe River	2010	8-11% low flow reductions, 8-18% high flow reductions, 8-14% medium flow reductions

Note: From SWFWMD and SRWMD websites; cfs = cubic feet per second

These same flow reductions were compared with MFLs established in the SJRWMD. MFLs for several segments of the St. Johns River have been established and flows at relevant gages on the St. Johns River at State Road (SR) 44 near DeLand in Volusia County (USGS gage 2236000) and St. Johns River at SR 50 near Christmas in Orange and Brevard counties (USGS gage 2232500) were reviewed with respect to established MFLs. SJRWMD MFL criteria established for the Christmas and DeLand gages are listed in Table 5-2. Percent flow reductions on the 0, 5, 10, 15, and 20 percent reduction scenarios were compared to the established MFLs to identify scenarios under which percent flow reductions (i.e. 0, 5, 10, 15, and 20 percent) resulted in a violation of the SJRWMD MFL.

Monthly median flows (i.e. period of record flows for the month of January, February) were calculated and graphed for the Christmas (period of record October 1933 through December 2012) and DeLand (period of record October 1933 through December 2012) gages, and MFL flow criteria specific to that river segment (e.g., frequent high, frequent low,

infrequent high, and/or infrequent low) were plotted on the same graphs to compare MFL flow criteria with period of record criteria. This comparison was used to ascertain if a given percent flow reduction (e.g. 5 or 10 percent) would violate MFLs at these gages. 0, 5, 10, 15, and 20 percent flow reductions were applied to discharge data and SJRWMD MFL criteria were plotted on the same graphs for comparison (Figure 5-1 and Figure 5-2).

Table 5-2: St. Johns River Water Management District Minimum Flows and Levels Criteria at the Christmas and DeLand Gages on the St. Johns River

Gage Site	Minimum Level	Flow (cfs)	Flow (mgd)*	Duration (days)	Return Interval (years)
DeLand	Frequent High	4,600	2,972	30	3
	Average	2,050	1,324	180	1.5
	Frequent Low	1,100	711	120	5
Christmas	Frequent High	1,950	1,260	30	2
	Average	580	375	180	1.5
	Frequent Low	140	90	120	5
	Infrequent Low	43	28	60	50

*Graphs of withdrawal scenarios are presented in mgd (million gallons per day)

Monthly median flows for the period of record under baseline conditions (0 percent withdrawals) and withdrawal scenarios (5, 10, 15, and 20 percent flow reductions) were calculated for each surface water source and compared to the MFL criteria and periods during which MFL criteria were not met (i.e. violated) were identified (i.e., MFL “violations” were identified based on whether flows met frequent high, average, frequent low, and/or infrequent low flows) and interval frequencies, for the Christmas and DeLand gages. Results are summarized in Table 5-3 (Christmas) and Table 5-4 (DeLand). For example, at the Christmas gage, all the years are listed for which the frequent high was not met: discharge flows under all three scenarios (no withdrawal, 5, and 10 percent withdrawals) violated the frequent high MFL criteria for maintaining 1,950 cfs for 30 days with a two-year return interval in both 2006 - 2007 and 1980 - 1981. Among those that did not meet the frequent high, years that did not meet the 2 year return interval are shaded.

The results indicate that the 5 percent flow reduction scenario is no different from the 0 percent (no withdrawal) flow reduction scenario with regard to SJRWMD MFL criteria and suggest that a 5 percent flow reduction would not violate MFL criteria for either District. Based on these analyses, an allowable flow constraint of 5 percent was considered acceptable as a conceptual withdrawal scenario for the five source waters given that it was no different than the no withdrawal scenario in terms of MFL criteria, and is also within the range of MFL criteria established by the SWFWMD. Future consideration of any newly designated MFL criteria for any of the proposed water sources would need to take precedent over the 5 percent flow constraint.

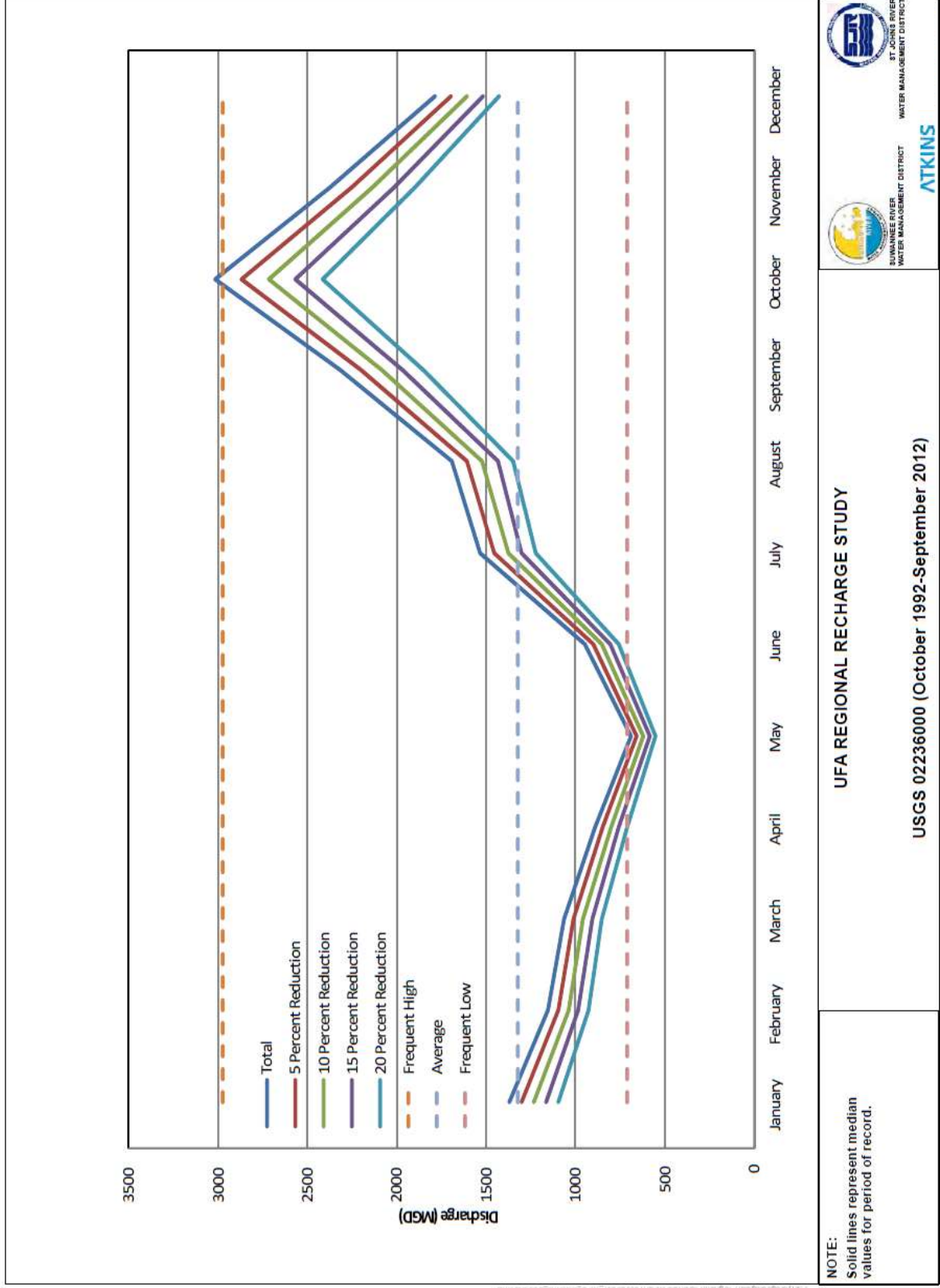


Figure 5-1: SJRWMD MFL Criteria for Withdrawal Scenarios at St. Johns River near DeLand

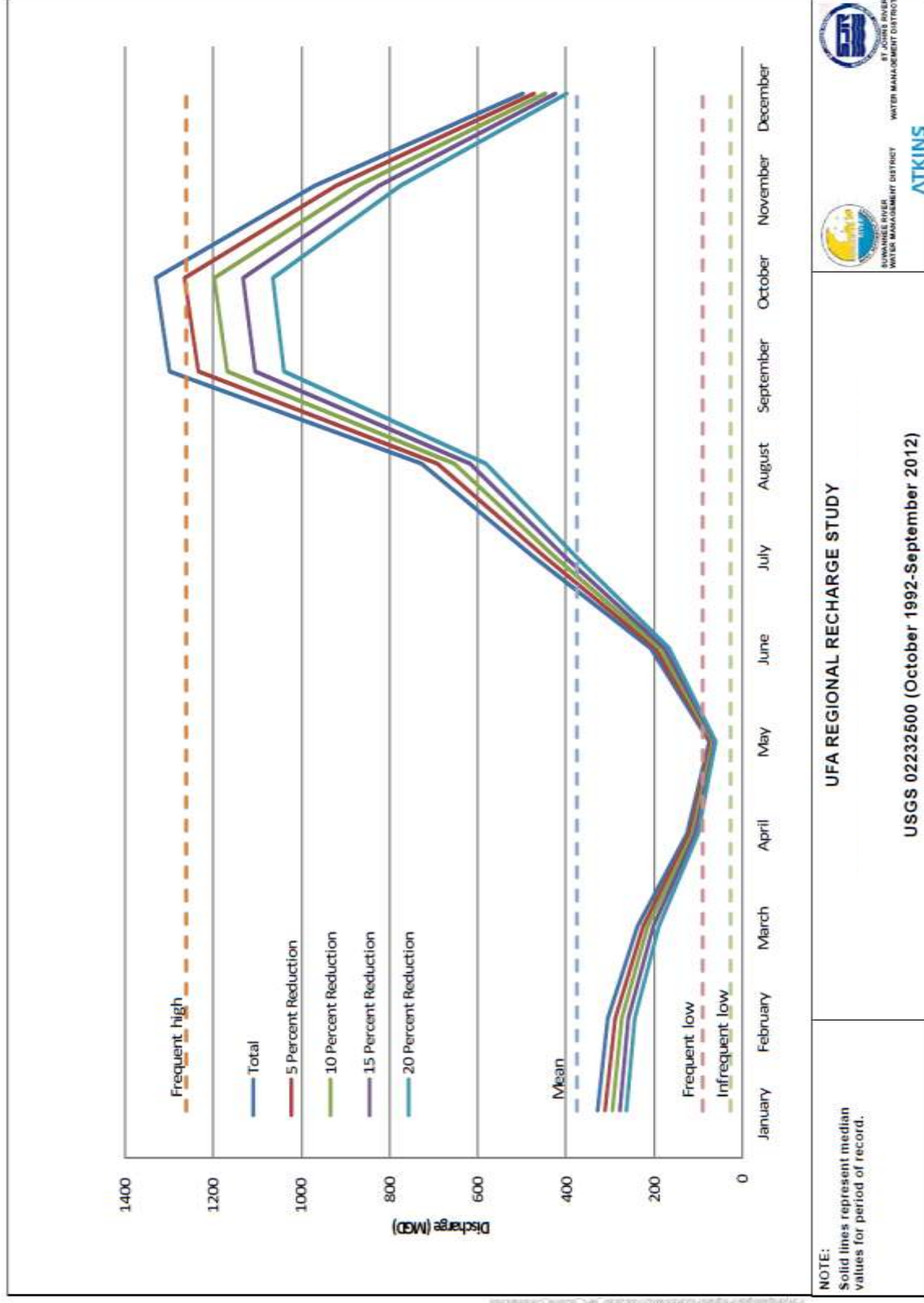


Figure 5-2: SJRWMD MFL Criteria for Withdrawal Scenarios at St. Johns River near Christmas

Table 5-3: Times during which Minimum Flows and Levels Criteria Were Not Met at the Christmas Gage under Proposed Withdrawal Scenarios

Years frequent high (1950 cfs for 30 days) and 2-year return interval (shaded) were not met ("-" is placeholder only to align years). Explanation - flows under a 5 percent withdrawal scenario are no different than no withdrawals.			
MFL Category	Discharge	5 percent withdrawal	10 percent withdrawal
Frequent High	2007	2007	2007
	2006	2006	2006
	2000	2000	2000
	1996	1996	1996
	1993	1993	1993
	-	-	1989
	1988	1988	1988
	1986	1986	1986
	1981	1981	1981
	1980	1980	1980
	1977	1977	1977
	1975	1975	1975
	1972	1972	1972
	1971	1971	1971
	--	-	1967
	1965	1965	1965
	1961	1961	1961
	-	1955	1955
	1942	1942	-
	1940	1940	-
	1938	1938	-
Years frequent low (140 cfs or 120 days) and 5-year return interval (shaded) not met. Explanation - No additional violations under frequent low or infrequent low.			
Frequent Low	-	2007	2007
	1977	1977	1977
	-	1975	1975
	1962	1962	1962
	1956	1956	1956
	-	1950	1950
Years frequent low (43 cfs or 60 days) and 50-year return interval (shaded) not met.			
Infrequent Low	None	1981	1981

Table 5-4: Times during which Minimum Flows and Levels Criteria Were Not Met at the Deland Gage under Proposed Withdrawal Scenarios

Years frequent high (4,600 cfs for 30 days) and 3-year return interval (shaded) were not met (Explanation - flows under a 5 percent withdrawal scenario were no different than for no withdrawals, while 10 percent has more “violations”) (“-“is a placeholder only to align years).			
MFL category	Discharge (no withdrawal)	5 percent withdrawal	10 percent withdrawal
Frequent High	2010	2010	2010
	2009	2009	2009
	2007	2007	2007
	2006	2006	2006
	1993	1993	1993
	1990	1990	1990
	1989	1989	1989
	1988	1988	1988
	1987	1987	1987
	1986	1986	1986
	1984	1984	1984
	1981	1981	1981
	1980	1980	1980
	1977	1977	1977
	1976	1976	1976
	1975	1975	1975
	1973	1973	1973
	1972	1972	1972
	1971	1971	1971
	-	-	1967
	1965	1965	1965
	-	-	1963
	1962	1962	1962
	1961	1961	1961
	-	-	1958
	1955	1955	1955
	1954	1954	1954
	-	-	1946
	1942	1942	1942
	1940	1940	1940
	1939	1939	1939
	1938	1938	1938
Years in which frequent low (1100 cfs or 120 days) and 5-year return interval (shaded) not			
MFL Category	Total Discharge	5 percent withdrawal	10 percent withdrawal
Frequent Low	None	None	1956

Source Waters Included for Further Analysis

Based on hydrogeological modeling and evaluation, the potential source waters for the proposed aquifer recharge concept were narrowed to include water sources with adequate available flows and adequate water quality (refer to TM-1 for water quality review). USGS and/or District discharge gages used for the five water sources (St. Marys, Ocklawaha, lower St. Johns rivers Black Creek and upper Suwannee River) are mapped as green dots (adequate data available) in Figure 5-3 (red dots indicate gage present, but data inadequate for analysis due to insufficient period of record or other constraint). Percent reductions (withdrawals) were calculated and graphed for 0, 5, 10, 15, and 20 percent scenarios for period of record ending December 2012 at 12 USGS stations on the potential source waters (Table 5-5) and are presented individually in Appendix A. The 5 and 10 percent mean and median flow reductions (the mean of the monthly means and median of the monthly medians) were calculated for gage locations with data over the period of 1992 – 2012 (Table 5-5). As a result, the following portions of four of the five source waters were excluded from further analysis:

- St. Marys River - the two sources on the St. Marys River were excluded due to low flows,
- Lower St. Johns River at Buffalo Bluff source was excluded due to water quality constraints,
- Black Creek sources were excluded due to low flows, and
- Upper Suwannee River - two source waters on the Suwannee River were excluded due to their location outside the study area.

The remaining sources, the Rodman Reservoir/Ocklawaha River and the upper Suwannee River from Benton (upstream of White Sulphur Springs) to Ellaville (shaded rows, Table 5-5), were analyzed further as potential withdrawal sources for aquifer recharge.

Mean and median values for potentially available flows are presented in Table 5-5. Means and medians are both measures of central tendency of the flow data, although the median is a better measure of highly variable data such as flows, because it is less sensitive to outliers and therefore, represents a more typical flow, while the mean indicates the “direction” of the outliers. For example, flows greater than the median flow indicates the flows are skewed right, i.e. the mean is influenced by fewer, but higher, flows. Except for the Rodman Reservoir/Ocklawaha River and Buffalo Bluff on the St. Johns River, the mean is much larger than the median, indicating the typical values are much lower than the mean and extreme high flows would provide opportunities for capture and use in recharge concepts.

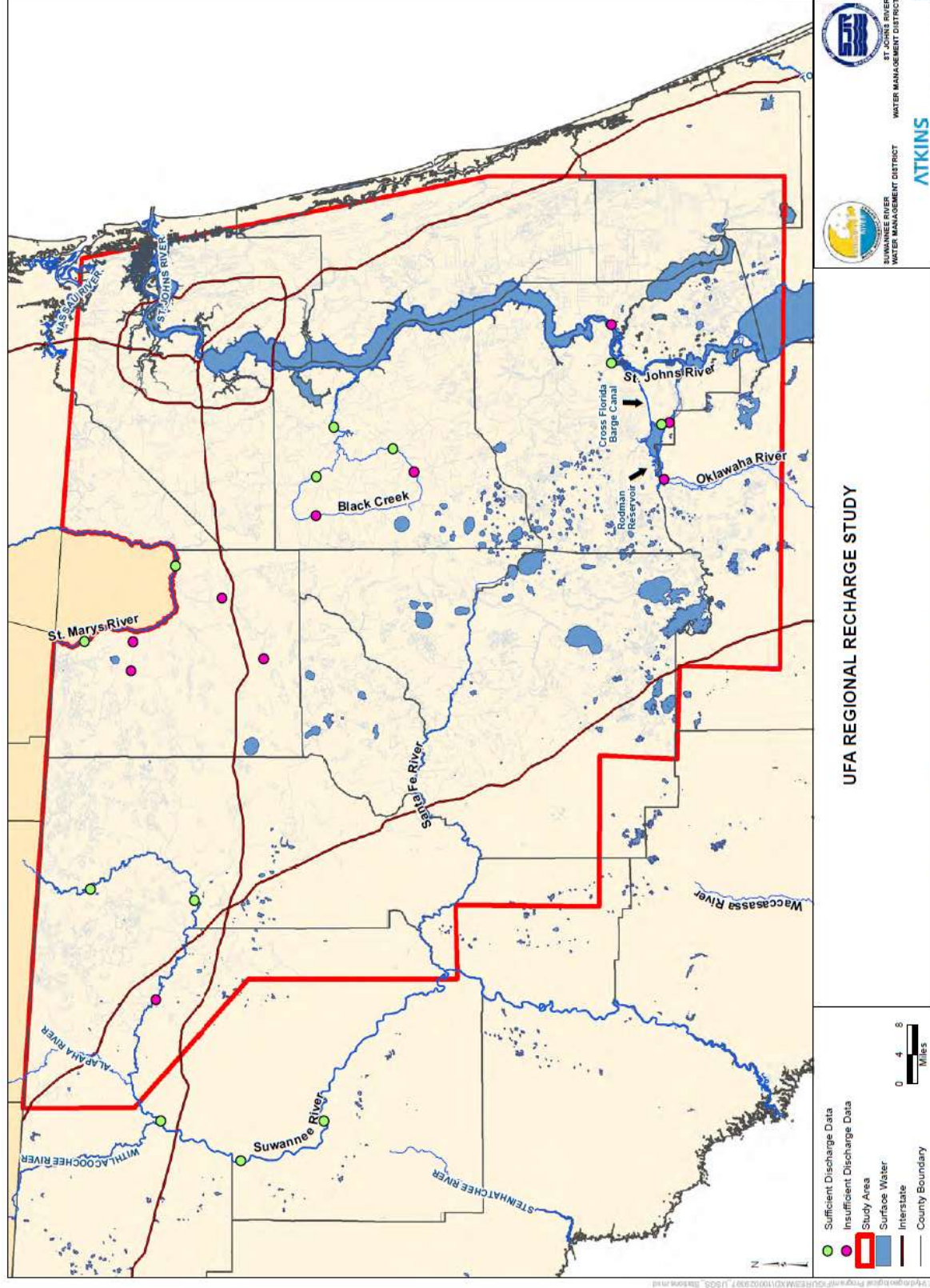


Figure 5-3: USGS Discharge Stations Compiled for Evaluation of Groundwater Recharge Concepts

**Table 5-5: Available Flows (mgd) at 5 and 10 Percent Flow Constraints
for Source Waters ***

River	Source Water Segment / Gage	5 percent		10 percent	
		Mean	Median	Mean	Median
St. Marys	North Prong St. Marys at Moniac, GA	4	1	7	2
	St. Marys River near MacClenny, FL	17	5	34	10
Ocklawaha	Rodman Reservoir/ Ocklawaha River) (at Orange Springs)	35	28	71	56
Lower St. Johns	St. Johns River at Buffalo Bluff near Satsuma, FL	153	142	306	284
Black Creek	South Fork Black Creek Near Penney Farms, FL	4	2	8	4
	North Fork Black Creek Near Middleburg, FL	5	2	11	5
	Black Creek Near Doctors Inlet, FL	15	9	30	18
Upper Suwannee	Suwannee River @ Benton	33	7	66	14
	Suwannee River @ White Springs	44	13	88	25
	Suwannee River at Ellaville, FL	164	75	328	150
	Suwannee River at Dowling Park, FL	151	72	302	143
	Suwannee River at Luraville, FL	162	83	323	165

Note: Shaded segments were retained for further analysis.

* Based on 1992-2012 Discharge USGS Data

5.2 Estimated Available Flows from the Rodman Reservoir/Ocklawaha River

Mean flows (35 cfs) over the period of record for the Rodman Reservoir/Ocklawaha River are very similar to median (28 cfs) flows, indicating less variability when compared with the other water sources examined and offer relatively uniform flows (in terms of seasonal variation) from which to calculate flows. The relatively stable flows can be attributed in large part to contributions from Silver River and Silver Springs, which have fairly stable flows when compared with surface water run-off driven systems that account for approximately half the flow into the reservoir during low flow periods. Consequently, opportunities for water capture would be similar throughout the year from the Rodman Reservoir. 0, 5, and 10 percent flow reduction scenarios for the Ocklawaha River (Reservoir) near Orange Springs (median monthly flows at USGS gage 02243960) are graphed in Figure 5-4. For the feasibility study, a withdrawal of 30 mgd was selected.

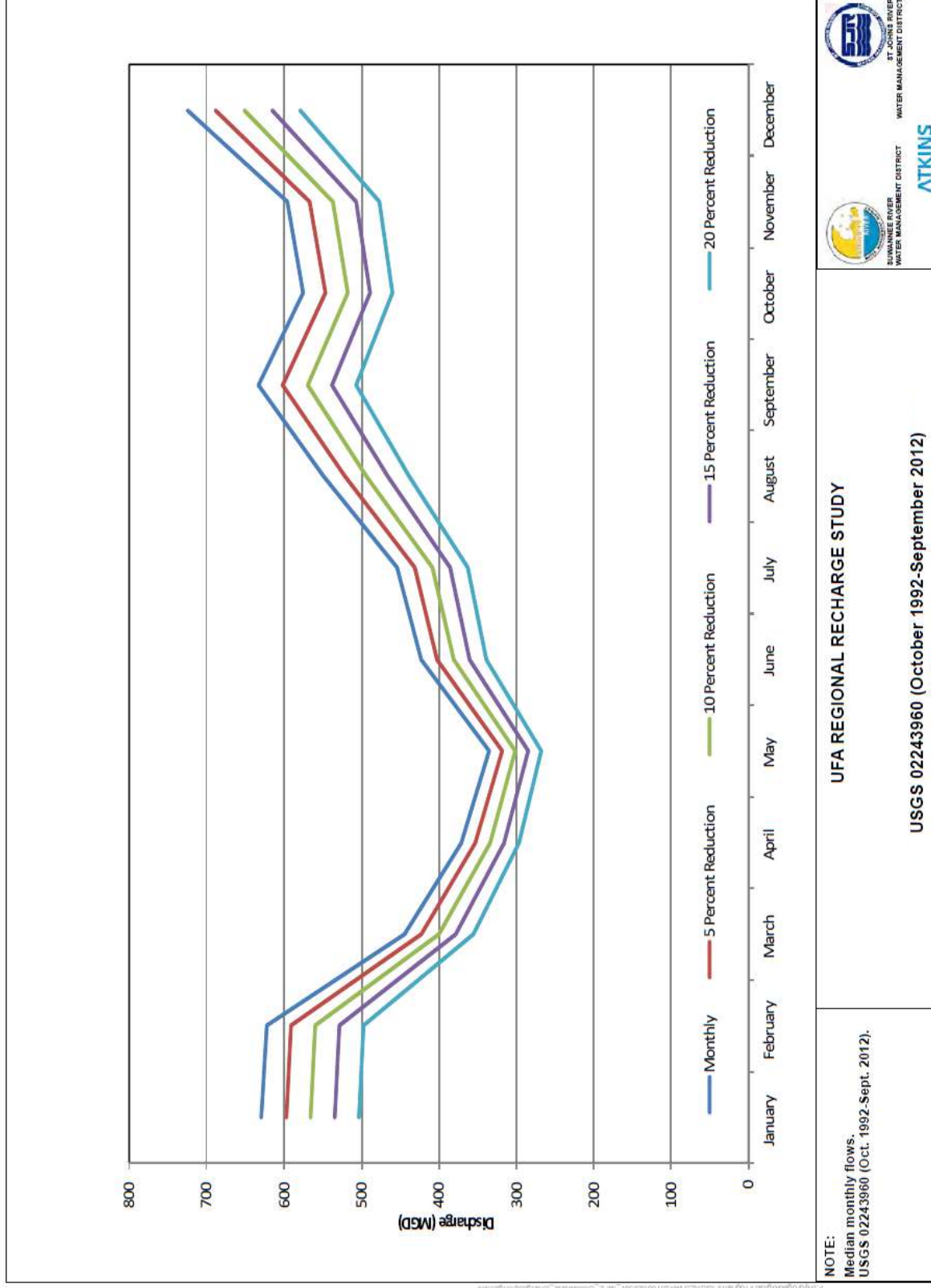


Figure 5-4: 0, 5 and 10 Percent Flow Reduction Scenarios for the Ocklawaha River near Orange Springs

5.3 Estimated Available Flows for Suwannee River at Suwannee Springs

Unlike the Ocklawaha River, the seasonal variation in flows in the Suwannee River is relatively high, demonstrated by the difference in mean (44 cfs) and median (13 cfs) flows at the Suwannee Springs gage (Table 5-6). Consequently, water would likely be available during the high wet season flows, but less so during the low dry season flows. However, analyses were completed to develop flows for use in the feasibility analysis and ultimately a 40 mgd withdrawal scenario was developed, as described in Section 8 (Conceptual Design).

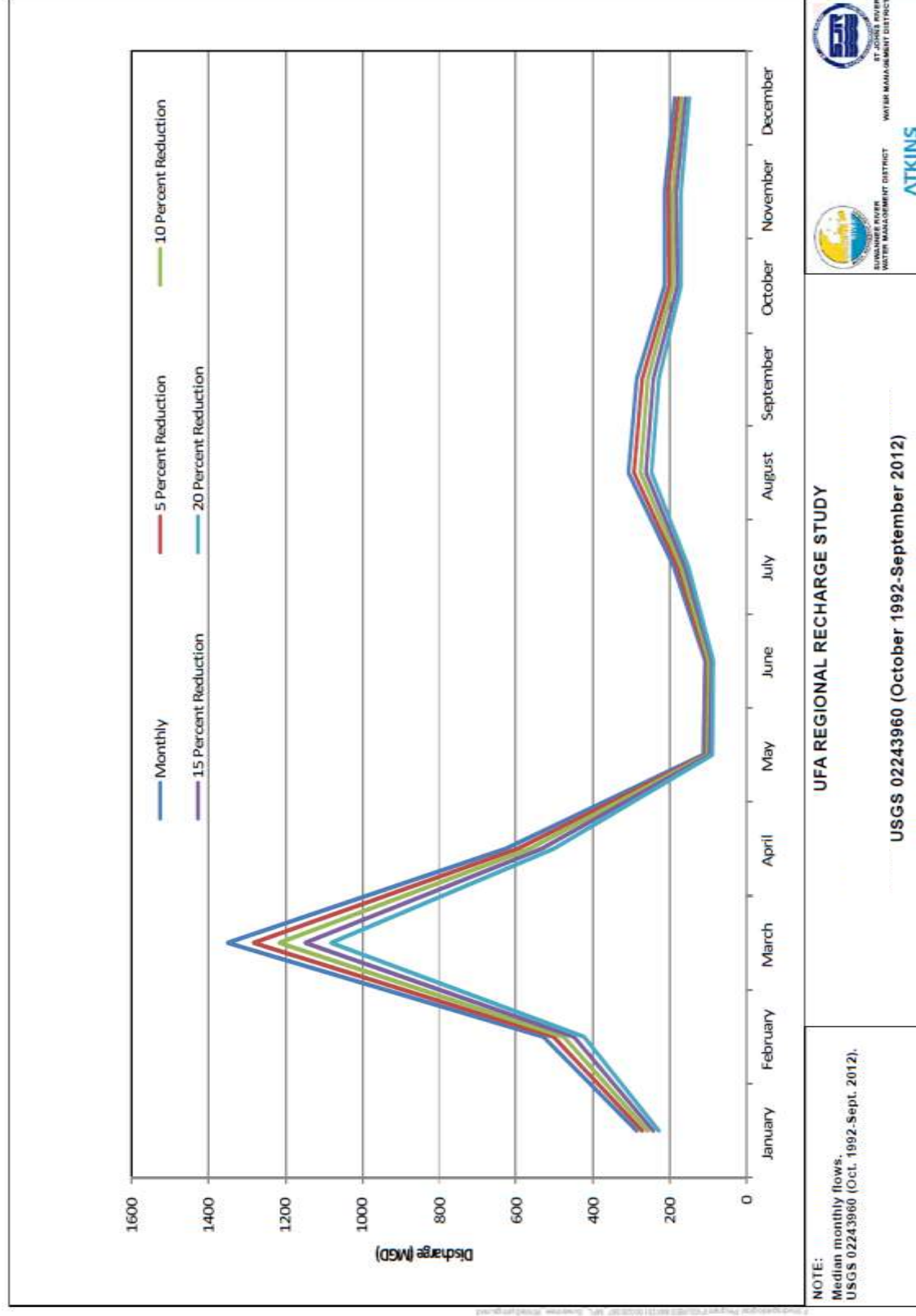
The segment of the Suwannee River from Benton to Ellaville was further evaluated based on potential locations for intake structures and recharge concepts (Section 3). The Ellaville gage is located downstream of the Withlacoochee and Alapaha rivers (Figure 5-3) and, therefore, not representative of Suwannee River flows in the study area. The closest USGS gage on the Suwannee River upstream of the Withlacoochee River is located on the Suwannee River at Suwannee Springs (USGS 02315550). The period of record for discharge data included October 1974 to September 1996 but, unfortunately, stage data collection was discontinued in September 1996 and only recently re-instated (September 2011). Therefore, discharge as a function of stage at the Suwannee Springs gage location could not be calculated. However, the USGS gage farther upstream on the Suwannee River at White Springs (02315500) includes discharge data from 1975 to present and the monthly mean and median of 5 and 10 percent flow reductions were calculated for two time periods (1975-1995 and 1992-2012) and used to calculate Suwannee Springs flows. 0, 5, and 10 percent flow reduction scenarios for the Suwannee River at White Springs (median monthly flows for the October 1992 to September 2012 period) are graphed in Figure 5-5. The mean of the monthly means and median of the monthly medians were calculated for each time period and gage location.

Based on the assumption that changes in discharge at the White Springs gage would be similar for Suwannee Springs, the relative percent change in flows was calculated for the White Springs gage and applied to Suwannee Springs. For example, the 5 percent mean flows on the Suwannee River at White Springs gage were 56 and 44 mgd for the 1975-1995 and 1992-2012 periods, respectively. Therefore, the relative percent reduction was 78.6 percent. Applying the same 78.6 percent reduction to the 1975-1995 Suwannee Springs mean of 59 mgd results in an estimated 46 mgd under the 5 percent withdrawal scenario. The potential available flows at the White Springs and Suwannee Springs gages along the Suwannee River over two 20-year periods are listed in Table 5-6.

Table 5-6: Available Flows (mgd) from the Suwannee River at 5 and 10 Percent Flow Constraints, Upstream of Eleven Ponds, and Downstream of the Suwannee River at White Springs Gage

Period	Source Water	5 percent		10 percent	
		Mean	Median	Mean	Median
1992-2012	White Springs	44	13	88	25
1992-2012 *	Suwannee Springs	46	17	92	33

Note: *= relative to White Springs, see text for explanation



5.4 Summary

Source waters identified in TM-1 were evaluated with respect to the available water and potential constraints (e.g. MFLs). Of the five initial source waters, the upper Suwannee River above its confluence with the Alapaha River and the Ocklawaha River at Rodman Reservoir, have been retained as possible water sources for the aquifer recharge concepts. Withdrawals were not evaluated with respect to historic or existing withdrawals. Consequently, withdrawals that may have already impacted historic flows have not been taken into consideration for this study.

A review of SRWMD and SJRWMD MFL criteria suggests a 5 percent reduction in flows represents a conservative reduction that is consistent with MFLs in both Districts (to date). Mean and median values for potentially available flows are presented in Table 5-5 (Rodman Reservoir) and Table 5-6 (upper Suwannee River). The median flow values are lower than the mean in both the Suwannee and the Ocklawaha rivers, albeit the difference is much greater for the Suwannee River, and indicate that typical flows are lower than the mean flows but that infrequent, very high flows may provide opportunities for capture and use in recharge concepts. For the purpose of conceptual design (Section 8), a maximum daily flow quantity of 40 mgd was selected for sizing of the water supply intake, pumping and piping infrastructure for Recharge Concepts 2 and 3 (upper Suwannee River) and 30 mgd was selected for Recharge Concept 4 (Rodman Reservoir).

6.0 HYDROGEOLOGIC ASSESSMENT

A brief summary of hydrologic and geologic conditions in the study area is presented in this section. The summary concentrates on the general area where hydrogeologic conditions indicate aquifer recharge will be most effective. The summary is primarily a compilation of information obtained from the USGS' Peninsular Florida Model (MegaModel) report entitled "Simulation of Ground-Water Flow in the Intermediate and FASs in Peninsular Florida", by the USGS 2002. This study concentrates primarily on the hydrogeologic characteristics identified within the SRWMD since the only aquifer recharge concepts that are simulated through computer modeling (Recharge Concepts 2 and 3) are located in the SRWMD. However, hydrogeologic information for the SJRWMD is briefly presented to assist in the level of analysis required for Recharge Concepts 1 and 4. Figure 6-1 presents the stratigraphic, lithologic, and hydrogeologic units referred to in this report.

6.1 Physiographic Regions

Major physiographic regions in the SJRWMD vary from coastal plains (St. Marys Meander Plain and Atlantic Beach Ridge), across the Eastern Valley physiographic region, to the Duval and Marion Uplands. Further west in the study area is the Central Valley physiographic region. These regions are linear, running north to south, and are more complex in the SJRWMD than in the SRWMD. Major physiographic regions in the SRWMD portion of the study area include the Northern Highlands, the Gulf Coastal Lowlands, and the Central Valley regions (Figure 6-2). The Northern Highlands are the most prominent physiographic feature within the study area. The topography in the Northern Highlands region is gently rolling, generally ranging from 100 to 200 feet above mean sea level (MSL). Topography generally slopes toward the southeast with soils typically ranging from sand to clayey sand. The study area within the Northern Highlands region includes the upper reaches of the Suwannee and Santa Fe rivers as well as numerous lakes and wetlands.

A significant geologic feature separating the Northern Highlands from the Gulf Coastal Lowlands is the Cody Scarp (Figure 6-3). The Cody Scarp has been described as the most "persistent topographic break in the state" by Puri and Vernon (1964). There can be as much as 80-100 feet of elevation relief along the Cody Scarp. It is a karst escarpment that has been highly modified by marine shoreline processes. Within the upper Suwannee River basin, the crest of the scarp generally corresponds with the 110-foot topographic contour, and its continuity is broken by the Suwannee and Alapaha rivers (Ceryak et al. 1983). The Gulf Coast Lowlands downslope of the Cody Scarp is characterized by numerous sinkholes, lakes, springs, sinking streams, and river resurgences. The Santa Fe and Alapaha rivers are completely captured by sinkholes (swallets) as they cross the Cody Scarp. Due to its size, the Suwannee River is the only river in the study area that is not captured by a swallet when it crosses the Cody Scarp. Upslope of the Cody Scarp (in the Northern Highlands), well-integrated surficial drainage has developed, with numerous small creeks draining to the upper Suwannee and Santa Fe rivers, and their tributaries. The Cody Scarp may be less than 0.5 mile to over 10 miles in width, depending on geologic and hydrologic conditions.

SYSTEM	SERIES	STRATIGRAPHIC UNIT	GENERAL LITHOLOGY	HYDROGEOLOGIC UNIT
QUATERNARY	HOLOCENE	SURFICIAL DEPOSITS	Undifferentiated fluvial sands and residuum with interbedded clay, shell, and limestone.	SURFICIAL AQUIFER SYSTEM
	PLEISTOCENE	SURFICIAL DEPOSITS	Undifferentiated terrace and shallow marine deposits.	
TERTIARY	PLIOCENE	UNDIFFERENTIATED DEPOSITS (southwest Florida)	Clayey and pebbly sand; clay, marl, shell, phosphatic,	INTERMEDIATE AQUIFER SYSTEM OR INTERMEDIATE CONFINING UNIT
	MIOCENE	HAWTHORN GROUP (generally absent in north-central Florida)	Highly variable sequence of mostly clay, silt, and sand - all phosphatic, phosphatic limestone, or dolomite, in lower part. In southwest Florida, white to light-gray, sandy, hard to soft, locally clayey, fossiliferous limestone containing phosphate and chert in some places.	
	OLIGOCENE	SUWANNEE LIMESTONE (absent in northeast Florida)	Cream to tan, crystalline, highly vuggy limestone containing prominent gastropod and pelecypod cast and molds,	UPPER FLORIDAN AQUIFER
	EOCENE	OCALA LIMESTONE	(UPPER) White, generally soft, somewhat friable, porous coquina composed of large foraminifera bryozoan fragments and whole to broken echinoid remains, all loosely bound by a matrix of micritic limestone. (LOWER) Cream to white, generally fine-grained, soft to semi-indurated micritic limestone containing abundant miliolid remains and scattered large foraminifers.	
		AVON PARK FORMATION	Mainly cream-colored, highly microfossiliferous chalky limestone that locally contains some gypsum and chert that is commonly partially dolomitized.	MIDDLE CONFINING/ MIDDLE SEMICONFINING UNIT
		OLDSMAR FORMATION	Consists mostly of off-white to light-gray micritic to finely pelletal limestone thickly to thinly interbedded with gray to tan to light-brown, fine to medium crystalline, and commonly vuggy, dolomite.	LOWER FLORIDAN AQUIFER
	PALEOCENE	CEDAR KEYS FORMATION	(UPPER) Gray to cream, coarsely crystalline dolomite that is moderately to highly porous. (LOWER) Tan to gray, finely crystalline to microcrystalline dolomite interbedded with white to clear anhydrite,	SUB-FLORIDAN CONFINING UNIT
UPPER FLORIDAN AQUIFER REGIONAL RECHARGE STUDY  SUWANNEE RIVER WATER MANAGEMENT DISTRICT  ST. JOHNS RIVER WATER MANAGEMENT DISTRICT SEPULVEDA, N. 2002. U.S. GEOLOGICAL SURVEY WATER-RESOURCES INVESTIGATION REPORT 02-4009 				

Figure 6-1: Stratigraphic Units, General Lithology and Hydrogeologic Units

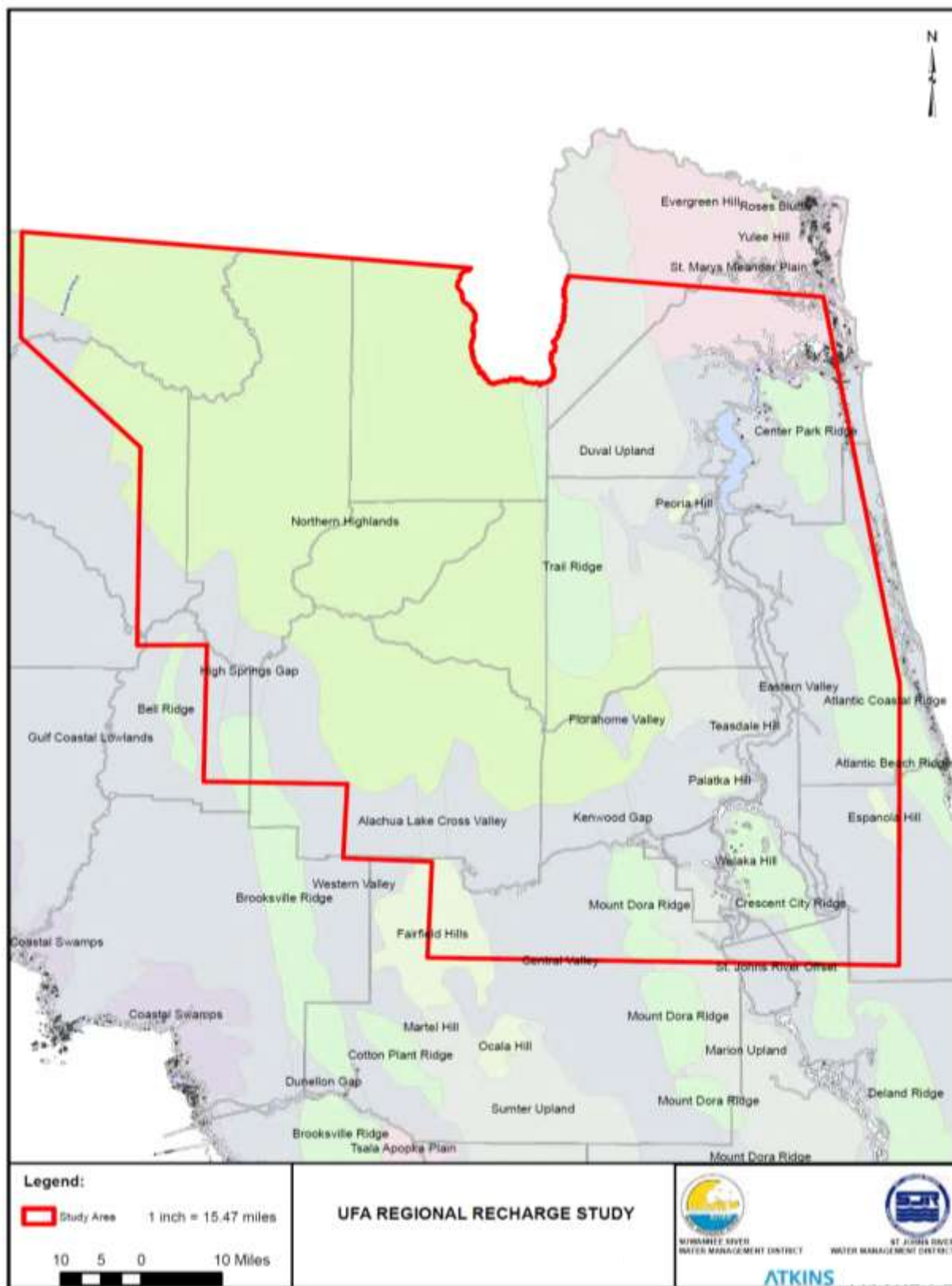


Figure 6-2: Physiographic Provinces

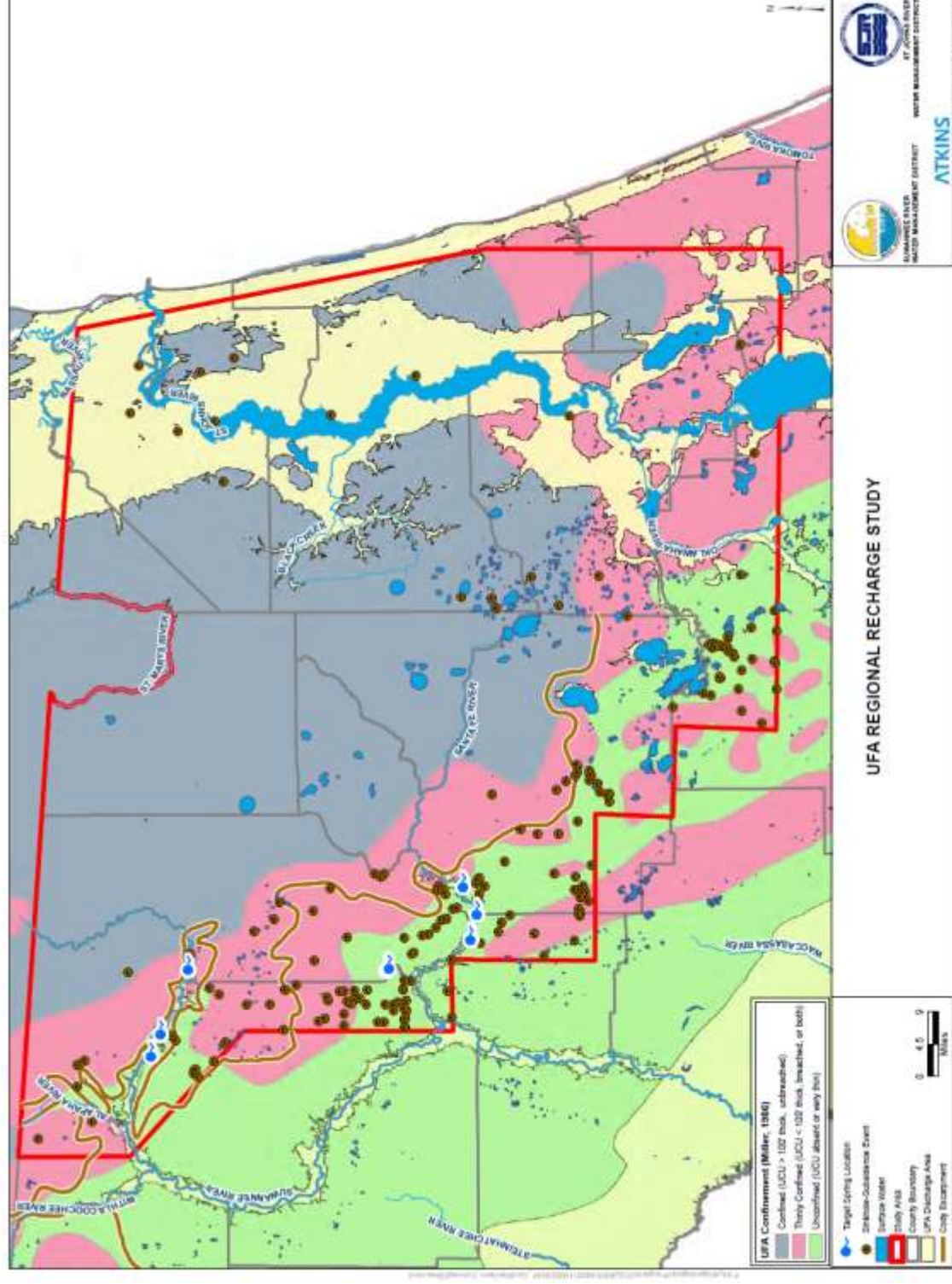


Figure 6-3: Cody Scarp and Recharge Potential within the Study Area

6.2 Surficial Aquifer System

The uppermost aquifer within the study area is the SAS. The SAS occurs within the undifferentiated, Plio-Pleistocene, marine-terrace sands with some clay, shell, and phosphatic material. The SAS is composed of sand, silt, shell, and clay beds which thin to the west in the study area, and becomes absent in areas west of the Cody Scarp. Above the Cody Scarp, the SAS ranges in thickness, being thinnest near the Cody Scarp. The SAS exists in most of the study area except where the UFA is unconfined, mostly in the western part of the study area. The SAS provides good water storage for indirect aquifer recharge if the water level is sufficiently below land surface. A high groundwater level in the SAS reduces storage volume and restricts the ability to store available water.

6.3 Intermediate Confining Unit

The Hawthorn Group of upper Miocene age is present in the northern and northeastern portions of the study area. It consists of interbedded clay, sand, and carbonate strata. The upper part of the Hawthorn Group is dominated by siliclastic materials, such as quartz sand and clay minerals. The lower part also contains sand and clay, but carbonate-rich strata (limestone and dolostone) are dominant. All of the Hawthorn Group contains disseminated phosphorite grains and cemented strata. The Hawthorn Group constitutes the intermediate confining unit (ICU) and/or an intermediate aquifer system (IAS) which separates the SAS from the UFA. The ICU is most prevalent in the northeast portion of the study area where it thickens to approximately 400 feet in the Jacksonville, Florida area.

The ICU limits recharge to the underlying UFA. The degree of confinement above the UFA is a critical factor in evaluating whether methods of indirect aquifer recharge (i.e., passive recharge via a manmade or natural feature, such as a RIB or sinkhole, respectively) will be successful. Thinly confined or unconfined formations tend to be rapidly recharged, while indirect aquifer recharge in highly confined areas may not prove feasible. Figure 6-3 shows the portions of the study area that are unconfined, thinly confined, or confined.

6.4 Upper Floridan Aquifer

The formations that make up the UFA include (from top to bottom) the Oligocene age Suwannee Limestone, and the upper to middle Eocene age Ocala Limestone, and the Avon Park Formation. The Suwannee Limestone, Ocala Limestone, and portions of the upper Avon Park Formation consist of variably permeable limestone and dolostone. The middle and lower Avon Park Formation consists of dolostone with interstitial gypsum and anhydrite, which limit formation permeability. The UFA is deepest in the eastern part of the study area where it is overlain by approximately 400 feet of confinement. It rises in the west part of the study area where it reaches the surface and outcrops south and west of the Cody Scarp.

In May 2010 (designated as representative of average hydrologic conditions) the elevation of the UFA potentiometric surface in the upper Suwannee River basin ranged from 20 to greater than 60 feet above MSL (Figure 6-4). Typically, average annual fluctuation of the

potentiometric surface is less than four feet for approximately two-thirds of the study area. The variability of the fluctuation of the potentiometric surface becomes an evaluation consideration of aquifer recharge. For example, a greater difference between the groundwater levels in the SAS and the potentiometric surface of the UFA improves the indirect aquifer recharge effectiveness since aquifer storage is available. However, for concepts utilizing direct aquifer recharge, this difference is less important since direct aquifer recharge is typically conducted under pressure through a recharge well. More detailed hydrogeologic descriptions are presented below with each aquifer recharge concept.

Figures 6-5, 6-6, 6-7, and 6-8 have been generated directly from the USGS MegaModel database for the study area to show the transmissivity of the UFA, leakage from the SAS to the UFA, hydraulic conductivity of the SAS (the ability to transmit water), and the simulated potentiometric level in the UFA in 1993 (calibrated water levels), respectively. Section 7 of this report elaborates on the use of the MegaModel. The hydrogeologic data from the model is used only to assess the effectiveness of the aquifer recharge concepts. Although the data representing this information are generalized in the MegaModel, site specific data would provide significantly more accurate information for engineering design purposes.

6.5 Aquifer Recharge Site Selection Criteria

Aquifer recharge through either natural or artificial means has the benefits of raising the hydraulic head in the UFA for sustaining spring and river baseflow, shifting local or regional groundwater basin boundaries, altering the hydraulic flow patterns, and replenishing groundwater supplies. In order to maximize these potential benefits, the aquifer to be recharged should exhibit the following preferred conditions:

- Sufficient hydraulic conductivity and storage characteristics to accept recharged water, and then provide sufficient lateral groundwater flow to influence spring and river baseflow,
- A groundwater level that exhibits the ability over an extended period of time to accept recharge and increase the potentiometric level, and
- A hydraulic gradient that will result in groundwater flow toward the targeted location (such as springs or river discharge points).

Four aquifer recharge concepts were assessed and evaluated based on two fundamental aquifer recharge principles:

- Indirect recharge of available source water using surface application systems such as RIBS, ponds, mine pits, depressional features such as sinkholes not directly connected to the UFA, and wetlands, (Recharge Concepts 3 and 4), and
- Direct recharge of available source water using recharge wells into the UFA, or sinkholes and swallets that are directly connected to the UFA (Recharge Concepts 1 and 2).



Figure 6-4: USGS 2010 Potentiometric Surface Contours Map

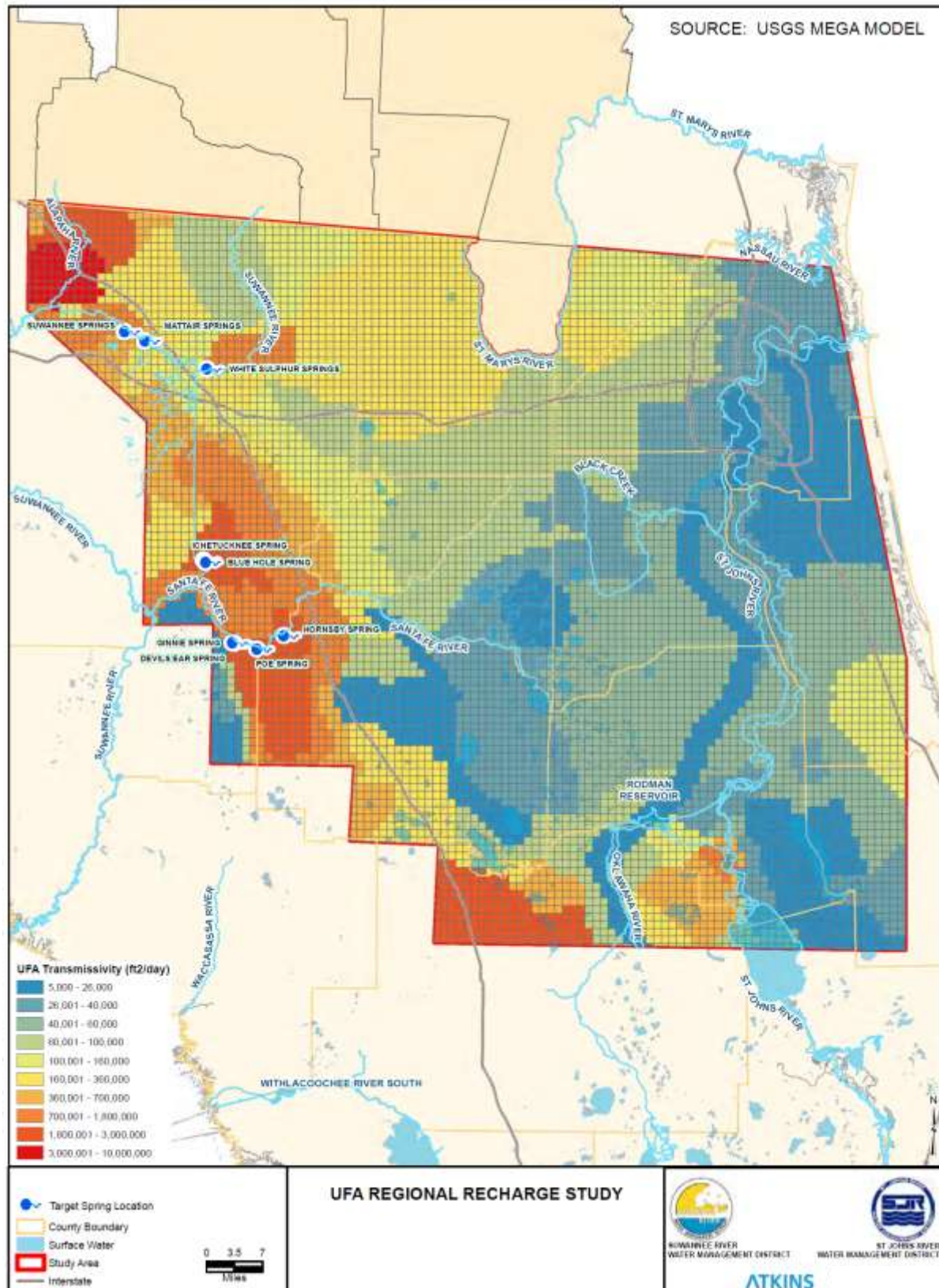


Figure 6-5: Model Derived Upper Floridan Aquifer Transmissivity

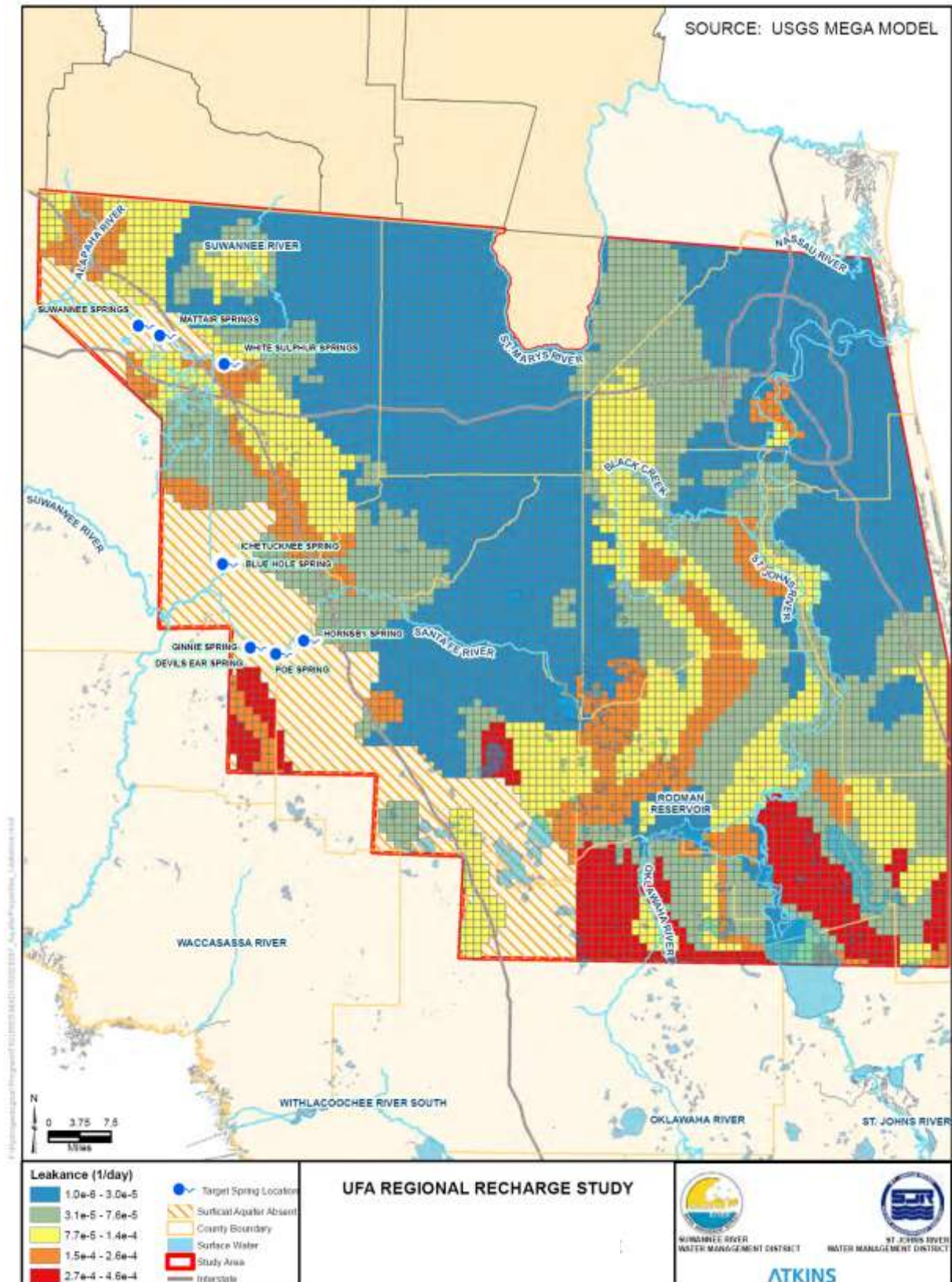


Figure 6-6: Model Derived Upper Floridan Aquifer Leakance

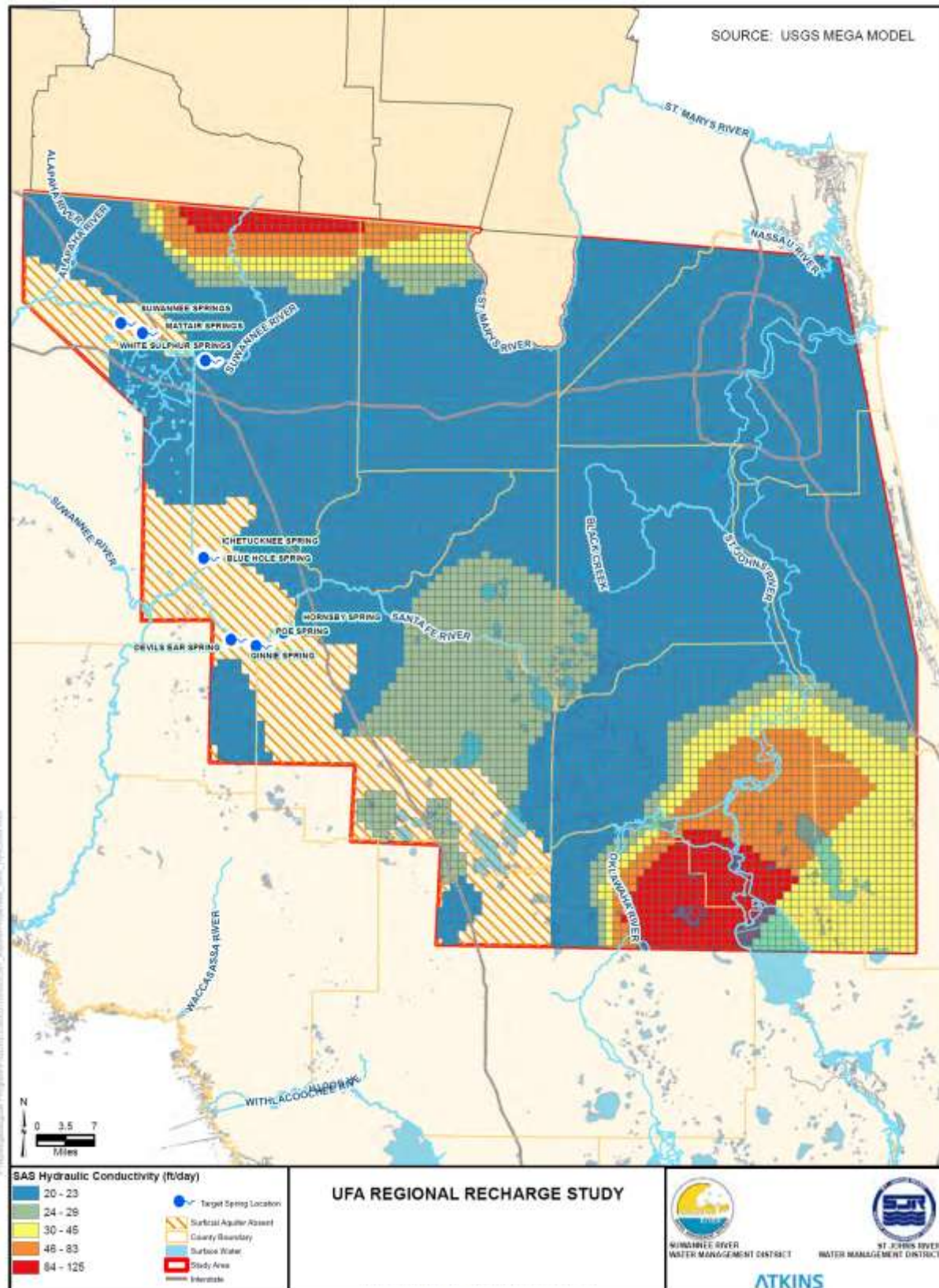


Figure 6-7: Model Derived Surficial Aquifer System Hydraulic Conductivity

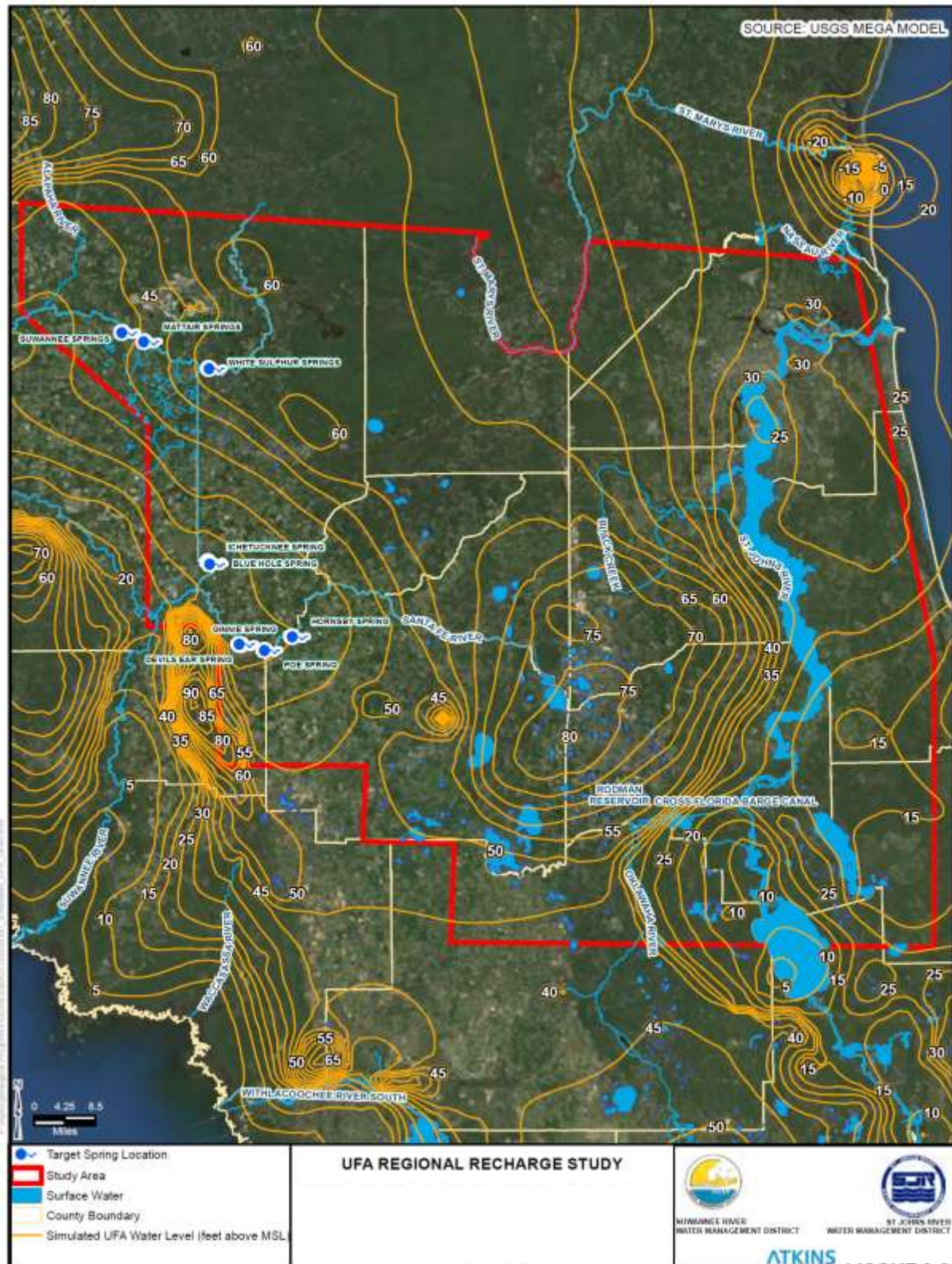


Figure 6-8: Simulated Potentiometric Surface of the Upper Floridan Aquifer, Average August 1993 through July 1994 Conditions

The primary site-specific hydrogeological conditions considered most important to the success of these aquifer recharge concepts are:

- Thickness and hydraulic properties of the SAS,
- Depth to, thickness, and hydraulic properties of confining bed(s) that separate the SAS from the UFA,
- Depth to the UFA,
- Hydraulic properties of the UFA,
- Difference in the water levels of both the SAS and the UFA (potentiometric level), and
- Hydraulic gradient and direction of flow in the UFA.

6.6 Indirect Aquifer Recharge

Indirect aquifer recharge occurs by storing available source water that then slowly percolates into the SAS, and then indirectly recharges the UFA through downward leakage. An indirect aquifer recharge concept may use storage ponds, wetlands, mine pits, lakes, reservoirs, RIBS, and sinkholes to store and indirectly recharge the available source water to the UFA. These recharge concepts generally require relatively large land areas to hold the volume of water required to make aquifer recharge effective. Therefore, assessing these aquifer recharge concepts requires locating areas where there are large public land holdings, or where sufficient private lands are available to meet the water storage needs.

Indirect aquifer recharge requires a receiving formation (typically the SAS) with a sufficiently high hydraulic conductivity to leak the stored water, has sufficient storage volume to receive and store the water to be recharged, and has sufficient hydraulic head differences between the SAS and the UFA to move water from the SAS into the UFA. Once the recharged water enters the UFA, the UFA's hydraulic conductivity dictates the rise in the potentiometric surface and travel time to the point of discharge to support spring discharge and river baseflow. To summarize, indirect aquifer recharge concepts require:

- A relatively thick unsaturated portion of the SAS,
- Sufficient hydraulic head differential between the SAS and the UFA to provide downward leakage of the stored water,
- Areas within the regional groundwater flow pattern that are upgradient of discharge target points (springs or rivers).
- The lack of, or limited confining beds below the SAS to allow downward leakage of the stored water with little impairment, and
- A surface formation or feature (e.g., wetland, pond, sinkhole, pit, mine, reservoir, or RIB) that has sufficient volume to provide adequate water storage.

Indirect aquifer recharge applications where the intent is to replenish or maintain river or spring flow may require the use of a reservoir or wetland to store available water, but aquifer recharge occurs at another location. River reaches that have exhibited reduced or declining river flow and nearby spring discharge decreases are favored. For surface water

storage and release at another site, the following hydrogeologic condition is preferred: an unsaturated zone at the storage site with underlying confinement that restricts vertical groundwater leakage so that maximum storage is contained in the surface feature for controlled water releases at the selected recharge site.

6.7 Direct Aquifer Recharge

The concept of direct aquifer recharge is intended to recharge the UFA by introducing the available water directly into the UFA without relying on leakage from a surface feature. Direct aquifer recharge typically uses wells completed into the UFA and available water is pumped into the well under pressure to maximize recharge rates. In most cases, approximately one acre of land is required initially for well construction due to equipment storage, but only an area of approximately 20 feet by 20 feet for security and maintenance of the wellhead (not including treatment facilities) is required when the well is completed. Direct aquifer recharge methods can also include sinkholes and swallets if they have direct connection to the UFA.

Successful direct aquifer recharge projects require slightly different hydrogeologic conditions than indirect aquifer recharge projects. The most important hydrogeologic parameter is the hydraulic conductivity of the receiving formation (in this case the UFA). Additionally, the existence of a confining bed above the UFA helps to assure an increase in potentiometric head without upward migration of the recharged water. Increasing the potentiometric head has two primary benefits. First, the hydraulic gradient in the UFA can be changed in both direction and slope, and secondly, it can result in increased spring discharge and river baseflow.

The preferred hydrogeologic conditions at a site for successful direct aquifer recharge applications using a recharge well would include:

- An overlying confining bed to contain the recharged water resulting in rising potentiometric pressure that generates flow to specific discharge locations such as springs,
- An overlying confining bed that allows aquifer recharge to locations that are at some distance from the area of discharge, and may alter the hydraulic boundary,
- An aquifer transmissivity adequate to allow sufficient recharge of water,
- An aerially extensive and thick aquifer to provide sufficient storage over a broad area, and
- A recharge location hydraulically upgradient of the desired point of discharge.

If the direct aquifer recharge concept includes recharging the UFA where the aquifer is near ground surface (such as using a sinkhole, swallet, or open mine pit), then some different hydrogeological conditions are favorable. These conditions are:

- A relatively high aquifer transmissivity that allows sufficient recharge of water,
- Thin or absent SAS, allowing rapid recharge,

- Thin or absent upper confining bed,
- Potentiometric level that is below the top of the aquifer to allow non-pressurized recharge,
- Sufficient surface area to maximize recharged water volume, and
- A recharge location hydraulically upgradient of the point of a desired discharge (spring or river).

The hydrogeological conditions within the study area have been assessed at several potential aquifer recharge sites to predict which type of aquifer recharge concept would be most successful. Computer modeling was conducted to assist in establishing which of the sites had the best probability of success. The modeling discussion is provided in Section 7 of this document.

6.8 Identification of Recharge Concept Sites

This study initially assessed numerous sites specifically along the upper Suwannee River and within the overall study area that potentially provided aquifer recharge benefits based on the four recharge concepts included in the Scope of Services. Using the hydrogeologic data, accessible land, potentiometric level information, and potential water availability, several potential aquifer recharge sites were chosen for further consideration (Figure 6-9). The following discussion provides details on the four aquifer recharge concepts, and the site best suited to each aquifer recharge concept.

6.8.1 Recharge Concept 1 - The Treatment of Reclaimed Water from Northeast Florida for Recharge into the Upper Floridan Aquifer in the Study Area

WWTFs should have a capacity of greater than 10 mgd to be considered a feasible source water option for aquifer recharge projects that will produce benefits on a regional scale. A review of the WWTF flow data provided by FDEP indicates that the only facilities in the study area with design flows exceeding 10 mgd are located in the SJRWMD and owned by the JEA, specifically, the Buckman Street, Southwest, District II, and Arlington East WWTFs.

JEA documents indicate that significant investments in reuse infrastructure such as WWTF upgrades and reclaimed water transmission lines on the east side of the St. Johns River have been made or proposed. Reclaimed water generated by the WWTFs east of the St. Johns River (i.e., District II and Arlington East) will most likely be used for JEA customers and would not be available for aquifer recharge and, therefore, were excluded from consideration in this study.

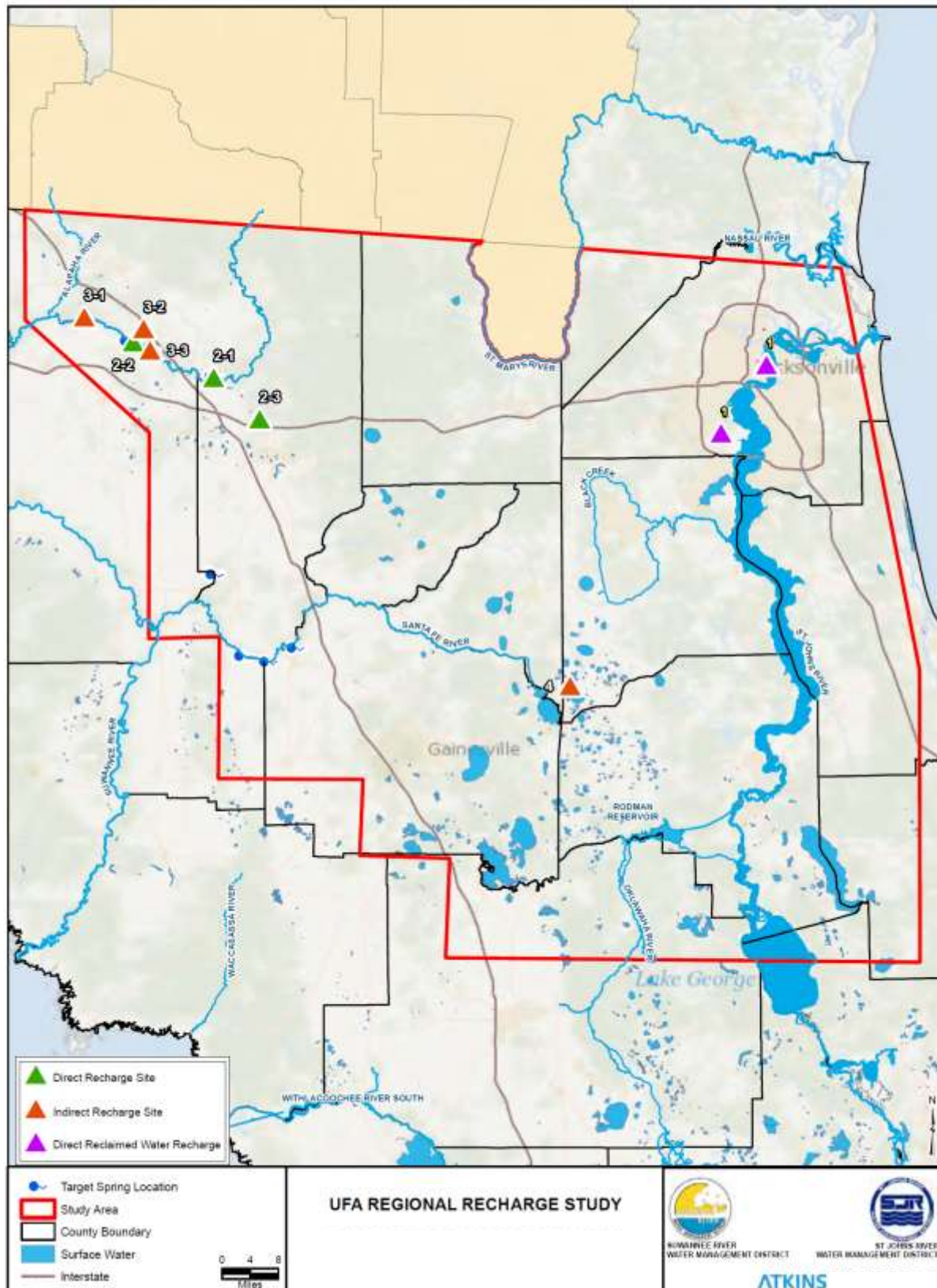


Figure 6-9: Evaluated Recharge Concept Site Locations

The WWTFs located west of the St. Johns River are Buckman Street and Southwest (Figure 6-10). According to the JEA Water Resource Master Plan (2010), there is no current or proposed public-access reuse system associated with the Buckman Street and Southwest facilities. Though effluent flow projections were not a component of this study, a September 2008 report conducted by CH2M Hill titled “Lower St. Johns River Reuse and Treatment Project, Phase II: Combined East and West River Reuse Initiative Solutions” estimates the following flow projections in Table 6-1:

Table 6-1: Wastewater Treatment Facility Projected Flows

Year	Buckman Street	Southwest
2015	32.18 mgd	12.40 mgd
2020	33.23 mgd	13.47 mgd
2025	34.22 mgd	14.56 mgd
2030	35.12 mgd	15.59 mgd

Note: MGD=million gallons per day

For the purpose of this study, it is assumed that up to 30 mgd and 10 mgd of reclaimed water are currently available from the Buckman Street and Southwest WWTF, respectively, for aquifer recharge. Currently, the wastewater produced from these two facilities is discharged to the St. Johns River.

Indirect aquifer recharge in the Jacksonville, Florida area is precluded by the significant depth to the top of the UFA, and the presence of a thick and continuous confining unit (significantly greater than 100 feet) in the Jacksonville area (Figure 6-3). Therefore, only direct recharge methods are applicable for Recharge Concept 1. A depressed UFA potentiometric surface in the Jacksonville area facilitates a direct aquifer recharge concept. The Buckman Street and Southwest WWTFs are located near the center of the JEA municipal wellfields within the area of greatest groundwater level drawdown (Figure 6-11). Direct aquifer recharge at the WWTF sites provides an opportunity to raise aquifer water levels in the depressed area without the cost of having to transport the excess reclaimed water to remote locations through new pumping and piping infrastructure.

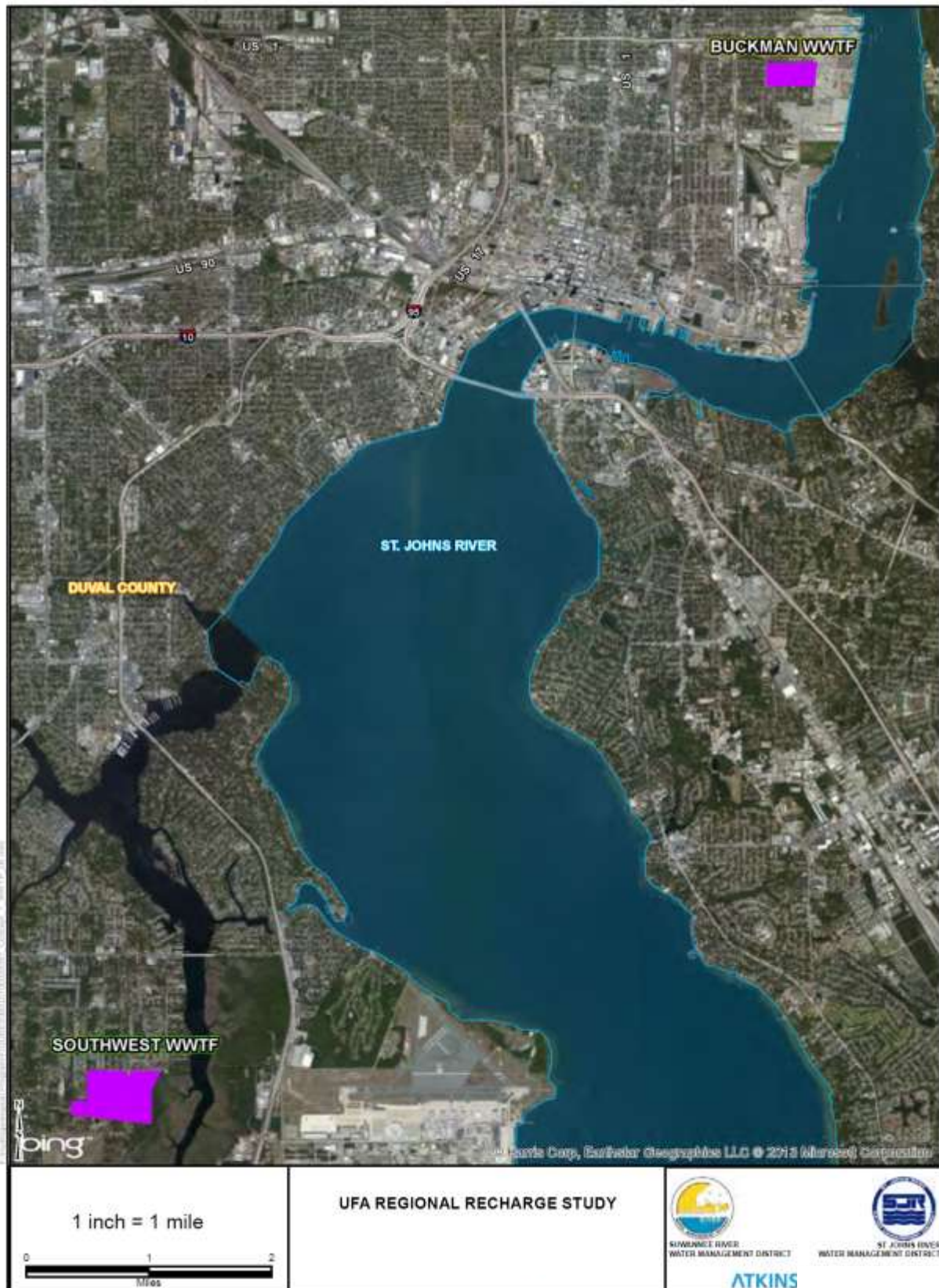


Figure 6-10: Recharge Concept 1 Reclaimed Water Site Map

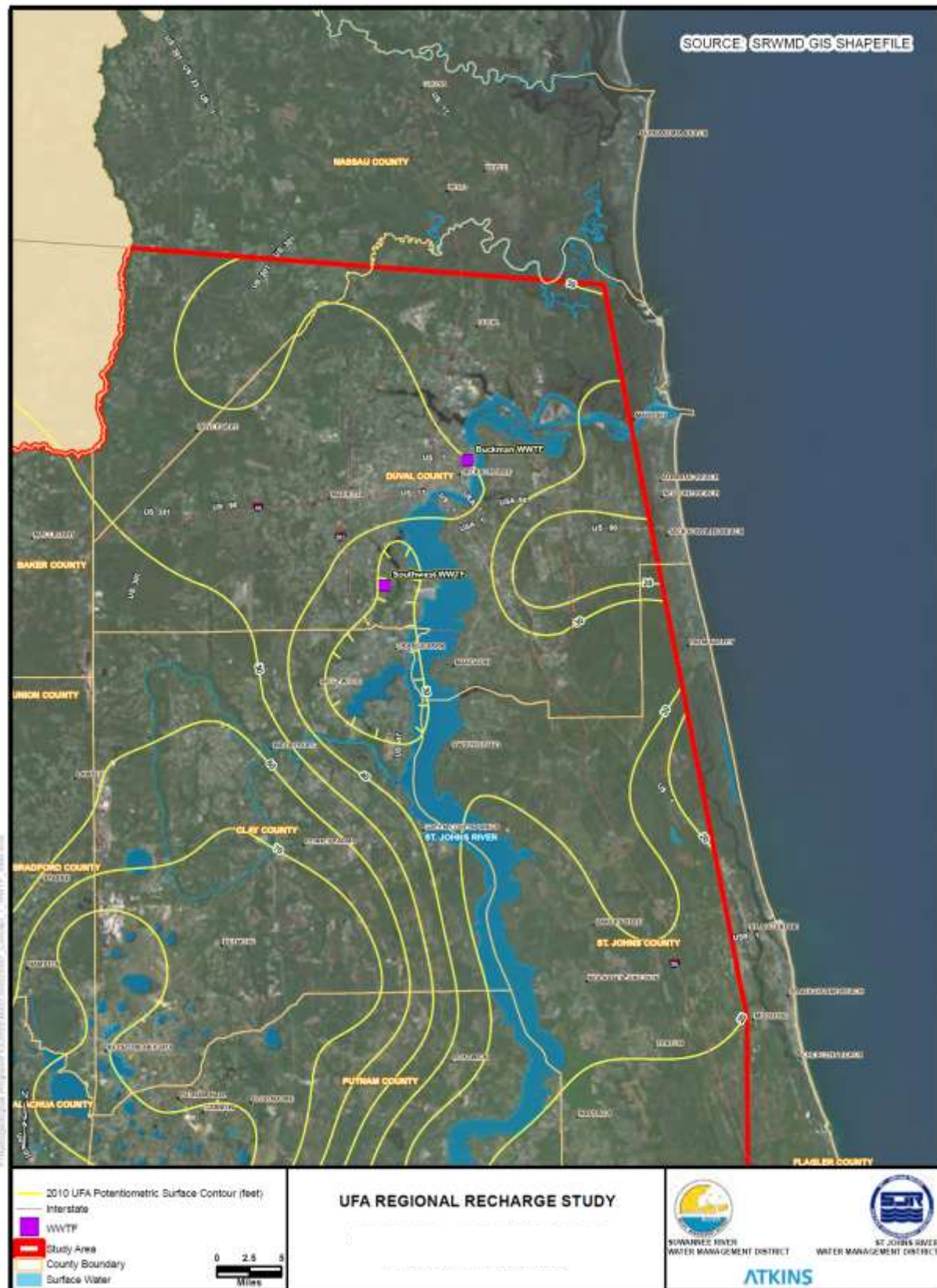


Figure 6-11: Concept 1-Potentiometric Surface Contours

The UFA occurs at approximately 400 to 500 feet below land surface and has a transmissivity of 32,000 feet squared per day (ft²/day), which is of sufficient permeability to support aquifer recharge wells with a capacity of several mgd. Review of available groundwater quality data indicates the area around the WWTF sites contain TDS concentrations of less than 500 mg/L (Figure 6-12). Therefore, a higher level of treatment is required than currently provided at those facilities (as presented in TM-1). Water quality treatment requirements and feasibility analysis for Recharge Concept 1 are discussed further in Section 8.

6.8.2 Recharge Concept 2 - The Capture and Storage of Surface Water from the Upper Suwannee River for Treatment and Direct Recharge into the Upper Floridan Aquifer

Recharge Concept 2 utilizes the surface water available from the upper Suwannee River when flows exceed those necessary to meet environmental needs. Numerous sites were initially considered in the upper Suwannee River basin. Surface features are less important for direct recharge than for other recharge concepts since this process typically includes the use of one or more recharge wells. Some sites that contain surface features such as sinkholes or swallets may be considered for direct recharge if they are directly connected to the UFA.

Ideally, the location for an aquifer recharge project is best suited for District-owned lands to facilitate permitting and construction. Most of the available District-owned lands occur adjacent to the Suwannee River and within close proximity to springs. Siting an aquifer recharge project in these locations may result in direct and rapid movement of recharged groundwater to the spring or river for rapid discharge, and may not provide long-term benefit to the regional water resources. Therefore, potential project sites were sought that were at greater distances away from the Suwannee River. Available public lands within the study area that would provide regional aquifer recharge benefits were preferred in the areas that may benefit not only the Suwannee River flows (and associated springs), but also other water bodies such as the Ichetucknee River and Santa Fe River. This approach provides regional benefits rather than just enhancing a more localized water resource.

Nine direct recharge candidate sites were initially evaluated to determine appropriate hydrogeological conditions and if sufficient public lands were available for concept implementation. Of these initial sites, three were selected for further analysis and they are identified as White Sulphur Springs (Recharge Concept 2-1), Suwannee Springs (Recharge Concept 2-2), and Falling Creek Falls Park (Recharge Concept 2-3). The general locations of the three candidate sites are mapped in Figure 6-9. Specific locations for Recharge Concepts 2-1, 2-2, and 2-3 are mapped in Figures 6-13, 6-14, and 6-15, respectively.

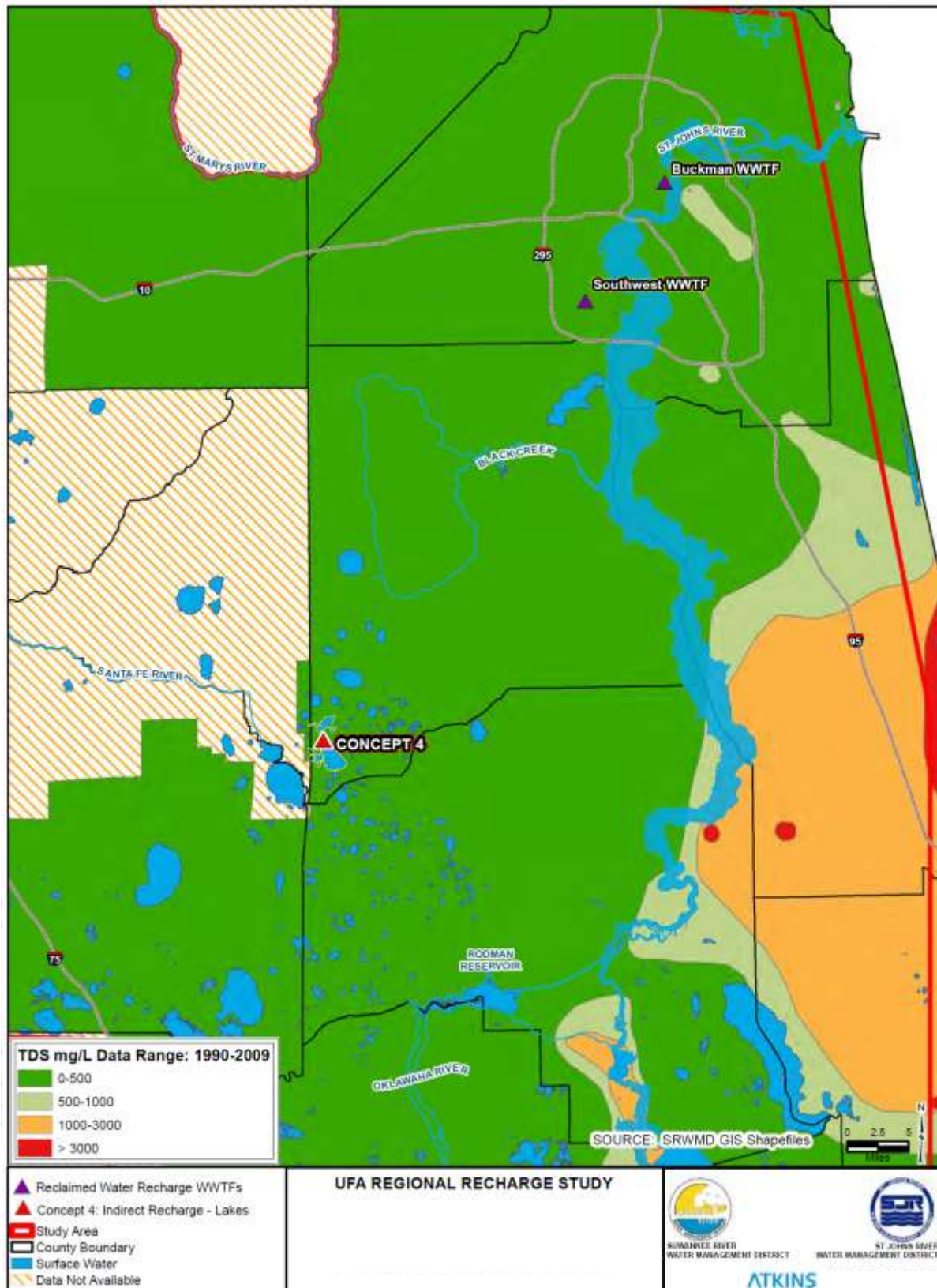


Figure 6-12: Distribution of Total Dissolved Solids in the Upper Floridan Aquifer

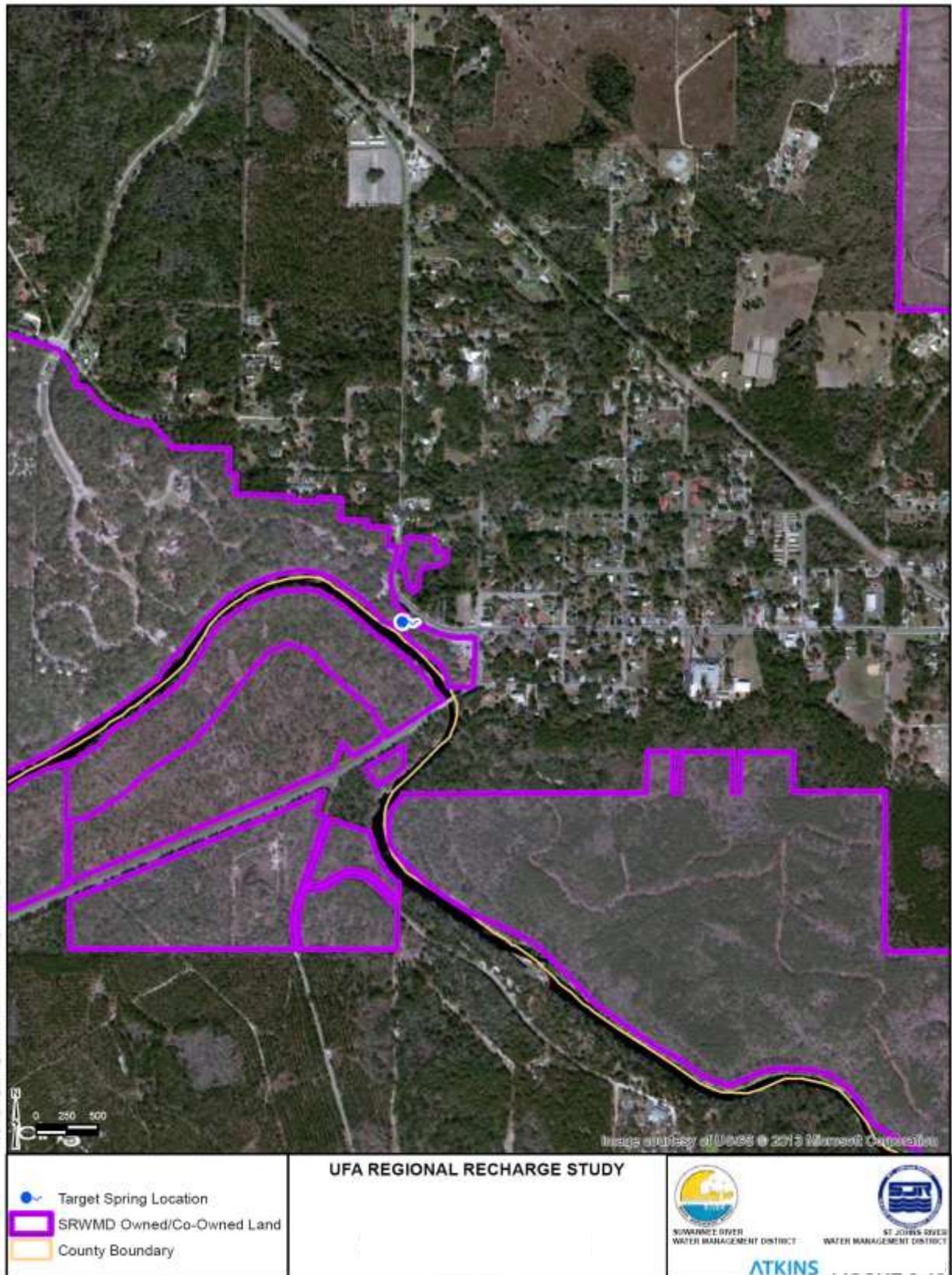


Figure 6-13: Direct Recharge at White Sulphur Springs Site Map

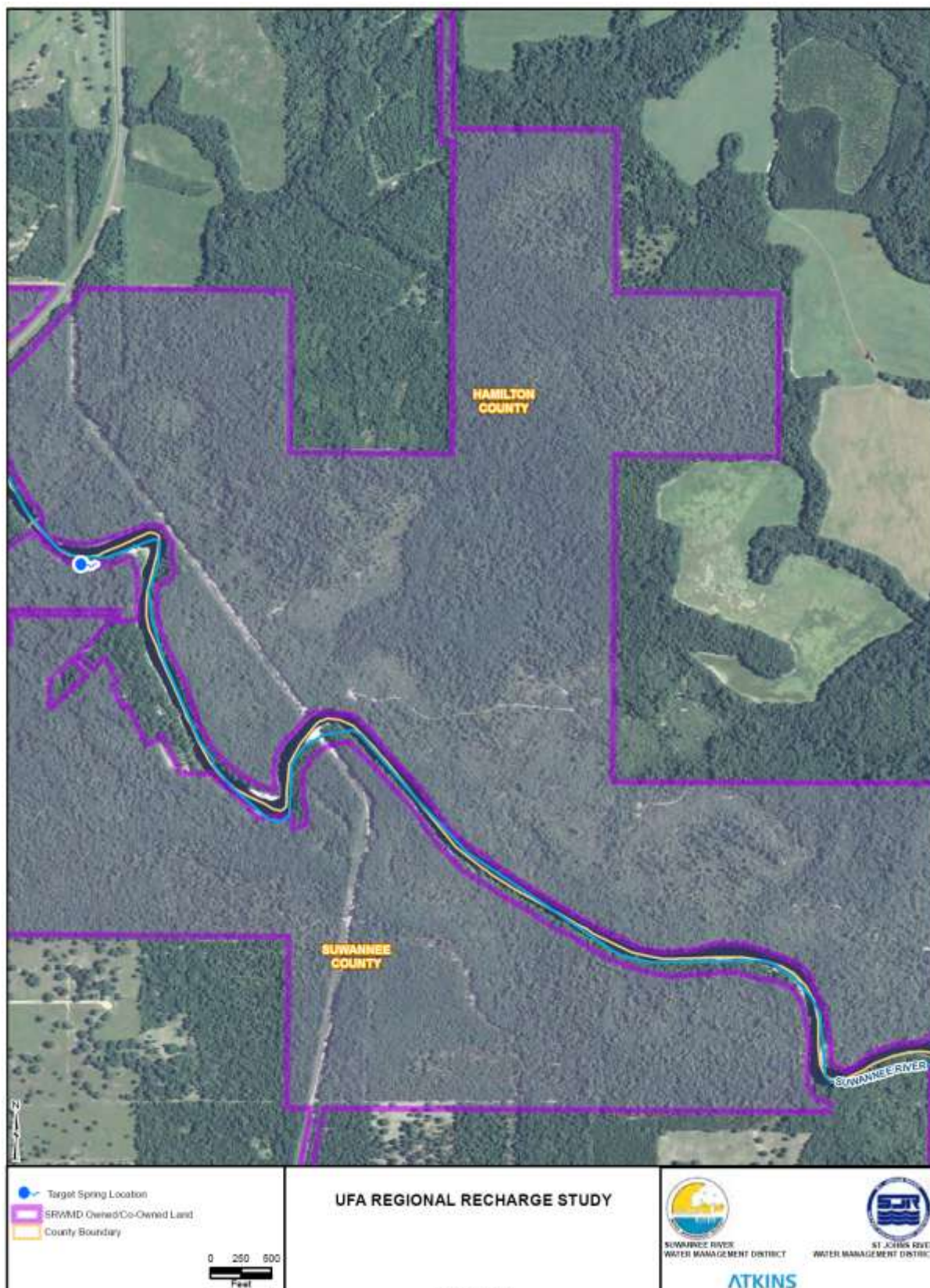


Figure 6-14: Concept 2-2_Direct Recharge at Suwannee Springs Site Map

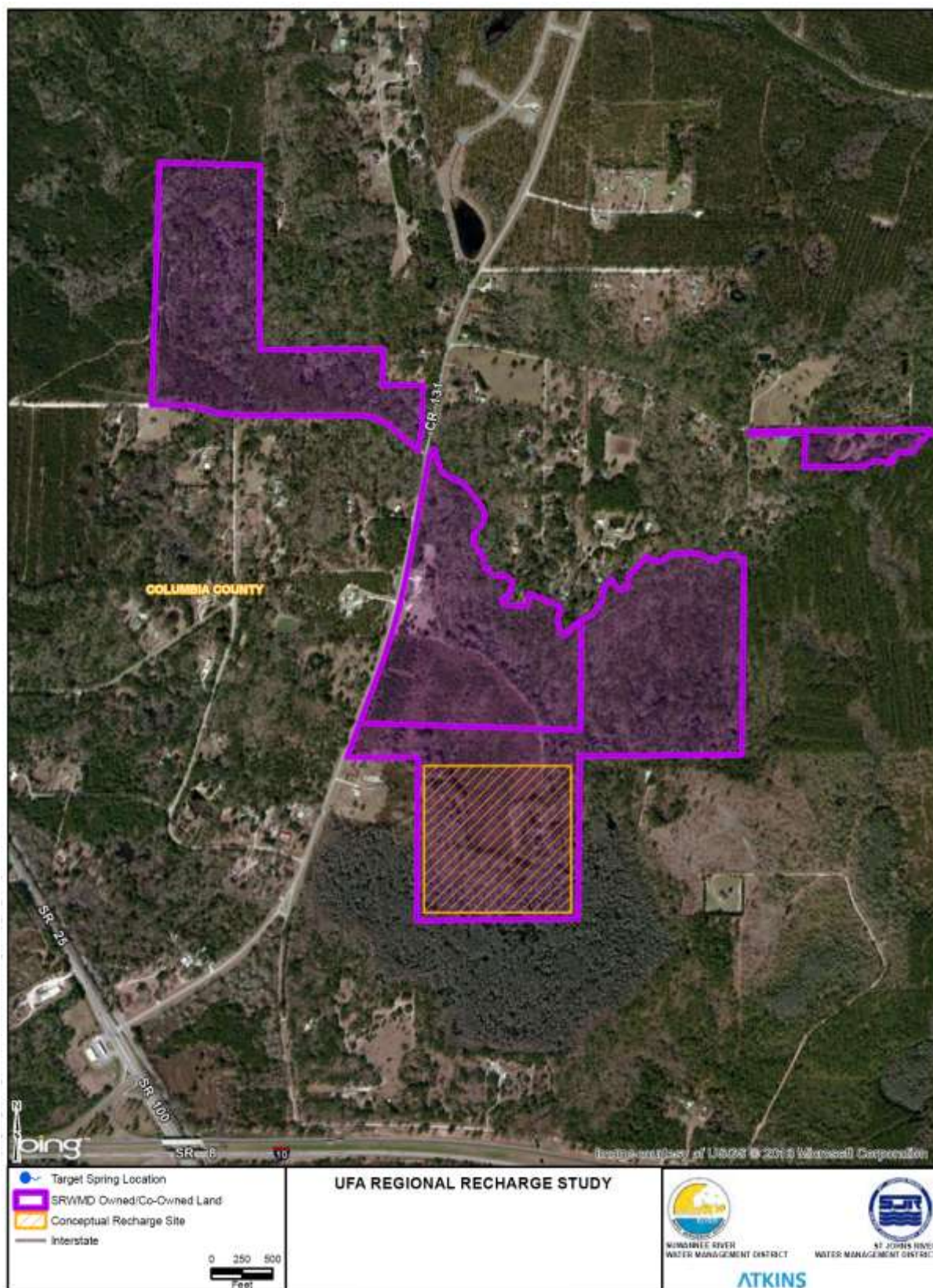


Figure 6-15: Concept 2-3_Direct Recharge at Falling Creek Falls Site Map

Conceptually, the two aquifer recharge sites located near springs may result in return of recharged water to the Suwannee River immediately without regional groundwater benefits, resulting in water being recharged and spring discharge potentially occurring nearly simultaneously. White Sulphur Springs is in a state park with sufficient land for a direct aquifer recharge project including water intake, treatment, pumping, piping and well infrastructure (Figure 6-13). However, the benefit to the upper Suwannee River downstream of White Sulphur Springs would probably result in very little regional water resources benefits. Suwannee Springs also has sufficient land available for aquifer recharge infrastructure (Figure 6-14). This site has high bluffs that require significant engineering with minimal regional water resources benefits, similar to White Sulphur Springs. The two spring sites have a thin SAS, a semi confined UFA, and a UFA with transmissivity values ranging from 250,000 ft²/day to 500,000 ft²/day (Figure 6-5).

In Falling Creek Falls Park, sufficient land is available for the treatment and aquifer recharge infrastructure (Figure 6-15). The SAS is approximately 50 feet thick and underlain by a semi-confining bed. These formations are interrupted by a deep ravine where Falling Creek enters a swallet. In the area, the UFA has a transmissivity of 120,000 ft²/day, which is of sufficient permeability to support aquifer recharge wells with capacities of several mgd. Direct aquifer recharge at this location eliminates localized impacts and immediate spring discharge that would occur at the Suwannee Springs and White Sulphur Springs locations. Conversely, direct aquifer recharge at Falling Creek Falls Park would provide a greater groundwater influenced area, and slower release of recharged water back to the springs and river systems.

Groundwater quality data in the vicinity of the Suwannee River indicates that TDS in the UFA is less than 1,000 mg/l (Figure 6-16). Therefore, any type of direct aquifer recharge into the UFA would require meeting the highest level of treatment requirements, which are presented in Section 4.

6.8.3 Recharge Concept 3 - The Capture of Flood Waters within the Floodplain along the Upper Suwannee River for Storage and Indirect Recharge of the Upper Floridan Aquifer

Recharge Concept 3 utilizes surface water available from the upper Suwannee River when flows exceed those necessary to meet environmental needs. Numerous publically owned sites in the Suwannee River basin were considered, including Big Shoals, White Sulphur Springs, Little Shoals, Stephen Foster, Woods Ferry, Mattair Springs, Suwannee Springs, and Eleven Ponds. In addition, privately owned, former mined land located near the upper Suwannee River was also considered. The preferred site would need a large land area, have appropriate topography to create areas for water storage, be hydraulically connected to the UFA, and provide ample space for infrastructure to extract water from the river source. Of all the sites considered based upon available land, access, engineering issues, project logistics, and hydrogeology, three sites were considered for further consideration. They are identified as: Eleven Ponds (Recharge Concept 3-1), phosphate mined lands north of the Suwannee River (Recharge Concept 3-2), and Mattair Springs (Recharge Concept 3-3).

Eleven Ponds is an area north of the Suwannee River and east of the Alapaha River. It is a combination of two SRWMD land tracks; the Tyree track of 213 acres and the Osteen track of 203 acres. It is collectively referred to as the Eleven Ponds site, and offers sufficient public land with relatively low bluff elevation to meet criteria for an off-river reservoir (Figure 6-17).

Mined lands also offer the availability of large tracks of land for off-river storage. Potentially available mined land exists on the PCS Phosphate property (Figure 6-18). A meeting with the PCS Phosphate, District representatives, and Atkins staff on January 25, 2013 resulted in a decision to move forward with development of a concept to potentially use mined land (such as sand tailings areas) for indirect aquifer recharge. Mined areas offer sufficient land with potentially high recharge rates. In follow-up communications with PCS Phosphate staff, existing clay settling areas (CSAs) were proposed as potential reservoirs for storage of surface water diverted from the Suwannee River. Available mined land is located north of the Suwannee River and within a feasible distance for project implementation. Consideration of potential recharge sites included areas between Interstate 75 and United States Highway 41. Such sites reduce piping costs and road crossings when compared to other mined land areas.

Mattair Springs offers sufficient public land (1,188 acres), and is adjacent to the Suwannee River (Figure 6-19). The site is located at a river bend allowing water withdrawals from one stretch of the river and water return at a lower stretch of the river. Mattair Springs is located at the Cody Scarp, and has a general topographic range from 45 to 105 feet MSL (Figure 6-20). However, the site sits on a high bluff and would have difficult engineering requirements.

Eleven Ponds has little overburden overlying a highly karstic limestone formation with numerous sinkholes that allows quick recharge of available water. Topography generally ranges from 40 to 90 feet MSL as shown in Figure 6-21. However, the combination of the close proximity of the Eleven Ponds site to the Suwannee River and the highly karstic nature of the site may result in rapid recirculation of recharge waters to the river and nearby springs.

The PCS Phosphate area has sufficient elevation at approximately 140 feet above MSL and has surficial sands approximately 40 feet thick (Figure 6-22). Reclamation of the mined lands into sand tailings enhances the permeability of the formations overlying the UFA. The depth to the UFA is approximately 100 feet below land surface, and the UFA transmissivity in the vicinity of Recharge Concept 3-2 is approximately 240,000 ft²/day.

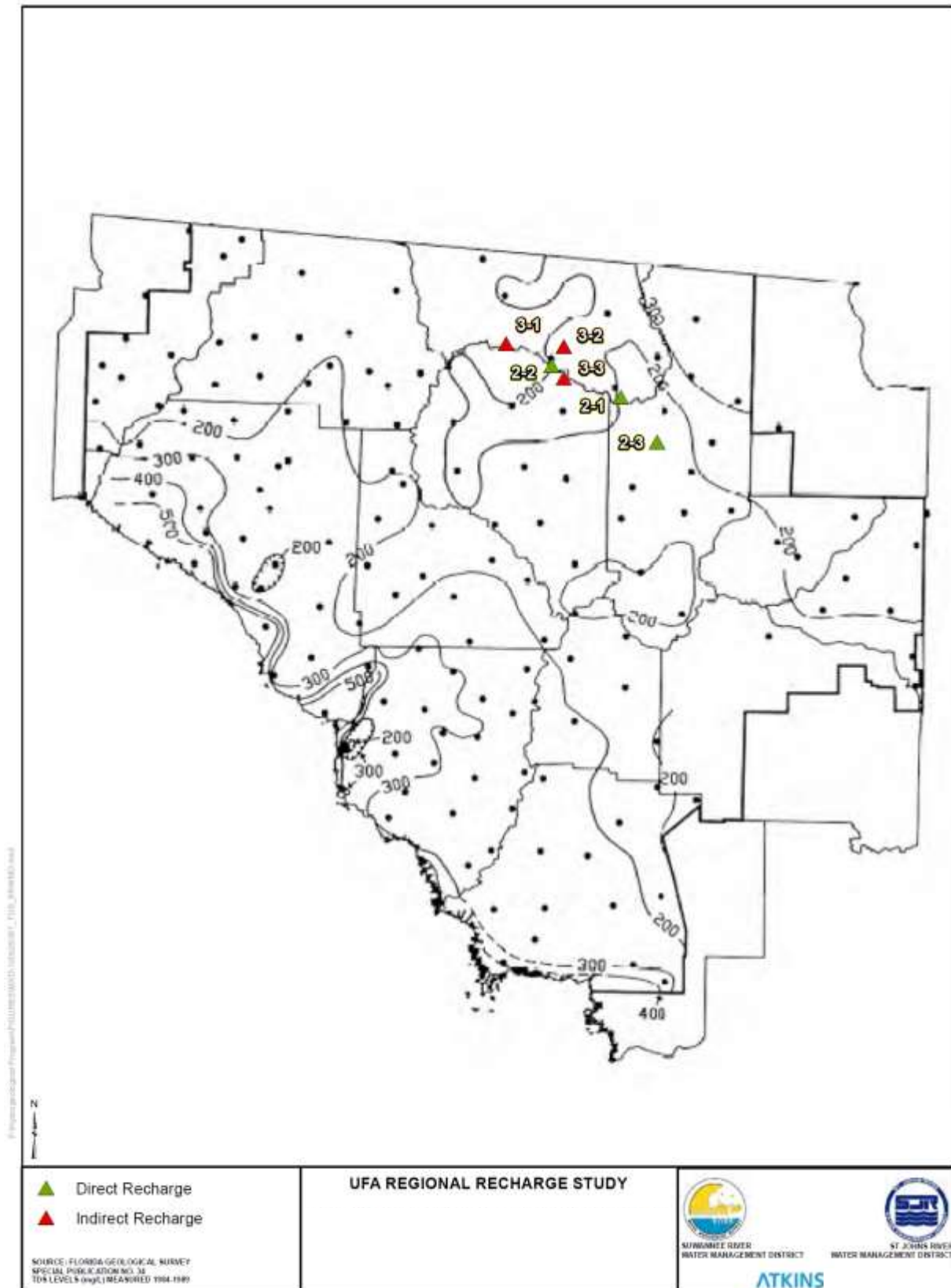


Figure 6-16: Distribution of Total Dissolved Solids in the Upper Floridan Aquifer within the Suwannee River Water Management District

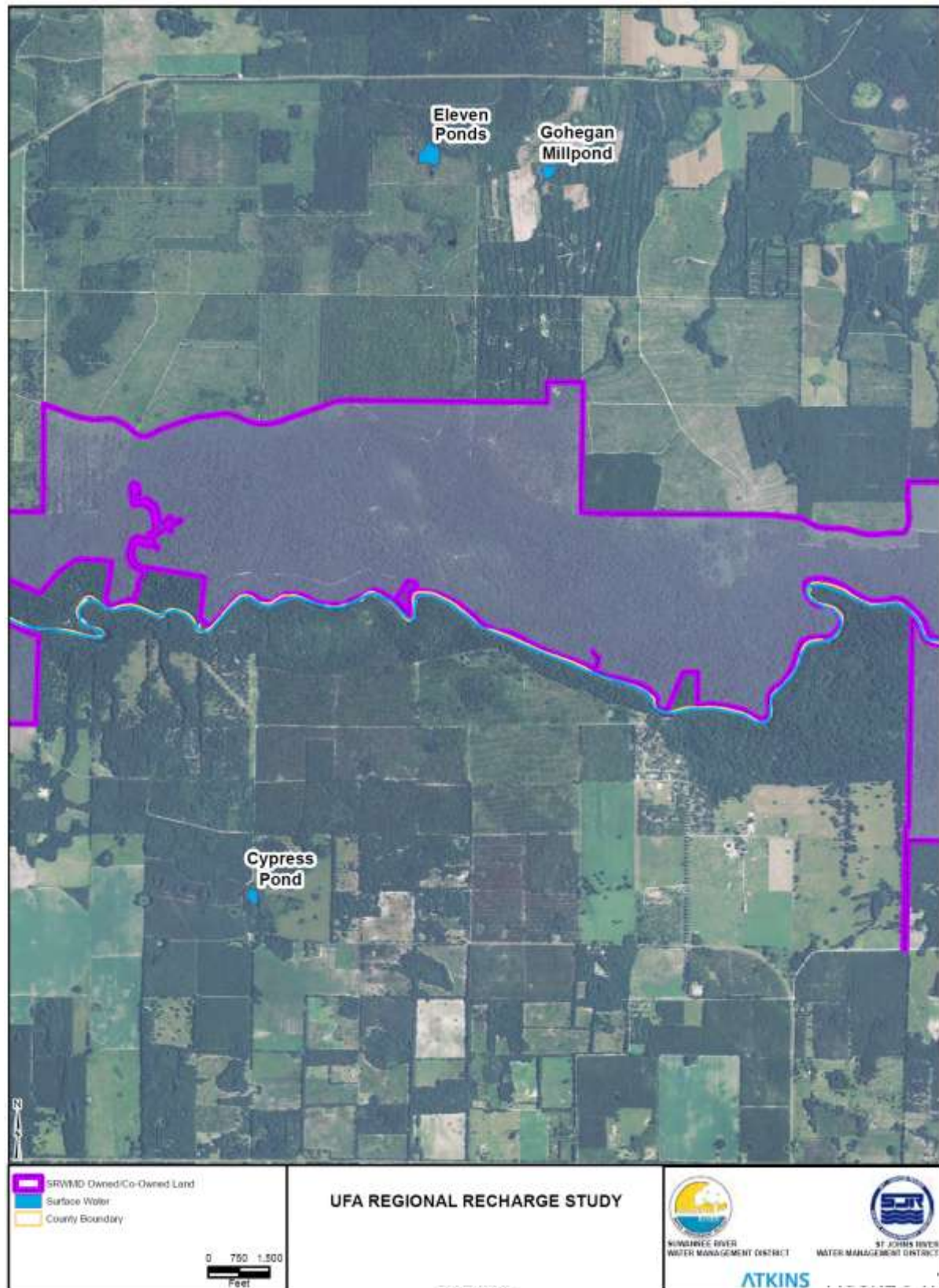


Figure 6-17: Concept 3-1_Indirect Recharge at Eleven Ponds Site Map



Figure 6-18: Concept 3-2_Indirect Recharge at PCS Phosphate Site Map

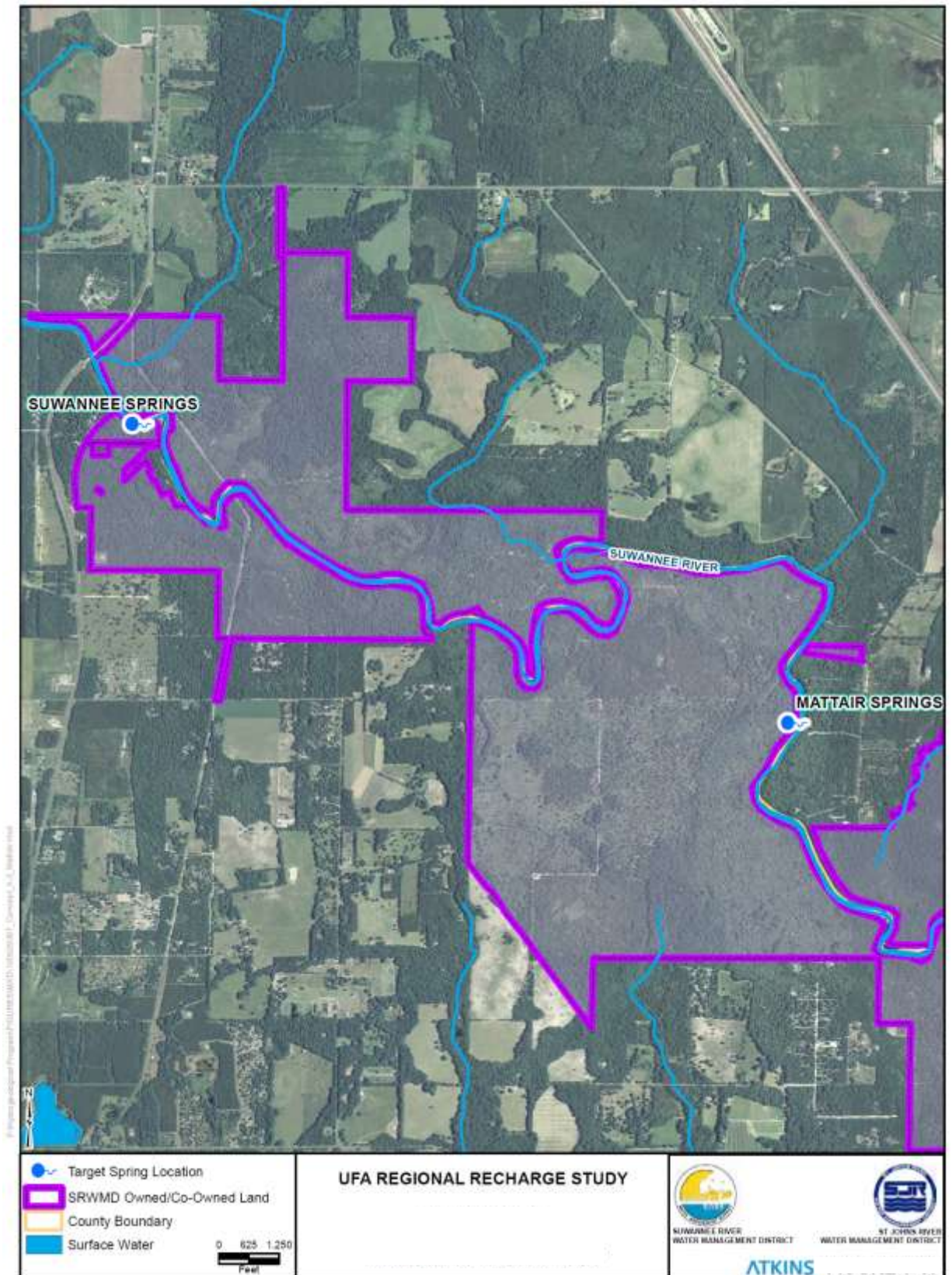


Figure 6-19: Concept 3-3_Indirect Recharge at Mattair Springs Site Map

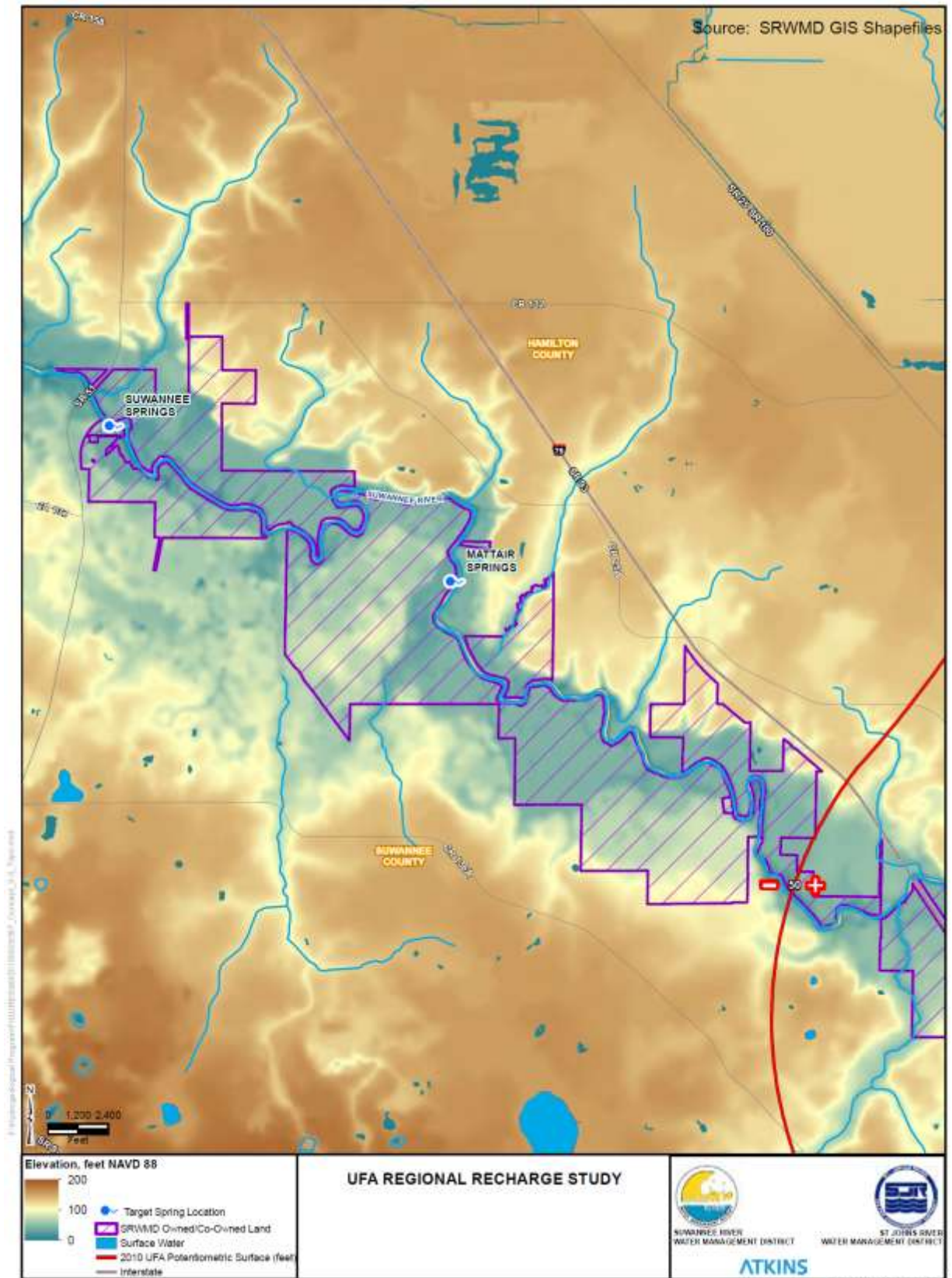


Figure 6-20: Concept 3-3_Topography

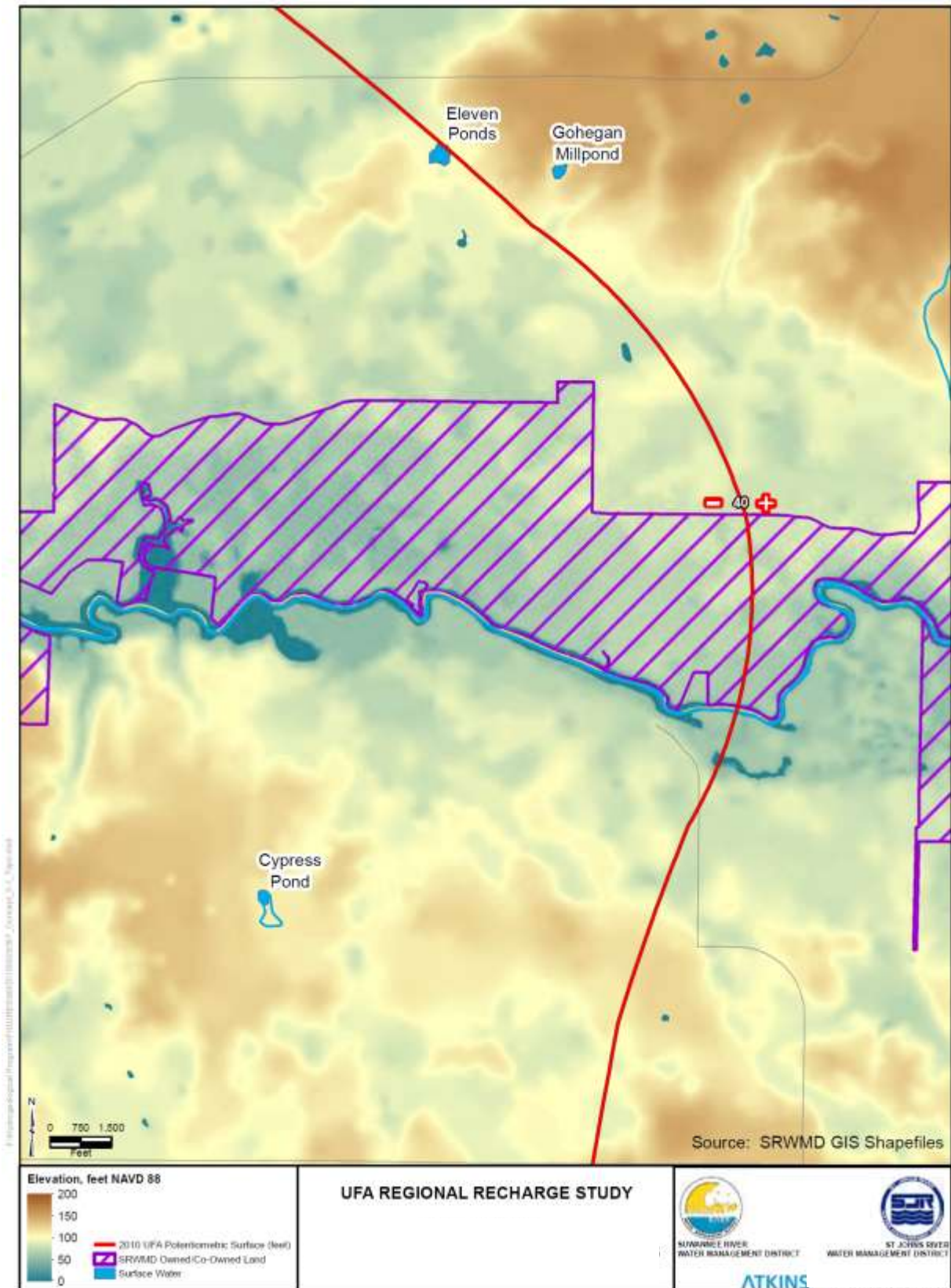


Figure 6-21: Concept 3-1 Indirect Recharge at Eleven Ponds Topography

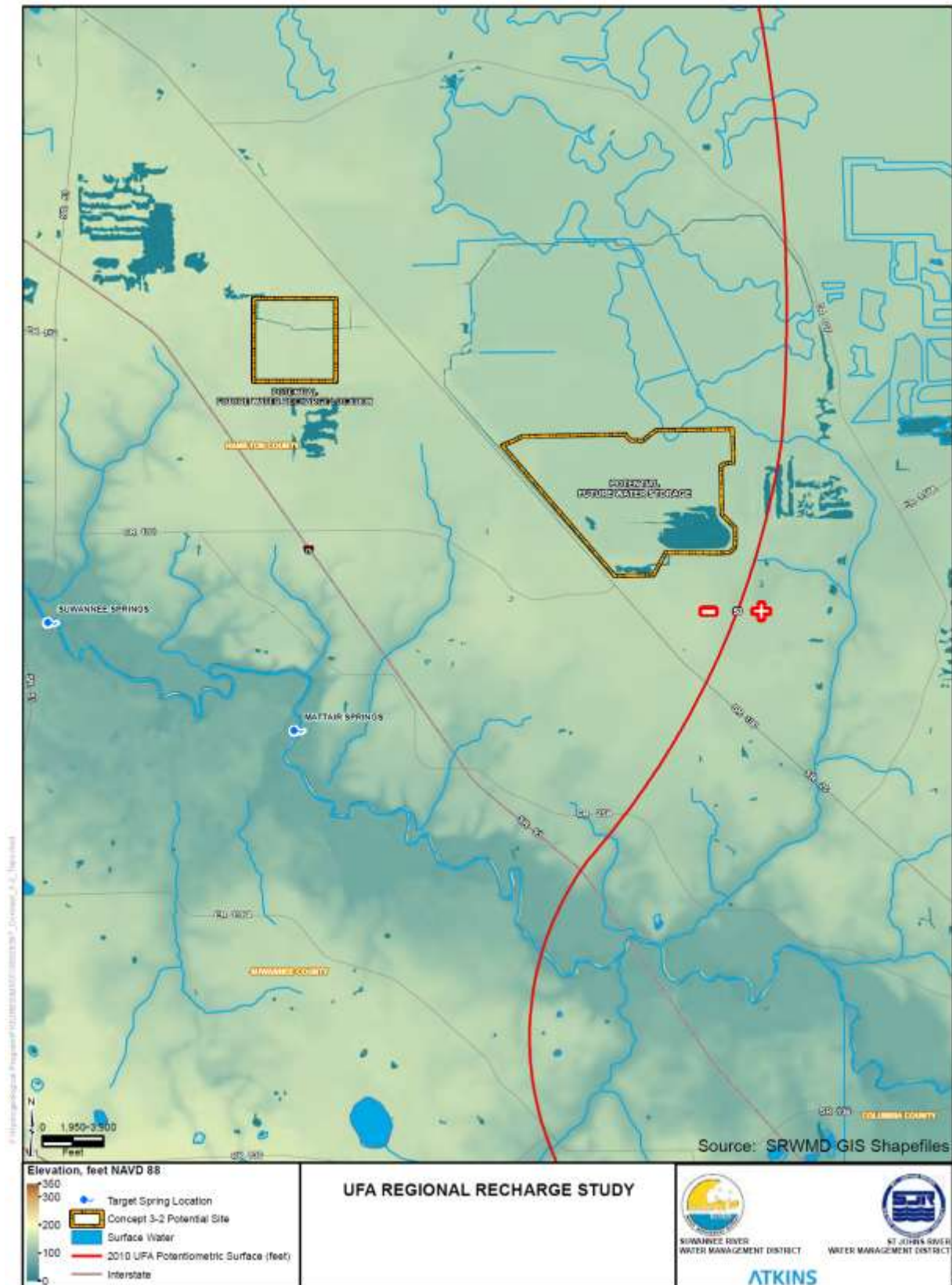


Figure 6-22: Concept 3-2_Topography

An indirect aquifer recharge project at one of the PCS Phosphate's mined areas would provide recharge to the UFA and result in delayed release of groundwater to the upper Suwannee River and associated springs. An aquifer recharge project off the river or away from spring sites theoretically provides greater regional aquifer benefits and slower release of groundwater to the springs and river baseflow. These characteristics may provide acceptable conditions for indirect aquifer recharge; however, site-specific testing would need to be conducted to assess the recharge potential.

6.8.4 Recharge Concept 4 – The Capture and Storage of Surface Water from the St. Johns River Water Management District for Treatment and Recharge into the Upper Floridan Aquifer

Recharge Concept 4 is based on the availability of surface water that can be withdrawn from rivers and streams in the SJRWMD portion of the study area when flows exceed those necessary to meet environmental needs. Rivers considered for this recharge concept include the St. Marys River, the lower St. Johns River and Black Creek (including major tributaries). As discussed in Section 2, the St. Marys River and Black Creek did not provide sufficient flows for aquifer recharge. The St. Johns River has sufficient flow throughout the study area but the presence of brackish water and the additional treatment required to meet recharge quality standards make this river less attractive as a surface water source for aquifer recharge. In order to maximize effectiveness, the aquifer recharge project should be located in an area that provides a benefit to the regional water resources. When considering the potential location of available river flow, and where a close proximity aquifer recharge project will result in maximum benefits, Rodman Reservoir on the Ocklawaha River presents the best source alternative.

Rodman Reservoir is a man-made reservoir in the lower reach of the Ocklawaha River, and stores surface water prior to discharge into the St. Johns River. It is located approximately 26 miles from an ideal recharge point: Keystone Heights, Florida. The Keystone Heights area exhibits significant surface water shortages and groundwater declines yet is also an UFA potentiometric high. An aquifer recharge project in this area would benefit both regional groundwater and surface water systems. The general location for Recharge Concept 4 is indicated in Figure 6-9.

The Keystone Heights area is typified by sinkhole lakes, shallow lakes and internally drained lakes. Topographic relief is high and underlain by approximately 40 feet of SAS thickness (Figure 6-23). Some lakes are directly connected to the UFA via sinkholes, or leaking lake bottoms with variable degrees of confinement. Where aquifer confinement does occur, it is comprised of 30 feet to 40 feet of ICU (Figure 6-3). The general recharge rates in the Keystone Heights area range from 0.01 inch per year to 10 inches per year.

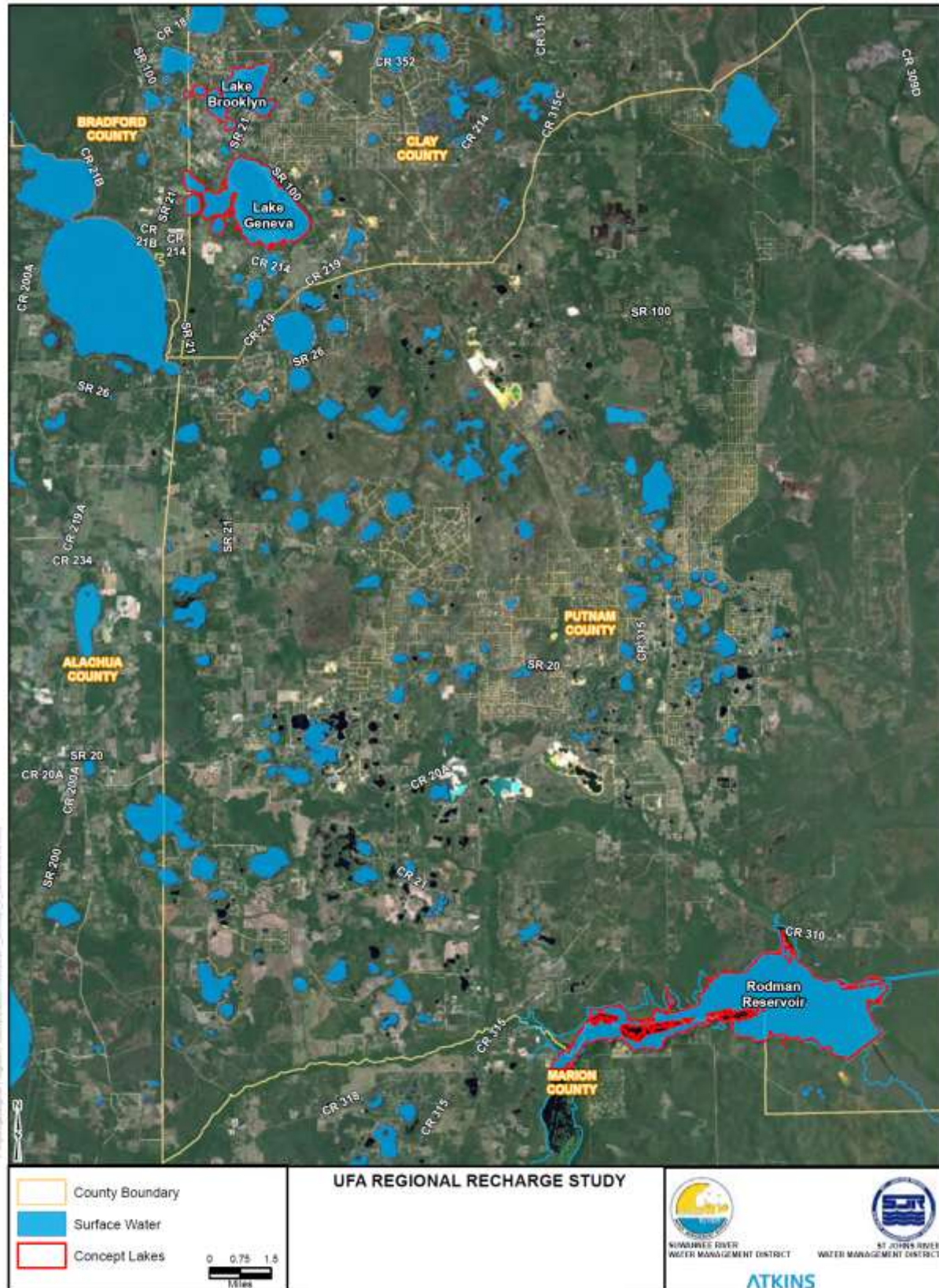


Figure 6-23: Concept 4 Indirect Recharge at Lake Geneva/Lake Brooklyn Site Map

Recharge Concept 4 involves collecting available water from Rodman Reservoir and piping it directly to the lakes in the Keystone Heights area (Figure 6-23). This concept would allow distribution of the available water to selected lakes for indirect aquifer recharge to the UFA. Indirect and direct aquifer recharge options can both be evaluated in this concept based on water treatment criteria, cost, hydrogeology, and appropriate lake selection. Direct aquifer recharge would occur if the lake bottom is directly connected to the UFA, or by completing a recharge well into the UFA. Since the Keystone Heights area is located on a potentiometric high, direct aquifer recharge would radiate outward to improve groundwater levels in all directions, and benefit the regional groundwater system as well as lake water level recovery.

Indirect aquifer recharge would occur from recharge through the lakes to the UFA from downward leakage. Specifically, impacted lakes such as lakes Brooklyn and Geneva would be ideal recharge locations. These lakes are at the southern end of a local chain of lakes, and receive minimal input from the upgradient surface water flow patterns. Recharge to these lakes would provide lake water level recovery, direct recharge to the SAS through lake seepage, and indirect recharge to the UFA through downward leakage.

In addition to providing recharge to the UFA, the recharge is radial, so that groundwater levels can be improved in all directions. The general potentiometric level in the area ranges from 75 to 80 feet above MSL (Figure 6-24). Ground elevation is highly variable, but approximately 160 feet above MSL. The model-calibrated transmissivity of the UFA is approximately 48,000 ft²/day and is sufficient for an aquifer recharge project.

6.9 Keystone Lake Area Water Quality Data

Water quality data for Lake Geneva, Lake Brooklyn, and the Rodman Reservoir were retrieved from FDEP's most recent Impaired Waters Database (Run 47). These data are used by FDEP to compile, store, and report chemical, physical, and biological water quality data in support of the Impaired Waters Rule (IWR) assessments (pursuant to Section 303(d) of CWA), the development of TMDLs, and BMAPs, as described in Section 2 of this report.

Water quality summary statistics for lakes Geneva and Brooklyn, and Rodman Reservoir are presented in Table 6-2. It should be noted that water quality conditions (e.g. impairment status) are lake-specific and direct comparisons of individual water quality parameters are not always appropriate between lakes. Based upon the data in Table 6-2, neither Lake Brooklyn nor the Rodman Reservoir is designated as impaired for any water quality parameters. However, Lake Geneva was identified as impaired for nutrients (based on the formerly used water quality "trophic state index" [TSI] criteria) and lead.

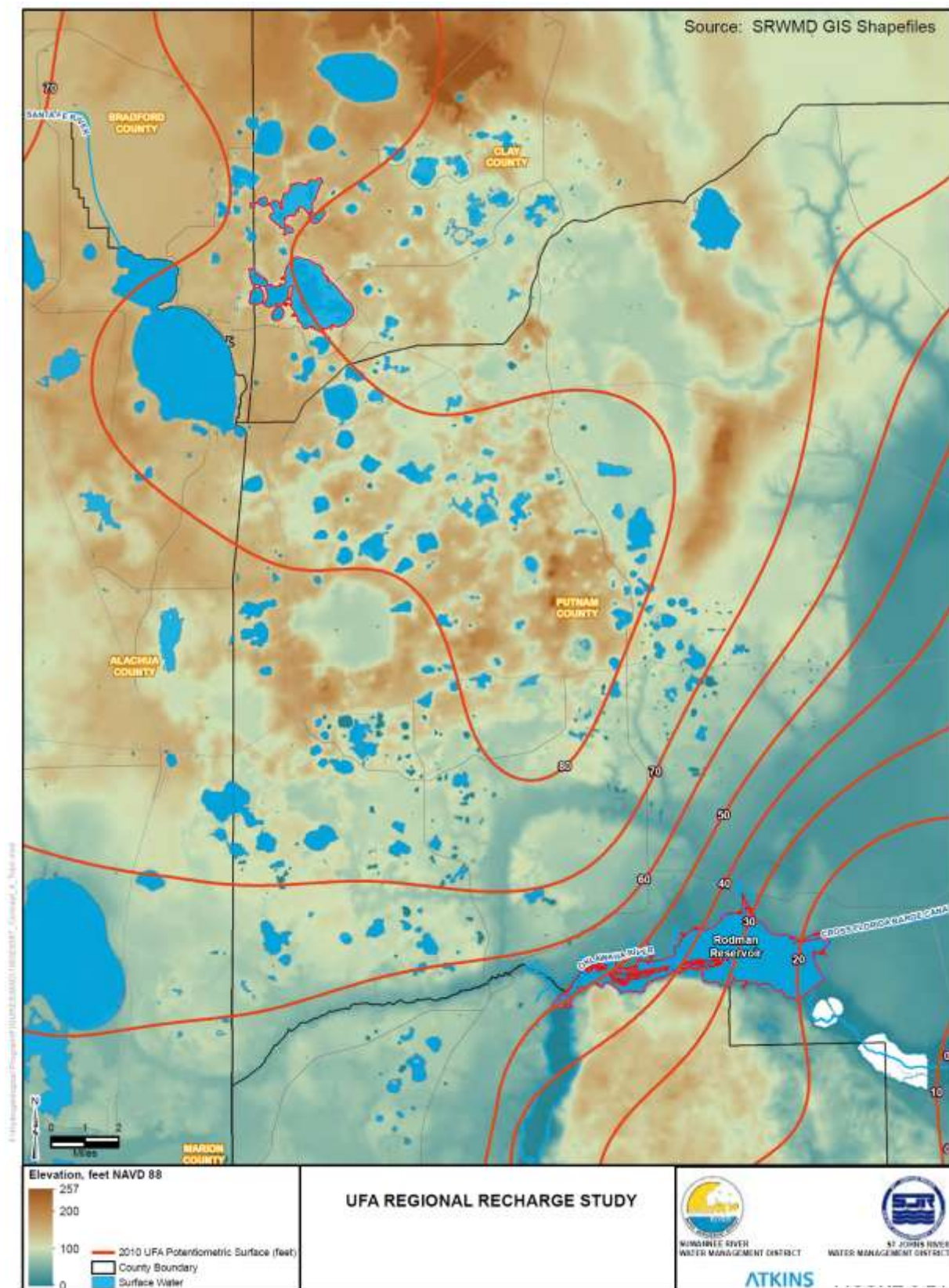


Figure 6-24: Concept 4_Topography

**Table 6-2: Water Quality Summary Statistics for January 2001 – June 30, 2008
for Lakes Geneva and Brooklyn, and the Rodman Reservoir**

Verified Period (Jan. 2001 - Jun. 2008)	Lake Geneva (impaired)		Rodman Reservoir (not impaired)		Lake Brooklyn (not impaired)		
Parameter	Mean	Median	Mean	Median	Mean	Median	12/14/2001*
Alkalinity, mg/L	2.4	2.5	-	-	-	-	75.7
Calcium, ug/L	3.8	3.8	65.8	67.0	-	-	22.1
Cadmium, ug/L	0.04	0.02	-	-	-	-	-
Chlorophyll-a, ug/L	1.9	1.8	7.1	4.0	6.0	11.0	10.0
Chloride, ug/L	13.7	13.7	50.9	50.0	-	-	6.1
Color, PCU	14.0	10.0	-	-	-	-	-
Conductivity, umhos/cm	99	99	625	502	-	-	165
Total Dissolved Solids, mg/L	59	57	334	335	-	-	-
Fecal Coliforms, #cfu/100mL	29	10	-	-	-	-	-
Iron, ug/L	84	64	77	64	-	-	637.2
Potassium, ug/L	1.1	1.2	1.7	1.7	-	-	0.5
Magnesium, ug/L	2.5	2.4	10.9	10.7	-	-	5.4
Lead, ug/L	1.8	1.5	9.0	10.8	-	-	-
pH	6.8	6.7	7.9	7.8	-	-	7.75
Total Nitrogen, mg/L	0.30	0.27	0.78	0.74	0.39	0.65	0.60
Total Organic Carbon, mg/L	3.2	2.9	11.3	10.7	-	-	-
Total Phosphorus, mg/L	0.01	0.01	0.04	0.04	0.02	0.03	0.03
Total Suspended Solids, mg/L	9.2	5.0	12.8	8.9	-	-	-

*Data reported by SJRWMD 2012; Units are indicated under the parameter

Note: Shaded parameters are addressed in text

Numeric Nutrient Criteria (NNC) established by EPA distinguish clear, acidic lakes from clear, alkaline lakes and chlorophyll a and nutrient targets for clear acidic lakes are lower (more stringent) than those for clear alkaline lakes. NNC are calculated using lake alkalinity in addition to color. While annual TSI values exceeded the historic TSI in two years (2004 and 2007), an initial evaluation of the currently used NNC for lakes indicates no nutrient reductions are required for Lake Geneva based on color, alkalinity, chlorophyll-a, TN and total phosphorus (TP) concentrations over the verified period or the entire period of record. Lake Geneva is classified as a low color, low alkalinity lake with chlorophyll-a concentrations below 6 micrograms per liter ($\mu\text{g/L}$). Calculated NNC for TN and TP would be 1.14 and 0.043 mg/L, respectively. TN and TP concentrations were reported below both thresholds over the verified period (0.3 mg/L TN and 0.01 mg/L TP).

Unlike TN and TP, lead impairments are lake specific (i.e. criteria may vary between lakes) and direct comparisons of individual water quality parameters (e.g. lead) are not always appropriate between lakes because other water quality parameters influence the solubility of lead in a water body. For example, lead solubility is a function of water hardness and therefore, a lake with “softer” water infers greater lead availability and thus greater opportunity to cause impairment. Average lead concentrations in the Rodman Reservoir (9 µg/L) are greater than concentrations in Lake Geneva (1.8 µg/L). Consequently, lead is more soluble (toxic to fish, for example) in the “soft” waters of Lake Geneva than in “hard” waters of Rodman Reservoir. However, because Lake Geneva is impaired due to lead and the Rodman Reservoir has relatively higher concentrations of lead, additional evaluation of the water quality conditions in both water bodies may be required. It is important to note that, lead impairment is not based solely on lead concentrations, and the effect of introducing water from the Rodman Reservoir into Lake Geneva on lead impairment requires further analysis.

A preliminary comparison of water quality in Lake Brooklyn and Rodman Reservoir indicate that water quality conditions are similar in the two lakes for the majority of parameters (Table 6-2). A single water quality sampling event in Lake Brooklyn reported a higher iron concentration relative to the Rodman Reservoir and would likely require more sampling for verification. As a result, additional water quality samples will likely be required to adequately characterize the water quality conditions in Lake Brooklyn prior to discharging water from Rodman Reservoir into the lake.

7.0 GROUNDWATER MODELING ANALYSIS

Groundwater flow modeling was conducted to assist in the evaluation of the benefits of each of the potential sites identified in Recharge Concepts 2 and 3, and to compare the modeled benefits between sites. Groundwater flow modeling for Recharge Concepts 1 and 4, both within the SJRWMD, were not within the scope of this project.

The selection of the groundwater flow model used for this project was a critical decision that required a detailed evaluation of the available computer models prior to implementation. The groundwater flow model utilized for this project was to be from a public domain source without conducting any modifications to the model. The selected groundwater flow model required an active SAS layer to simulate the indirect aquifer recharge concepts, and required an accurate discretization of river and spring systems within the upper Suwannee River, Santa Fe River, and Ichetucknee River. The revised USGS MegaModel (Intera, 2011) was selected to simulate the benefits of aquifer recharge to Recharge Concepts 2 and 3 since it met these criteria.

Originally developed in 2002, the MegaModel covers most of the Florida Peninsula, including the entire study area. The model grid consists of a series of uniformly spaced 5,000-feet by 5,000-feet cells. The MegaModel is a steady-state groundwater flow model calibrated to the time frame of August 1, 1993 through July 31, 1994, which represents average groundwater conditions. Calibration was based on over 1,600 observation points, or targets, scattered throughout the modeled area. The model is calibrated to measured or estimated spring flows at 156 locations including all of the major springs within the study area, and baseflow at 37 river reaches. The River Package of MODFLOW was used to simulate rivers and springs that are located at or near the river cells. The Drain Package of MODFLOW was used to simulate springs that are located outside of river cells.

The MegaModel is quasi-three-dimensional, meaning that only aquifer layers are simulated. Confining layers are simulated through a vertical leakance component. In the original MegaModel, the SAS is constructed as a constant head source only to apply recharge to or discharge from the underlying layers. Recharge is applied directly to the portions of the FAS that are unconfined. Model calibration was generally very good, with an overall root-mean-squared (RMS) residual of 3.4 feet in the UFA, and simulated spring flows equaled 96 percent of the measured or estimated spring flow for the time period. The maximum head differences ranged from -9.90 feet in Manatee County, Florida to +9.90 feet in Camden County, Georgia. Due to the SAS being simulated as a constant head source for the model, the 2002 version of the MegaModel would not be appropriate for use in this study.

In 2011, the SJRWMD, through a contract with Intera, Inc., adapted the MegaModel for the prediction of 2030 groundwater impacts in and around the SJRWMD area. As a part of that study, the MegaModel was updated to allow for the evaluation of impacts to surface water features. As part of this revision, the SAS was activated by replacing the existing constant head layer with active cells to include river cells, and revisions to the recharge package. In addition, a more accurate accounting of 1993 – 1994 well pumping data was used to revise the well package. Other existing databases were also updated, including land surface

elevations, water table elevations, and calibration targets. The northwest corner of the MegaModel, which was previously inactive, was also activated. Aquifer properties were assigned in the northwest corner, where possible, using the data from a previous Suwannee River groundwater flow model. The revised River Package was developed using the National Hydrography Dataset and Strahler stream ordering, which allowed for a more accurate calibration of river cells in the MegaModel. Figure 7-1 illustrates the grid of the revised USGS MegaModel within the study area.

Additional revisions to the MegaModel, specifically of interest to this project, included the development of an artificial neural network (ANN) to estimate the spring flow at White Sulphur Springs, and to revise the spring cell type for White Sulphur Springs. White Sulphur Springs historically was a second magnitude spring with only limited spring flow data. The 2011 MegaModel modification changed the cell representing White Sulphur Springs from a drain cell to a General Head Boundary (GHB) cell. A GHB cell can support both flow into and out of a cell, whereas a drain cell can only support flow out of a cell. Therefore, the revised MegaModel can correctly simulate the discharge and recharge abilities of White Sulphur Springs.

The revised MegaModel is a also steady-state flow model calibrated to the time frame of August 1, 1993 through July 31, 1994. Figure 6-8 presents the simulated 1993-1994 potentiometric surface of the UFA. The simulated potentiometric surface of the revised MegaModel replicated the main features of the actual potentiometric surface fairly accurately, within an average of 0.45 foot throughout the model area.

7.1 Model Results

Each of the three direct and three indirect potential aquifer recharge sites for Recharge Concepts 2 and 3 were evaluated for 20 mgd and 40 mgd recharge rates, which represents the range of flows potentially available from the upper Suwannee River as previously discussed in Section 5. The Recharge Concept 2 direct aquifer recharge sites were simulated as recharge wells installed into the UFA using the Well Package of MODFLOW. The Recharge Concept 3 indirect aquifer recharge sites were simulated as aquifer recharge into the uppermost active layer of the model using the Recharge Package of MODFLOW. Each of the aquifer recharge sites were evaluated based on simulated benefits to three water resource criteria:

1. Overall increase in the potentiometric surface of the UFA using a series of target wells previously located within the MegaModel, in addition to an evaluation of the overall extent of the recharge groundwater mound,
2. Increase in spring discharge at selected target locations within the upper Suwannee River, Ichetucknee River, and Santa Fe River, and
3. Increase in river baseflows at selected river reaches within the upper Suwannee River, Ichetucknee River, and Santa Fe River.

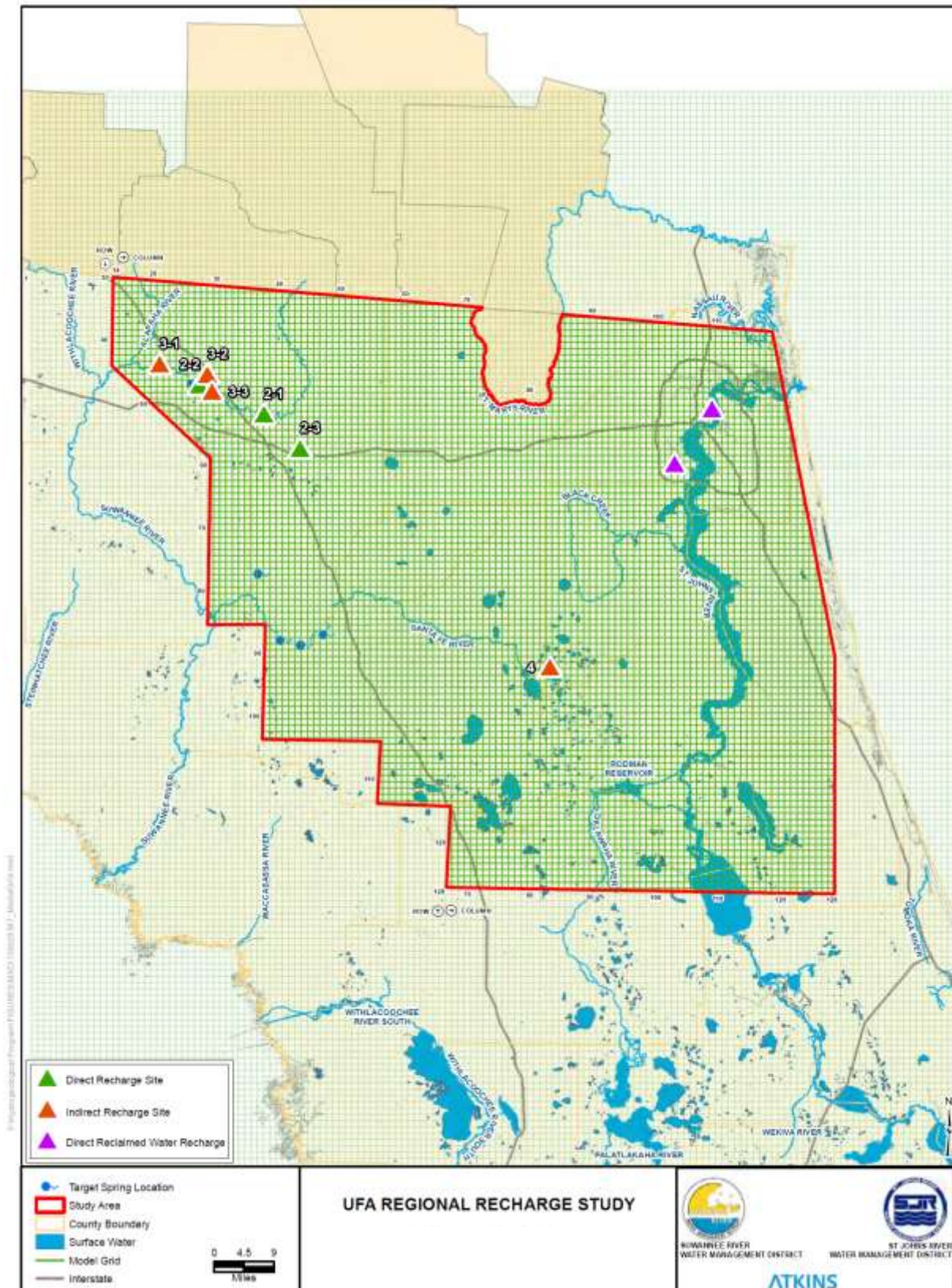


Figure 7-1: MegaModel Grid

Nine target wells were selected based on the array of existing targets that were previously created from the 2011 MegaModel. Three targets each were selected to define the eastern, central, and western portions of the study area. The eastern targets were identified as #871, #971, and #1050 in the MegaModel. The central targets were identified as #963, #993, and #1030, and the western targets were identified as #866, #997, and #1048. The residuals from these targets were compared for each model simulation to determine the overall benefit of each recharge concept, along with a comparison of the overall increase in the potentiometric surface of the UFA. The change in the potentiometric surface of the UFA was determined by comparing the simulated water level elevations of each aquifer recharge concept with the results of the base simulation. The target locations are shown on Figure 7-2, and summary of the water level benefits are shown on Table 7-1.

River reaches were defined at five locations, three along the upper Suwannee River, and one each along the Ichetucknee and Santa Fe rivers. The uppermost reach of the upper Suwannee River was defined from the Florida state line downstream to the USGS gage at White Springs, located upstream of White Sulphur Springs. The second river reach along the upper Suwannee River was defined from the White Springs gage downstream to the USGS gage at Suwannee Springs, and the third reach was defined from Suwannee Springs gage downstream to the edge of the study area, which is immediately upstream of the confluence of the Suwannee River and Withlacoochee River; and downstream of the confluence of the Suwannee River and Alapaha River. The Ichetucknee River reach is defined from its headwaters at Ichetucknee Head Spring downstream to the confluence with the Santa Fe River. The Santa Fe River reach extends from the Santa Fe Rise downstream to the confluence with the Suwannee River. The locations of selected river reaches are mapped in Figure 7-3, and a summary of the river reach benefits are listed in Table 7-2.

Seven target springs within the study area were evaluated for benefits from the potential aquifer recharge projects including two on the upper Suwannee River, two on the Ichetucknee River, and three on the Santa Fe River. The upper Suwannee River springs included White Sulphur Springs and Suwannee Springs. The Ichetucknee River springs included Ichetucknee Head Spring and Blue Hole Spring. The Santa Fe River springs included Ginnie Springs, Poe Springs, and Hornsby Springs. Target spring locations are mapped in Figures 7-2 and 7-3, and a summary of the spring flow benefits are shown on Table 7-3.

The remaining portions of this section summarize the results of each model simulation. Each aquifer recharge concept is discussed separately. Tables 7-1, 7-2, and 7-3 include the increase in target head elevations, increase in flow from the selected river reaches, and the increase in selected target spring flows, respectively, based on 40 mgd recharge simulations. The 20 mgd simulations provided results that were consistently approximately one-half of the 40 mgd simulations.

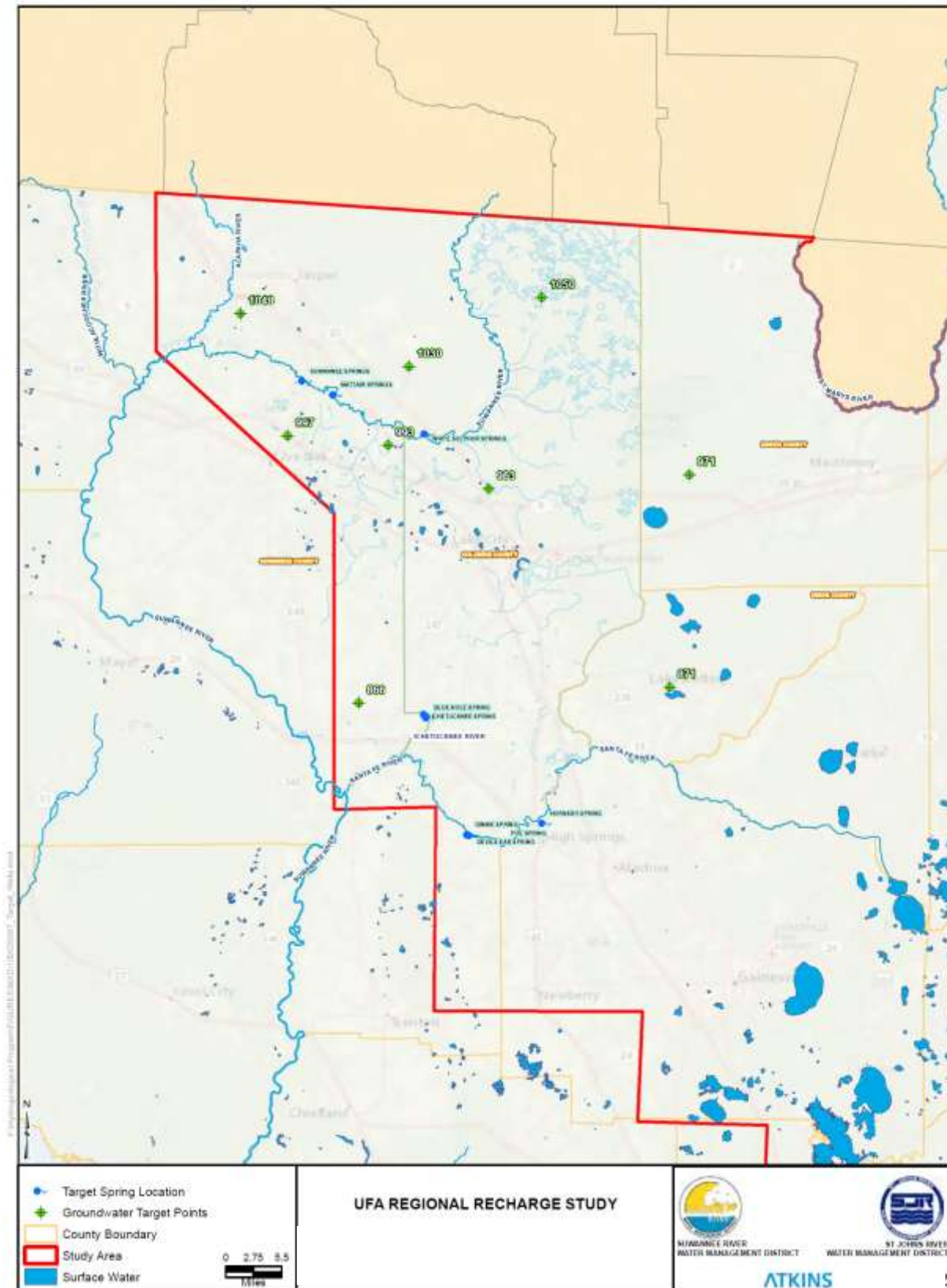


Figure 7-2: Selected Groundwater Target Points Used in the Model Assessment

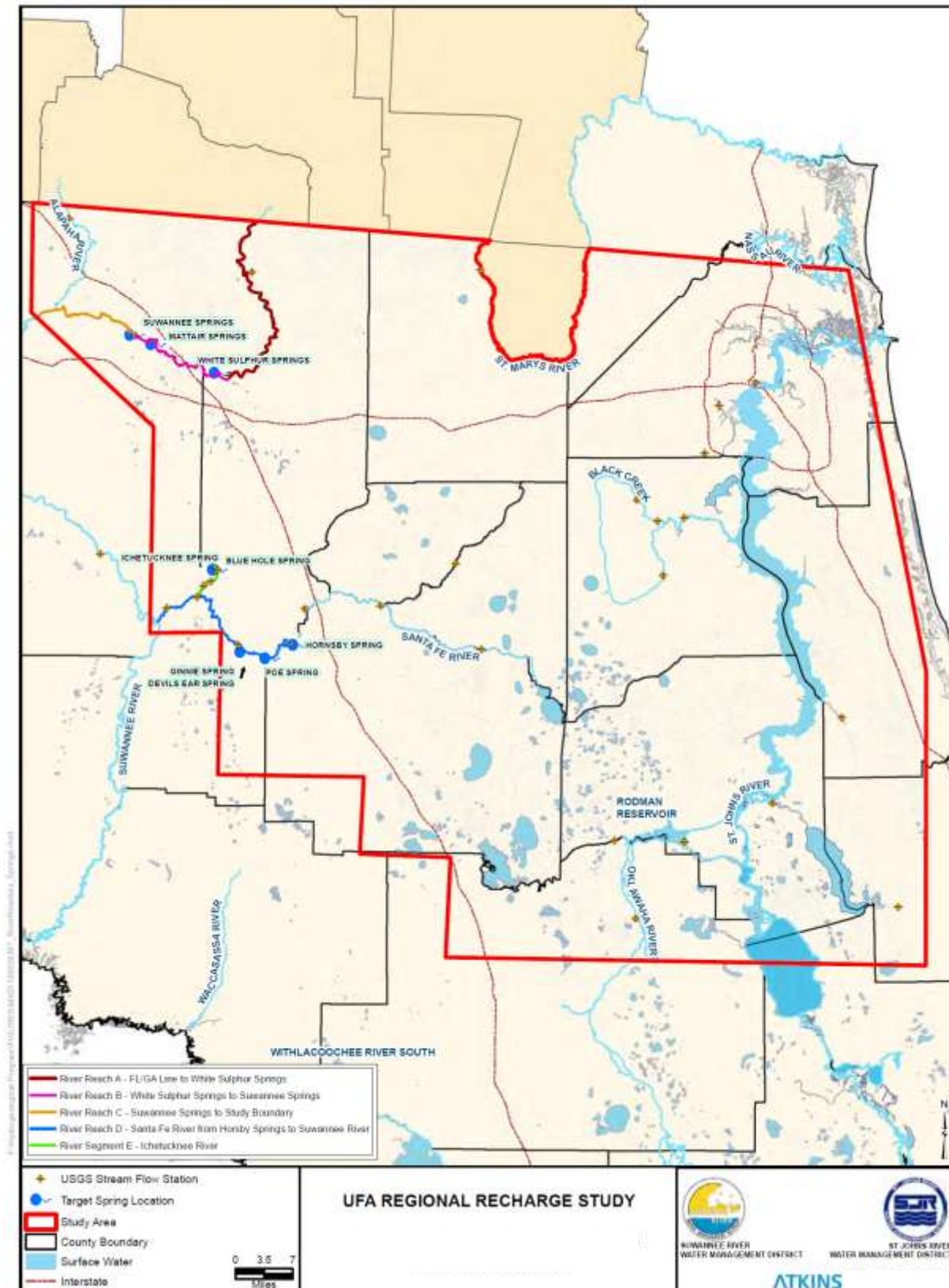


Figure 7-3: River Reaches, Target Springs and USGS Gages

**Table 7-1: Simulated Target Water Level Elevations
and Difference at 40 MGD Recharge Rate, in Feet**

Simulation	Target #866		Target #871		Target #963	
	Simulated Head	Difference	Simulated Head	Difference	Simulated Head	Difference
Base Condition	30.17	0.00	51.83	0.00	57.65	0.00
Recharge Concept 2-1 White Sulphur Springs	30.21	0.04	51.95	0.12	58.68	1.03
Recharge Concept 2-2 Suwannee Springs	30.19	0.02	51.85	0.02	57.74	0.09
Recharge Concept 2-3 Falling Creek Falls Park	30.43	0.26	52.41	0.58	65.41	7.76
Recharge Concept 3-1 Eleven Ponds	30.17	0.00	51.84	0.01	57.67	0.02
Recharge Concept 3-2 PCS Phosphate	30.19	0.02	51.86	0.03	57.77	0.12
Recharge Concept 3-3 Mattair Springs	30.20	0.03	51.86	0.03	57.79	0.14
Simulation	Target #971		Target #993		Target #997	
	Simulated Head	Difference	Simulated Head	Difference	Simulated Head	Difference
Base Condition	56.33	0.00	52.95	0.00	43.64	0.00
Recharge Concept 2-1 White Sulphur Springs	56.67	0.34	53.56	0.61	43.72	0.08
Recharge Concept 2-2 Suwannee Springs	56.37	0.04	53.17	0.22	44.24	0.60
Recharge Concept 2-3 Falling Creek Falls Park	57.35	1.02	53.48	0.53	43.81	0.17
Recharge Concept 3-1 Eleven Ponds	56.34	0.01	52.99	0.04	43.81	0.17
Recharge Concept 3-2 PCS Phosphate	56.39	0.06	53.20	0.25	44.18	0.54
Recharge Concept 3-3 Mattair Springs	56.38	0.05	53.41	0.46	44.47	0.83
Simulation	Target #1030		Target #1048		Target #1050	
	Simulated Head	Difference	Simulated Head	Difference	Simulated Head	Difference
Base Condition	51.93	0.00	41.41	0.00	59.17	0.00
Recharge Concept 2-1 White Sulphur Springs	52.82	0.89	41.43	0.02	59.80	0.63
Recharge Concept 2-2 Suwannee Springs	52.53	0.60	41.55	0.14	59.26	0.09
Recharge Concept 2-3 Falling Creek Falls Park	52.51	0.58	41.43	0.02	60.14	0.97
Recharge Concept 3-1 Eleven Ponds	52.04	0.11	41.88	0.47	59.20	0.03
Recharge Concept 3-2 PCS Phosphate	52.90	0.97	41.57	0.16	59.31	0.14
Recharge Concept 3-3 Mattair Springs	52.59	0.66	41.50	0.09	59.27	0.10

Notes: Each concept assumes a 40 MGD recharge rate. Each Recharge Concept 2 option is simulated as a recharge well directly into the UFA. Each Recharge Concept 3 option is simulated as recharge into the SAS. Bold and shaded cells denote the option with the most significant increase in head.

**Table 7-2: Total Baseflow Change in Selected River Reaches
for 40 MGD Recharge Rate, in Million Gallons per Day**

River Reach	Base Condition	Recharge Concept 2-1 White Sulphur Springs	Recharge Concept 2-2 Suwannee Springs	Recharge Concept 2-3 Falling Creek Falls	Recharge Concept 3-1 Eleven Ponds	Recharge Concept 3-2 PCS	Phosphate Recharge Concept 3-3 Mattair Springs
Santa Fe	0	0.88	0.23	5.29	0.06	0.26	0.39
Ichetucknee	0	0.84	0.26	5.27	0.07	0.28	0.44
From Suwannee Springs gage to west study area Boundary	0	1.17	15.27	1.44	29.83	15.8	9.47
Suwannee Springs gage to White Springs gage	0	31.52	17.51	12.29	1.68	16.41	22.81
White Springs gage to FL-GA state line	0	0.48	0.13	0.82	0.06	0.19	0.13
Total Change in River Flow (mgd)		34.89	33.4	25.11	31.7	32.94	33.24

Note: Bold and shaded denotes the option with the most significant change in baseflow.

Table 7-3: Increase in Total Spring Flow for 40 Million Gallons per Day Recharge Rate*

Spring	Base Condition White Sulphur Springs at 57.5'		Concept 2-1 White Sulphur Springs		Concept 2-2 Suwannee Springs		Concept 2-3 Falling Creek Falls Park		Concept 3-1 Eleven Ponds		Concept 3-2 PCS Phosphate		Concept 3-3 Mattair Springs	
	Simulated Spring Flow	Increase in Spring Flow	Simulated flow	Increase in Spring Flow	Simulated Spring Flow	Increase in Spring Flow	Simulated Spring Flow	Increase in Spring Flow	Simulated Spring Flow	Increase in Spring Flow	Simulated Spring Flow	Increase in Spring Flow	Simulated Spring Flow	Increase in Spring Flow
White Sulphur Springs	-3.45	0.00	25.22	28.67	-2.23	1.22	6.70	10.15	-3.23	0.22	-1.69	1.76	-1.65	1.80
Suwannee Springs	4.86	0.00	4.98	0.12	9.14	4.28	4.99	0.13	5.27	0.41	8.18	3.32	6.88	2.02
Ichetucknee Springs	28.52	0.00	28.69	0.17	28.57	0.05	29.54	1.02	28.54	0.02	28.58	0.06	28.61	0.09
Blue Springs	162.11	0.00	162.78	0.67	162.32	0.21	166.27	4.16	162.17	0.06	162.33	0.22	162.46	0.35
Ginnie Springs	32.44	0.00	32.49	0.05	32.45	0.01	32.77	0.33	32.44	0.00	32.46	0.02	32.46	0.02
Poe Springs	36.72	0.00	36.79	0.07	36.74	0.02	37.14	0.42	36.73	0.01	36.74	0.02	36.75	0.03
Hornsby Springs	35.02	0.00	35.16	0.14	35.06	0.04	35.85	0.83	35.03	0.01	35.06	0.04	35.08	0.06
Total Change in Spring Flow (mgd)		0.00		29.89		5.83		17.04		0.73		5.44		4.37

Note: Bolded and shaded denotes the option with the most significant change in spring flow.

7.2 Recharge Concept 2-1 – White Sulphur Springs

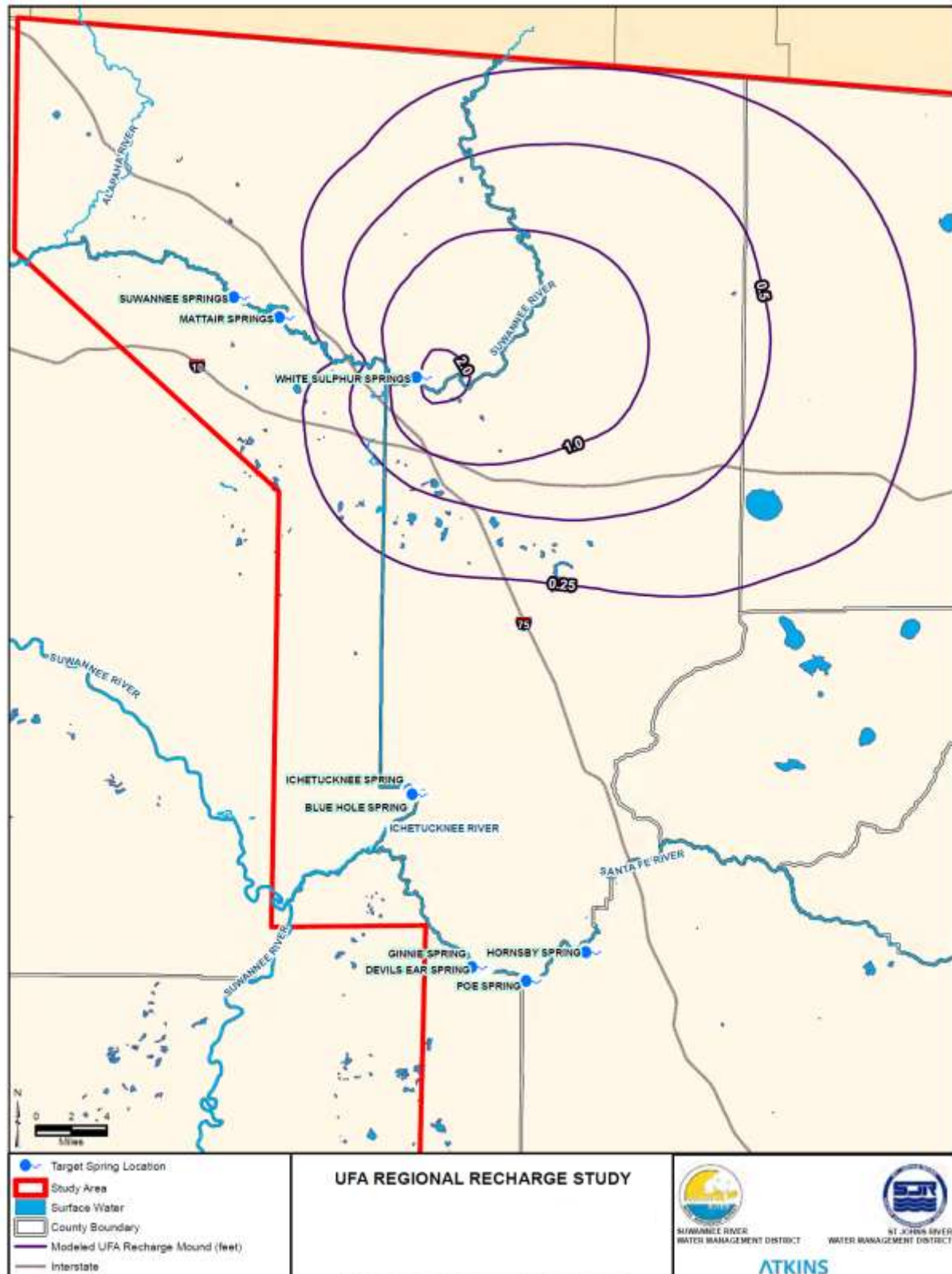
Recharge Concept 2-1 involves a series of recharge wells with a total capacity of either 20 mgd or 40 mgd that are installed within one mile of White Sulphur Springs. Figure 6-9 shows the general location of the aquifer recharge concept, and Figure 6-13 shows the close-up view of Recharge Concept 2-1. The model derived UFA transmissivity value in the vicinity of Recharge Concept 2-1 is the highest of the various concepts at 1,600,000 ft²/day. This model cell is located within a semi-confined area; therefore, it can be assumed that the SAS overlies the UFA in the vicinity of Recharge Concept 2-1.

As expected, Recharge Concept 2-1 had the greatest benefit on target spring, White Sulphur Springs; and, due to the upgradient location, it showed a significant overall increase in the regional UFA potentiometric surface based on the nine target wells. This option was only one of two options that were able to reverse the flow in White Sulphur Springs during the simulation time period by converting the cell from an overall sink, i.e. flow into the UFA, to a spring with discharging flow. The increase in simulated flow in White Sulphur Springs based on a 40 mgd recharge capacity was 28.7 mgd. The overall increase in spring flow from all of the target springs was 29.9 mgd. Due to the proximity of this site to White Sulphur Springs, the benefits on the springs located on both the Ichetucknee and Santa Fe rivers were minimal. Table 7-3 summarizes the benefits to target spring locations from Recharge Concept 2-1.

The overall increase in the UFA potentiometric surface at the nine target wells totaled 3.76 feet based on the 40 mgd simulation. Target well #993 located near White Sulphur Springs showed an increase of 0.6 foot. Recharge Concept 2-1 exhibited the largest increase, or mounding, on target well #993. Figure 7-4 shows the overall increase in the potentiometric surface of the UFA based on a 20 mgd recharge simulation, and Figure 7-5 shows the increase based on the 40 mgd simulation. As shown in Figure 7-4, the 0.25 foot contour encompasses a significant portion of the upper Suwannee River basin. Table 7-1 summarizes the benefits to the UFA potentiometric surface at the target well locations from Recharge Concept 2-1.

Recharge Concept 2-1 had the greatest benefit on the baseflow of the various Suwannee River segments. The greatest benefit was on the upper Suwannee River from White Sulphur Springs to Suwannee Springs. Baseflow was increased by a total of 31.5 mgd in this river reach based upon the 40 mgd aquifer recharge concept. The total increase in all river reaches was 34.9 mgd. There were negligible benefits in upper Suwannee River flows upstream of the White Springs gage. The total increase in baseflow to the Ichetucknee River and Santa Fe River based on a 40 mgd recharge capacity was 0.84 and 0.88 mgd, respectively. Table 7-2 summarizes the benefits to the selected river segments from Recharge Concept 2-1.





**Figure 7-5: Modeled UFA Recharge Mounding Concept 2-1
Direct Recharge at White Sulphur Springs 40 MGD**

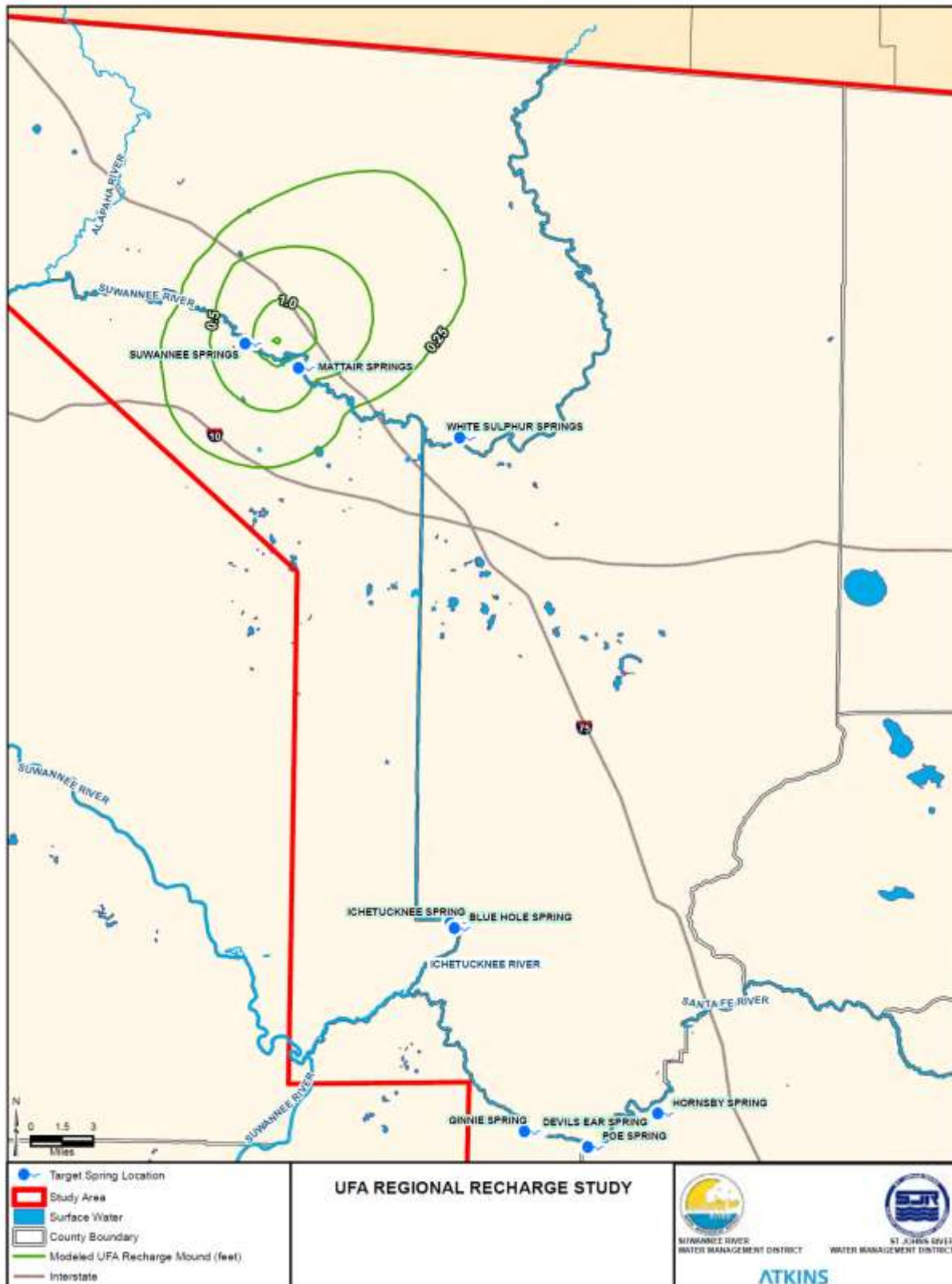
7.3 Recharge Concept 2-2 – Suwannee Springs

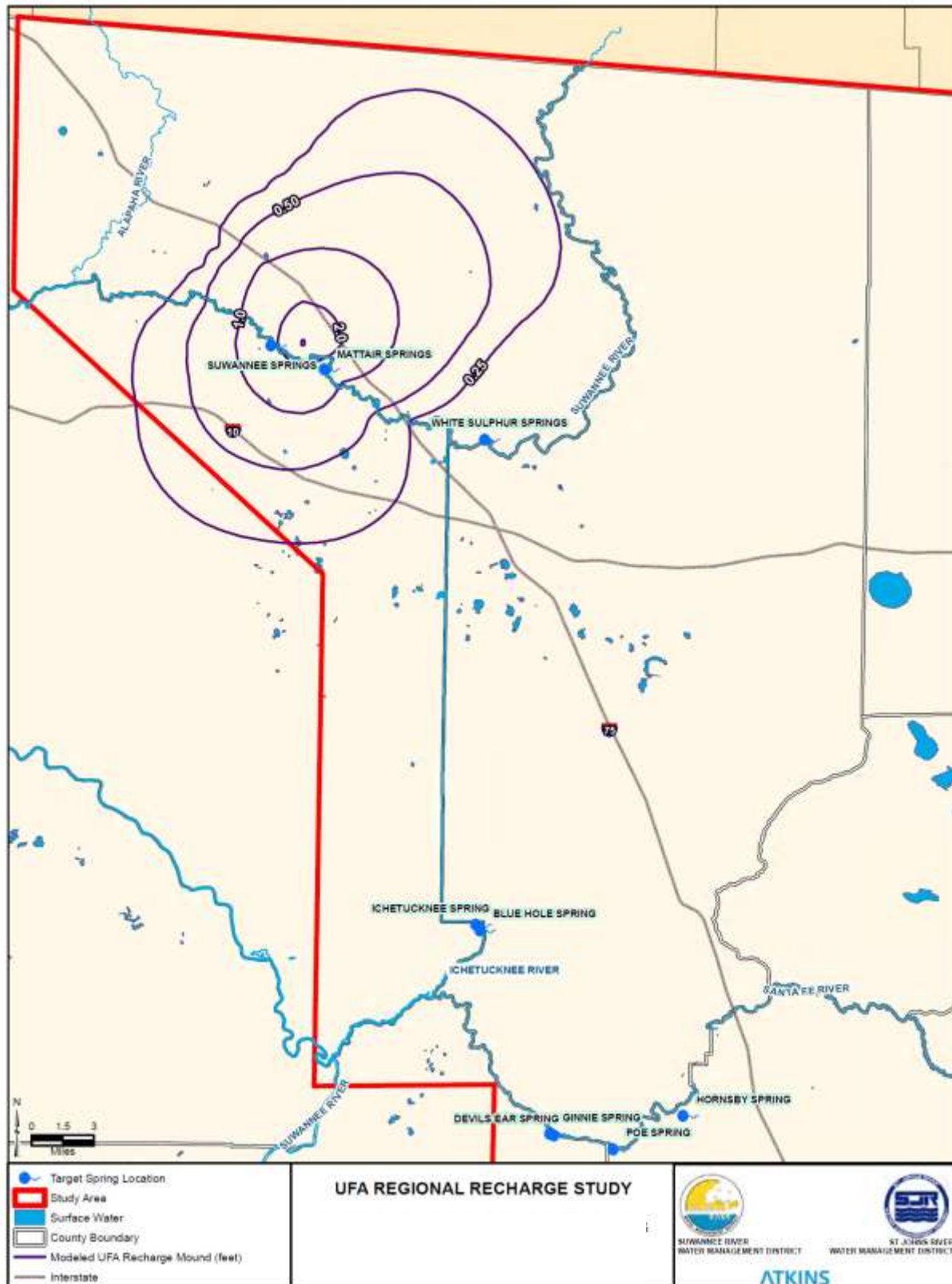
Recharge Concept 2-2 involves a series of recharge wells with a total capacity of either 20 mgd or 40 mgd that are installed within 1 mile of Suwannee Springs, which is located along the south bank of the Suwannee River. Figure 6-9 shows the general location, and Figure 6-14 shows the close-up view of Recharge Concept 2-2. The modeled UFA transmissivity value in the vicinity of Recharge Concept 2-2 is 500,000 ft²/day. This model cell is located within an unconfined area, therefore, the SAS and ICU are absent in this portion of the model area.

Recharge Concept 2-2 had the greatest benefit on Suwannee Springs, but had limited benefits on the other target springs in the study area. This result was due to the relative downgradient location of this site and close proximity to the Suwannee River. The increase in simulated flow in Suwannee Springs based on a 40 mgd recharge capacity was 4.3 mgd during the simulation. The overall increase in spring flow from all of the target springs was 5.8 mgd. Since this site is located down-gradient of White Sulphur Springs, even with a recharge capacity of 40 mgd at the Suwannee Springs location, the simulated flow in White Sulphur Springs was still not enough to overcome the negative baseflow characteristic of the spring cell. There was only a negligible increase in spring flow in springs located on the Ichetucknee River and Santa Fe River from Recharge Concept 2-2. Table 7-3 summarizes the benefits to target spring locations from Recharge Concept 2-2.

The overall increase in the potentiometric surface of the UFA at the nine target well locations totaled only 1.82 feet based on the 40 mgd simulation. Target well #993, located near White Sulphur Springs, showed an increase of 0.22 foot. Figure 7-6 shows the overall increase in the potentiometric surface of the UFA based on a 20 mgd recharge simulation, and Figure 7-7 shows the increase based on the 40 mgd simulation. As shown in the figures, the 0.25 foot contour is fairly limited in extent, when compared with the other aquifer recharge concepts. Table 7-1 summarizes the benefits to the UFA potentiometric surface at the nine target well locations from Recharge Concept 2-2.

Recharge Concept 2-2, as compared to the other direct recharge concepts, had the greatest benefit on the baseflow of the upper Suwannee River from Suwannee Springs downstream to the study area boundary. Baseflow was increased by a total of 15.3 mgd in this river reach from the 40 mgd simulation. This result was due to the location of this aquifer recharge concept within close proximity to the river segment. There was an increase in baseflow to the reach from White Sulphur Springs to Suwannee Springs. The increase in baseflow in this river reach was 17.5 mgd and the total increase in all river reaches was 33.4 mgd. Similar to the other aquifer recharge concepts, there were negligible benefits in the upper Suwannee River upstream of the White Springs gage. The total increase in baseflow to the Ichetucknee River and Santa Fe River based on a 40 mgd recharge capacity was negligible, at 0.26 and 0.23 mgd, respectively. Table 7-2 summarizes the benefits to the selected river segments from Recharge Concept 2-2.



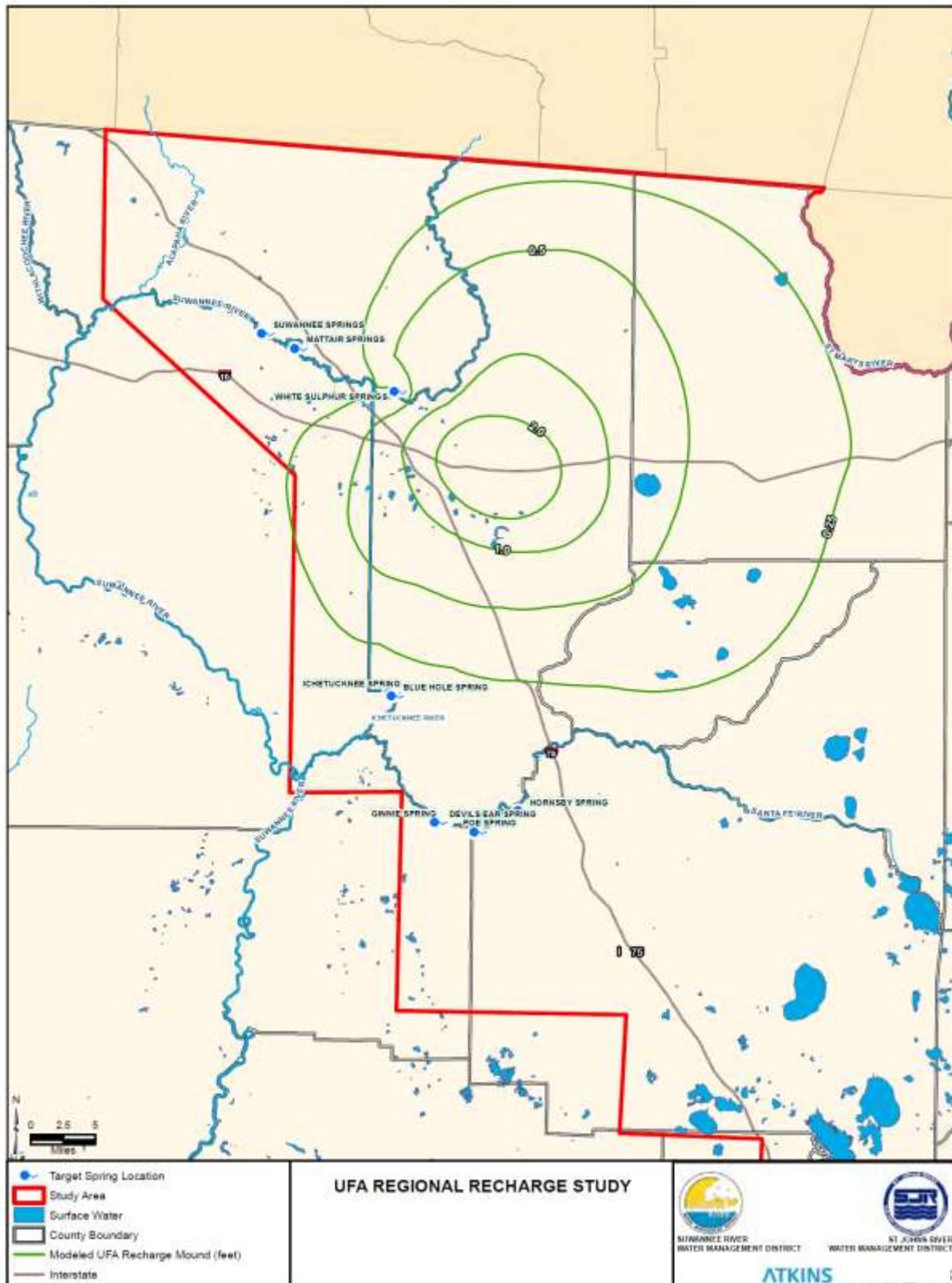


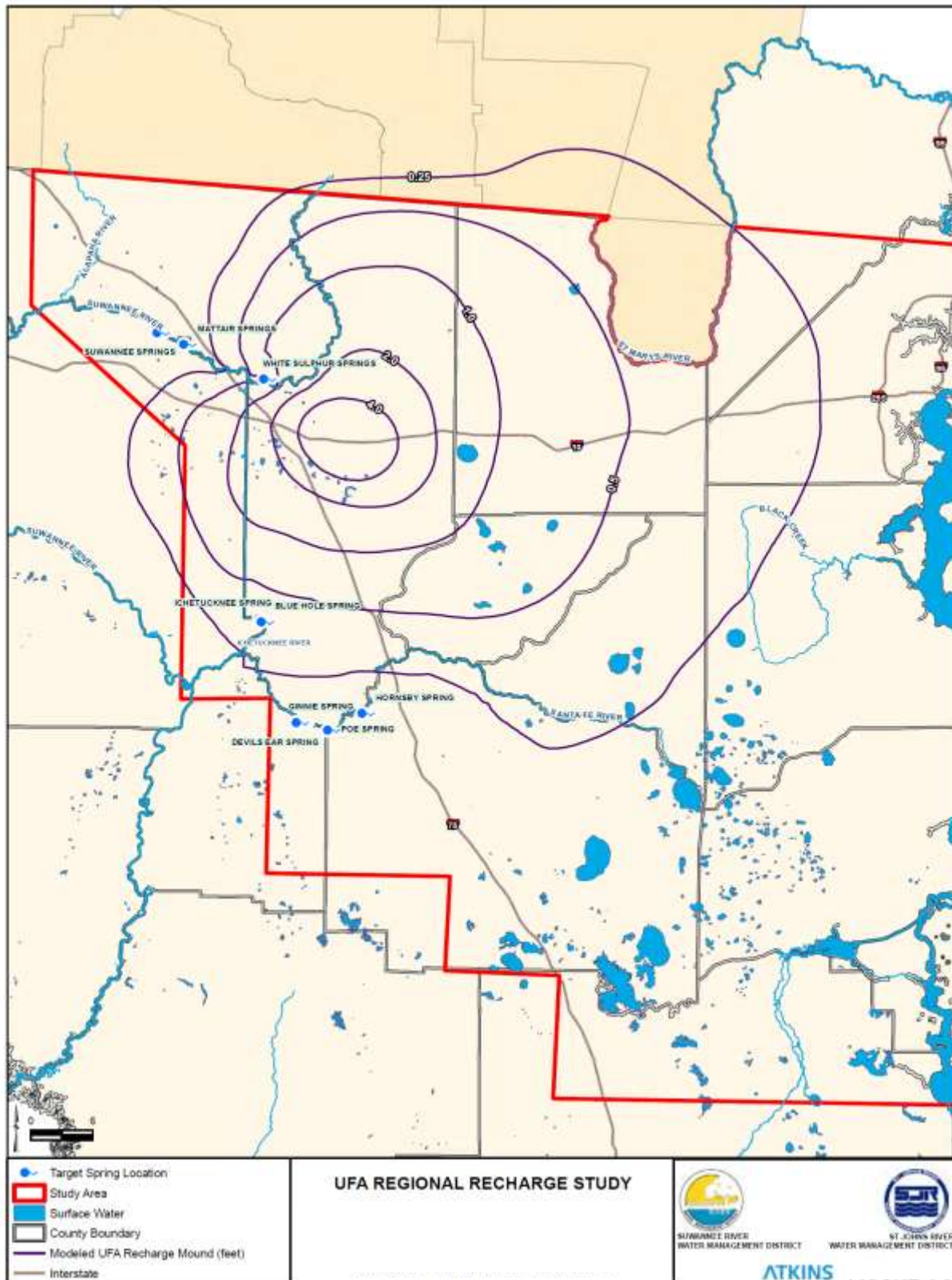
7.4 Recharge Concept 2-3 – Falling Creek Falls Park

Recharge Concept 2-3 involves a series of recharge wells with a total capacity of both 20 mgd and 40 mgd installed within one mile of Falling Creek Falls Park. Figure 6-9 shows the general location, and Figure 6-15 shows the close-up view of Recharge Concept 2-3. The modeled UFA transmissivity value in the vicinity of Recharge Concept 2-3 from the MegaModel was 120,000 ft²/day. The model cell that contained Recharge Concept 2-3 is located within a semi-confined area; therefore, the SAS is assumed to be present in the vicinity of the site.

Due to the relatively lower transmissivity and distance from the upper Suwannee River, Recharge Concept 2-3 had the greatest benefit on the regional potentiometric surface of the UFA, but also had moderate benefits on target springs and river reaches. Due to the site location, Recharge Concept 2-3 had the greatest benefits on the baseflow of the Santa Fe and Ichetucknee rivers, and target spring flows. Recharge Concept 2-3 was the only other evaluated option that was able to reverse the flow in White Sulphur Springs from a negative sink to a discharging spring during the 1993 – 1994 simulation period. The increase in simulated flow in White Sulphur Springs based on a 40 mgd recharge capacity was 10.2 mgd during the simulation, and the overall increase in spring flow from all of the target springs was 17.0 mgd. However, the increase in simulated flow in Suwannee Springs was negligible, at 0.13 mgd. There was a significant increase in spring flow in the springs located on the Ichetucknee River. The flow in Ichetucknee Head Spring increased by 1.0 mgd, and the flow in Blue Hole Spring was increased by 4.2 mgd under Recharge Concept 2-3 at a rate of 40 mgd of direct recharge. There were moderate benefits on the springs located within the Santa Fe River, with increases at Ginnie, Poe, and Hornsby springs of 0.33 mgd, 0.42 mgs, and 0.83 mgd, respectively. Table 7-3 summarizes the benefits to target spring locations from Recharge Concept 2-3.

Recharge Concept 2-3 had the greatest benefit of all the concepts on the overall increase in the potentiometric surface of the UFA. The overall increase in the potentiometric surface of the UFA at the nine target well locations totaled 11.89 feet based on the 40 mgd simulation. Most of the target wells, including #866, #963, #871, #971, and #1050 had the highest water level increase of any of the recharge concepts (Table 7-1). Figure 7-8 shows the overall increase in the potentiometric surface of the UFA based on a 20 mgd recharge simulation, and Figure 7-9 shows the increase based on the 40 mgd simulation. As shown on the figures, the 0.25 foot contour is extensive when compared to the other aquifer recharge concepts, and encompasses most of the upper Suwannee River basin, as well as portions of the Ichetucknee and Santa Fe River basins. Table 7-1 summarizes the benefits to the UFA potentiometric surface at the target well locations from Recharge Concept 2-3.





**Figure 7-9: Modeled UFA Recharge Mounding Concept 2-3
Direct Recharge at Falling Creek Falls Park 40 MGD**

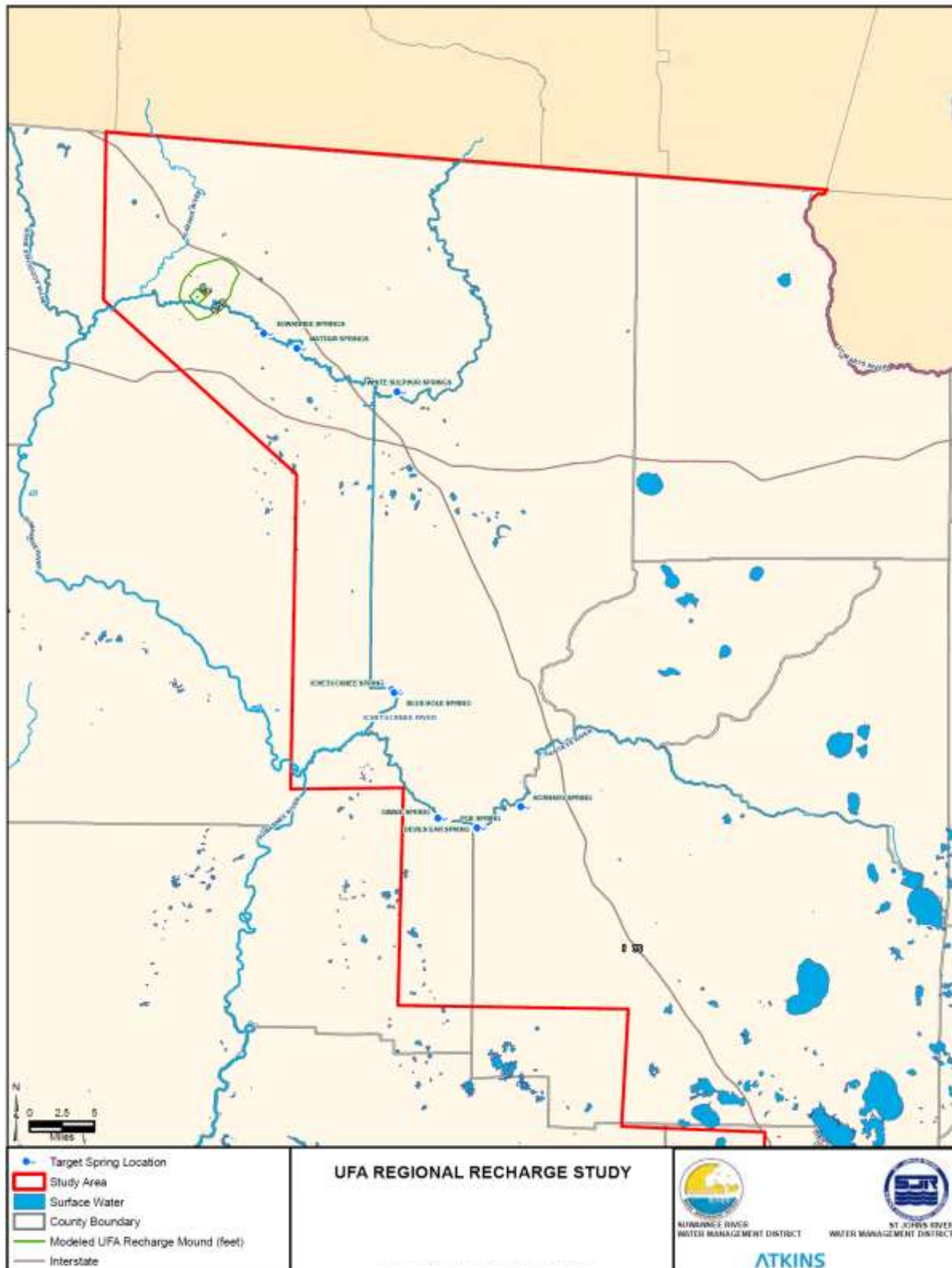
Recharge Concept 2-3, when compared to the other direct recharge concepts, had the greatest overall benefit on the baseflow of the Ichetucknee and Santa Fe rivers, and also had a moderate benefit on the baseflow of the upper Suwannee River. Baseflow of the upper Suwannee River from White Sulphur Springs to Suwannee Springs was increased by a total of 12.3 mgd in this river reach based upon the 40 mgd aquifer recharge concept. The total increase in all river reaches was 25.1 mgd. As in all of the aquifer recharge concepts, there were negligible benefits in the upper Suwannee River upstream of the White Springs gage. The total increase in baseflow to both the Ichetucknee River and Santa Fe River based on a 40 mgd recharge capacity was 5.3 mgd each. Table 7-2 summarizes the benefits to the selected river segments from Recharge Concept 2-3.

7.5 Recharge Concept 3-1 – Eleven Ponds

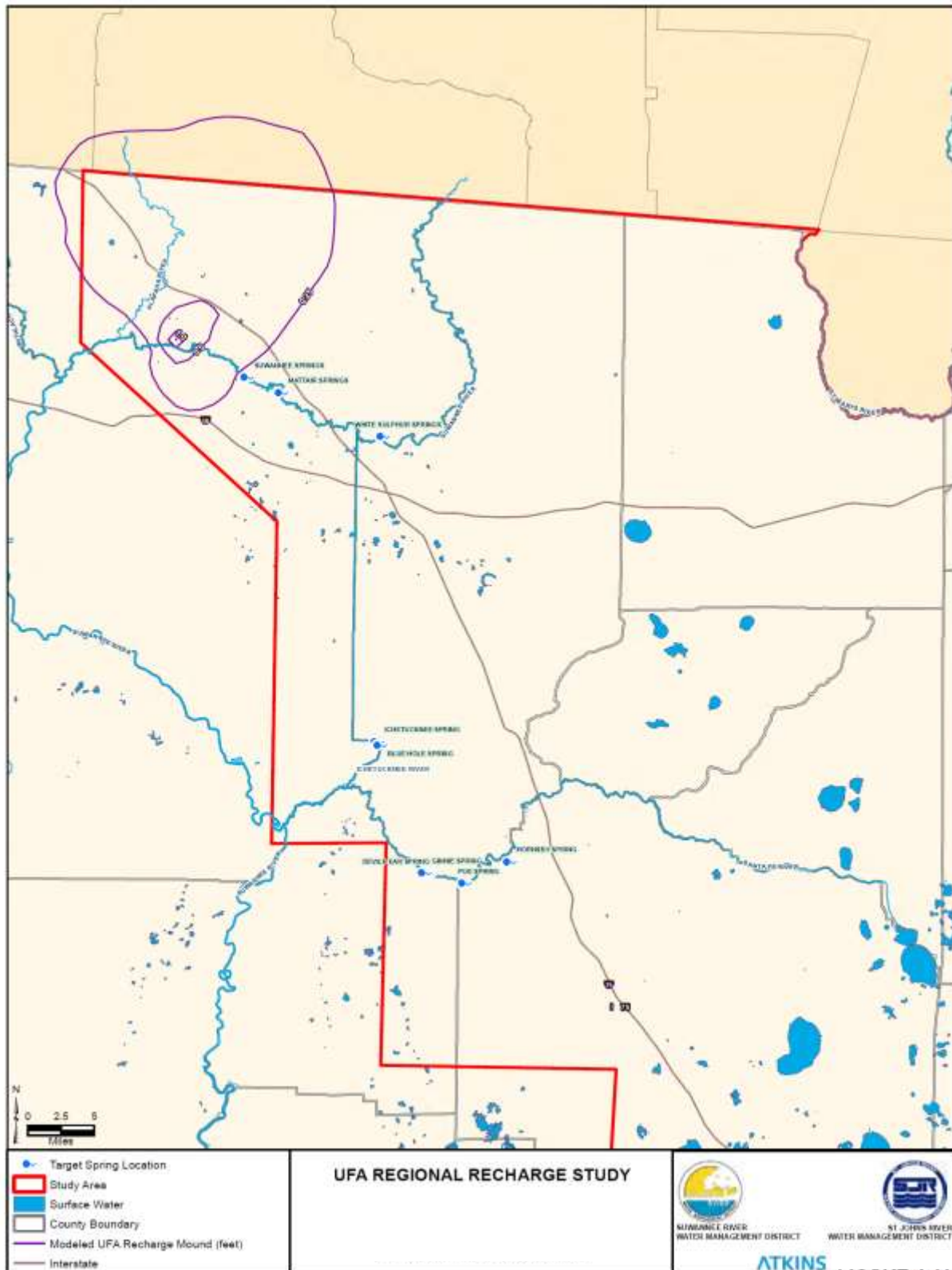
Recharge Concept 3-1 involves indirect infiltration of river water using a RIB or series of RIBs, or sinkholes with a total capacity of either 20 mgd or 40 mgd located within a 1 square mile area in Eleven Ponds Park. Figure 6-9 shows the general location of the aquifer recharge concept, and Figure 6-17 shows the close-up view of Recharge Concept 3-1. The modeled UFA transmissivity value in the vicinity of Recharge Concept 3-1 is 1,200,000 ft²/day. This model cell is located within an unconfined area with little to no SAS or ICU present.

Due to the downgradient location and close proximity of Recharge Concept 3-1 to the upper Suwannee River, this aquifer recharge concept had the least benefit on target springs and potentiometric surface of the UFA, but had the most benefit to the downstream Suwannee River reach. The maximum increase in simulated spring flow at a 40 mgd recharge rate was to Suwannee Springs, but the total increase was only 0.41 mgd during the simulation. The overall increase in spring flow from all of the target springs was only 0.73 mgd. Since this site is located down-gradient of White Sulphur Springs, even with a recharge capacity of 40 mgd the simulated flow in White Sulphur Springs was still not enough to overcome the negative flow characteristic of the spring cell. Similarly, there was only a negligible increase in spring flow in springs located on the Ichetucknee River and Santa Fe River. Table 7-3 summarizes the benefits to the target spring locations from Recharge Concept 3-1.

The overall increase in the potentiometric surface of the UFA at the nine target well locations totaled only 0.8 foot based on the 40 mgd simulation. This was due to the location near the Suwannee River and extremely high UFA transmissivity. Target well #993, located near White Sulphur Springs, showed an increase of only 0.04 foot. Figure 7-10 shows the overall increase in the potentiometric surface of the UFA based on a 20 mgd recharge simulation, and Figure 7-11 shows the increase based on the 40 mgd simulation. As shown in the figures, the 0.25-foot contour is fairly limited in extent, when compared with the other aquifer recharge concepts. Under the 40 mgd simulation, the 0.25-foot contour extends toward the north in the vicinity of the Alapaha River, which was not included as a river reach for this study. Table 7-1 summarizes the benefits to the UFA potentiometric surface at the target well locations from Recharge Concept 3-1.



**Figure 7-10: Modeled UFA Recharge Mounding Concept 3-1
Indirect Recharge at Eleven Ponds 20 MGD**



**Figure 7-11: Modeled UFA Recharge Mounding Concept 3-1
Indirect Recharge at Eleven Ponds 40 MGD**

Recharge Concept 3-1, as compared to all other aquifer recharge concepts, had the most benefit on the baseflow of the upper Suwannee River from the Suwannee Springs gage downstream to the edge of the study area. Baseflow was increased by a total of 29.9 mgd in this river reach based upon the 40 mgd aquifer recharge concept. This result was due to the close proximity of this site to the river and the extremely high UFA transmissivity. However, there was only a negligible increase in baseflow to the reach from the White Springs gage to the Suwannee Springs gage. The increase in baseflow in this river reach was 1.7 mgd. The total increase in all river reaches was 31.7 mgd, the lowest of all of the indirect aquifer recharge concepts. The total increase in baseflow to the Ichetucknee River and Santa Fe River was negligible. Table 7-2 summarizes the benefits to the selected river segments from Recharge Concept 3-1.

7.6 Recharge Concept 3-2 – PCS Phosphate Land

Recharge Concept 3-2 involves indirect recharge of upper Suwannee River water into a future sand tailings area located near the southwest corner of PCS Phosphate property. Figure 6-9 shows the general location of the aquifer recharge concept, and Figure 6-18 shows the close-up view of Recharge Concept 3-2. This aquifer recharge concept includes a potential CSA that can store available water during the rainy season, and then release it to the sand tailings area for ultimate recharge into the UFA. According to data in the revised MegaModel, the model cell containing the sand tailings area is located within an unconfined area, therefore, the SAS and ICU may be absent in this portion of the model area. However, hydrogeologic data provided by PCS Phosphate indicate the ICU is present, and therefore, justifies the need to conduct site specific testing if the aquifer recharge concept is pursued further.

Recharge Concept 3-2 had the greatest benefit of all indirect aquifer recharge concepts on target spring flows, as well as significant benefits on target river reaches and groundwater level elevations of the UFA. The increase in simulated flow at Suwannee Springs based on a 40 mgd aquifer recharge capacity was 3.3 mgd during the simulation. The overall increase in spring flow from all of the target springs in the project area was 5.4 mgd. Since this site is located down-gradient of White Sulphur Springs, even with an aquifer recharge capacity of 40 mgd, the simulated flow in White Sulphur Springs was still not enough to overcome the negative flow characteristic of the spring cell. The simulated flow in White Sulphur Springs was -1.7 mgd under this recharge concept. Since Recharge Concept 3-2 is located north of the upper Suwannee River, there was only a negligible increase in spring flow in springs located on the Ichetucknee River and Santa Fe River. This is due to the significant distance of Recharge Concept 3-2 from the Ichetucknee and Santa Fe rivers and the hydrologic barrier formed by the upper Suwannee River. Table 7-3 summarizes the benefits to target spring locations from Recharge Concept 3-2.

The overall increase in the potentiometric surface of the UFA at the nine target well locations totaled 2.3 feet based on the 40 mgd simulation. Target well #993, located near White Sulphur Springs, showed an increase of 0.25 foot. Figure 7-12 shows the overall increase in the potentiometric surface of the UFA based on a 20 mgd recharge simulation, and Figure 7-13 shows the increase based on the 40 mgd simulation. As shown in

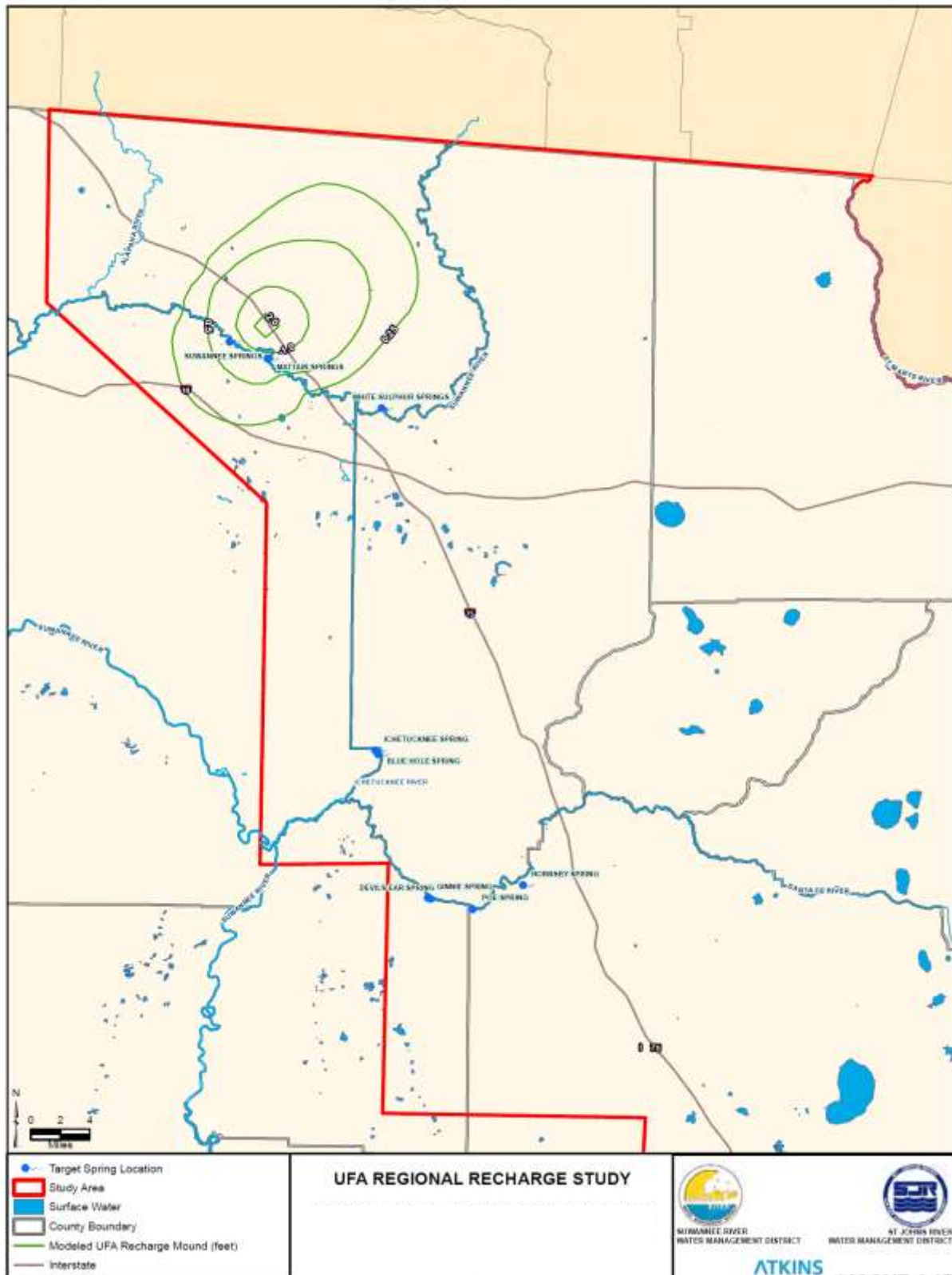
Figure 7-13, the 0.25-foot contour covers much of the upper Suwannee River basin area, and comprises the largest simulated increase in the potentiometric surface of the UFA based on a comparison of the other indirect aquifer recharge concepts. Table 7-1 summarizes the benefits to the UFA potentiometric surface at the target well locations from Recharge Concept 3-2.

Recharge Concept 3-2, as compared to the other indirect aquifer recharge concepts, had moderate benefits on the baseflow of the upper Suwannee River from Suwannee Springs downstream to the edge of the study area. Baseflow was increased by a total of 15.8 mgd in this river reach based upon the 40 mgd aquifer recharge concept. There was a moderate increase in baseflow to the reach from White Sulphur Springs to Suwannee Springs. The increase in baseflow in this river reach was 16.4 mgd. The total increase in all selected river reaches was 32.9 mgd. There were negligible benefits in the upper Suwannee River upstream of the White Springs gage. The total increase in baseflow to the Ichetucknee River and Santa Fe River based on a 40 mgd aquifer recharge capacity were negligible, at 0.3 mgd each. Table 7-2 summarizes the benefits to the selected river segments from Recharge Concept 3-2.

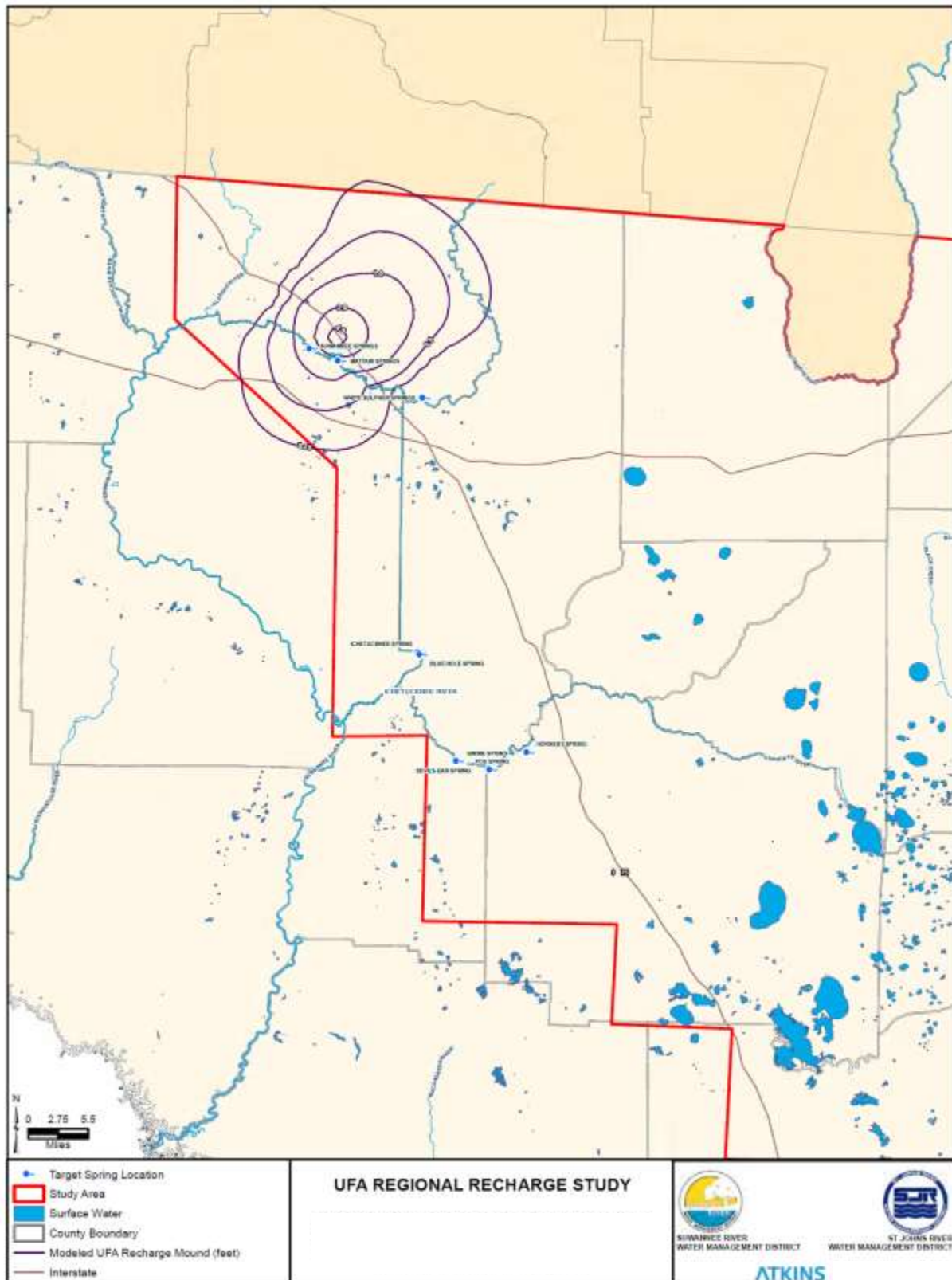
7.7 Recharge Concept 3-3 – Mattair Springs

Recharge Concept 3-3 involves indirect aquifer recharge of upper Suwannee River water into a future RIB or RIBs located within a one-square mile area within the Mattair Springs Park site. Figure 6-9 shows the general location of the aquifer recharge concept, and Figure 6-19 shows the close-up view of Recharge Concept 3-3. The UFA transmissivity value in the vicinity of Recharge Concept 3-3 based on the MegaModel data is approximately 240,000 ft²/day. This model cell is located within an unconfined area, therefore, the SAS and ICU are absent in this portion of the model area.

The simulated results for Recharge Concept 3-3 were very similar to Recharge Concept 3-2. Recharge Concept 3-3 had slightly improved benefits on river baseflows and water level elevations of the UFA, but slightly less benefit to the target spring flows. The increase in simulated flow in Suwannee Springs based on a 40 mgd aquifer recharge capacity was 2.0 mgd during the simulation. The overall increase in spring flow from all of the target springs was 4.4 mgd, or approximately 1.0 mgd less than Recharge Concept 3-2. Since this site is located downgradient of White Sulphur Springs, even with an aquifer recharge capacity of 40 mgd, the simulated flow in White Sulphur Springs was still not enough to overcome the negative flow characteristic of the spring cell. The simulated flow in White Sulphur Springs was -1.7 mgd, similar to Recharge Concept 3-2. There was only a negligible simulated increase to spring flows on the Ichetucknee River and Santa Fe River. Table -3 summarizes the benefits to target spring locations from Recharge Concept 3-3.



**Figure 7-12: Modeled UFA Recharge Mounding Concept 3-2
Indirect Recharge at PCS Phosphate 20 MGD**



**Figure 7-13: Modeled UFA Recharge Mounding Concept 3-2
Indirect Recharge at PCS Phosphate 40 MGD**

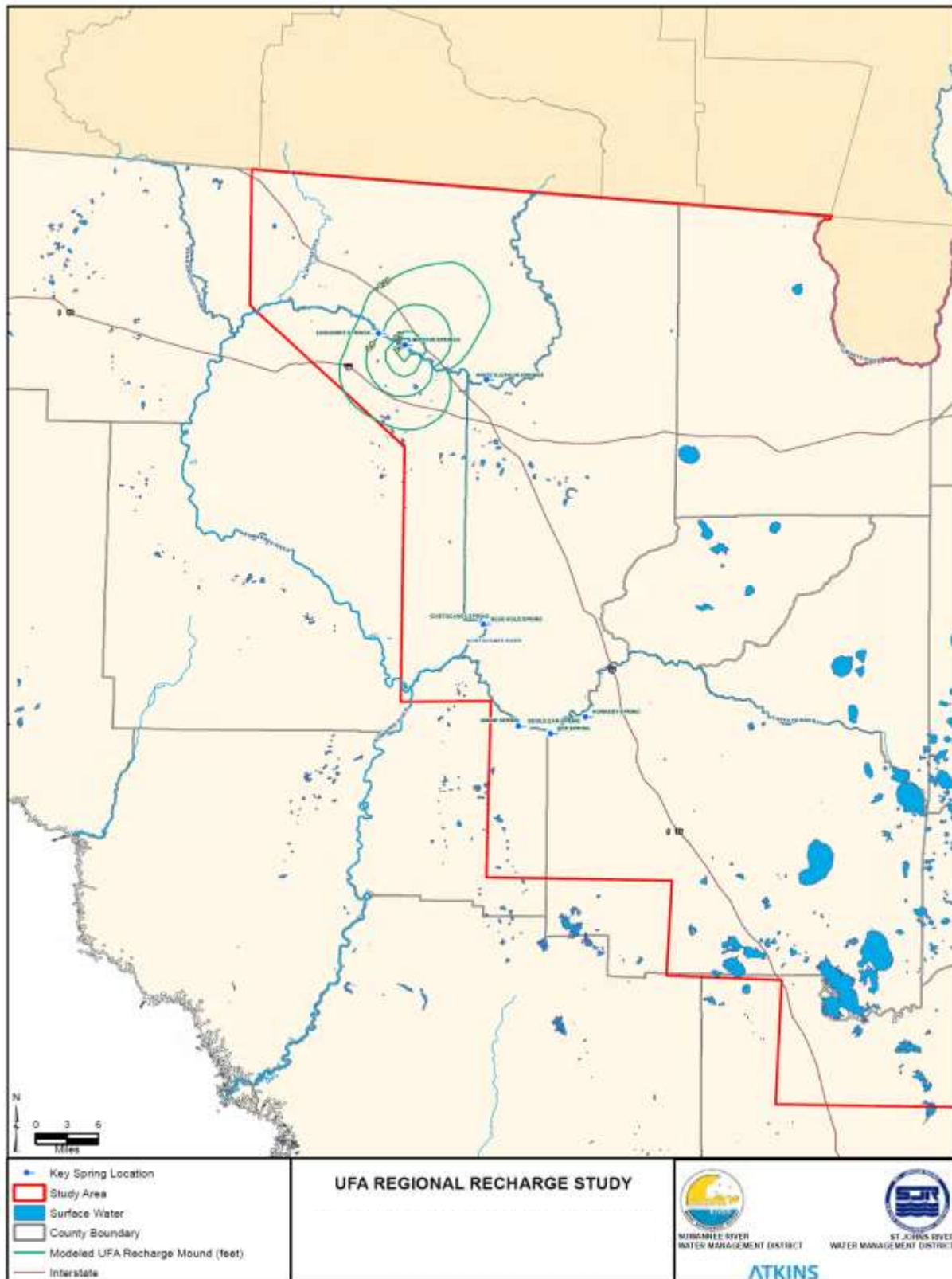
The overall increase in the potentiometric surface of the UFA at the nine target well locations totaled 2.4 feet based on the 40 mgd simulation, which is very similar to Recharge Concept 3-2. Target well #993, located near White Sulphur Springs, showed an increase of 0.46 foot. Figure 7-14 shows the overall increase in the potentiometric surface of the UFA based on a 20 mgd recharge simulation, and Figure 7-15 shows an increase based on the 40 mgd simulation. As shown on Figures 7-14 and 7-15, the 0.25-foot contour covers an area similar to Recharge Concept 3-2; however, the contour extends further toward the south in the direction of the Ichetucknee and Santa Fe rivers. Table 7-1 summarizes the benefits to the UFA potentiometric surface at the target well locations from Recharge Concept 3-3.

Recharge Concept 3-3, as compared to the other indirect aquifer recharge concepts, had moderate benefits on the baseflow of the upper Suwannee River from Suwannee Springs downstream to the edge of the study area. Baseflow was increased by a total of 9.5 mgd in this river reach based upon the 40 mgd aquifer recharge concept. There was a moderate increase of 22.8 mgd in baseflow to the reach from White Sulphur Springs to Suwannee Springs. The total increase in all river reaches was 33.2 mgd. As expected, there were negligible benefits in the upper Suwannee River upstream of the White Springs gage. The total increase in baseflow to the Ichetucknee River and Santa Fe River based on a 40 mgd aquifer recharge capacity were negligible, at 0.4 mgd each. Table 7-2 summarizes the benefits to the selected river segments from Recharge Concept 3-3.

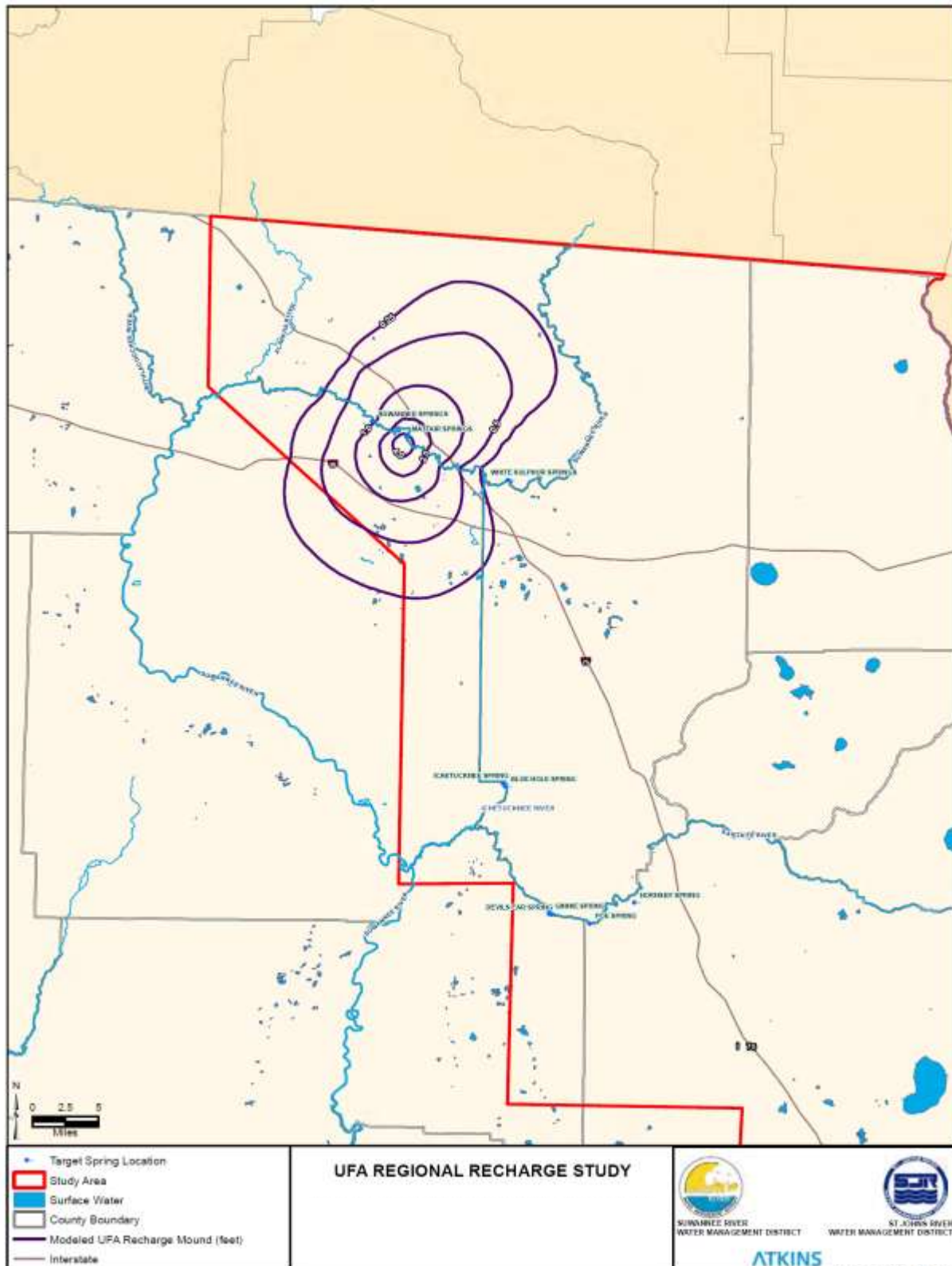
7.8 Summary of Recharge Concept 2 – Direct Recharge

As discussed above, Recharge Concept Sites 2-1 and 2-2, both located near springs, would result in immediate return of recharged water to the Suwannee River without significant regional groundwater benefits, resulting in water being recharged and spring discharge occurring nearly simultaneously. The benefit to the upper Suwannee River downstream of White Sulphur Springs would result in very little regional water resources benefits. The two spring sites have a thin SAS, a semi-confined UFA, and a UFA with medium transmissivity values ranging from 250,000 ft²/day to 500,000 ft²/day. The Suwannee Springs site additionally has high bluffs that would require significant engineering with minimal regional water resources benefits.

In the Falling Creek Falls Park site, due to its location away from the immediate vicinity of a spring, direct aquifer recharge eliminates the condition for localized impacts and immediate spring discharge as would occur at the Suwannee Springs and White Sulphur Springs locations. Conversely, direct aquifer recharge at Falling Creek Falls Park would positively influence the potentiometric surface within greater radial distance from the recharge location, and would result in slower release of recharged water back to the springs and river systems.



**Figure 7-14: Modeled UFA Recharge Mounding Concept 3-3
Indirect Recharge at Mattair Springs 20 MGD**



**Figure 7-15: Modeled UFA Recharge Mounding Concept 3-3
Indirect Recharge at Mattair Springs 40 MGD**

Based on modeled assessment for direct Recharge Concept 2, the Falling Creek Falls Park site is, therefore, recommended for additional study and analysis (see Section 5). This site is preferred over the other two direct recharge concept sites because the overall simulated benefits to water resources (springs and river flows, and aquifer levels) in the SRWMD portion of the study area were more widely distributed (i.e., upper Suwannee River and Santa Fe River areas). The Falling Creek Falls Park site had the greatest benefit on the regional potentiometric surface of the UFA of all the simulated recharge concepts, and also had the greatest benefits on the selected river segments baseflow, and target spring flow located within the Santa Fe and Ichetucknee rivers. The Falling Creek Falls Park and White Sulphur Springs sites were the only evaluated options that were able to reverse the flow in White Sulphur Springs from a negative sink to a discharging spring.

7.9 Summary of Recharge Concept 3 – Indirect Recharge

Recharge Concept 3-1, Eleven Ponds and Recharge Concept 3-3, Mattair Springs, as with all of the other potential sites located adjacent to the Suwannee River, results in rapid discharge of stored/recharge water back to the river and spring system with little regional and long-term benefits. Consequently, Recharge Concept 3-2, the more distant PCS Phosphate property, was considered to provide more regional and long-term benefits. The PCS Phosphate land site has sufficient elevation at approximately 140 feet above MSL, has surficial sands of approximately 40 feet in thickness, and according to the revised MegaModel, has either an unconfined or semi-confined UFA. Reclamation of the mined lands with sand tailings potentially enhances the permeability of the formations overlying the UFA. These characteristics provide acceptable conditions for indirect aquifer recharge.

An indirect aquifer recharge project at one of the PCS Phosphate's mined areas would provide leakage to the UFA through direct recharge, and would result in delayed release of stored water to the Suwannee River and selected springs. An aquifer recharge project off the river or away from spring sites provides greater regional aquifer recharge benefits.

Based on modeled assessment for indirect Recharge Concept 3, the PCS Phosphate land site is recommended for additional study and analysis (Section 5). This site is preferred over the other two indirect aquifer recharge concept sites because of its overall simulated benefits to water resources in the study area; specifically to increase the potentiometric surface of the UFA, target spring flows, and river baseflows in the upper Suwannee River.

Furthermore, the addition of the CSA to Recharge Concept 3-2 provides other options for use of the stored water that Concepts 3-1 and 3-3 do not. Specifically, the CSA provides the flexibility to time the release stored water to the upper Suwannee River seasonally to augment low flows. This may be advantageous with respect to maintaining a future MFL for the upper Suwannee River (currently in development by the SRWMD). However, the feasibility of this option needs to be addressed in future studies.

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8.0 CONCEPTUAL DESIGN OF SELECTED AQUIFER RECHARGE CONCEPTS

The purpose of the conceptual design phase is to establish basic engineering criteria for the selected aquifer recharge concepts. The engineering criteria are general in nature and derived from the information presented in this document (detailed in TM-2) and compiled under TM-1; as well as assumptions based on past project experience, published references, and accepted engineering principles. The conceptual engineering criteria in this document are not site-specific and are not to be used for actual design purposes. The next phase of work would include site-specific testing, and data collection and analysis as part of the preliminary design for aquifer recharge concepts deemed appropriate by the Districts.

8.1 Recharge Concept 1

Recharge Concept 1 involves treating up to 30 mgd of reclaimed water from the Buckman Street WWTF and 10 mgd from the Southwest WWTF and discharging the effluent to aquifer recharge wells within the respective WWTF property. Treatment of the reclaimed water is required because the existing effluent from these WWTFs do not meet FDEP effluent quality requirements for direct aquifer recharge. Additional conceptual treatment includes filtration, high level disinfection, and activated carbon adsorption.

The treated effluent would be pumped to aquifer recharge wells. For conceptual design purposes, it is assumed that each well would accommodate up to 5 mgd of recharge water. Therefore, six recharge wells are proposed for the Buckman WWTF site and two recharge wells are proposed for the Southwest WWTF. The conceptual design includes a ground storage tank (GST) to dampen peak flows, and reduce the size of the proposed treatment processes and number of recharge wells required. Conceptual treatment layouts for the Buckman Street WWTF and Southwest WWTF are shown in Figures 8-1 and 8-2, respectively. A treatment schematic for Recharge Concept 1 is presented in Figure 8-3.

Water Treatment

Available data indicate that UFA TDS concentrations in the area of Recharge Concept 1 are less than 3,000 mg/l. According to FDEP Chapters 62-600 and 62-610, F.A.C., reclaimed water that is to be used to directly recharge an aquifer with less than 3,000 mg/L TDS shall meet the following criteria:

- Secondary treatment and filtration,
- High level disinfection,
- Primary and secondary DWS,
- TSS: 5 mg/L maximum before application of disinfectant,
- TOC: 3 mg/L – monthly average and 5 mg/L - maximum single sample,
- Total Organic Halogen (TOX): 0.2 mg/L – monthly average and 0.3 mg/L - maximum single sample, and
- TN: 10 mg/L maximum annual average.



Figure 8-1: Buckman Street Wastewater Treatment Facility with Proposed UFA Recharge System Site Layout



Figure 8-2: Southwest Wastewater Treatment Facility with Proposed UFA Recharge System Site Layout

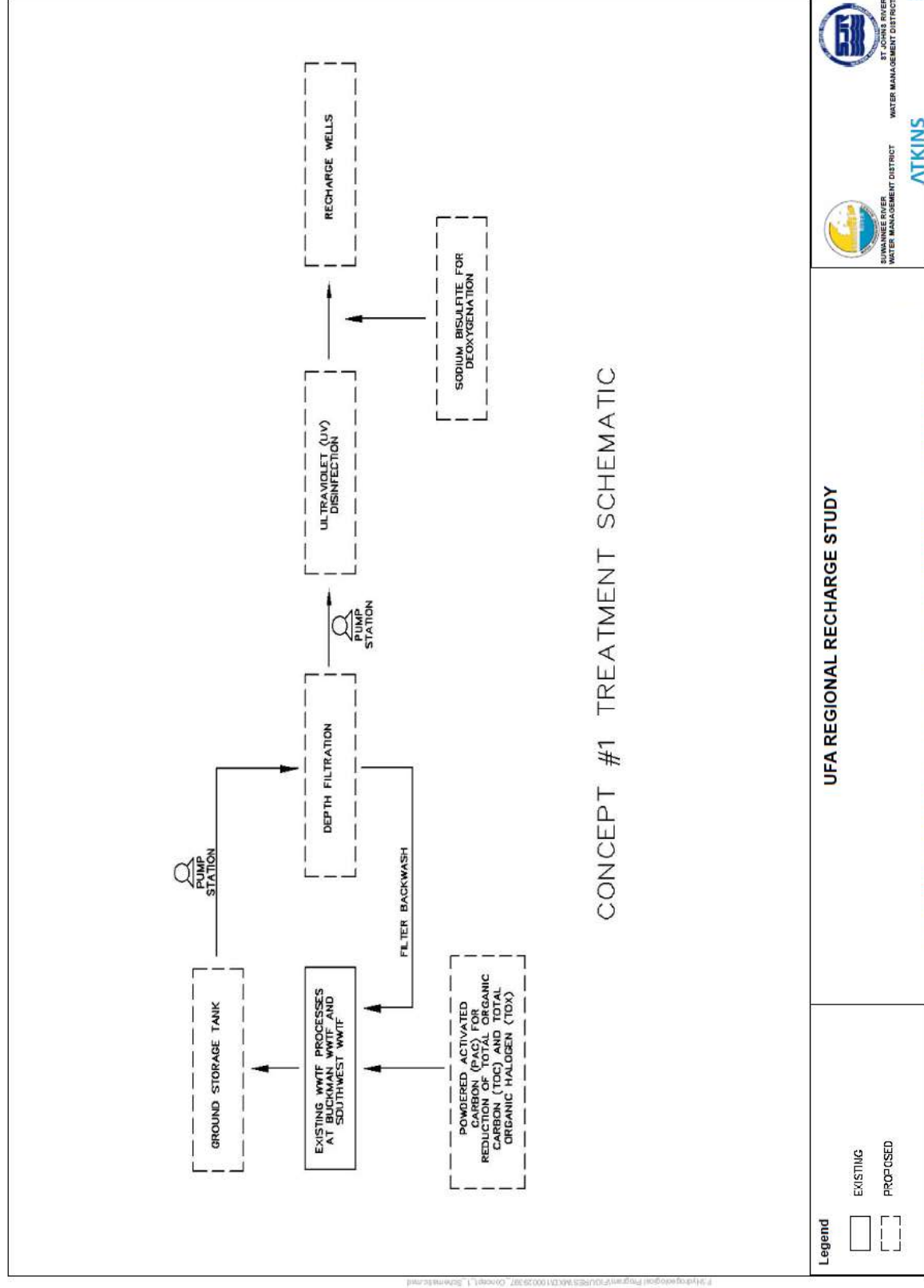


Figure 8-3: Concept 1 Proposed Treatment Schematic Reclaimed Water Recharge at Wastewater Treatment Facilities

Based on these water quality requirements, the following treatment processes would be required:

1. Powdered Activated Carbon

The purpose of powdered activated carbon (PAC) adsorption is to reduce TOC and TOX levels to the required effluent limits. In addition, organic compounds regulated under the DWS, including pesticides, may be removed through PAC. The required rate of feed of carbon is site specific and will be dependent on TOC and TOX levels in the water. Recommended guidelines for PAC treatment include:

- PAC should be added as early as possible in the treatment process to provide maximum contact time. Typically the PAC is added in the aeration tank, and
- The carbon could be added as pre-mixed slurry or by means of a dry-feed machine. If a pre-mix slurry is used, continuous agitation or resuspension equipment shall be used.

2. Ground Storage Tank

The existing treatment trains at the Buckman Street WWTF and Southwest WWTF do not have an equalization basin to dampen peak flows that are typically experienced during the morning and evening hours. To reduce the size of the proposed treatment processes and number of recharge wells required, a GST could be installed at each WWTF so that treatment can be limited to a maximum rate of 30 mgd for the Buckman Street WWTF and 10 mgd for the Southwest WWTF. Sizing for the GSTs are shown in Table 8-1.

Table 8-1: Ground Storage Tank Sizing

Parameter	Buckman Street WWTF	Southwest WWTF
Design Flow Rate (mgd)	30	10
GST Capacity (hours)*	6 (or 0.25 days)	6 (or 0.25 days)
GST Volume Design (MG)	7.5	2.5

* Assumed

Note: MGD=million gallons per day, MG=million Gallons

3. Deep Bed Filtration

The purpose of deep bed filtration is to reduce TSS levels to less than 5 mg/L. The typical filtering medium is sand or anthracite with downward or upward flow through the media. In addition to TSS removal, deep bed filtration can remove phosphorus, protozoan cysts, and oocysts. Deep bed filtration equipment includes backwash facilities to flush out accumulated debris and particles from the filters. For the purposes of this study, it is assumed that the backwash water is directed back to the WWTFs headworks for treatment. Sizing assumptions for a 10 mgd and 30 mgd deep bed filtration systems are shown in Table 8-2.

Table 8-2: Deep Bed Filter Sizing

Parameter	Buckman Street WWTF	Southwest WWTF
Design Flow Rate (mgd)	30	10
Design Flow Rate (gpm)	20,835	6,945
Filtration Rate (gpm/ft ²)*	2.0	2.0
Filtration Area Required (ft ²)	10,418	3,473
Area per Filter (ft ²)*	1,500	1,500
Number of Filters (duty)	7	3
Number of Filters (stand-by)*	1	1
Total Number of Filters	8	4

* Assumed

Note: MGD=million gallons per day; GPM=gallons per minute; ft²=square feet

4. Ultraviolet Disinfection

The purpose of UV disinfection is two-fold: the first is to oxidize organic compounds, including pesticides, which are regulated under the primary DWS, and second to inactivate bacteria and viruses in the water that are not removed through deep bed filtration, including *Cryptosporidium* and *Giardia*.

The UV system must comply with NWRI Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse (August 2012). These guidelines require the following performance criteria for deep bed (sand) filtration effluent:

- The design UV dose shall be at least 100 milli-joules per centimeter square (mJ/cm²) under maximum daily flow. The design dose must take into consideration validated lamp age and fouling factors,
- The filtered effluent UV transmittance shall be 55 percent or greater at 254 nano-meters (nm), and
- The maximum TSS limit for a single sample is 5 mg/L.

There are two types of UV systems: open channel and closed vessel. UV installations for wastewater treatment have been traditionally open channel consisting of multiple UV lamp modules dropped into concrete channels. Most of these installations were retrofits using existing chlorine contact basins. Closed vessel systems incorporate UV lamps in chambers which are fitted with American National Standards Institute (ANSI) flanges. Unlike open channel UV systems, closed vessel systems eliminate the need of precision alignment of poured concrete walls and floor, which significantly reduce installation costs. Other advantages include:

- Installation flexibility – closed vessel systems can be installed incrementally as the WWTF expands and in either a horizontal or vertical orientation. Vertical installations lead to a smaller footprint if space is limited,
- Minimized pollution from airborne material,

- Easier to service and maintain, and
- Reduced safety concerns – minimal personnel exposure to UV and no open water surfaces.

For the purpose of this study, it is assumed that closed vessel UV systems would be used.

In addition to the type of UV system (closed vessel and open channel), there are three types of available lamps: low pressure (LP), low pressure hi intensity (LPHI), and medium pressure (MP). In closed vessel systems, LPHI and MP lamps are typically used. However, LPHI lamps are more efficient than MP lamps (e.g. reduced energy costs) and offer greater reliability. Due to these reasons, it would be assumed that LPHI lamps would be used in this recharge concept.

Summaries of design criteria and sizing assumptions for a 10 mgd and 30 mgd UV system are shown in Tables 8-3 and 8-4. For the purpose of this study, it is assumed that one redundant treatment train would be required in this recharge concept.

Table 8-3: Ultraviolet System Design Assumptions

Parameter	Buckman Street WWTF	Southwest WWTF
Design Flow Rate (mgd)	30	10
Type of Effluent	Deep Bed (Sand) Filtration	Deep Bed (Sand) Filtration
Transmittance	≥ 55% at 254 nm	≥ 55% at 254 nm
TSS (mg/L)	≤ 5	≤ 5
Dosage (mJ/cm ²)	≥ 100 at max daily flow	≥ 100 at max daily flow
Total & Fecal Coliform (cfu/100 ml)	Non-Detect	Non-Detect

Note: MGD=million gallons per day; mg/L= milligrams per liter; mJ/cm²=milli-joule per centimeter square; NM=nano-meter; cfu/100ml=

Table 8-4: Ultraviolet System Design Parameters

Parameter	Buckman Street WWTF	Southwest WWTF
Design Flow Rate (mgd)	30	10
Flow Rate per UV Reactor (mgd) – assumed	1.25	1.25
Number of UV Reactors (duty)	24	8
Number of Treatment Trains (duty)* -	12	4
Number of Treatment Trains (standby)	1	1
Total Number of Treatment Trains	13	5

*Assumes 2 reactors per train

5. Deoxygenation

To minimize the mobilization of arsenic in the groundwater, the effluent is dosed with sodium bisulfite for deoxygenation prior to discharge to the aquifer recharge wells. The concentration and required rate of feed of sodium bisulfite is site specific and would need to be determined through bench-scale testing of the water during the design phase of the treatment system.

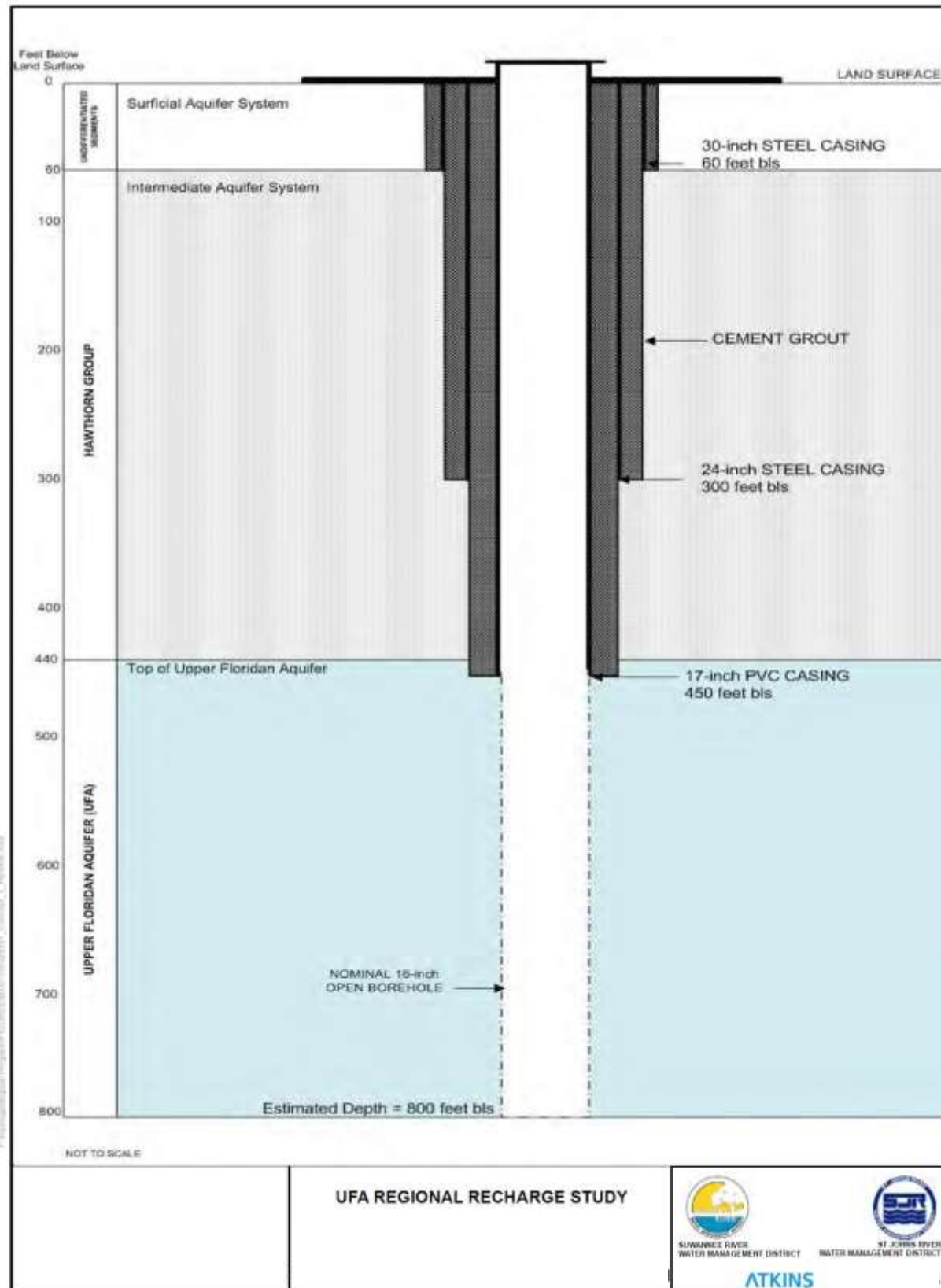
A schematic for a proposed aquifer recharge well is presented in Figure 8-4. The recharge well is assumed to penetrate the UFA to a depth of approximately 800 feet below land surface. A final water-bearing casing string consisting of 17-inch (outer) diameter poly vinyl chloride (PVC) casing will accommodate up to 5 mgd of recharge water. For conceptual design purposes, six aquifer recharge wells are proposed for the Buckman WWTF site, and two aquifer recharge wells are proposed for the Southwest WWTF site. Site-specific data collected during the preliminary design phase will be utilized to accurately determine the number and capacity of recharge wells at each site, as well as the construction characteristics of each aquifer recharge well (i.e., casing depths and diameters).

8.2 Recharge Concept 2

Recharge Concept 2 involves pumping up to a maximum daily capacity of 40 mgd from Suwannee River to District-owned land in Falling Creek Falls Park where it would be treated and discharged to aquifer recharge wells. In this recharge concept, raw water intake structures consisting of intake screens, intake piping, and a pump station would be installed in District-owned land approximately 0.5 mile east of White Sulphur Springs. From the pump station, 48-inch transmission main piping would run approximately 11 miles in roadway easements to a proposed water treatment plant at Falling Creek Falls Park. A conceptual pipeline route is mapped in Figure 8-5. It should be noted that this route is conceptual in nature and a routing analysis will need to be conducted during the design phase to confirm the feasibility of this route.

Treatment of the surface water is required because it does not meet current FDEP effluent quality requirements for direct aquifer recharge. It is assumed that additional treatment includes activated carbon adsorption, chemical conditioning, coagulation/flocculation, clarification/sedimentation, filtration, high level disinfection, and deoxygenation.

The treated surface water would be pumped to aquifer recharge wells. For conceptual design purposes, it is assumed that each well would accommodate up to 5 mgd of recharge water. Therefore, eight recharge wells are proposed for this concept. A conceptual treatment layout and schematic for Recharge Concept 2 are shown in Figures 8-6 and 8-7, respectively.



**Figure 8-4: Conceptual Duval County Recharge Well
Proposed Well Construction Diagram**

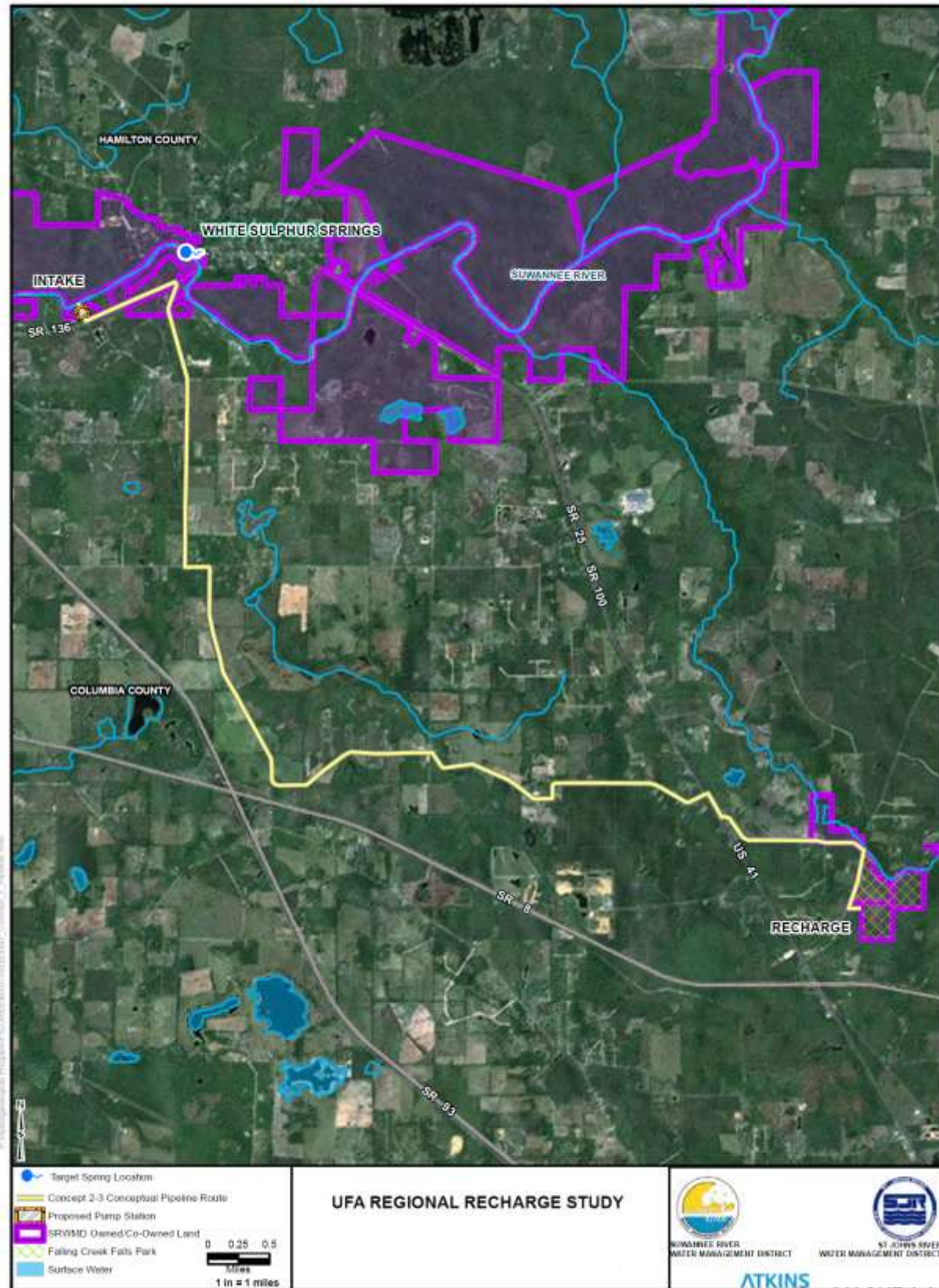


Figure 8-5: Concept 2-3 Conceptual Pipeline Route

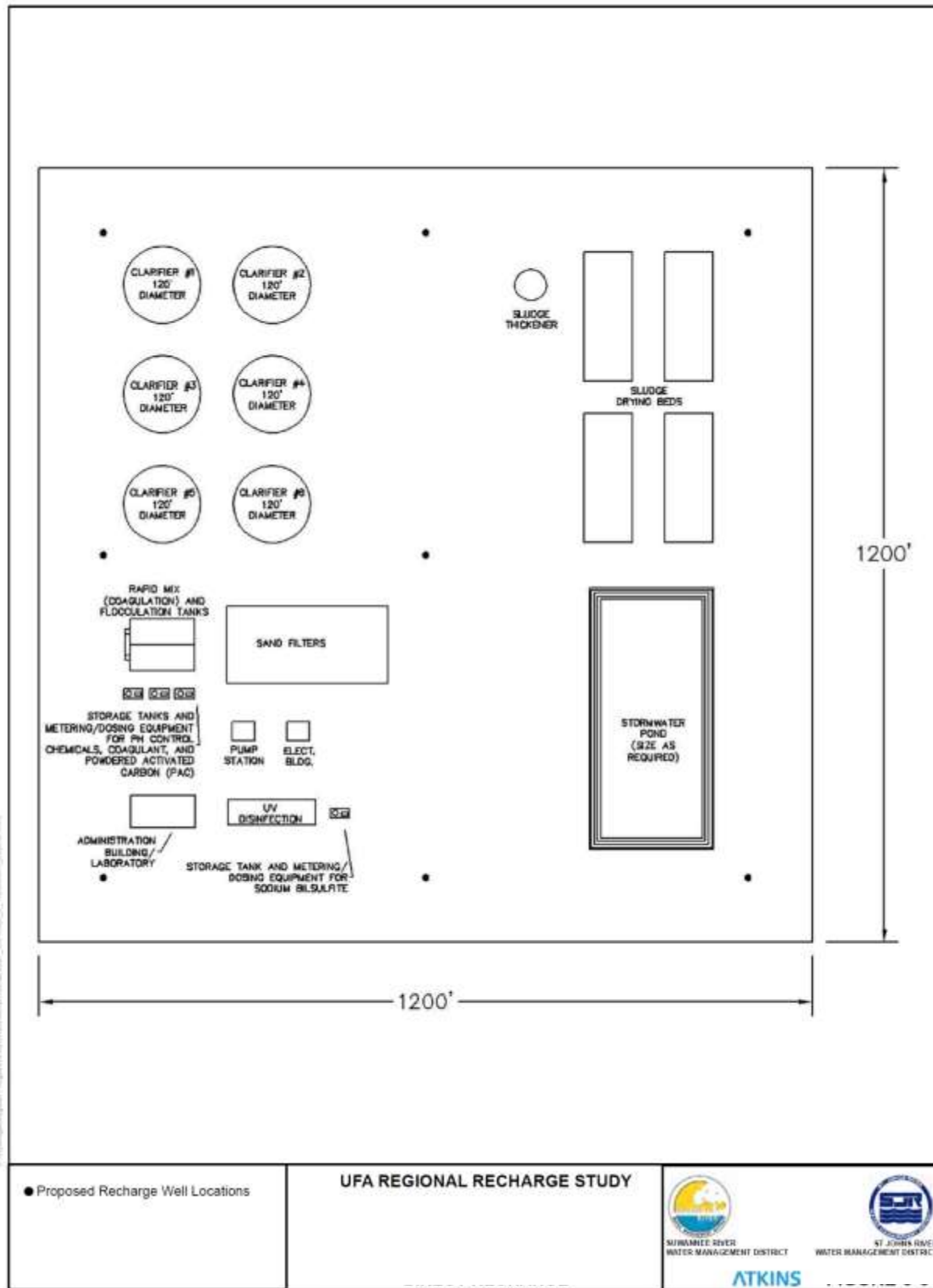


Figure 8-6: Concept 2-3 Proposed Treatment Layout Direct Recharge

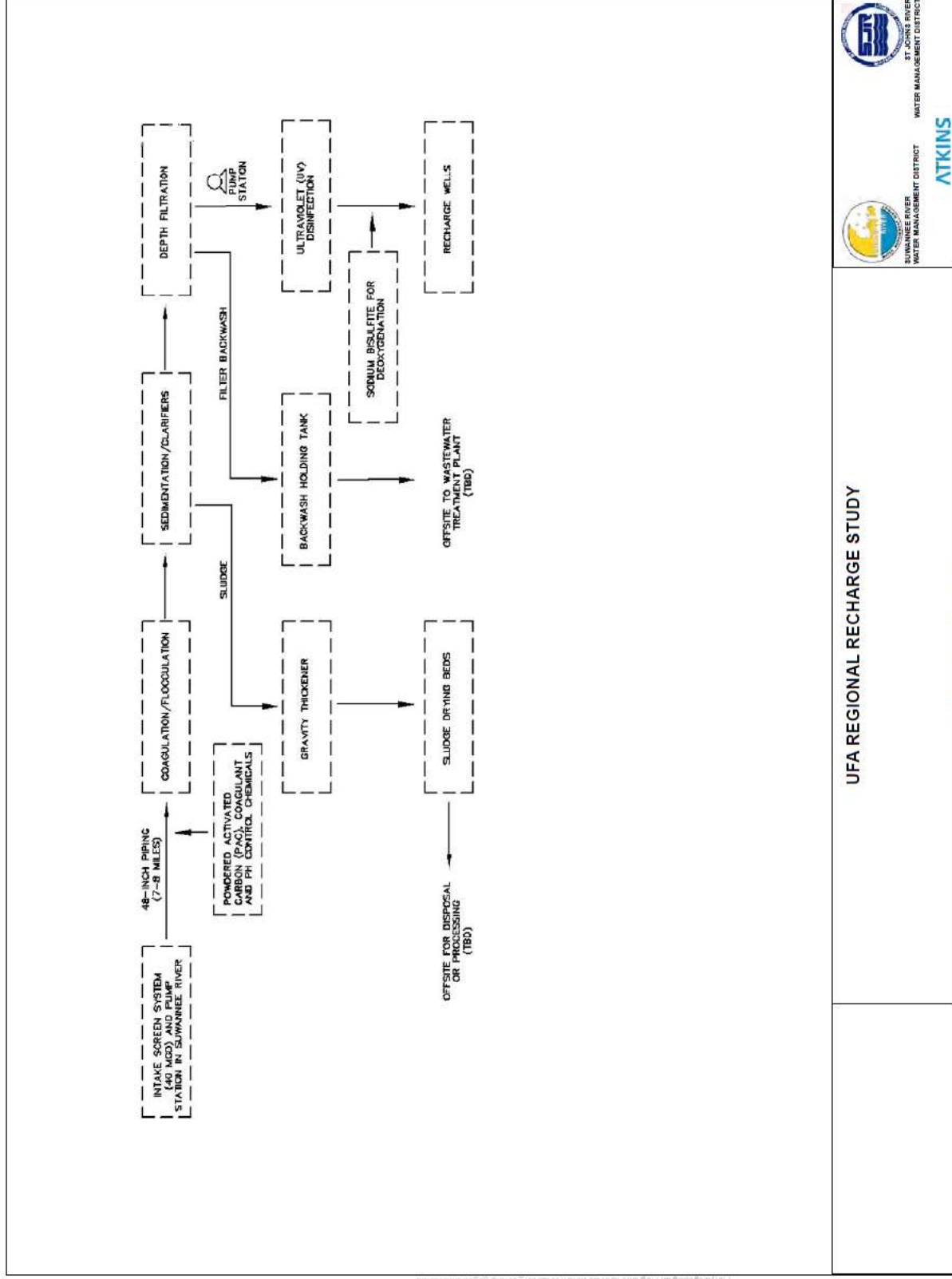


Figure 8-7: Concept 2-3 Proposed Treatment Schematic Direct Recharge

8.2.1 Raw Water Intake Structures

The intake structure location was identified for the Suwannee River (Figure 8-7). The location, which was coordinated with SRWMD and SJRWMD personnel, is located approximately 0.5 mile east of White Sulphur Springs on District-owned land. The conceptual raw water intake structure design would consist of intake screens, intake piping, and a pump station. The conceptual design assumptions for the intake structure are outlined below:

- Assumed minimum available water depth at intake structure location is 8 feet,
- Assumed minimum width of river at intake structure location is 8 feet plus the width needed for navigation,
- The intake capacity is assumed 40 mgd or 28,000 gallons per minute (gpm), and
- The velocities in the intake pipe and transmission main are assumed to be less than five feet per second (fps). 5 fps is the maximum velocity that is typically recommended to minimize water hammer or surge pressure.

1. River Intake Screens

The conceptual design for the water intake screens includes tubular 48-inch diameter stainless steel wire screens manufactured in a tee configuration. For this project, it is assumed that the available water depth at the intake structure is 8 feet since screen manufacturers typically recommend a minimum vertical clearance of a half diameter (i.e., 24-inches) from top and bottom. This prevents silt from being sucked from the river bottom and vortexes being created from the top. If there is not sufficient water depth, the river bed would require excavation or an intake channel outside of the existing river bank would need to be constructed. In addition to vertical clearances, screen manufacturers may recommend horizontal clearances. For the purposes of this study, it is assumed that a horizontal clearance of 8 feet would be required. The actual number of screens and screen size may change based on the available water depth at the chosen intake location. Based on the intake screen capacity, three 48-inch screens would be needed. Each screen would be approximately 15 to 16 feet in length, have a slot size of 0.125 inches, and would be constructed of Type 304 stainless steel with a design velocity of less than 0.5 fps. A typical representation of an intake screen is provided in Appendix B.

2. Intake Pipe

The proposed material for the intake pipe from the intake screens to the pump station is ductile iron and installed by conventional trenching methods. To minimize impact to the shoreline and trees, directional drilling with high density polyethylene pipe may also be considered. Assuming a maximum velocity of 5.0 fps, a 48-inch ductile iron pipe would be needed. The actual length of the pipe has not yet been determined and would depend on the final locations of the intake screens and pump station.

3. Pump Station

The conceptual pump station design is based on a rectangular concrete structure that would contain three vertical turbine pumps equipped with Variable Frequency Drives (VFDs). Under normal conditions, up to two of the pumps would be running and the third pump on standby. Based on the conceptual routing from the pump station to Falling Creek Falls Park, each of the pumps would be 1,000 horsepower (Hp). Each pump outlet piping would have a pressure gauge, control/isolation valve, check valve, and air valve. The check valve would need to be slow closing to mitigate water hammer. Water hammer is the momentary pressure surge inside a pipe caused by a sudden change of direction or velocity of the liquid in the pipe. Water hammer effects range from noise and vibration to pipe collapse and equipment damage. Medium voltage electrical power must be brought to the site to power the pumps and associated controls. A typical representation of a pump station is shown in Appendix B.

4. Transmission Main

Based on the conceptual routing in Figure 8-7, approximately 11 miles of piping would be needed to connect the pump station and the water treatment facility at Falling Creek Falls Park. The conceptual design is based on ductile iron pipe with installation by conventional trenching. Assuming a maximum velocity of 5.0 fps, a 48-inch ductile iron pipe would be needed. The transmission main would be restrained as required to support water hammer load and equipped with air valves at the high points and at long runs to protect the pipe from collapse due to vacuum conditions. Based on previous project experience with similar sized pipes, it is assumed that temporary construction and permanent easements of 70 feet and 40 feet respectively would be required along the pipe route.

8.2.2 Water Treatment (40 mgd)

FDEP Chapter 62-528, F.A.C., requires that surface water used to directly recharge an aquifer shall meet primary and secondary DWS (TM-1). Based on the raw surface water quality data that Atkins has reviewed as part of TM-1, the following treatment processes would be required:

1. Powdered Activated Carbon

The purpose of PAC adsorption is to remove organic compounds regulated under the DWS (including pesticides) that may be found in surface waters. The required rate of feed of carbon is site specific and will be dependent on levels of organic compounds in the water. Recommended guidelines for PAC treatment include:

- PAC should be added as early as possible in the treatment process to provide maximum contact time, and
- The carbon could be added as pre-mixed slurry or by means of a dry-feed machine. If a pre-mix slurry is used, continuous agitation or resuspension equipment shall be used.

2. pH Control

Lime is added to raise and maintain the pH of the water to between 5.5 and 7.5 which is the optimal pH for the coagulation/flocculation processes. If the pH is outside this range, the effectiveness of the coagulation/flocculation processes decreases and additional (excessive) coagulant would be required. The amount of lime to raise the pH to between 5.5 and 7.5 would depend on the initial source water alkalinity and pH. Determining this amount would require bench-scale testing of the source water and is beyond the scope of this study.

3. Coagulation/Flocculation

After the pH has been adjusted, a coagulant (such as aluminum sulfate or alum) is injected and rapidly mixed with the water. The purpose of the coagulant is to cause colloidal particles to destabilize and form larger particles referred to as floc. Coagulation/flocculation results in the reduction of TSS, TOC, color, turbidity, algae, pathogens, Cryptosporidium, iron, manganese, and arsenic. Sizing assumptions for the rapid mix tank and flocculation tank are shown in Table 8-5.

Table 8-5: Tank Sizing Requirements

Parameter	Rapid Mix Tank	Flocculation Tank
Detention Time (minutes)*	0.5	30
Required Volume (gallons)	14,000	840,000
Number of Tanks	2	2
Assumed Height (feet)	15	14.5
Area per Tank (square feet)	62	3872
Dimension of Each Tank (Length x Width)	8 feet Long x 8 feet Wide	100 feet Long x 40 feet Wide

* Per Ten State Standards (2012) – Recommended Standards for Water Works.

4. Clarification/Sedimentation

Flocs that are formed are allowed to settle out and are removed from the water as residuals. The residuals are then thickened and dewatered prior to offsite disposal or processing. Sizing assumptions for the sedimentation clarifiers are shown in Table 8-6.

Table 8-6: Clarifier Sizing Requirements

Parameter	Sedimentation Clarifier
Detention Time (hours)*	4
Required Volume (gallons)	6,720,000
Number of Clarifiers	6
Assumed Height (feet)	14
Area per Clarifier (square feet)	10,684
Required Diameter (feet)	120

* Per Ten State Standards (2012) – Recommended Standards for Water Works

5. Deep Bed Filtration

The purpose of deep bed filtration is to reduce TSS levels to less than 5 mg/L. The typical filtering medium is sand or anthracite with downward or upward flow through the media. In addition to TSS removal, deep bed filtration can remove phosphorus, protozoan cysts, and oocysts. Deep bed filtration equipment includes backwash facilities to flush out accumulated debris and particles from the filters. For the purposes of this study, it is assumed that the backwash water would be stored in a backwash holding tank which would be transported offsite to a WWTF. Sizing assumptions for the deep bed filters are shown in Table 8-7.

Table 8-7: Deep Bed Filter Sizing Requirements

Parameter	Deep Bed Filter
Design Flow Rate (mgd)	40
Design Flow Rate (gpm)	27,780
Filtration Rate (gpm/ ft ²)*	2.0
Filtration Area Required (ft ²)	13,890
Area per Filter (ft ²)*	1400
Number of Filters (duty)	10
Number of Filters (stand-by)*	1
Total Number of Filters	11

* Assumed

6. Ultraviolet Disinfection

The purpose of UV disinfection is two-fold: the first is to oxidize organic compounds, including pesticides, which are regulated under the primary DWS, and second to inactivate bacteria and viruses in the water that are not removed through depth filtration, including *Cryptosporidium* and *Giardia*.

The UV system should comply with the NWRI Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse (August 2012). These guidelines require the following performance criteria for deep bed (sand) filtration effluent:

- The design UV dose shall be at least 100 mJ/cm² at maximum daily flow. The design dose must take into consideration validated lamp age and fouling factors,
- The filtered effluent UV transmittance shall be 55 percent or greater at 254 nm, and
- The maximum TSS limit for a single sample is 5 mg/L.

There are two types of UV systems: open channel and closed vessel. UV installations for wastewater treatment have been traditionally open channel consisting of multiple UV lamp modules dropped into concrete channels. Most of these installations were retrofits using existing chlorine contact basins. Closed vessel systems incorporate UV lamps in chambers which are fitted with ANSI

flanges. Unlike open channel UV systems, closed vessel systems eliminate the need of precision alignment of poured concrete walls and floor, which significantly reduce installation costs. Other advantages over open-channel systems include:

- Installation flexibility – closed vessel systems can be installed incrementally as the water treatment plant expands and in either a horizontal or vertical orientation. Vertical installations lead to a smaller footprint if space is limited,
- Minimized pollution from airborne material,
- Easier to service and maintain, and
- Reduced safety concerns – minimal personnel exposure to UV and no open water surfaces.

For the purpose of this study, it is assumed that closed vessel UV systems would be used.

In addition to the type of UV system (closed vessel and open channel), there are three types of available lamps: LP, LPHI, and MP. In closed vessel systems, LPHI and MP lamps are typically used. However, LPHI lamps are more efficient than MP lamps (e.g. reduced energy costs) and offer greater reliability. Due to these reasons, it is assumed that LPHI lamps would be used in this recharge concept.

Summaries of design criteria and sizing assumptions for a 40 mgd UV system are shown in Tables 8-8 and 8-9, respectively. For the purpose of this study, it is assumed that one redundant treatment train would be required in this recharge concept.

Table 8-8: System Design Assumptions

Parameter	UV Design Criteria
Design Flow Rate (mgd)	40
Type of Effluent	Deep Bed (Sand) Filtration
Transmittance	≥ 55% at 254 nm
TSS (mg/L)	≤ 5
Dosage (mJ/cm ²)	≥ 100 at max daily flow
Total & Fecal Coliform (cfu/100 ml)	Non-Detect

Table 8-9: Ultraviolet System Design Parameters

Parameter	UV Sizing Assumptions
Design Flow Rate (mgd)	40
Flow Rate per UV Reactor (mgd) – assumed	1.25
Number of UV Reactors (duty)	32
Number of Treatment Trains (duty)	16
Number of Treatment Trains (standby)	1
Total Number of Treatment Trains	17

* Assumes 2 reactors per train

7. Deoxygenation

To minimize the mobilization of arsenic in the groundwater, the effluent is dosed with sodium bisulfite for deoxygenation prior to discharge to the aquifer recharge wells. The concentration and required rate of feed of sodium bisulfite is site specific and will need to be determined through bench-scale testing of the water during the design phase of the treatment system.

A schematic for a proposed aquifer recharge well is presented in Figure 8-8 for the Falling Creek Falls Park site. The aquifer recharge well is assumed to fully penetrate the UFA to a depth of approximately 900 feet below land surface. A final water-bearing casing string consisting of 17-inch (outer) diameter PVC casing would accommodate up to 5 mgd of recharge water. For conceptual design purposes, eight aquifer recharge wells are proposed for the Falling Creek Falls Park site. Site-specific data collected during the preliminary design phase would be utilized to accurately determine the number and capacity of aquifer recharge wells at the site, as well as the construction characteristics of each aquifer recharge well (i.e., casing depths and diameters).

8.3 Recharge Concept 3

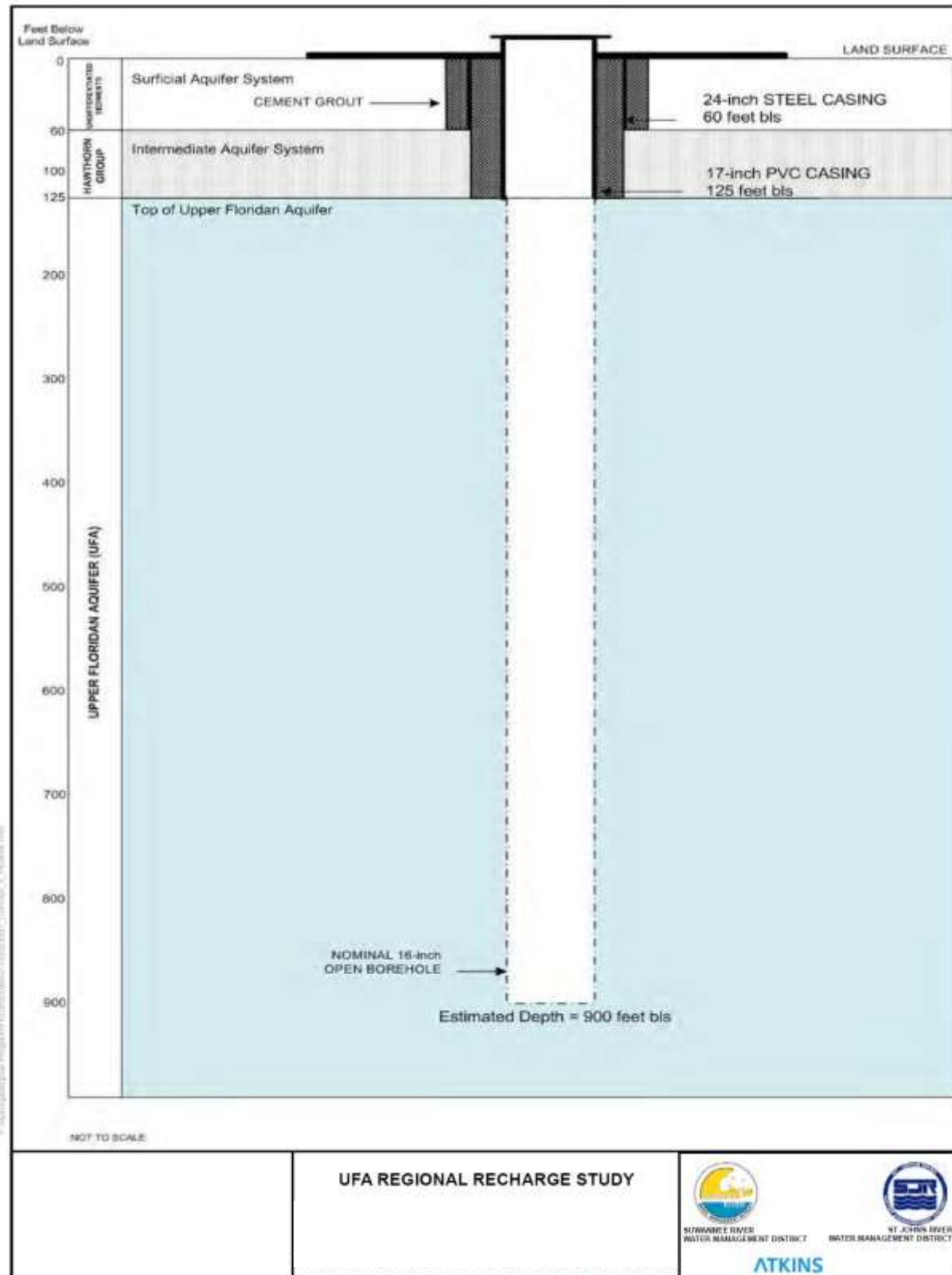
Recharge Concept 3 involves pumping up to a maximum daily capacity of 40 mgd from the upper Suwannee River to a CSA reservoir. From the CSA, the water would be pumped to a phosphate mining sand tailing area for filtration and ultimately aquifer recharge or back to the upper Suwannee River during periods of low flow.

In this recharge concept, raw water intake structures consisting of intake screens, intake piping, and a pump station would be installed in District-owned land along of the banks of the upper Suwannee River and approximately 5 to 6 miles south of the CSA. From the pump station, 48-inch transmission main piping would run approximately 6 miles in roadway easements to the CSA for storage.

Water intake structures would be constructed at the CSA consisting of intake screens, intake pipe, and a pump station. From the CSA pump station, 48-inch transmission main piping would run approximately 5 miles in roadway easements to the sand tailing area for dispersal and aquifer recharge. Alternatively, the CSA pump station may pump the water back to the upper Suwannee River to augment river flow.

The potential intake structures, piping alignment, CSA reservoir, and sand tailings area locations for Recharge Concept 3-2 are indicated in Figure 8-9. It should be noted that the piping alignment is conceptual in nature and a routing analysis will need to be conducted during the design phase to confirm the feasibility of this route.

It is assumed that treatment of the surface water would not be required because the recharge concept involves indirect aquifer recharge where the source water undergoes natural treatment/filtration as it flows down through the sand tailings.



**Figure 8-8: Conceptual Falling Creek Recharge Well
Proposed Well Construction Diagram**

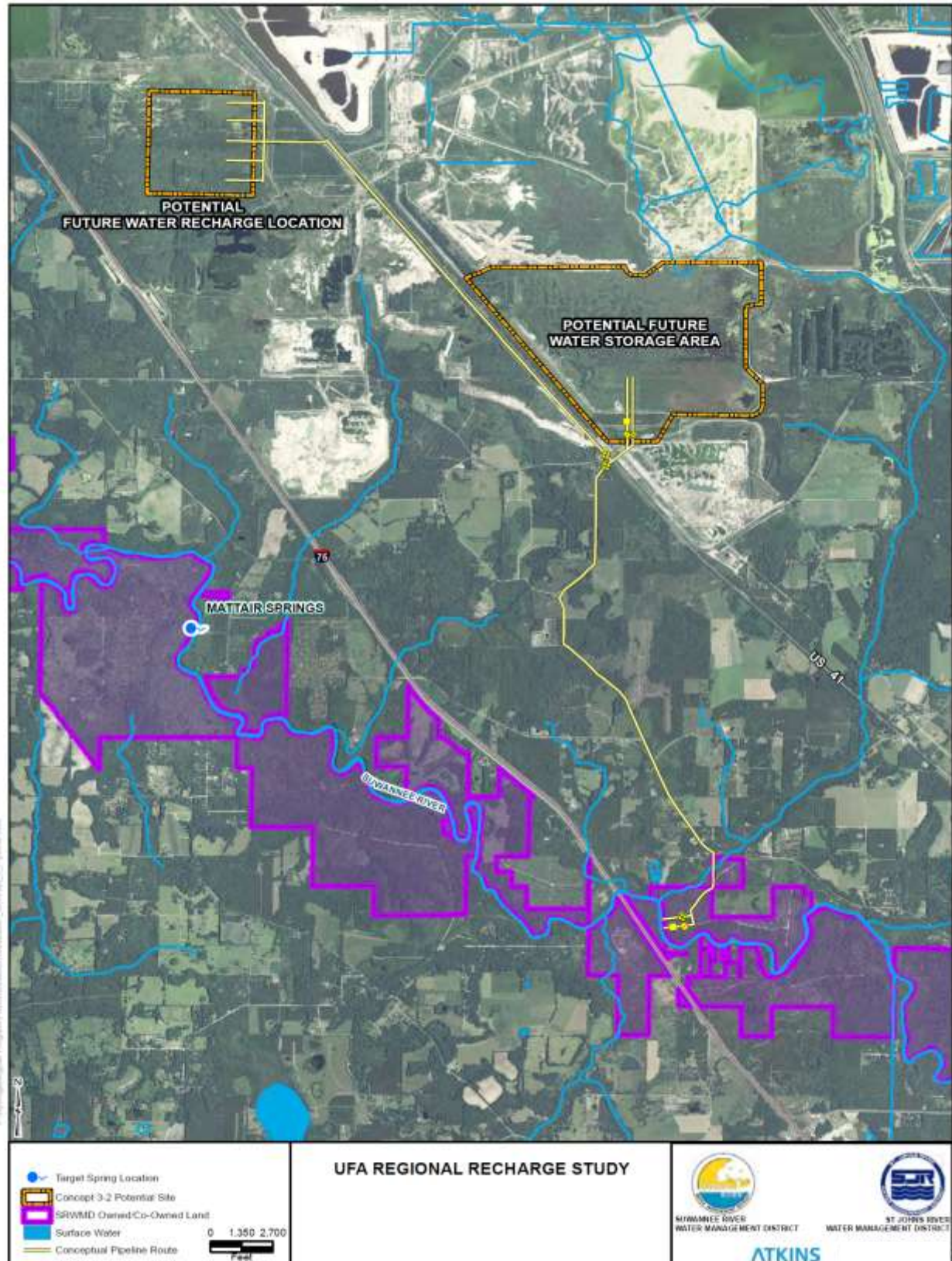


Figure 8-9: Concept 3-2 Conceptual Pipeline Route

Intake Structures (Suwannee River and Clay Settling Area Reservoir)

The conceptual design would consist of intake screens, intake piping, and a pump station. The conceptual design assumptions for the intake structure are outlined below:

- Assumed minimum available water depth at intake structure location is 8 feet,
- Assumed minimum width of the river at the intake structure location is 8 feet plus the width needed for navigation,
- The intake capacity is assumed to be 40 mgd or 28,000 gpm, and
- The velocities in the intake pipe and transmission main are assumed to be less than 5 fps. 5 fps is the maximum velocity that is typically recommended to minimize water hammer or surge pressure.

1. River and CSA Reservoir Intake Screens

The conceptual design for the water intake screens at the Suwannee River and CSA reservoir consists of tubular 48-inch diameter stainless steel wire screens manufactured in a tee configuration. For this project, it is assumed that the available depth at the intake structure is 8 feet since screen manufacturers typically recommend a minimum vertical clearance of a half diameter (i.e., 24-inches) from top and bottom. This prevents silt from being sucked from the bottom and vortexes being created from the top. If there is not sufficient depth, the river bed or CSA reservoir would require excavation or an intake channel outside of the existing river or reservoir bank would need to be constructed. In addition to vertical clearances, screen manufacturers may recommend horizontal clearances. For the purposes of this study, it is assumed that a horizontal clearance of 8 feet would be required. The actual number of screens and screen size may change based on the available water depth at the chosen intake location. Based on the intake screen capacity, three 48-inch screens would be needed for each location. Each screen would be approximately 15 to 16 feet in length, have a slot size of 0.125 inch, and would be constructed of Type 304 stainless steel with a design velocity less than 0.5 fps. A typical representation of an intake screen is shown in Appendix B.

2. Intake Pipe

The proposed material for the intake pipe from the intake screens to the pump station is ductile iron and installed by conventional trenching methods. To minimize impact to the shoreline and trees, directional drilling with high density polyethylene pipe may also be considered. Assuming a maximum velocity of 5.0 fps, a 48-inch ductile iron pipe would be needed. The actual length of the pipe has not yet been determined and would depend on the final locations of the intake screens and pump station.

3. Pump Station

The conceptual pump station design is based on a rectangular concrete structure that would contain three vertical turbine pumps equipped with VFDs. Under normal conditions, up to two of the pumps would be running and the third pump on standby. Based on the conceptual routing from the pump stations at Suwannee River and the CSA

reservoir, the pumps serving the Suwannee River would be 1,000 Hp, while the pumps at the CSA reservoir shall be 750 Hp. Each pump outlet piping would have a pressure gauge, control/isolation valve, check valve, and air valve. The check valve would need to be slow closing to mitigate water hammer. Water hammer is the momentary pressure surge inside a pipe caused by a sudden change of direction or velocity of the liquid in the pipe. Water hammer effects range from noise and vibration to pipe collapse and equipment damage. Medium voltage electrical power must be brought to the site to power the pumps and associated controls. A typical representation of a pump station is shown in Appendix B.

4. Transmission Main

Based on the conceptual routing in Figure 8-9, the pipe lengths needed are listed in Table 8-10. The conceptual design is based on ductile iron pipe with installation by conventional trenching. Assuming a maximum velocity of 5.0 fps, 48-inch ductile iron pipe would be needed for Segments 1 and 2. The transmission main would be restrained as required to support water hammer load and equipped with air valves at the high points and at long runs to protect the pipe from collapse due to vacuum conditions. The transmission main would be set up with valves and piping such that water from the CSA reservoir can either be pumped to the sand tailing filtration area or back to the Suwannee River. Based on previous project experience with similar sized pipes, it is assumed that temporary construction and permanent easements of 70 feet and 40 feet respectively would be required along the pipe route.

Table 8-10: Pipeline Lengths

Segment	Description	Design Flow (mgd)	Pipe Size (inches)	Length (miles)
1	Pump Station at Suwannee River to CSA Reservoir	40	48	6
2	CSA Reservoir to Sand Tailing Filtration Area	40	48	5

5. Water Storage

Clay Settling Area Reservoir

The chosen CSA has an area of approximately 1,375 acres. This CSA had been retired and taken out of service in 2009. Over the next 20 years, it is anticipated that the clay would consolidate (i.e. settle) to an ultimate elevation of around 20 feet below the dam crest. Assuming 10 feet of freeboard and 20 feet of total depth, the storage capacity of the CSA after long-term settlement would be approximately 4,480 MG. It should be noted that the amount of freeboard required (i.e., 10 feet) and total depth available (i.e., 20 feet) are only assumptions and will need to be determined during preliminary design.

Once the clay has been consolidated, the clay will form a crust on the surface that may support lightweight equipment for grading and contouring. Typically a soft, plastic, clay underlies the crust and it should be fairly impervious to water, which makes the CSA suitable for storing water (Ardaman & Associates, 2005).

The purpose of the CSA is to contain clay and not water. Therefore, its embankments are not designed for wave action that is commonly encountered with a water reservoir. In a 2005 report titled "Potential Technologies to Reduce or Replace Groundwater Consumption in the Southwest Florida Water Management District" (Ardaman & Associates, 2005), the following recommendations were suggested to convert a retired CSA to a water storage reservoir:

- The upper slope of the CSA will have to be rip-rapped to prevent erosion,
- An operating freeboard should be provided to prevent wave run-up from reaching the dam crest, and
- The existing outlet structures of the CSA should be properly abandoned and replaced with new outlet structures to provide an overflow spillway.

Determining whether these recommendations are applicable to the conceptual CSA of this project is beyond the scope of this study. If applicable, these recommendations should be addressed during the design phase of the project.

6. Sand Tailing Filtration and Aquifer Recharge

From the CSA, the water would be pumped to a sand tailing area for filtration and ultimately aquifer recharge. During periods of low river flow, the water may be pumped back to the upper Suwannee River for flow augmentation.

Chapter 62-610.523(3), F.A.C. states that the initial average annual hydraulic loading rate shall be limited to three inches per day or 1.9 gpd/ft² for RIBs, percolation cells, and absorption fields. Assuming this loading rate for the sand tailing filtration area, a total area of approximately 500 acres or 0.8 square miles is required to recharge up to 40 mgd. Site specific geotechnical and hydrological/water balance investigations should be conducted to verify the conceptual hydraulic loading rate assumption.

It is assumed that the water distribution within the sand tailing filtration area would be similar to that of a gravel trench absorption field for wastewater. The conceptual gravel trench is made up of a 24 to 36-inch wide by 18 to 24-inch deep trench containing approximately 12 inches of gravel. Embedded in the gravel is 6-inch perforated pipe to distribute the water throughout the trench. The pore space between the gravel allows the water to travel from the pipe through the trench and into the sand tailing. It is assumed that the trench centerline spacing is 10 feet which is typical for a gravel trench absorption field.

8.4 Recharge Concept 4

Recharge Concept 4 involves pumping up to 30 mgd from the Rodman Reservoir to Lake Brooklyn and Lake Geneva in Keystone Heights, Florida. Of the 30 mgd, up to 10 mgd would be directed to Lake Geneva where it would be treated prior to discharge. The remainder of the flow would be discharged to Lake Brooklyn. In this concept, raw water intake structures consisting of intake screens, intake piping, and a pump station would be installed at Rodman Reservoir. From the pump station, 48-inch transmission main piping would run approximately 26 miles in roadway and utility easements to the Lake Geneva water treatment plant connection point. From the connection point, 36-inch transmission main piping would run approximately 4 miles to Lake Brooklyn and 24-inch transmission main piping would run less than 0.5 mile to the proposed Lake Geneva water treatment plant. A conceptual pipeline route is shown in Figure 8-10 for Recharge Concept 4. It should be noted that this route is conceptual in nature, and a routing analysis will need to be conducted during the design phase to confirm the feasibility of this route.

Treatment of the surface water being discharged to Lake Geneva is required because Lake Geneva is impaired for lead. Conceptual treatment includes chemical conditioning, coagulation/flocculation, clarification/sedimentation, and filtration. It is assumed that surface water being discharged to Lake Brooklyn will not require treatment.

A conceptual treatment layout and schematic for Recharge Concept 4 are shown in Figures 8-11 and 8-12, respectively.

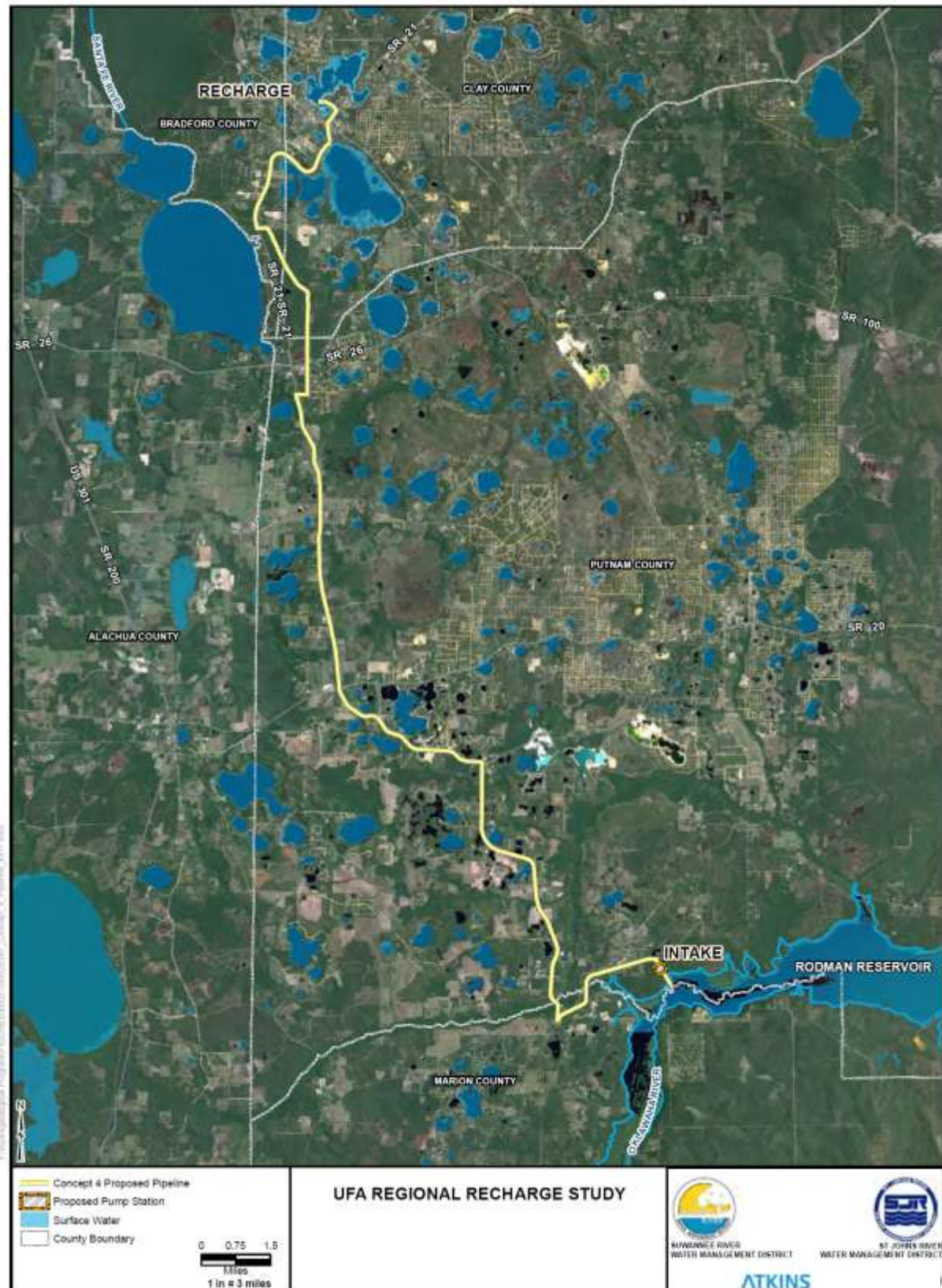


Figure 8-10: Concept 4 Conceptual Pipeline Route

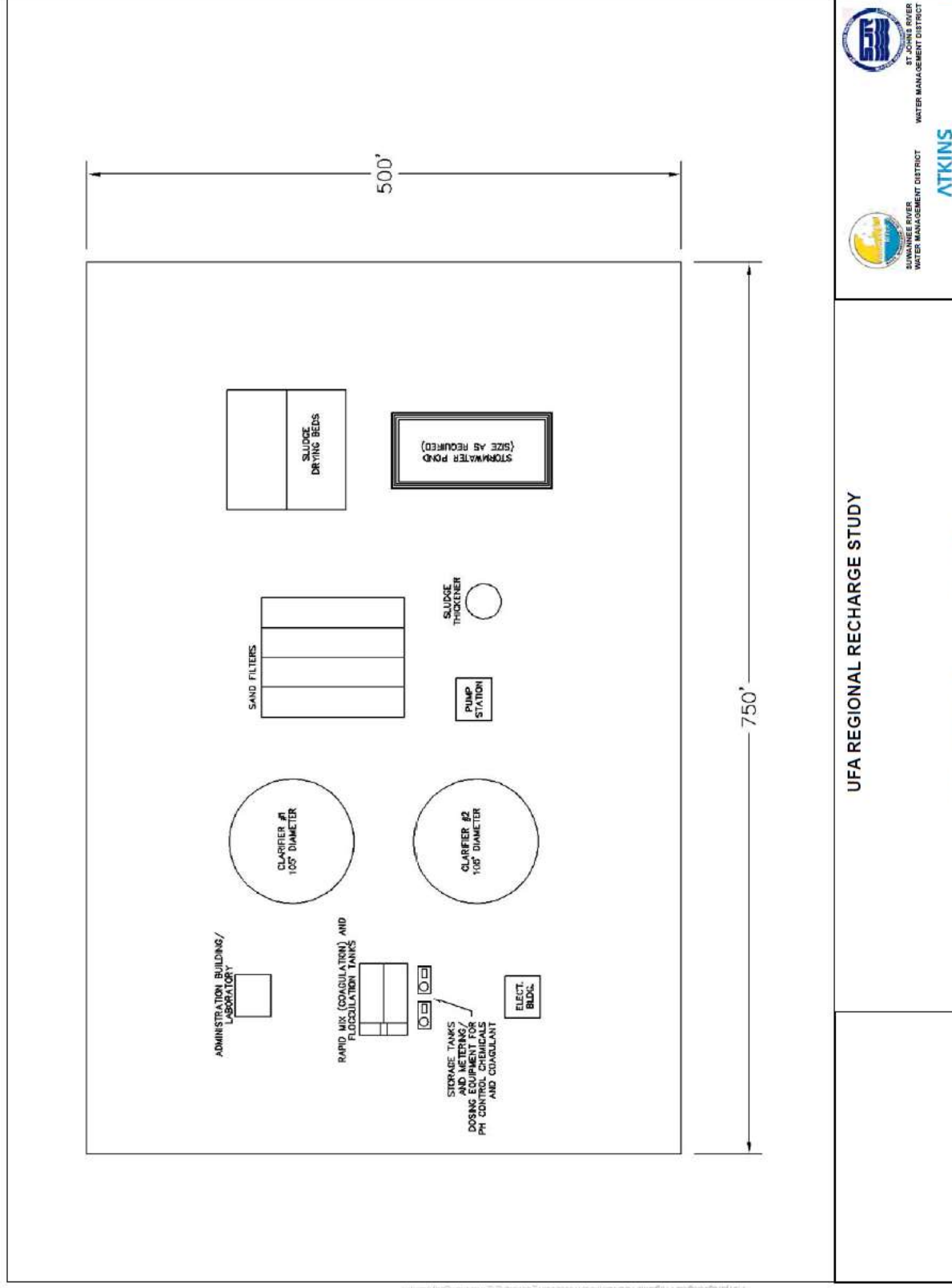


Figure 8-11: Concept 4 Proposed Treatment Layout Indirect Recharge at Lake Geneva

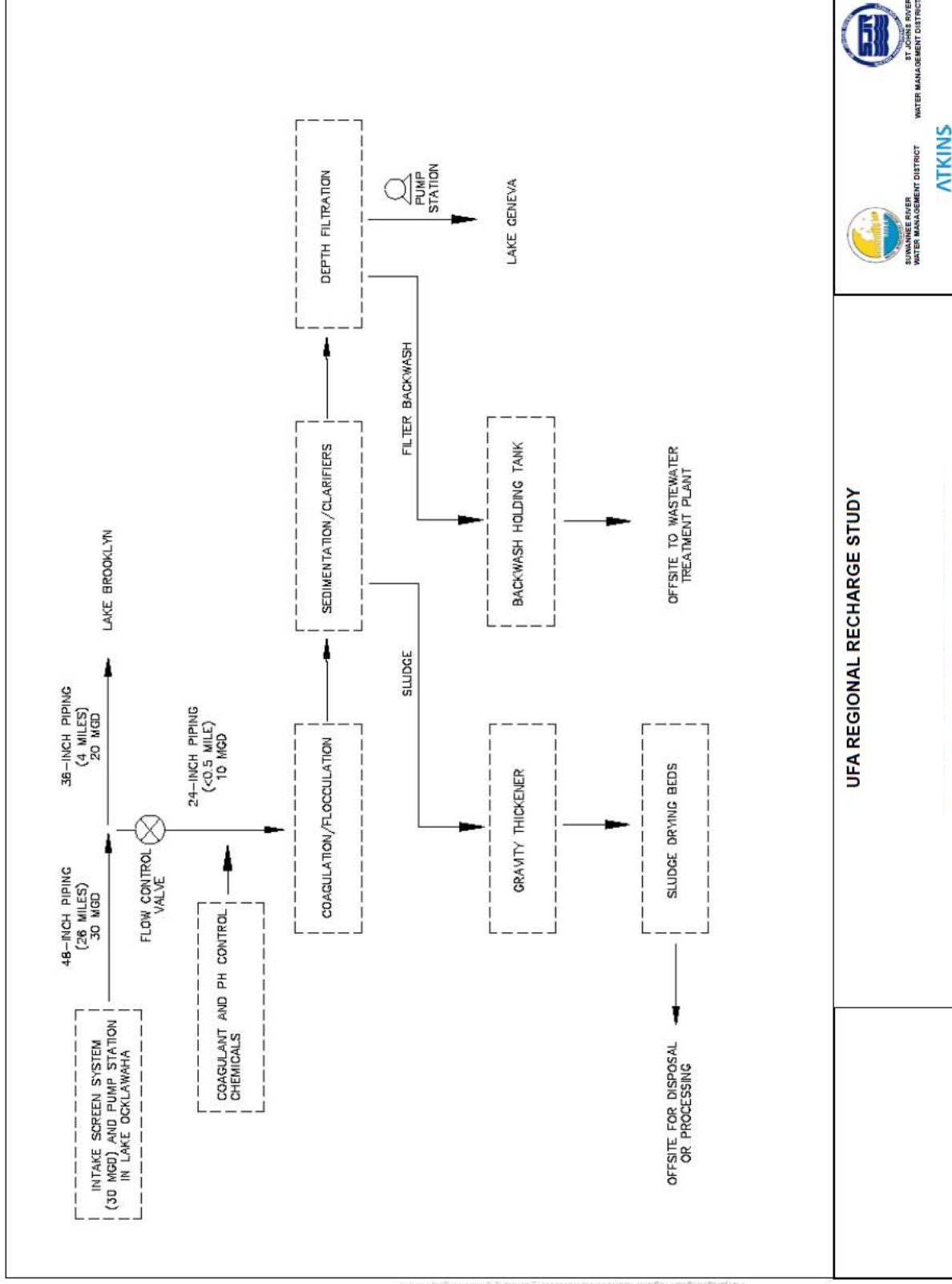


Figure 8-12: Concept 4 Proposed Treatment Schematic Indirect Recharge at Lake Geneva

8.4.1 Water Quality

The water from Lake Brooklyn and the Rodman Reservoir are not impaired, while Lake Geneva is impaired for lead. It is therefore assumed that water may not be pumped to Lake Geneva without treatment for lead. This assumption would need to be validated through additional data and evaluation that are beyond the scope of this study.

8.4.2 Raw Water Intake Structures

A bathymetric survey from a 1994 SJRWMD study titled “Environmental Studies Concerning Four Alternatives for Rodman Reservoir and the Lower Ocklawaha River” was used to identify the intake structure location. The location chosen provided the greatest depth for the intake structure. The conceptual raw water intake structure design would consist of intake screens, intake piping, and a pump station. The conceptual design assumptions for the intake structure are outlined below:

- Assumed minimum available water depth at intake structure location is 8 feet,
- Assumed minimum width of river at intake structure location is 8 feet plus the width needed for navigation,
- The intake capacity is assumed 30 mgd or 21,000 gpm, and
- The velocities in the intake pipe and transmission main are assumed to be less than 5 fps and 5 fps is the maximum velocity that is typically recommended to minimize water hammer or surge pressure.

1. River Intake Screens

The conceptual design for the water intake screens includes tubular 48-inch diameter stainless steel wire screens manufactured in a tee configuration. For this project, it is assumed that the available water depth at the intake structure is 8 feet since screen manufacturers typically recommend a minimum vertical clearance of a half diameter (i.e., 24-inches) from top and bottom. This prevents silt from being sucked from the lake bed and vortexes being created from the top. If there is not sufficient water depth, the lake bed would require excavation or an intake channel outside of the existing lake bank would need to be constructed. In addition to vertical clearances, screen manufacturers may recommend horizontal clearances. For the purposes of this study, it is assumed that a horizontal clearance of 8 feet would be required. The actual number of screens and screen size may change based on the available water depth at the chosen intake location. Based on the intake screen capacity, two 48-inch screens would be needed. Each screen would be approximately 15 to 16 feet in length, have a slot size of 0.125 inches, and would be constructed of Type 304 stainless steel with a design velocity of less than 0.5 fps. A typical representation of an intake screen is provided in Appendix B.

2. Intake Pipe

The intake pipe from the pump station to the intake screens is based on ductile iron pipe with installation by conventional trenching. To minimize impact to the

shoreline and trees, directional drilling with high density polyethylene pipe may also be considered. The conceptual design layout has each intake screen connected to a common header pipe which leads to the pump station. Assuming a maximum velocity of 5.0 fps, a 42-inch ductile iron pipe would be needed. The actual length of the pipe has not yet been determined and would depend on the final locations of the intake screens and pump station.

3. Pump Station

The conceptual pump station design is based on a rectangular concrete structure that would contain three vertical turbine pumps equipped with VFDs. Under normal conditions, up to two of the pumps would be running and the third pump on standby. Based on the conceptual routing from the pump station to Lake Brooklyn and Lake Geneva, each of the pumps would be 1,250 Hp. Each pump outlet piping would have a pressure gauge, control/isolation valve, check valve, and air valve. The check valve would need to be slow closing to mitigate water hammer. Water hammer is the momentary pressure surge inside a pipe caused by a sudden change of direction or velocity of the liquid in the pipe. Water hammer effects range from noise and vibration to pipe collapse and equipment damage. Medium voltage electrical power must be brought to the site to power the pumps and associated controls. A typical representation of a pump station is provided in Appendix B.

4. Transmission Main

Based on the conceptual routing in Figure 8-10, the following pipe lengths would be needed:

Table 8-11: Pipeline Lengths

Segment	Description	Design Flow (mgd)	Pipe Size (inches)	Length (miles)
1	Pump Station at Rodman Reservoir to Lake Geneva Water Treatment Plant connection point	30	48	26
2	Lake Geneva Water Treatment Plant connection point to Lake Brooklyn discharge	20	36	4
3	Lake Geneva service line connection point to Water Treatment Plant	10	24	< 0.5 mi

The conceptual design is based on ductile iron pipe with installation by conventional trenching. Assuming a maximum velocity of 5.0 fps, a 42-inch ductile iron pipe may be used for Segment 1. However, due to the length of the transmission main and to minimize friction losses, a 48-inch ductile iron pipe was selected. The conceptual sizes for Segments

2 and 3 are 36-inch and 24-inch, respectively. Segment 3 includes a flow control valve that would limit the flow to the water treatment plant at Lake Geneva to 10 mgd. The transmission main would be restrained as required to support water hammer load and equipped with air valves at the high points and at long runs to protect the pipe from collapse due to vacuum conditions. Based on previous project experience with similar sized pipes, it is assumed that the easements listed in Table 8-12 would be required.

Table 8-12: Easement Segments

Segment	Description	Temporary Easement (ft)	Permanent Easement (ft)
1	Pump Station at Rodman Reservoir to Lake Geneva Water Treatment Plant connection point	70	40
2	Lake Geneva Water Treatment Plant connection point to Lake Brooklyn discharge	60	35
3	Lake Geneva service line connection point to Water Treatment Plant	50	30

5. Water Treatment (10 mgd) – Lake Geneva Only

The following treatment processes would be required to treat the water prior to discharge to Lake Geneva:

pH Control

Lime is added to raise and maintain the pH of the water to between 5.5 and 7.5 which is the optimal pH for the coagulation/flocculation processes. If the pH is outside this range, the effectiveness of the coagulation/flocculation processes decreases and additional (excessive) coagulant would be required. The amount of lime to raise the pH to between 5.5 and 7.5 would depend on the initial source water alkalinity and pH. Determining this amount would require bench-scale testing of the source water and is beyond the scope of this study.

Coagulation/Flocculation

After the pH has been adjusted, a coagulant (such as aluminum sulfate) is injected and rapidly mixed with the water. The purpose of the coagulant is to cause colloidal particles to destabilize and form larger particles referred to as floc. Coagulation/flocculation results in the reduction of TSS, TOC, color, turbidity, algae, pathogens, *Cryptosporidium*, and heavy metals such as lead and iron. Sizing assumptions for the rapid mix tank and flocculation tank are shown in Table 8-13.

Table 8-13: Tank Sizing

Parameter	Rapid Mix Tank	Flocculation Tank
Detention Time (minutes)*	0.5	30
Required Volume (gallons)	3,500	21,000
Number of Tanks	1	2
Assumed Height (feet)	15	14.5
Area per Tank (feet ²)	31	968
Dimension of Each Tank	6 feet Long x 6 feet Wide	50 feet Long x 20 feet Wide

* Per Ten State Standards (2012) – Recommended Standards for Water Works.

Clarification/Sedimentation

Flocs that are formed are allowed to settle out and are removed from the water as residuals. The residuals are then thickened and dewatered prior to offsite disposal or processing. Sizing assumptions for the sedimentation clarifiers are shown in Table 8-14.

Table 8-14: Clarifier Sizing

Parameter	Sedimentation Clarifiers
Detention Time (hours)*	4
Required Volume (gal)	1,680,000
Number of Clarifiers	2
Assumed Height (ft)	14
Area per Clarifier (ft ²)	8,021
Required Diameter (ft)	105

* Per Ten State Standards (2012) – Recommended Standards for Water Works.

Deep Bed Filtration

The purpose of deep bed filtration is to further reduce the lead concentration in the water. The typical filtering medium is sand or anthracite with downward or upward flow through the media. Deep bed filtration equipment includes backwash facilities to flush out accumulated debris and particles from the filters. For the purposes of this study, it is assumed that the backwash water would be stored in a backwash holding tank which would be transported offsite to a WWTF. Sizing assumptions for the deep bed filters are shown in Table 8-15.

Table 8-15: Deep Bed Filter Sizing

Parameter	Deep Bed Filters
Design Flow Rate (mgd)	10
Design Flow Rate (gpm)	7,000
Filtration Rate (gpm/ft ²)*	2.0
Filtration Area Required (ft ²)	3,500
Area per Filter (ft ²)*	1,400
Number of Filters (duty)	3
Number of Filters (stand-by)*	1
Total Number of Filters	4

* Assumed

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9.0 PLANNING LEVEL COST ESTIMATES AND IMPLEMENTATION SCHEDULE

The purpose of this section is to develop planning level cost estimates (opinion of probable costs) for each of the four aquifer recharge concepts that were selected for this feasibility study. The four aquifer recharge concepts with some site specific information are as follows:

- Recharge Concept 1 – Treating up to 30 mgd of reclaimed water from the Buckman WWTF and 10 mgd from the Southwest WWTF and discharging the effluent to aquifer recharge wells within the respective WWTF property,
- Recharge Concept 2 – Pumping a maximum daily capacity of 40 mgd from Suwannee River to SJRWMD owned land in Falling Creek Falls Park where it will be treated and discharged to aquifer recharge wells,
- Recharge Concept 3 – Pumping up to a maximum daily capacity of 40 mgd from the upper Suwannee River to a CSA reservoir for storage. From the CSA, the water would be pumped either to a phosphate mining sand tailing area for filtration and ultimately aquifer recharge or back to the upper Suwannee River to augment low flows, and
- Recharge Concept 4 – Pumping up to 30 mgd from the Rodman Reservoir to Lake Brooklyn and Lake Geneva in Keystone Heights, Florida. Up to 10 mgd would be directed to Lake Geneva where it would be treated prior to recharge. The remaining 20 mgd would be directed to Lake Brooklyn without the need for treatment prior to recharge.

9.1 Methods

Cost estimates for each of the four aquifer recharge concepts are broken down to capital costs, annual operating and maintenance (O&M) cost, and annual project cost. Capital costs includes (1) construction costs such as infrastructure and equipment for the various treatment processes, well drilling, and site work, (2) non-construction costs such as engineering, permitting, and administration, and (3) land costs if required. O&M costs include costs associated in operation, maintenance, repair, and replacement of the equipment. Annual project cost provides an annualized cost (capital and O&M) over 20 years and a production cost per 1,000 gallons.

As directed by the Districts, Special Publication SJ2008-SP10 (*Engineering Assistance in Updating Information on Water Supply and Reuse System Component Costs, May 2008*), was used as an aid in the development of the opinion of probable cost (OPC) for the four aquifer recharge concepts. The publication addressed planning level construction and maintenance costs and included line item cost for specific components typically within the water supply infrastructure and treatment process systems and percentage of construction costs for items such as yard piping, site work, and construction markup.

Through the development of the OPC, other costing references were used because some components of the aquifer recharge concepts were not covered under Special Publication SJ2008-SP10. These references and the components covered include:

Table 9-1: Opinion of Probable Costs References

Reference	Component Covered
Special Publication SJ2010-SP4 (<i>Cost Estimating and Economic Criteria for 2010 District Water Supply Plan, September 2009</i>)	- Land Costs (per acre) - \$48,000 Residential, \$12,500 Rural - Land Acquisition Cost – 18% of land value - Pipeline Right-of-Way (ROW) Corridor Costs \$0.50 per square foot – Rural and \$1.00 per square foot – Suburban
Special Publication SJ2008-SP13 (<i>Water Supply Facilities Cost Equations for Application to Alternative Water Supply Projects Investigations and Regional Water Supply Planning, June 2008</i>)	Construction ROW Width – 30 feet for 24 inch pipe and 65 feet for 30 inch and larger pipe
Palmetto Class V ASR Test Well Pumping and Treatment System Bid Tabulation (April 2013) – Average of Contractor Estimates	- Sodium Bisulfite Deoxygenation System - \$59,615 per million gallons treated - UV electrical cost - \$18,396 per million gallons treated - Aquifer recharge well cost (\$1.0M – \$1.5M per well, depending on well depth)
Ardaman & Associates, Inc. 2005. <i>Potential Technologies to Reduce or Replace Groundwater Consumption in the Southwest Florida Water Management District.</i>	- CSA modification costs (\$4,000 per acre) - Non-Construction Capital Costs (45% of construction cost)
Engineering Judgment	Tailing sand piping cost (\$15,000 per acre)

**All costs shown are based on the year the reference was published. Engineering judgment cost is based on 2013 dollars.*

9.1.1 Cost Index

Engineering News Record (ENR) publishes a Construction Cost Index (CCI) that can be used to convert costs to a common-time basis. The cost indexes used to calculate the escalation rate are as follows:

Table 9-2: Cost Indexes Used to Calculate Construction Cost Index

Reference	Cost Index	Escalation Rate to 2013
Special Publication SJ2008-SP10	8005	119.33%
Special Publication SJ2010-SP4	8566	111.51%
Palmetto Class V ASR Test Well Pumping and Treatment System Bid Tabulation	9552	100.00%
Ardaman & Associates, Inc.	7446	128.28%

9.1.2 Discount Rate

The Water Resources Planning Act (1965) and the Water Resources Development Act (1974) require an annual determination of a discount rate for federal water resources planning. The current rate (fiscal year 2013) is 3.75 percent. This rate shall be used for all economic calculations in this document.

9.1.3 Economic Service Life

The following economic service life for the various water supply system components used for this document were adopted from Special Publication SJ2010-SP4 (*Cost Estimating and Economic Criteria for 2010 District Water Supply Plan, September 2009*) and are summarized below:

Table 9-3: Economic Service Life for Water Supply System Components

Component Type	Service Life (Years)
Water Conveyance Structures (pipelines, collection, and transmission systems)	40
Other Structures (buildings, tankage, site improvements, etc.)	35
Wells	30
Process and Auxiliary Equipment (treatment equipment, pump motors, mechanical equipment, etc.)	20

For the purpose of this document, a service life of 20 years was assumed. It is also assumed that the residual value of the components after the service life is zero.

9.1.4 Electrical Costs

Using electrical consumption data from two UV manufacturers that were obtained for a previous project, UV electrical cost is estimated to be \$18,396 per MGs treated. Electrical cost calculations were performed for the transfer pump station and high service pump station based on the following:

Table 9-4: Electrical Cost Calculations

	Transfer Pump Station	High Service Pump Station and Surface Water Pump Station
Total Dynamic Head (feet)	20	200
Overall Efficiency (%)	65	65
Electrical Cost (\$/kWh)	0.10	0.10

Based on these assumptions, it was calculated that the electrical cost per mgd per year for the transfer pump station and high service pump station are \$3,571 and \$35,710, respectively. Lastly, it was assumed that electrical costs from other processes or areas such as chemical metering pumps, chemical building, and operations building are not significant and could be included the contingency cost.

9.1.5 Other Assumptions

Other assumptions in developing the OPC include:

- Each treatment facility would have 2 operators and 2 maintenance personnel per shift, with three shifts a day, 7 days a week, 365 days a year. Hourly cost for the operators and maintenance personnel were based on what is stated in Special Publication SJ2008-SP10 adjusted to 2013 dollars,
- Contingency, which includes the cost of chemicals, miscellaneous electrical, water quality testing/monitoring, accounts for 30% of the annual O&M costs,
- O&M costs of the recharge wells are similar to that of ASR wells listed in Special Publication SJ2008-SP10,
- O&M costs for the CSA and sand tailing filtration area are similar to that of RIBS listed in Special Publication SJ2008-SP10. An equation based on the RIBS O&M costs was generated to extrapolate the O&M costs of the CSA and sand tailing filtration area, and
- Based on initial discussions with Potash Corporation of Saskatchewan Inc. (PCS), there are no land costs associated with the CSA and sand tailing filtration area.

9.1.6 Summary of Opinion of Probable Cost

Based on the methodology and assumptions previously described, OPCs were developed for each of the Aquifer Recharge Options. A summary of OPCs is presented below. A detailed breakdown of the OPCs is attached in Appendix C.

Table 9-5: Opinion of Probable Cost Summary

Aquifer Recharge Concept	Total Capital Cost	Annual O&M Cost	Annualized Capital Cost (20 years @ 3.75%)	Total Unit Production Cost (\$/1000 gallons)*
1	\$182,455,391	\$7,872,007	\$21,001,880	\$1.44
2	\$303,823,830	\$7,766,829	\$29,630,629	\$2.03
3	\$173,693,169	\$7,105,458	\$19,604,783	\$1.34
4	\$278,972,563	\$3,915,766	\$23,991,217	\$2.19

*Total unit production costs assumed design flow, 24 hours/day, 365 days/year.

9.2 Recharge Concept Implementation Schedules

A considerable length of time will be required to implement an aquifer recharge project from start to finish. Following completion of this feasibility study, five primary project phases remain to be completed:

- Preliminary Design,
- Final Design,
- Construction and Pilot Testing,
- Operational Testing and Permitting, and
- System Expansion.

The preliminary design phase consists of obtaining the construction-based permits required to build the aquifer recharge concept system, and collection of site specific data and bench scale testing to confirm the suitability of selected aquifer recharge sites and prepare the preliminary engineering design with updated engineering costs.

The final design phase consists of preparing technical specifications that provide the details required to construct the aquifer recharge system components according to permit conditions and to the owner's requirements. The technical specifications are used to solicit bids from potential contractors which result in the selection of a qualified contractor through a procurement process.

Construction and pilot testing is typically the longest phase duration involving large scale construction projects. The construction time period is highly variable and is dependent upon the work sequencing set forth in the technical specifications. Generally, aggressive construction schedules increase project costs; therefore, estimates of the construction time period provided at conceptual feasibility may be very different from those developed at final design. In most aquifer recharge well projects (direct recharge), the system infrastructure is built in phases in order to reduce owner's risk and in compliance with construction permitting. Successful construction and testing of a test recharge well system is required by regulatory agencies prior to construction and testing of the remaining recharge wells and associated infrastructure is completed as part of system expansion (as discussed below). Pilot testing is required in projects involving water treatment to demonstrate to the FDEP that the constructed treatment system is capable of producing water that meets the appropriate treatment requirement and DWS.

Operational testing involves a full scale operational demonstration that the constructed aquifer recharge test system is meeting construction permit testing requirements. Typically, a comprehensive set of analytical operational (system flow and pressure) and water quality data is collected in order to assess if the aquifer recharge system is performing as intended and can be permitted for long-term operation without adverse impacts to the environment and other surrounding legal users.

System expansion, if necessary, is the final project phase performed to take the aquifer recharge project to build out. System expansion involves elements of the previous project phases including construction permitting, modifications to the final design based on knowledge gained from the operational testing of the recharge test well system, construction of the remainder of the aquifer recharge system which may include additional recharge wells, pumps, piping, and treatment system components.

Project implementation schedules for all four selected recharge concepts are presented in Table 9-6 through Table 9-9 and are based on Atkins' past experience with aquifer recharge and similar large scale construction projects. The timeline estimates for Recharge Concepts 1, 2 and 3 is 9 years and 8 years for Recharge Concept 4, which does not include the system expansion phase on the assumption that the system infrastructure is likely to be constructed as part of the initial test construction phase due to the absence of recharge wells and limited treatment and testing requirements. The similarity of the timeline estimates is a function of several factors that impact scheduling such as budget availability, permit and regulatory rule changes, contracting difficulties, work sequencing and contractor performance which can change significantly over the course of a 9-year project and are difficult to anticipate their impact at the feasibility stage. The implementation schedule includes the project costs needed annually in order to execute the five phases of the aquifer recharge project. The project costs include construction, non-construction, land, and O&M costs that were derived from the engineer's OPC.

Table 9-6: Recharge Concept 1-Implementation Schedule

	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7		Year 8		Year 9		TOTAL
Activity	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	
1) Preliminary Design (1.5 years)																			
Construction Permitting																			
Site Specific Data																			
Bench Testing																			
2) Final Design (1 year)																			
3) Construction and Pilot Testing (3 years)																			
4) Operational Testing & Permitting (2 years)																			
5) System Expansion (1.5 years)																			
CONSTRUCTION COSTS	\$		\$	-	\$15,464,985	\$30,929,969	\$30,929,969	\$15,464,985	\$30,929,969	\$30,929,969	\$15,464,985	\$	-	\$	\$4,680,000	\$9,360,000	\$106,829,908		
NON-CONSTRUCTION COSTS	\$341,495		\$5,341,495	\$5,341,495	\$5,341,495	\$5,341,495	\$5,341,495	\$5,341,495	\$5,341,495	\$5,341,495	\$5,341,495	\$5,341,495	\$5,341,495	\$5,341,495	\$5,341,495	\$5,341,495	\$48,073,458		
OPERATION AND MAINTENANCE	\$	-	\$	-	\$	-	\$	-	\$	-	\$3,936,004	\$7,872,007	\$7,872,007	\$7,872,007	\$7,872,007	\$7,872,007	\$27,552,025		
LAND COSTS	\$	-	\$	-	\$	-	\$	-	\$	-	\$	-	\$	-	\$	-	\$	-	
TOTAL COSTS	\$5,341,495		\$5,341,495	\$5,341,495	\$20,806,480	\$36,271,465	\$36,271,465	\$20,806,480	\$36,271,465	\$36,271,465	\$24,742,483	\$13,213,502	\$17,893,502	\$22,573,502	\$17,893,502	\$22,573,502	\$182,455,391		

Table 9-7: Recharge Concept 2-Implementation Schedule

Activity	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7		Year 8		Year 9		TOTAL
	Sep - Feb	Mar- Aug	Sep - Feb	Mar- Aug	Sep - Feb	Mar- Aug	Sep - Feb	Mar- Aug	Sep - Feb	Mar- Aug	Sep - Feb	Mar- Aug	Sep - Feb	Mar- Aug	Sep - Feb	Mar- Aug	Sep - Feb	Mar- Aug	
1) Preliminary Design (1.5 years)																			
Construction Permitting																			
Site Specific Data																			
Bench Testing																			
2) Final Design (1 year)																			
3) Construction and Pilot Testing (3 years)																			
4) Operational Testing & Permitting (2 years)																			
5) System Expansion (1.5 years)																			
CONSTRUCTION COSTS	\$		\$		\$30,237,693		\$60,475,386		\$60,475,386		\$30,237,693		\$		\$3,120,000		\$6,240,000		\$190,786,157
NON-CONSTRUCTION COSTS	\$ 9,539,308		\$ 9,539,308		\$ 9,539,308		\$ 9,539,308		\$ 9,539,308		\$ 9,539,308		\$ 9,539,308		\$ 9,539,308		\$ 9,539,308		\$ 85,853,771
OPERATION AND MAINTENANCE	\$ -		\$ -		\$ -		\$ -		\$ -		\$ 3,883,415		\$7,766,829		\$7,766,829		\$7,766,829		\$27,183,902
LAND COSTS	\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -
TOTAL COSTS	\$9,539,308		\$9,539,308		\$39,777,001		\$70,014,694		\$70,014,694		\$43,660,415		\$17,306,137		\$ 20,426,137		\$ 23,546,137		\$303,823,830

Table 9-8: Recharge Concept 3-Implementation Schedule

Activity	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7		Year 8		Year 9		TOTAL
	Sep - Feb	Mar - Aug	Sep - Feb	Mar - Aug	Sep - Feb	Mar - Aug	Sep - Feb	Mar - Aug	Sep - Feb	Mar - Aug	Sep - Feb	Mar - Aug	Sep - Feb	Mar - Aug	Sep - Feb	Mar - Aug	Sep - Feb	Mar - Aug	
1) Preliminary Design (1.5 years)																			
Construction Permitting																			
Site Specific Data																			
Bench Testing																			
2) Final Design (1 year)																			
3) Construction and Pilot Testing (3 years)																			
4) Operational Testing & Permitting (2 years)																			
5) System Expansion (1.5 years)																			
CONSTRUCTION COSTS	\$ -	\$ -	\$ -	\$ -	\$15,696,214	\$15,696,214	\$31,392,429	\$31,392,429	\$31,392,429	\$31,392,429	\$15,696,214	\$ -	\$ -	\$ -	\$2,820,000	\$2,820,000	\$5,640,000	\$5,640,000	\$102,637,286
NON-CONSTRUCTION COSTS	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$46,186,779
OPERATION AND MAINTENANCE	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$3,552,729	\$7,105,458	\$7,105,458	\$7,105,458	\$7,105,458	\$7,105,458	\$7,105,458	\$7,105,458	\$24,869,103
LAND COSTS	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
TOTAL COSTS	\$5,131,864	\$5,131,864	\$5,131,864	\$5,131,864	\$20,828,079	\$20,828,079	\$36,524,293	\$36,524,293	\$36,524,293	\$36,524,293	\$24,380,808	\$12,237,322	\$12,237,322	\$15,057,322	\$17,877,322	\$17,877,322	\$17,877,322	\$17,877,322	\$173,693,169

Table 9-9: Recharge Concept 4-Implementation Schedule

Activity	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7		Year 8		TOTAL
	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	Sep- Feb	Mar- Aug	
1) Preliminary Design (1.5 years)																	
Construction Permitting																	
Site Specific Data																	
Bench Testing																	
2) Final Design (1 year)																	
3) Construction and Pilot Testing (3.5 years)																	
4) Operational Testing & Permitting (2 years)																	
CONSTRUCTION COSTS	\$ -	\$ -	\$ -	\$ -	\$26,651,175	\$53,302,349	\$53,302,349	\$53,302,349	\$53,302,349	\$53,302,349	\$53,302,349	\$53,302,349	\$ -	\$ -	\$ -	\$ -	\$186,558,223
NON-CONSTRUCTION COSTS	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$83,951,200
OPERATION AND MAINTENANCE	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$7,831,533
LAND COSTS	\$ -	\$ -	\$ -	\$ -	\$631,607	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$631,607
TOTAL COSTS	\$10,493,900	\$10,493,900	\$10,493,900	\$10,493,900	\$37,776,682	\$63,796,249	\$63,796,249	\$63,796,249	\$63,796,249	\$63,796,249	\$63,796,249	\$63,796,249	\$14,409,666	\$14,409,666	\$14,409,666	\$14,409,666	\$278,972,563

10.0 SUMMARY

This project involved an evaluation of four different aquifer recharge concepts, including:

- Recharge Concept 1: the treatment of reclaimed water from northeast Florida for recharge into the UFA in the study area,
- Recharge Concept 2: the capture and storage of surface water from the upper Suwannee River for treatment and direct recharge into the UFA,
- Recharge Concept 3: the capture of flood waters within the floodplain along the upper Suwannee River for storage and indirect recharge into the UFA, and
- Recharge Concept 4: the capture and storage of surface water from within the SJRWMD for treatment and recharge into the UFA.

A total of 18 different potential aquifer recharge sites were initially assessed during this study based on these four recharge concepts. Under Recharge Concept 1, a total of four sites were assessed initially that met the available source water criteria of 10 mgd. Under Recharge Concept 2, a total of nine sites were initially evaluated based on site availability. Under Recharge Concept 3, a total of 10 sites were initially selected based on site availability. All of the sites included in the initial evaluation of Recharge Concept 2 were evaluated in Recharge Concept 3. In addition, PCS Phosphate land was included in the evaluation of Recharge Concept 3 due to their large land holdings within close proximity to the upper Suwannee River. A total of four initial surface water systems were evaluated within the SJRWMD area to address Recharge Concept 4.

These aquifer recharge concepts were evaluated for the following criteria:

- Site availability – Suitable land area is available for construction,
- Source water quality – The source water quality is acceptable for aquifer recharge with minimal treatment,
- Source water availability – The quantity of available source water is sufficient to justify implementation of the recharge concept,
- Appropriate hydrogeological conditions – The aquifer hydrogeological characteristics are suitable to support a successful aquifer recharge project,
- Site logistics – The site is suitable for construction of an aquifer recharge project, and
- Regional benefits to water resources – Implementation of an aquifer recharge project at the site will result in regional water resources benefits (an increase in the potentiometric surface of the UFA over a broad area).

Table 10-1 presents a summary of the recharge concepts and the initial evaluation based on the above criteria. An “X” placed in the appropriate category indicates that the referenced site beneficially met the stated criteria. Those sites selected for further evaluation are shown in the last column. Since Recharge Concept 1 resulted in both Buckman and Southwest WWTFs meeting the evaluation criteria, they were grouped together as a single concept for further evaluation.

Table 10-1: Recharge Concept Assessment Summary

RECHARGE CONCEPTS	SITE AVAILABILITY	SOURCE WATER QUALITY	SOURCE WATER AVAILABILITY	APPROPRIATE HYDROGEOLOGICAL CONDITIONS	SITE LOGISTICS	REGIONAL BENEFITS TO WATER RESOURCES	SELECTED FOR FURTHER EVALUATION
Recharge Concept 1							
Buckman WWTF	X	X	X	X	X		X
Southwest WWTF	X	X	X	X	X		X
<i>District II WWTF</i>		X		X			
<i>Arlington East WWTF</i>		X		X			
Recharge Concept 2							
Big Shoals	X	X			X		
<i>White Sulphur Springs (2-1)</i>	X	X	X		X		
Little Shoals	X	X			X		
Stephen Foster	X	X	X	X	X		
Woods Ferry	X	X	X	X			
Mattair Springs	X	X	X	X			
<i>Suwannee Springs (2-2)</i>	X	X	X	X			
Eleven Ponds	X	X	X		X		
Falling Creek Falls Park(2-3)	X	X	X	X	X	X	X
Recharge Concept 3							
Big Shoals	X	X			X		
White Sulphur Springs	X	X	X		X		
Little Shoals	X	X			X		
Stephen Foster	X	X	X	X			
Woods Ferry	X	X	X	X			
<i>Mattair Springs (3-3)</i>	X	X	X	X			
Suwannee Springs	X	X	X	X			
<i>Eleven Ponds (3-1)</i>	X	X	X		X		
PCS Phosphate Land (3-2)	X	X	X	X	X	X	X
Falling Creek Falls Park	X	X	X		X	X	
Recharge Concept 4							
St. Marys River	X	X		X	X		
Black Creek				X			
St. Johns River	X		X	X	X		
Ocklawaha River	X	X	X	X	X		X

The four recharge concepts that were selected for further evaluation are presented in Table 10-2. This table provides a summary of the issues that were identified and anticipated benefits that will be provided by each of the selected recharge concepts. The principle issues have been categorized and include:

- Regulatory: Rules and Permitting,
- Environmental: Source Availability and Modeling Results,
- Technical: Water Treatment, and
- Economics: Cost.

Within these principle issues, Atkins determined that each of the four selected recharge concepts provide regional benefits to the UFA, including an increase in river baseflow, spring flow, and/or an overall increase in the potentiometric surface of the UFA.

The purpose of the conceptual design phase is to establish basic engineering criteria for the selected aquifer recharge concepts. The engineering criteria are general in nature and derived from the information presented in this document (detailed in TM-2) and compiled under TM-1; as well as assumptions based on past project experience, published references, and accepted engineering principles). The conceptual engineering criteria in this document are not site-specific and are not to be used for actual design purposes. The next phase of work would include site-specific testing, and data collection and analysis as part of the preliminary design for aquifer recharge concepts deemed appropriate by the Districts.

Table 10-2: Recharge Concept Benefits and Issues/Constraints

SELECTED RECHARGE CONCEPT	REGULATORY : RULES AND PERMITS	ENVIRONMENTAL : SOURCE AVAILABILITY AND MODELING RESULTS	TECHNICAL : WATER TREATMENT	ECONOMICS : COST
1. BUCKMAN/ SOUTHWEST WWTF	• Recharge well permitting • Reclaimed water regulations • WWTF operating permit	• Available source water • Limited source water piping • Anticipated regional benefits to potentiometric surface	• Additional reclaimed water treatment required • Existing onsite infrastructure utilized	• Capital - \$182,455,391 • \$/1000 gal - \$1.44 • O&M - \$7,872,007
2. FALLING CREEK FALLS PARK	• Recharge well permitting • Surface water diversion permitting • Pipeline transmission permitting	• Available source water • Significant source water piping • Regional benefits to spring and river flow	• Significant engineering required • Significant water treatment required	• Capital - \$303,823,830 • \$/1000 gal - \$2.03 • O&M - \$7,766,829
3. PCS PHOSPHATE LAND	• Reservoir permitting • Surface water diversion permitting • Water quality regulations	• Available source water • Moderate source water piping • Regional benefits to spring and river flow	• Significant engineering required • No additional water treatment required	• Capital \$173,693,169 • \$/1000 gal - \$1.34 • O&M - \$7,105,458
4. OCKLAWAHA RIVER/RODMAN RESERVOIR	• Surface water diversion permitting • Water quality regulations • Pipeline transmission permitting	• Available source water • Significant source water piping • Anticipated regional benefits to potentiometric surface	• Significant engineering required • Minimal water treatment required	• Capital - \$278,972,563 • \$/1000 gal - \$2.19 • O&M - \$3,915,766

11.0 LIST OF ACRONYMS

ANN	Artificial Neural Network
ANSI	American National Standards Institute
APT	Aquifer Performance Test
ASR	Aquifer Storage and Recovery
BMAP	Basin Management Action Plan
cfs	Cubic Feet per Second
CBOD5	Carbonaceous Biochemical Oxygen Demand
CCI	Construction Cost Index
CFU	Colony forming units
CPU	Consumptive Use Permits
CSA	Clay Settling Area
CWA	Clean Water Act
Districts	Combined SJRWMD and SRWMD
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
DWS	Drinking Water Standards
EPA	United States Environmental Protection Agency
ENR	Engineering News Record
ERP	Environmental Resource Permit
F.A.C.	Florida Administrative Code
FAS	Floridan Aquifer System
FAVA	Florida Aquifer Vulnerability Assessment
FDEP	Florida Department of Environmental Protection
FEMA	Federal Emergency Management Agency
fps	Feet per Second
Ft	Feet
ft ²	Square feet
ft ² /day	Feet squared per day
GHB	General Head Boundary
GIS	Geographic Information System
gpm	Gallons Per Minute
GST	Ground Storage Tank
Hp	Horsepower
IAS	Intermediate Aquifer System
ICU	Intermediate Confining Unit
IWR	Impaired Water Rule

JEA	Jacksonville Electric Authority
LP	Low Pressure
LPHI	Low Pressure High Intensity
LT1ESWTR	Long-term 1 Enhanced Surface Water Treatment Rule
LT2ESWTR	Long-term 2 Enhanced Surface Water Treatment Rule
Max	Maximum
MegaModel	Simulation of Groundwater Flow in North Florida and South-Central Georgia
MF	Microfiltration
MFL	Minimum Flows and Levels
mgd	Million Gallons per Day
mg/L	Milligrams per Liter
MG	Million Gallons
Min	Minimum
mJ/cm ²	Milli-joule per centimeter square
mL	Milliliters
MP	Medium Pressure
MSL	Mean Sea Level
N	Nitrate-nitrogen
NFARI	North Florida Aquifer Replenishment Initiative
nm	Nano-meter
NNC	Numeric Nutrient Criteria
NPDES	National Pollutant Discharge Elimination System
NWRI	National Water Resource Institute
O&M	Operating and Maintenance
OPC	Opinion of Probable
PAC	Powdered Activated Carbon
PCS	PCS Phosphate
PVC	Poly Vinyl Chloride
RASA	Regional Aquifer System Analysis
RIB	Rapid Infiltration Basin
RMS	Root-mean-squared
RO	Reverse Osmosis
SAS	Surficial Aquifer System
SDI	Silt Density Index
SJRWMD	St. Johns River Water Management District
SR	State Road
SRWMD	Suwannee River Water Management District
STORET	U.S. Environmental Protection Agency Data Warehouse
SWFWMD	Southwest Florida Water Management District

SWTR	Surface Water Treatment Rule
T	Transmissivity
TDS	Total Dissolved Solids
TM	Technical Memorandum
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TOC	Total Organic Carbon
TOX	Total Organic Halogen
TP	Total Phosphorus
TSS	Total Suspended Solids
TSI	Trophic State Index
UF	ultrafiltration
UFA	Upper Floridan Aquifer
Ug/l	micrograms per liter
UIC	Underground Injection Control
USACE	U.S. Army Corps of Engineers+
USDW	underground sources of drinking water
USGS	United States Geological Survey
UV	Ultraviolet
VFD	Variable Frequency Drive
WQCE	Water Quality Criteria exemption
WWTF	Wastewater Treatment Facility

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12.0 REFERENCES

- American Membrane Technology Association (AMTA). 2012. Pretreatment for Membrane Processes.
http://www.amtaorg.com/wp-content/uploads/12_Pretreatment.pdf.
- Ardaman & Associates, Inc. 2005. Potential Technologies to Reduce or Replace Groundwater Consumption in the Southwest Florida Water Management District.
- Arthur, J.D., A.E Baker, J.R. Cichon, A.R. Wood, and A. Rudin. 2005. Florida Aquifer Vulnerability Assessment (FAVA): Contamination Potential of Florida's Principal Aquifer Systems: Florida Geological Survey.
- Bellino, J.C. 2011. Digital surfaces and hydrogeologic data for the Floridan aquifer system in Florida and in parts of Georgia, Alabama, and South Carolina: U.S. Geological Survey Data Series 584.
- Bollman P.E, Patrick. 2012. Closed Vessel UV for Municipal Wastewater (*PowerPoint Presentation*).
- CH2MHill, Inc. 2008. Lower St. Johns River Reuse and Treatment Project, Phase II: Combined East and West River Reuse Initiative Solutions.
- FDEP Chapter 62-302, Florida Administrative Code, Surface Water Quality Standards.
- FDEP Chapter 62-303, Florida Administrative Code, Identification of Impaired Surface Waters.
- FDEP Chapter 62-520, Florida Administrative Code, Ground Water Classes, Standards, and Exemptions.
- FDEP Chapter 62-528, Florida Administrative Code, Underground Injection Control.
- FDEP Chapter 62-600, Florida Administrative Code, Domestic Wastewater Facilities.
- FDEP Chapter 62-610, Florida Administrative Code, Reuse of Reclaimed Water and Land Application.
- FDEP. 2012. IWR WBID Run46 database. Watershed Assessment Program.
<http://www.dep.state.fl.us/water/basin411/download.htm>. August 2012.
- Florida Geological Survey. 1992. Special Publication No. 34. Florida's Ground Water Quality Monitoring Program Background Hydrogeochemistry.
- Hornsby, D., R. Ceryak, and W. Zwanka. 2002. Groundwater Quality Annual Report. Suwannee River Water Management District, Live Oak, Florida, WR-01-02-05, 47 pp.

- IFC (Instream Flow Council). 2004. Instream Flows for Riverine Resource Stewardship. Instream Flow Council. 411 pp.
- Katz, B.G., H. D. Hornsby, J.F. Bohlke, and M.F. Mokray. 1999. Sources and chronology of nitrate contamination in spring waters, Suwannee River basin, Florida. USGS Water Resources Investigation Report 99-4252.
- Lee B., Jones D., Bourke C. 2004. Gravel and Gravelless Trench Soil Absorption Fields. Retrieved from <http://www.extension.purdue.edu/extmedia/henv/henv-8-w.pdf>.
- Macesich Milena, Martinez, Nettie, Martinez, Mark, Graszos, Frank Rupert, and White, Ron. 1992. Mines and quarries greater than 10 acres in size in the Suwannee River Water Management District, Florida Geologic Survey, Open File Map Series, No.1.
- Metcalf & Eddy, G. Tchobanoglous, F. L. Burton and H. D. Stensel. 2003. Wastewater Engineering, Treatment and Reuse, Fourth Edition, McGraw Hill Education.
- Miller, J.A. 1986. Hydrogeologic Framework of the Floridan Aquifer System in Florida and in Parts of Georgia, Alabama, and South Carolina: U.S. Geological Survey Professional Paper 1403-B.
- MWH. 2009. Feasibility of Using Reclaimed Water for Aquifer Recharge, prepared for the Southwest Florida Water Management District, March 2009.
- National Water Research Institute (NWRI). 2012. Ultraviolet Disinfection – Guidelines for Drinking Water and Water Reuse (Third Edition).
- PCS Phosphate. 2012. Dorr Oliver Cooling Pond, Closure Permit Application, File Number 11-0107.
- Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. *Conservation Biology* 10: 1163-1174.
- Richter, B.D., M.M. Davis, C. Apse, and C. Konrad. 2011. A presumptive standard for environmental flow protection. *River Res. Applic.* (wileyonlinelibrary.com) DOI:10.1002/rra1511.
- Schneider, J.W., S.B. Upchurch, J. Chen, and C. Cain. 2008. Simulation of Groundwater Flow in North Florida and South-Central Georgia, a 3-Dimensional Model of Groundwater Flow in the Surficial, Intermediate, and Floridan Aquifer Systems: SDII Global, Inc., Prepared for the SRWMD.
- Schreuder, Inc. 2012. Feasibility of Natural Treatment and Recharge of Wastewater and Surface Waters using Mined Phosphate Lands.

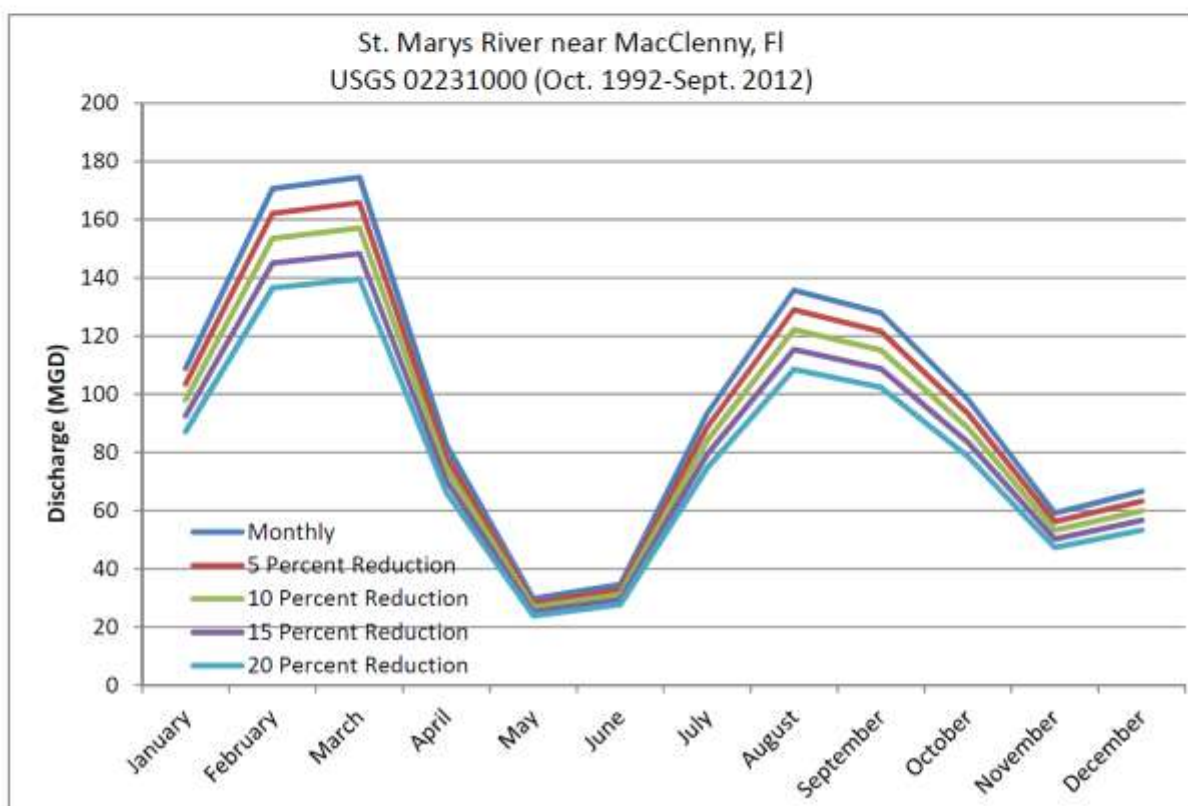
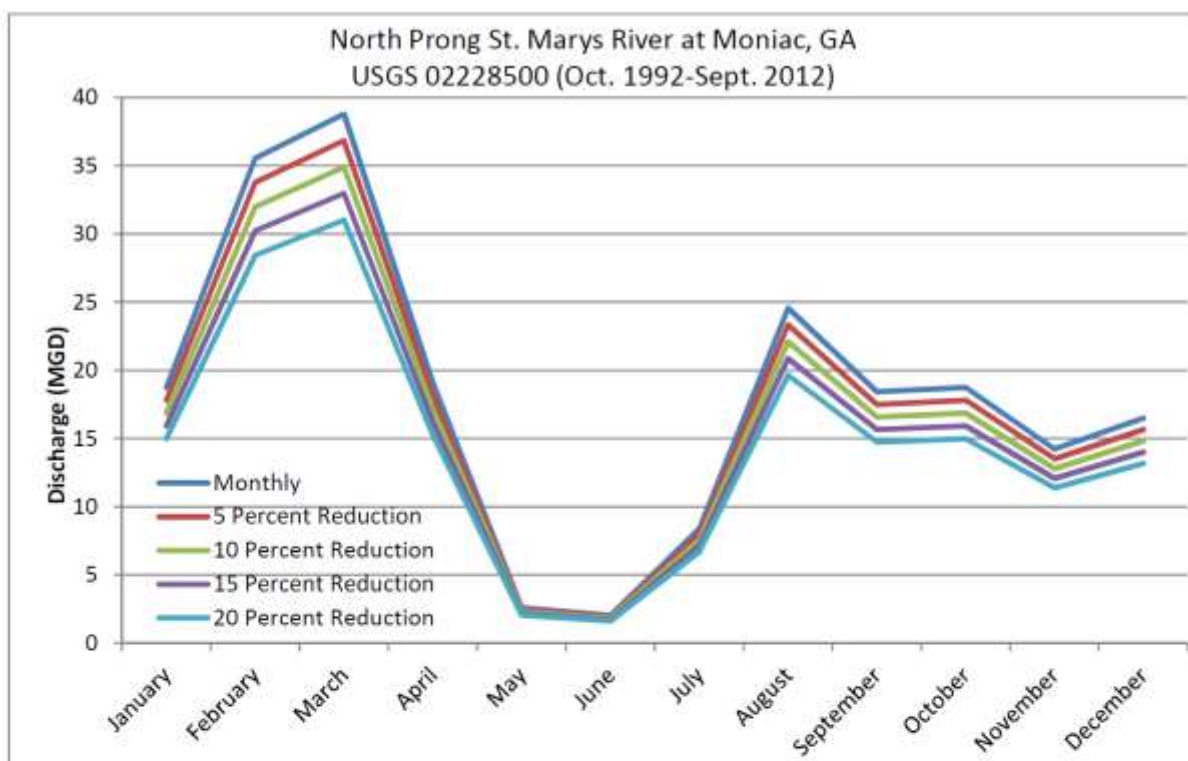
- Scott, Tom. 1993. Geologic Map of Columbia County, Open File Map Series, #32, Florida Geological Survey.
- Scott, Tom. 1993. Geologic Map of Hamilton County, Open File Map Series, #37, Florida Geological Survey.
- Sepúlveda, Nicasio, 2002, Simulation of Ground-Water Flow in the Intermediate and Floridan Aquifer Systems in Peninsular Florida, U. S. Geological Survey Water Resource Investigations Report 02-4009, Prepared in cooperation with the South Florida Water Management District and St. Johns River Water Management District.
- SJRWMD. 1994. Environmental Studies Concerning Four Alternatives for Rodman Reservoir and the Lower Ocklawaha River.
- SJRWMD. 2012. Assessment of State Water Quality Standards: Proposed Augmentation of Lake Brooklyn with Lower Florida Aquifer Water.
ftp://ftp.sjrwmd.com/wsm/MFLs/PRStrategies/ClayPutnam/InterimMeasuresSubcomm/IMSubcomm_062112
- Ten State Standards (2012) – Recommended Standards for Water Works
- Ten State Standards (2004) – Recommended Standards for Wastewater Facilities
- United States Environmental Protection Agency. 2012. Enforcement & Compliance History Online (ECHO). http://www.epa-echo.gov/echo/compliance_report_water_icp.html.
- United States Environmental Protection Agency. 2002. Long Term 1 Enhanced Surface Water Treatment Rule.
<http://water.epa.gov/lawsregs/rulesregs/sdwa/mdbp/lt1/lt1eswtr.cfm>.
- United States Environmental Protection Agency. 2010. Long Term 2 Enhanced Surface Water Treatment Rule.
<http://water.epa.gov/lawsregs/rulesregs/sdwa/lt2/basicinformation.cfm>.
- United States Environmental Protection Agency. 1989. Surface Water Treatment Rule.
<http://water.epa.gov/lawsregs/rulesregs/sdwa/lt2/basicinformation.cfm>.

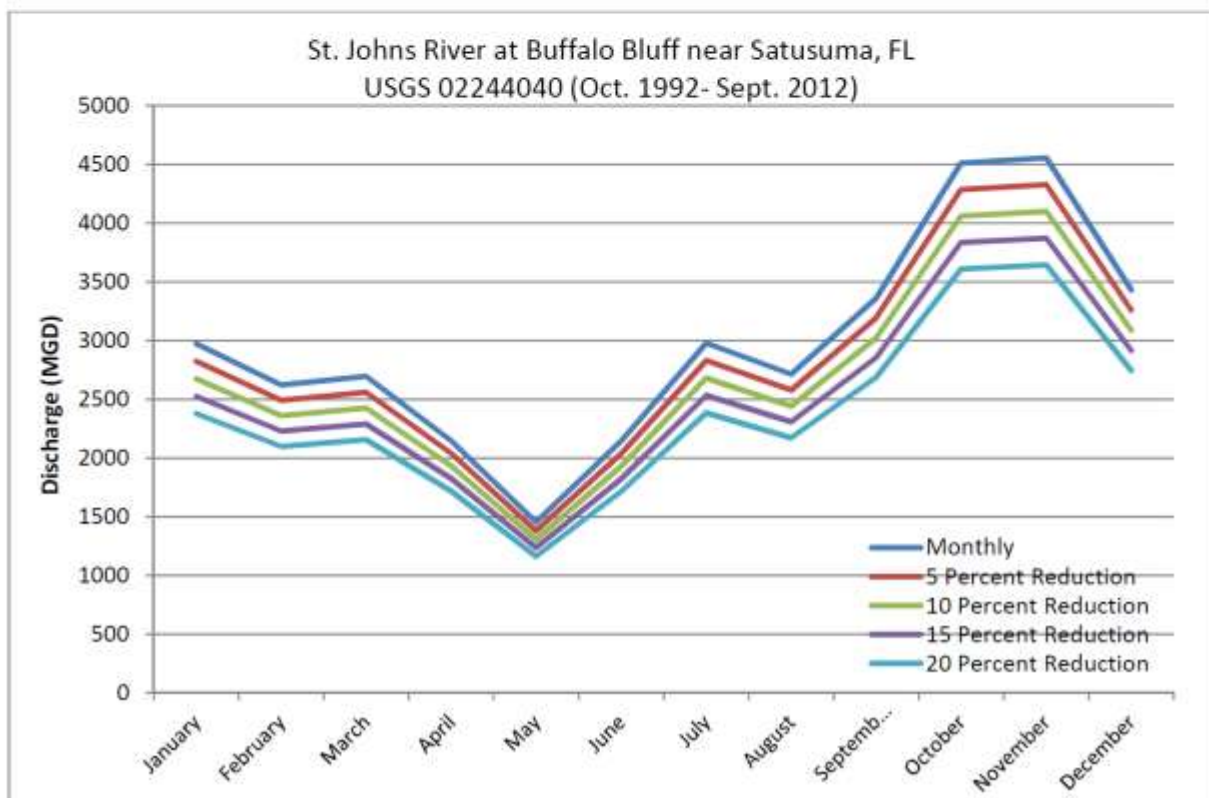
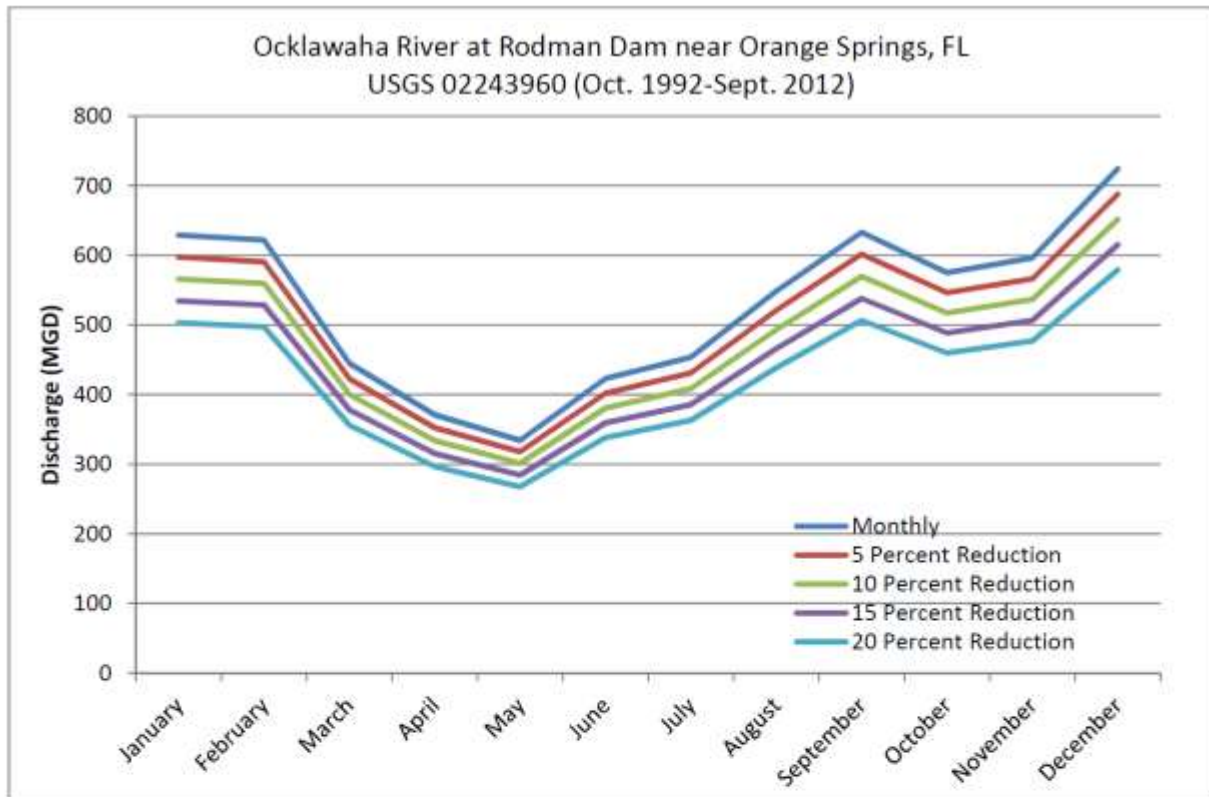
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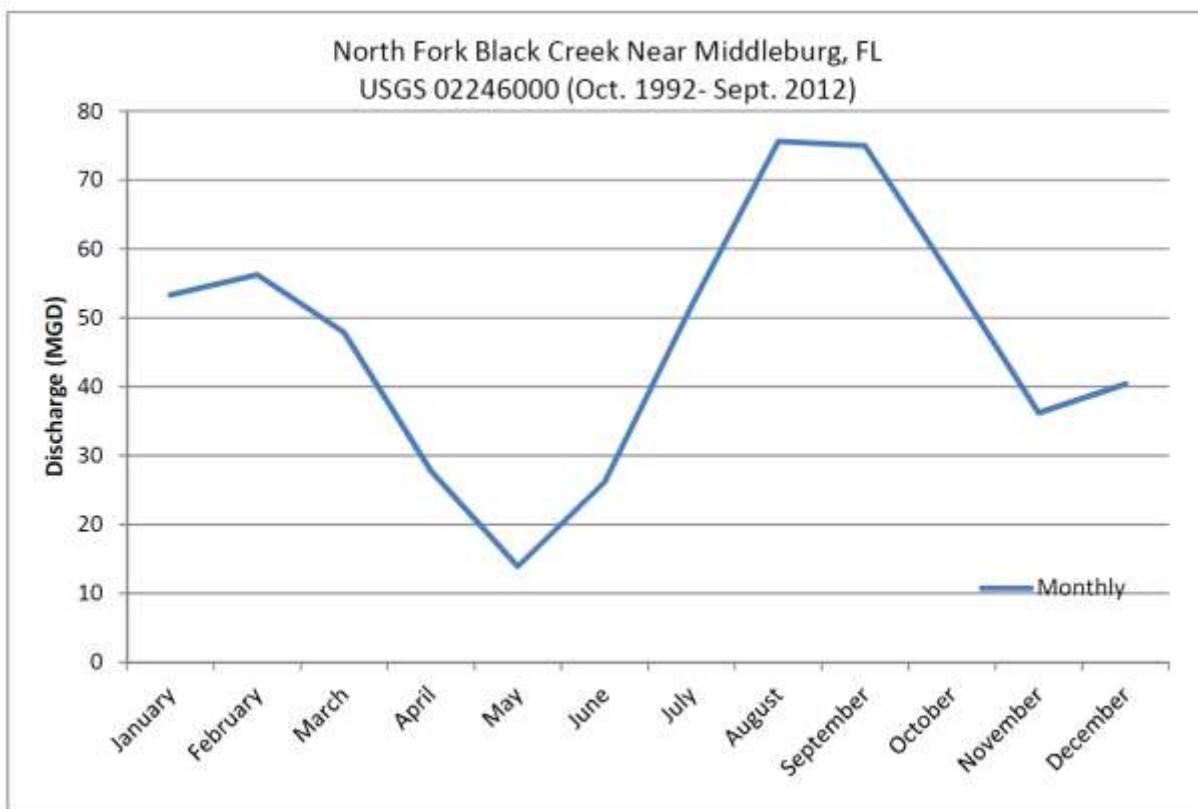
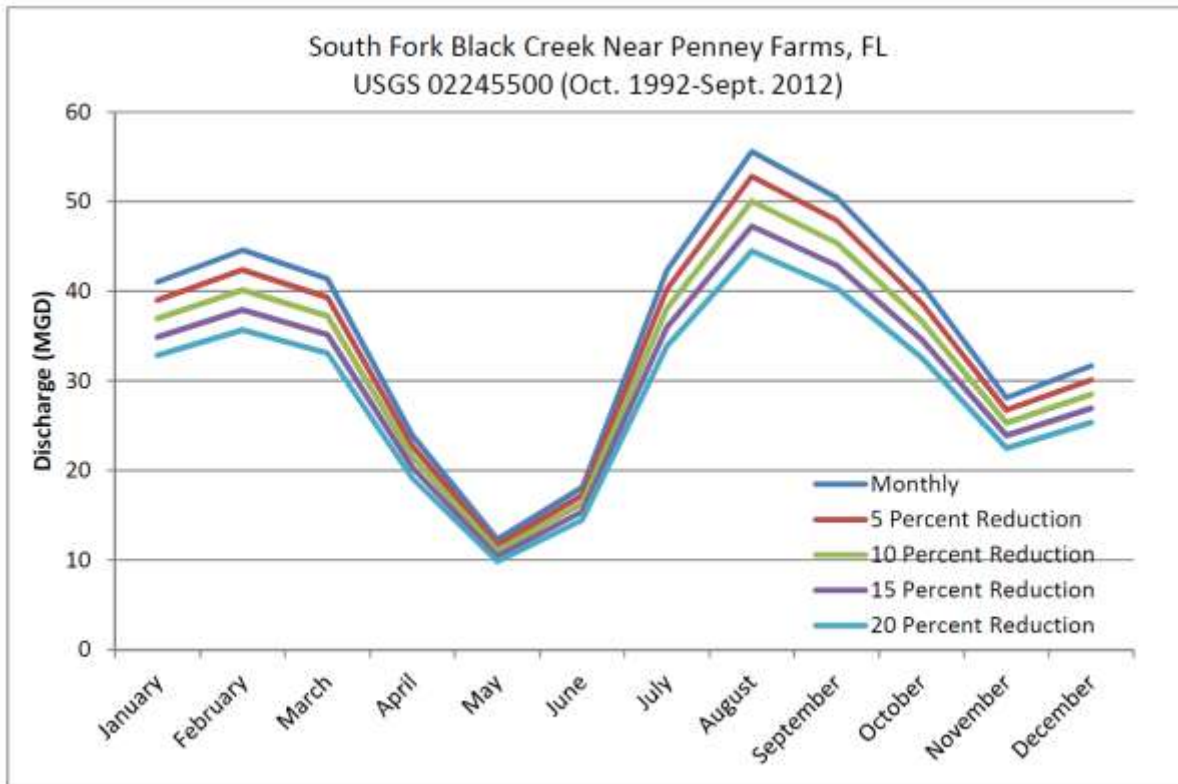
Appendix A

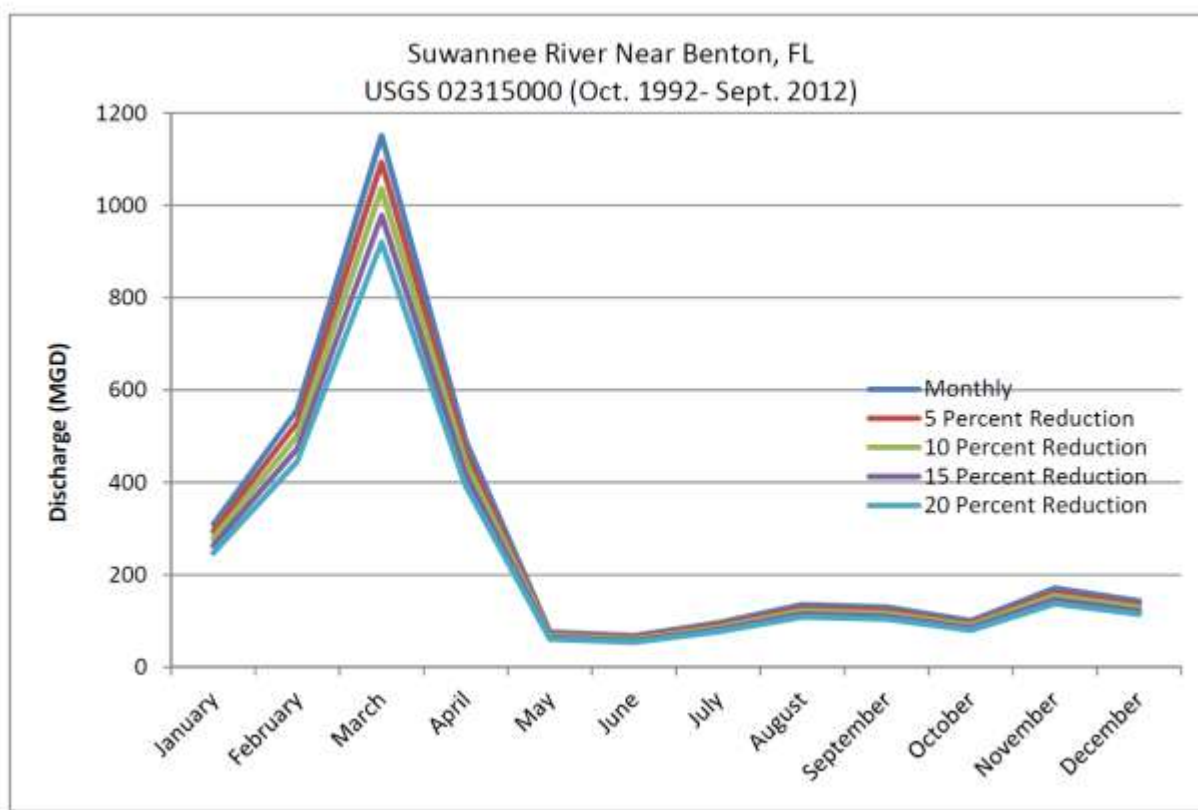
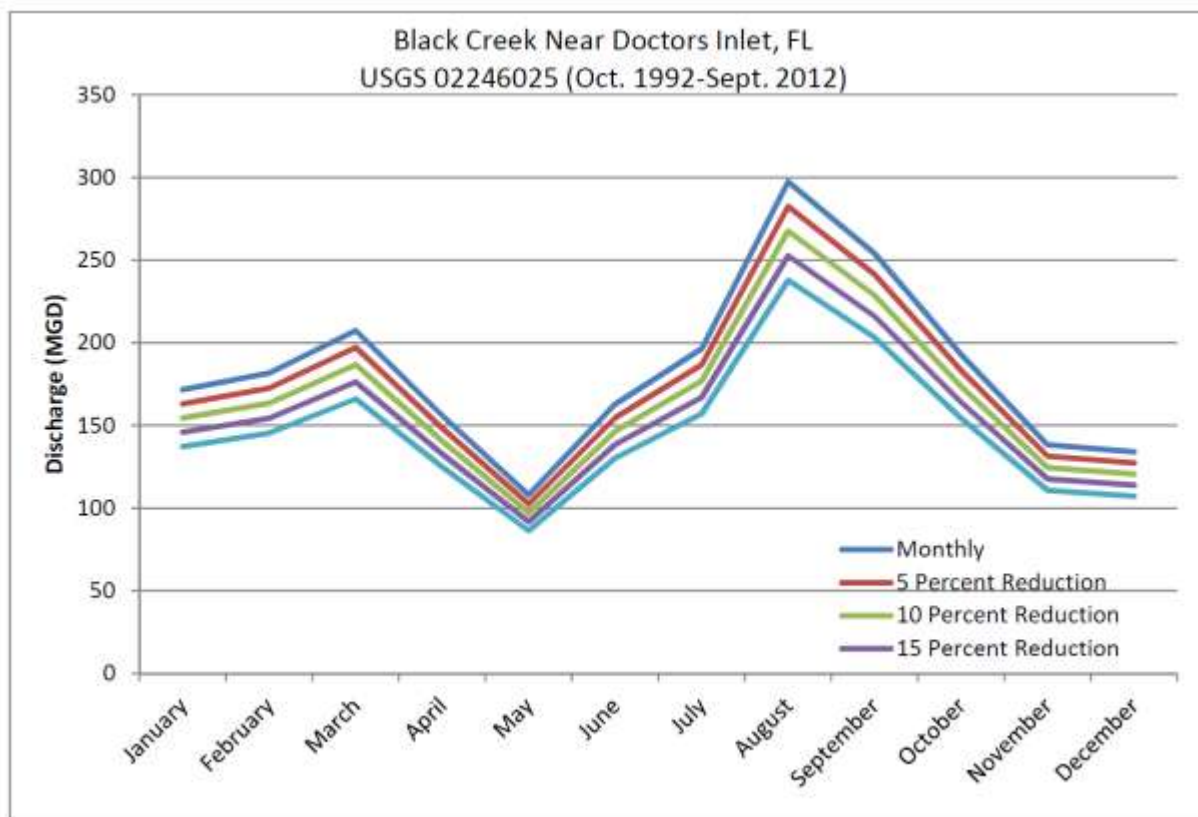
**Percent Reductions (withdrawals) for 0, 5, 10, 15 and 20 Percent Scenarios
for Period of Record at 12 USGS Stations on the St. Marys River, Ocklawaha River,
Black Creek and upper Suwannee River (in the study area)**

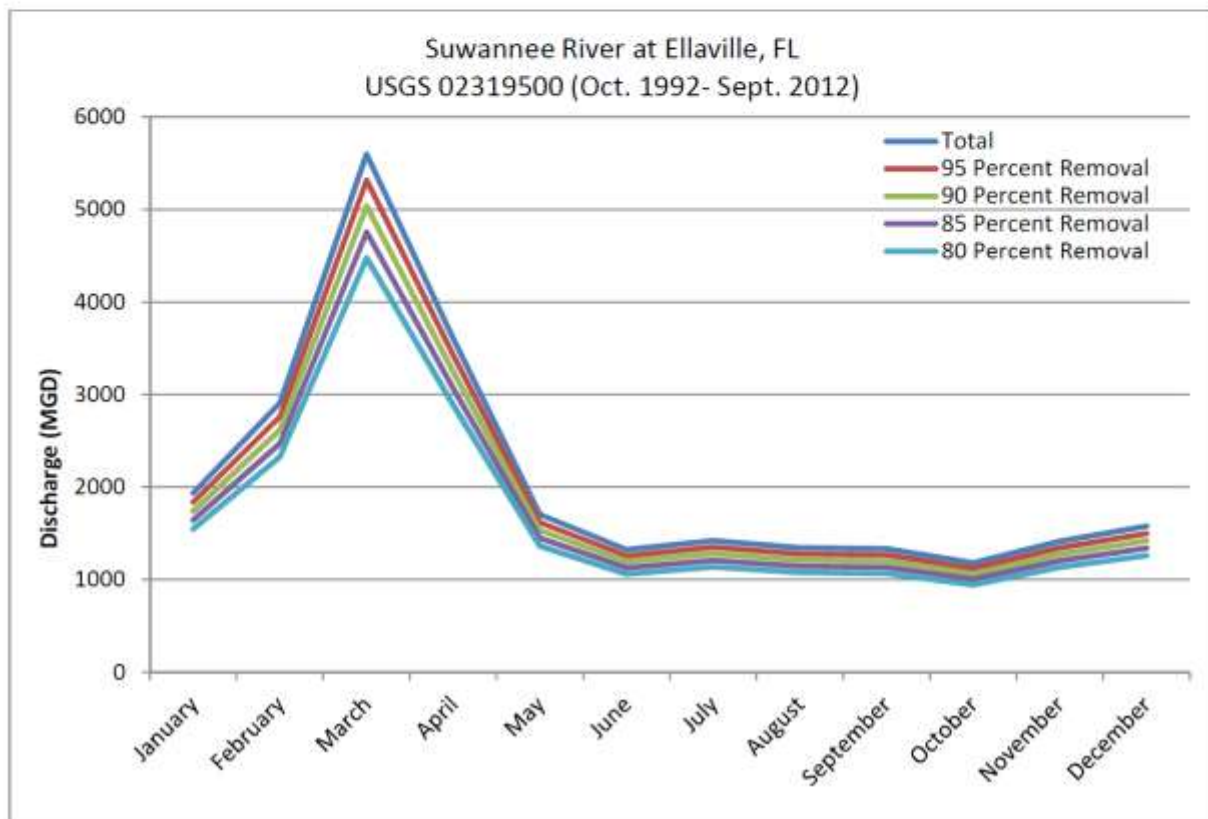
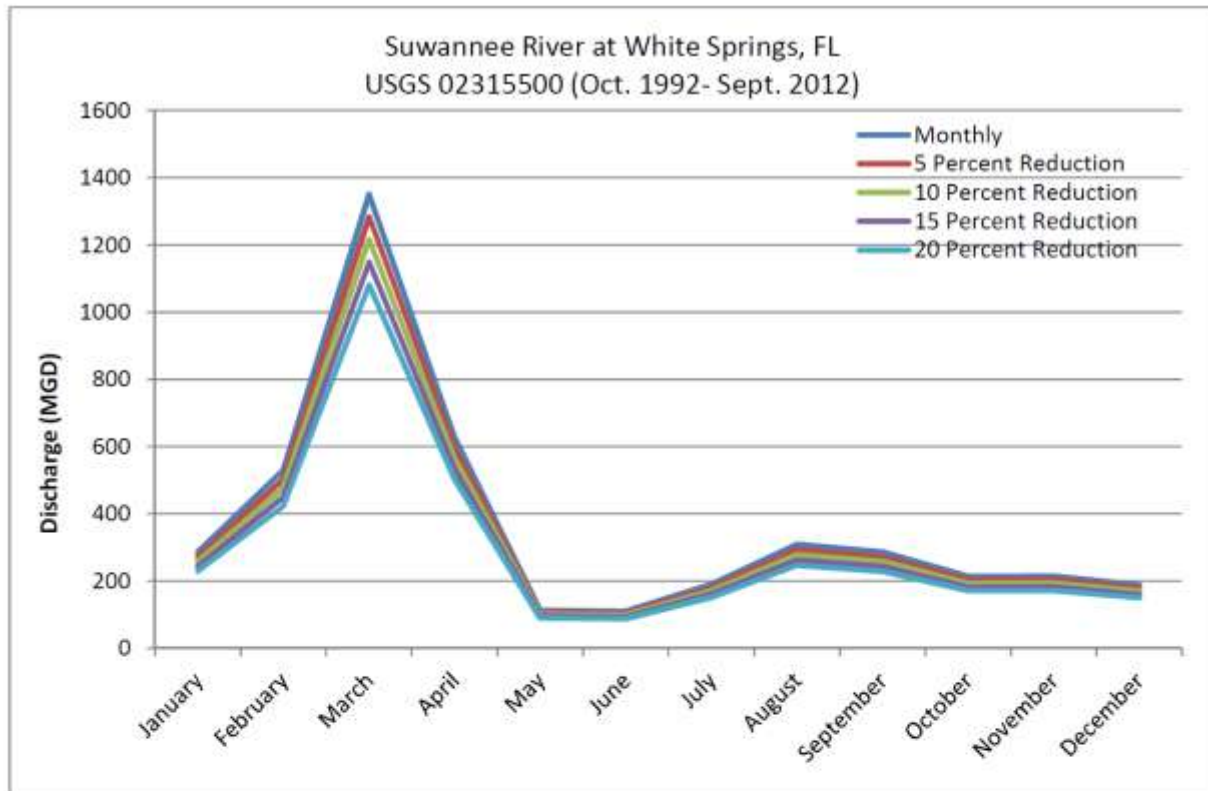
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Appendix B

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AS REQUIRED
PER SCREEN MFR.

INTAKE SCREEN (TYPICAL)

EDGE OF BANK

TO PUMP STATION

INTAKE DETAIL (PLAN) - TYPICAL
SCALE: NTS

UFA REGIONAL RECHARGE STUDY

INTAKE DISCHARGE DETAIL



SUWANNEE RIVER
WATER MANAGEMENT DISTRICT



ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT

ATKINS

FIGURE B-1



INTAKE DETAIL (SECTION) - TYPICAL
SCALE: NTS

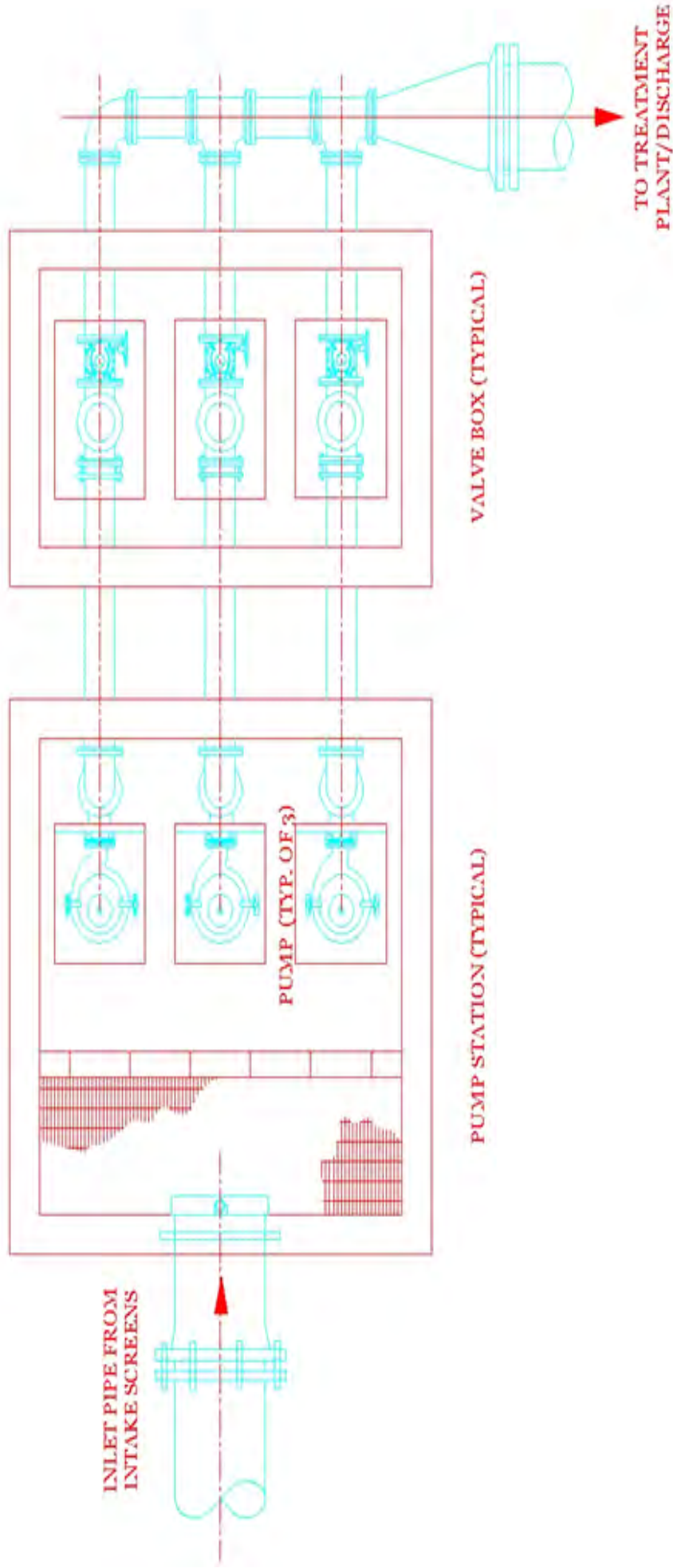
UFA REGIONAL RECHARGE STUDY
INTAKE DISCHARGE DETAIL SECTION



ST. JOHNS RIVER
 WATER MANAGEMENT DISTRICT



ATKINS



PUMP STATION DETAIL (PLAN) - TYPICAL
SCALE: NTS

UFA REGIONAL RECHARGE STUDY

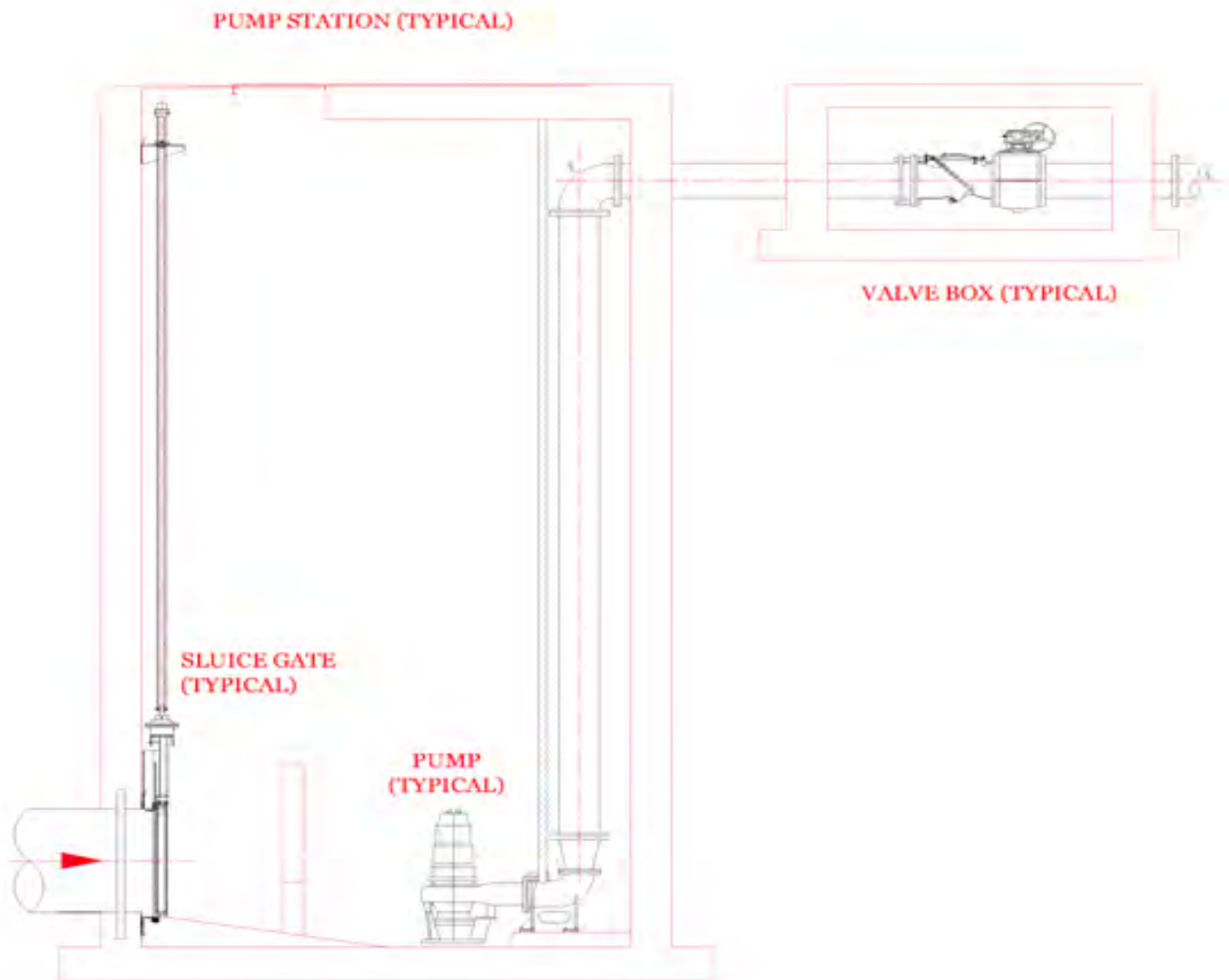
PUMP STATION PLAN



SUWANNEE RIVER
 WATER MANAGEMENT DISTRICT



ST. JOHNS RIVER
 WATER MANAGEMENT DISTRICT



PUMP STATION DETAIL (SECTION) - TYPICAL
SCALE: NTS

UFA REGIONAL RECHARGE STUDY
PUMP STATION DETAIL SECTION



SUWANNEE RIVER
 WATER MANAGEMENT DISTRICT



ST JOHNS RIVER
 WATER MANAGEMENT DISTRICT

Appendix C

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Recharge Concept #1 Opinion of Probable Cost

TOTAL CAPITAL COST					
I. Construction Costs					
Item	Item	Quantity	Unit	Unit Cost	Item Cost
1	Powdered Activated Carbon (PAC) - 30 mgd	1	ea	\$ 2,251,273.00	\$ 2,251,273.00
2	Powdered Activated Carbon (PAC) - 10 mgd	1	ea	\$ 871,076.00	\$ 871,076.00
3	7.5 MG Ground Storage Tank	1	ea	\$ 2,513,292.00	\$ 2,513,292.00
4	2.5 MG Ground Storage Tank	1	ea	\$ 1,085,564.00	\$ 1,085,564.00
5	Deep Bed Filtration - 30 mgd	1	ea	\$ 11,940,895.00	\$ 11,940,895.00
6	Deep Bed Filtration - 10 mgd	1	ea	\$ 5,894,676.00	\$ 5,894,676.00
7	Ultraviolet Disinfection -30 mgd	1	ea	\$ 4,626,247.00	\$ 4,626,247.00
8	Ultraviolet Disinfection - 10 mgd	1	ea	\$ 3,603,628.00	\$ 3,603,628.00
9	Deoxygenation - 30 mgd	1	ea	\$ 1,788,000.00	\$ 1,788,000.00
10	Deoxygenation - 10 mgd	1	ea	\$ 596,000.00	\$ 596,000.00
11	Transfer Pump Station - 30 mgd	1	ea	\$ 1,089,839.00	\$ 1,089,839.00
12	Transfer Pump Station - 10 mgd	1	ea	\$ 536,694.00	\$ 536,694.00
13	High Service Pump Station - 30 mgd	1	ea	\$ 7,835,703.00	\$ 7,835,703.00
14	High Service Pump Station - 10 mgd	1	ea	\$ 2,279,116.00	\$ 2,279,116.00
15	Chemical Building (120x80) - 30 mgd	1	ea	\$ 2,112,060.00	\$ 2,112,060.00
16	Chemical Building (80x50) - 10 mgd	1	ea	\$ 906,874.00	\$ 906,874.00
17	Operations Building & Lab - 30 mgd	1	ea	\$ 4,054,678.00	\$ 4,054,678.00
18	Operations Building & Lab - 10 mgd	1	ea	\$ 2,495,095.00	\$ 2,495,095.00
19	Recharge Wells	8	ea	\$ 1,500,000.00	\$ 12,000,000.00
20	Yard Piping	15%	%	\$ 68,480,710.00	\$ 10,272,106.50
21	Site Work	6%	%	\$ 68,480,710.00	\$ 4,108,842.60
22	Construction Markup	35%	%	\$ 68,480,710.00	\$ 23,968,248.50
TOTAL CONSTRUCTION COST					\$ 106,829,907.60
II. Non-Construction Capital Cost (assumed at 45% of Construction Cost)					
1	Engineering, Permitting, Construction Admin, Bonds, Permit, and General Conditions	45%	%	\$ 106,829,907.60	\$ 48,073,458.42
TOTAL NON-CONSTRUCTION CAPITAL COSTS					\$ 48,073,458.42
III. Land Costs					
1	Land Costs	0	acres	\$ -	\$ -
2	Land Acquisition	18%	%	\$ -	\$ -
TOTAL LAND COSTS					\$ -
IV. Total Operation and Maintenance Cost during Testing and System Expansion					
1	Operation and Maintenance Cost	3.5	years	\$ 7,872,007.00	\$ 27,552,024.50
TOTAL OPERATION AND MAINT. COST DURING TESTING AND SYSTEM EXPANSION					\$ 27,552,024.50
TOTAL CAPITAL COST					\$ 182,455,390.52

OPERATING AND MAINTENANCE COST (ANNUAL)					
I. Maintenance Costs					
1	Powdered Activated Carbon (PAC) - 30 mgd	1	ea	\$ 26,928.00	\$ 26,928.00
2	Powdered Activated Carbon (PAC) - 10 mgd	1	ea	\$ 12,052.00	\$ 12,052.00
3	Deep Bed Filtration - 30 mgd	1	ea	\$ 15,274.00	\$ 15,274.00
4	Deep Bed Filtration - 10 mgd	1	ea	\$ 9,904.00	\$ 9,904.00
5	Ultraviolet Disinfection -30 mgd	1	ea	\$ 106,598.00	\$ 106,598.00
6	Ultraviolet Disinfection - 10 mgd	1	ea	\$ 44,150.00	\$ 44,150.00
7	Deoxygenation - 30 mgd	1	ea	\$ 24,609.00	\$ 24,609.00
8	Deoxygenation - 10 mgd	1	ea	\$ 9,957.00	\$ 9,957.00
9	Transfer Pump Station - 30 mgd	1	ea	\$ 25,138.00	\$ 25,138.00
10	Transfer Pump Station - 10 mgd	1	ea	\$ 12,291.00	\$ 12,291.00
11	High Service Pump Station - 30 mgd	1	ea	\$ 70,601.00	\$ 70,601.00
12	High Service Pump Station - 10 mgd	1	ea	\$ 26,968.00	\$ 26,968.00
13	Contingency	30%	%	\$ 384,470.00	\$ 115,341.00
TOTAL ANNUAL MAINTENANCE COST					\$ 499,811.00
II. Operating Costs					
1	Power (UV)	40	mgd	\$ 18,396.00	\$ 735,840.00
2	Power (Transfer Pump Station - 30 mgd)	30	ea	\$ 3,571.00	\$ 107,130.00
3	Power (Transfer Pump Station - 10 mgd)	10	ea	\$ 3,571.00	\$ 35,710.00
4	Power (High Service Pump Station - 30 mgd)	30	ea	\$ 35,710.00	\$ 1,071,300.00
5	Power (High Service Pump Station - 10 mgd)	10	ea	\$ 35,710.00	\$ 357,100.00
6	Labor (Plant Operator) - 2 per shift 24/7	35040	hours	\$ 60.00	\$ 2,102,400.00
3	Labor (Maintenance) - 2 per shift 24/7	35040	hours	\$ 36.00	\$ 1,261,440.00
4	Contingency	30%	%	\$ 5,670,920.00	\$ 1,701,276.00
TOTAL ANNUAL OPERATING COST					\$ 7,372,196.00
TOTAL ANNUAL O&M COST					\$ 7,872,007.00
ANNUAL PROJECT COST					
Capital Cost annualized over 20 years at 3.75% interest rate plus annual O&M cost					\$ 21,001,879.57
Total Unit Production Cost (\$/1,000 gallons)					\$ 1.44

Recharge Concept #2 Opinion of Probable Cost

TOTAL CAPITAL COST					
I. Construction Costs					
Item	Item	Quantity	Unit	Unit Cost	Item Cost
1	Surface Water Pumping System - 40 mgd	1	ea	\$ 10,190,392.00	\$ 10,190,392.00
2	Transmission Piping (48-inch) - rural	58080	lf	\$ 529.00	\$ 30,724,320.00
3	Transmission Piping (ROW) - rural	3775200	sft	\$ 0.56	\$ 2,104,874.53
4	Valves (48-inch)	11	ea	\$ 41,764.00	\$ 459,404.00
5	Powdered Activated Carbon (PAC)	1	ea	\$ 3,078,596.00	\$ 3,078,596.00
6	pH Control	1	ea	\$ 7,994,804.00	\$ 7,994,804.00
7	Flocculation/Clarification	1	ea	\$ 7,064,065.00	\$ 7,064,065.00
8	Deep Bed Filtration	1	ea	\$ 14,653,162.00	\$ 14,653,162.00
9	Ultraviolet Disinfection	1	ea	\$ 4,975,871.00	\$ 4,975,871.00
10	Deoxygenation	1	ea	\$ 2,385,000.00	\$ 2,385,000.00
11	Transfer Pump Station - 40 mgd	1	ea	\$ 1,312,580.00	\$ 1,312,580.00
12	High Service Pump Station - 40 mgd	1	ea	\$ 9,546,034.00	\$ 9,546,034.00
13	Chemical Building (150x100)	1	ea	\$ 2,863,811.00	\$ 2,863,811.00
14	Operations Building and Lab	1	ea	\$ 4,054,678.00	\$ 4,054,678.00
15	Residuals Handling	1	ea	\$ 17,158,996.00	\$ 17,158,996.00
16	Recharge Wells	8	ea	\$ 1,000,000.00	\$ 8,000,000.00
17	Yard Piping	15%	%	\$ 126,566,587.53	\$ 18,984,988.13
18	Site Work	6%	%	\$ 126,566,587.53	\$ 7,593,995.25
19	Construction Markup (Equip. & Wells)	35%	%	\$ 93,277,989.00	\$ 32,647,296.15
20	Construction Markup (Pipelines & Valves)	15%	%	\$ 33,288,598.53	\$ 4,993,289.78
TOTAL CONSTRUCTION COST					\$ 190,786,157.00
II. Non-Construction Capital Cost (assumed at 45% of Construction Cost)					
1	Engineering, Permitting, Construction Admin, Bonds, Permit, and General Conditions	45%	%	\$ 190,786,157.00	\$ 85,853,770.65
TOTAL NON-CONSTRUCTION CAPITAL COSTS					\$ 85,853,770.65
III. Land Costs					
1	Land Costs	0	acres	\$ -	\$ -
2	Land Acquisition	18%	%	\$ -	\$ -
TOTAL LAND COSTS					\$ -
IV. Total Operation and Maintenance Cost during Testing and System Expansion					
1	Operation and Maintenance Cost	3.5	years	\$ 7,766,829.20	\$ 27,183,902.20
TOTAL OPERATION AND MAINT. COST DURING TESTING AND SYSTEM EXPANSION					\$ 27,183,902.20
TOTAL CAPITAL COST					\$ 303,823,829.85

OPERATING AND MAINTENANCE COST (ANNUAL)					
I. Maintenance Costs					
1	Surface Water Pumping System - 40 mgd	1	ea	\$ 22,792.00	\$ 22,792.00
2	Powdered Activated Carbon (PAC) - 40 mgd	1	ea	\$ 35,440.00	\$ 35,440.00
3	pH Control	1	ea	\$ 19,093.00	\$ 19,093.00
4	Flocculation/Clarification	1	ea	\$ 71,596.00	\$ 71,596.00
5	Deep Bed Filtration	1	ea	\$ 18,138.00	\$ 18,138.00
6	Ultraviolet Disinfection -40 mgd	1	ea	\$ 119,326.00	\$ 119,326.00
7	Deoxygenation - 40 mgd	1	ea	\$ 32,762.00	\$ 32,762.00
8	Transfer Pump Station - 40 mgd	1	ea	\$ 30,309.00	\$ 30,309.00
9	High Service Pump Station - 40 mgd	1	ea	\$ 78,875.00	\$ 78,875.00
10	Residuals Handling	1	ea	\$ 128,753.00	\$ 128,753.00
10	Contingency	30%	%	\$ 557,084.00	\$ 167,125.20
TOTAL ANNUAL MAINTENANCE COST					\$ 724,209.20
II. Operating Costs					
1	Power (UV)	40	mgd	\$ 18,396.00	\$ 735,840.00
2	Power (Surface Water Pumping System)	40	mgd	\$ 35,710.00	\$ 1,428,400.00
3	Power (Transfer Pump Station)	40	mgd	\$ 3,571.00	\$ 142,840.00
4	Power (High Service Pump Station)	40	mgd	\$ 35,710.00	\$ 1,428,400.00
5	Labor (Plant Operator) - 2 per shift 24/7	17520	hours	\$ 60.00	\$ 1,051,200.00
6	Labor (Maintenance) - 2 per shift 24/7	17520	hours	\$ 36.00	\$ 630,720.00
7	Contingency	30%	%	\$ 5,417,400.00	\$ 1,625,220.00
TOTAL ANNUAL OPERATING COST					\$ 7,042,620.00
TOTAL ANNUAL O&M COST					\$ 7,766,829.20
ANNUAL PROJECT COST					
Capital Cost annualized over 20 years at 3.75% interest rate plus annual O&M cost					\$ 29,630,629.21
Total Unit Production Cost (\$/1,000 gallons)					\$ 2.03

Recharge Concept #3 Opinion of Probable Cost

TOTAL CAPITAL COST					
I. Construction Costs					
Item	Item	Quantity	Unit	Unit Cost	Item Cost
1	Surface Water Pumping System - 40 mgd	2	ea	\$ 10,190,392.00	\$ 20,380,784.00
2	Transmission Piping (48-inch) - rural	58080	lf	\$ 529.00	\$ 30,724,320.00
3	Transmission Piping (ROW)	3775200	sft	\$ 1.12	\$ 4,209,749.05
4	Valves	11	ea	\$ 41,764.00	\$ 459,404.00
5	CSA Reservoir Modification	1375	acres	\$ 5,132.00	\$ 7,056,500.00
6	Sand Tailing Filtration Area Piping	500	acres	\$ 15,000.00	\$ 7,500,000.00
7	Yard Piping	15%	%	\$ 70,330,757.05	\$ 10,549,613.56
8	Site Work	6%	%	\$ 70,330,757.05	\$ 4,219,845.42
9	Construction Markup (Equip. & Wells)	35%	%	\$ 34,937,284.00	\$ 12,228,049.40
10	Construction Markup (Pipelines & Valves)	15%	%	\$ 35,393,473.05	\$ 5,309,020.96
TOTAL CONSTRUCTION COST					\$ 102,637,286.39
II. Non-Construction Capital Cost (assumed at 45% of Construction Cost)					
1	Engineering, Permitting, Construction Admin, Bonds, Permit, and General Conditions	45%	%	\$ 102,637,286.39	\$ 46,186,778.88
TOTAL NON-CONSTRUCTION CAPITAL COSTS					\$ 46,186,778.88
III. Land Costs					
1	Land Costs (Rural)	0	acres	\$ -	\$ -
2	Land Acquisition	18%	%	\$ -	\$ -
TOTAL LAND COSTS					\$ -
IV. Total Operation and Maintenance Cost during Testing and System Expansion					
1	Operation and Maintenance Cost	3.5	years	\$ 7,105,458.10	\$ 24,869,103.35
TOTAL OPERATION AND MAINT. COST DURING TESTING AND SYSTEM EXPANSION					\$ 24,869,103.35
TOTAL CAPITAL COST					\$ 173,693,168.62
OPERATING AND MAINTENANCE COST (ANNUAL)					
I. Maintenance Costs					
1	Surface Water Pumping System - 40 mgd	1	ea	\$ 22,792.00	\$ 22,792.00
2	CSA (assume same as RIBS) - 1375 acres	1	ea	\$ 1,472,807.00	\$ 1,472,807.00
3	Sand Area (assume same as RIBS) 500 ac	1	ea	\$ 1,113,338.00	\$ 1,113,338.00
4	Contingency	30%	%	\$ 2,608,937.00	\$ 782,681.10
TOTAL ANNUAL MAINTENANCE COST					\$ 3,391,618.10

II. Operating Costs					
1	Power (Surface Water Pumping System)	80	mgd	\$ 35,710.00	\$ 2,856,800.00
2	Labor (included above)	1	ea	\$ -	\$ -
3	Contingency	30%	%	\$ 2,856,800.00	\$ 857,040.00
TOTAL ANNUAL OPERATING COST					\$ 3,713,840.00
TOTAL ANNUAL O&M COST					\$ 7,105,458.10
ANNUAL PROJECT COST					
Capital Cost annualized over 20 years at 3.75% interest rate plus annual O&M cost					\$ 19,604,782.81
Total Unit Production Cost (\$/1,000 gallons)					\$ 1.34

Recharge Concept #4 Opinion of Probable Cost

TOTAL CAPITAL COST					
I. Construction Costs					
Item	Item	Quantity	Unit	Unit Cost	Item Cost
1	Surface Water Pumping System	1	ea	\$9,530,124.00	\$9,530,124.00
2	Transmission Piping (48-inch) - rural	137280	lf	\$529.00	\$72,621,120.00
3	Transmission Piping (ROW) - 48 inch rural	8923200	sft	\$0.56	\$4,975,157.97
4	Valves (48-inch)	26	ea	\$41,764.00	\$1,085,864.00
5	Transmission Piping (36-inch) - suburban	21120	lf	\$514.00	\$10,855,680.00
6	Transmission Piping (ROW) - 36 inch suburban	1372800	sft	\$1.12	\$1,530,817.84
7	Valves (36-inch)	4	ea	\$51,430.00	\$205,720.00
8	Transmission Piping (24-inch) - suburban	2640	lf	\$269.00	\$710,160.00
9	Transmission Piping (ROW) - 24 inch suburban	79200	sft	\$1.12	\$88,316.41
10	Valves (24-inch)	2	ea	\$23,388.00	\$46,776.00
11	pH Control	1	ea	\$4,033,200.00	\$4,033,200.00
12	Flocculation/Clarification	1	ea	\$2,947,388.00	\$2,947,388.00
13	Deep Bed Filtration	1	ea	\$5,894,676.00	\$5,894,676.00
14	Transfer Pump Station	1	ea	\$536,965.00	\$536,965.00
15	High Service Pump Station	1	ea	\$2,279,116.00	\$2,279,116.00
16	Chemical Building (100x60)	1	ea	\$1,431,906.00	\$1,431,906.00
17	Operations Building and Lab	1	ea	\$2,495,095.00	\$2,495,095.00
18	Residuals Handling	1	ea	\$10,130,729.00	\$10,130,729.00
19	Yard Piping	15%	%	\$131,398,811.23	\$19,709,821.68
20	Site Work	6%	%	\$131,398,811.23	\$7,883,928.67
21	Construction Markup (Equip. & Wells)	35%	%	\$39,279,199.00	\$13,747,719.65
22	Construction Markup (Pipelines & Valves)	15%	%	\$92,119,612.23	\$13,817,941.83
TOTAL CONSTRUCTION COST					\$186,558,223.07
II. Non-Construction Capital Cost (assumed at 45% of Construction Cost)					
1	Engineering, Permitting, Construction Admin, Bonds, Permit, and General Conditions	45%	%	\$186,558,223.07	\$83,951,200.38
TOTAL NON-CONSTRUCTION CAPITAL COSTS					\$83,951,200.38
III. Land Costs					
1	Land Costs	10	acres	\$53,526.00	\$535,260.00
2	Land Acquisition	18%	%	\$535,260.00	\$96,346.80
TOTAL LAND COSTS					\$631,606.80
IV. Total Operation and Maintenance Cost during Testing and System Expansion					
1	Operation and Maintenance Cost	2	years	\$3,915,766.40	\$7,831,532.80
TOTAL OPERATION AND MAINT. COST DURING TESTING AND SYSTEM EXPANSION					\$7,831,532.80
TOTAL CAPITAL COST					\$278,972,563.05

OPERATING AND MAINTENANCE COST (ANNUAL)					
I. Maintenance Costs					
1	Surface Water Pumping System - 30 mgd	1	ea	\$20,723.00	\$20,723.00
2	pH Control - 10 mgd	1	ea	\$9,069.00	\$9,069.00
3	Flocculation/Clarification - 10 mgd	1	ea	\$28,639.00	\$28,639.00
4	Deep Bed Filtration - 10 mgd	1	ea	\$9,905.00	\$9,905.00
5	Transfer Pump Station - 10 mgd	1	ea	\$12,291.00	\$12,291.00
6	High Service Pump Station - 10 mgd	1	ea	\$26,968.00	\$26,968.00
7	Residuals Handling	1	ea	\$73,863.00	\$73,863.00
8	Contingency	30%	ea	\$181,458.00	\$54,437.40
TOTAL ANNUAL MAINTENANCE COST					\$235,895.40
II. Operating Costs					
1	Power (Surface Water Pumping System)	30	mgd	\$35,710.00	\$1,071,300.00
2	Power (Transfer Pump Station)	10	mgd	\$3,571.00	\$35,710.00
3	Power (High Service Pump Station)	10	mgd	\$35,710.00	\$357,100.00
4	Labor (Plant Operator) - 2 per shift 24/7	17520	hours	\$60.00	\$1,051,200.00
5	Labor (Maintenance) - 1 per shift 24/7	8760	hours	\$36.00	\$315,360.00
6	Contingency	30%	%	\$2,830,670.00	\$849,201.00
TOTAL ANNUAL OPERATING COST					\$3,679,871.00
TOTAL ANNUAL O&M COST					\$3,915,766.40
ANNUAL PROJECT COST					
Capital Cost annualized over 20 years at 3.75% interest rate plus annual O&M cost					\$23,991,217.13
Total Unit Production Cost (\$/1,000 gallons)					\$2.19