TECHNICAL SERVICES FOR SURFACE WATER SUPPLY FACILITIES PLANNING AND FEASIBILITY ANALYSES

FINAL REPORT

CONCEPTUAL ALTERNATIVE WATER SUPPLY DEVELOPMENT PROJECTS AND PLANNING LEVEL COST ESTIMATES

Water Supply Planning Region II

PREPARED FOR

NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT

81 WATER MANAGEMENT DRIVE

HAVANA, FLORIDA 32333

Prepared by

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October 2006

Document No. 060208
PBS&J Job No. 091812

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Printed on recycled paper

Contents

Page

Figures

Tables

Executive Summary

This evaluation of surface water alternatives for Okaloosa County was initiated as part of the Northwest Florida Water Management District's Regional Water Supply Plan (RWSP) for Region II (Santa Rosa, Okaloosa, and Walton Counties), as well as the plan update that is nearing completion. The effort is designed to assist Okaloosa County in a countywide initiative to ensure future water supply demands will be met. Information contained in this report will also facilitate implementation of the Water Protection and Sustainability Program and other recent directives of the Florida Legislature.

The Conceptual Alternative Water Supply Development Projects and Planning Level Cost Estimates, as described in this report, were presented to the Okaloosa County Board of County Commissioners on September 26, 2006. This work also included a review of the *Yellow River Reservoir Water Supply Feasibility Study*, completed by the U.S. Army Corps of Engineers in 2004, to facilitate comparison with other surface water supply alternatives developed on a broader countywide basis. It is anticipated that follow-on efforts to develop one or more of the surface water supply alternatives that appear to be feasible will continue under the District's RWSP and in cooperation with Okaloosa County, as well as other utilities and local governments.

The report provides an initial assessment and conceptual planning level cost estimates to help evaluate the feasibility of several inland surface water supply alternatives for Okaloosa County. The alternative projects identified are intended to provide a reliable yield of up to 25-million gallons per day (mgd) to communities throughout Okaloosa County. Based on NWFWMD demand projections, it is anticipated that the additional 25 mgd, together with the sustainable use of existing sources, will exceed foreseeable demands through 2025 and beyond. Although the 25-mgd supply is not needed in the near future, the typical modular or incremental approach to development of surface water supply systems would be useful for supporting increased demands while also supporting the NWFWMD's efforts to maintain the sustainability of existing water resources, as well as the County's efforts to protect water sources throughout the county. Such approaches also reduce the often long periods of time needed to actually have infrastructure in place soon enough to meet future demands.

The current report provides the county and the NWFWMD with preliminary, yet sufficient, information to fully evaluate the feasibility of surface water alternative supplies based on general assumptions about system integration points and delivery considerations. The cost comparisons are developed and stated in consistent relative terms. As alternatives are narrowed and more specific proposals are made, more detailed water supply needs analysis will be needed to address institutional issues, define system integration points, and identify where supplementation will need to occur within the county.

A key factor in the development of a preferred alternative will likely be the capability of that alternative to reduce current groundwater withdrawals from the Floridan Aquifer along the coast as well as future demands on the Floridan Aquifer in the northern part of the county. The conjunctive use of surface water with groundwater may play a significant long-term alternative in protecting the Floridan Aquifer as potable drinking water source.

Alternative water supplies evaluated in this report are limited to fresh surface water sources and conceptually designed facilities at selected sites in inland Okaloosa County, Florida. Specifically, this conceptual planning level analysis has focused on the following infrastructure and surface water facilities elements:

- **Intakes:** Consist of a diversion structure such as a short diversion channel, head wall, an intake structure with screens, a pump station, an electrical substation and a discharge pipeline to either a surface water treatment plant (WTP) or small tributary reservoir.
- **Tributary Reservoirs:** Small scale reservoirs formed by channel dams on the minor tributaries to the Shoal or Yellow Rivers in Okaloosa County, Florida.
- **Surface Water Transmission Facilities:** Consist of an intake structure in a tributary reservoir, a pump station, an electrical substation and a pipeline from the reservoir to a surface WTP. Additionally, transmission facilities will also include a pump station and distribution pipeline from the surface WTP to tie-in on existing distribution system.
- **Surface Water Treatment Plant Facilities:** Treatment plant, supporting facilities (i.e., forebay and operations/maintenance facilities) and where applicable ground storage tanks.
- **Riverbank Collector Well Fields:** Defined as shallow horizontal or vertical groundwater wells penetrating the riverbed soils and electrical power supply network, piping to water supply treatment system, and supporting facilities.

Planning level cost estimates were prepared for each conceptual alternative project to show the estimated total construction and nonconstruction costs, total project costs (the sum of construction costs and other project costs), and total annual project costs. The unit cost of each alternative per unit of water delivered (total project cost per 1,000 gallons of water delivered) is also presented for further comparison.

1. Pond Creek Reservoir
    - Cost: $206.7 million
    - Legal constraints make this option unrealistic. It is estimated that $83 million is needed for environmental mitigation, which contributes to the high cost for the project.
2. Bear Creek Reservoir
    - Cost: $84.9 million
    - A small impoundment with augmentation, as needed, from the Shoal River.
3. West Dog Creek Reservoir
    - Cost: $86.2 million
    - Would not require much land. Similar to alternative 2, but in a different location.

4. Shoal River Direct Diversion

   - Cost: $55.8 million
   - Would not require much land. Similar to alternatives 2 and 3, but without a reservoir pond.

5. Riverbank Filtration

   - Cost: $88.6 million
   - Basically a horizontal well running alongside the river that would use natural filtration for the river water. Through this process, the water is partially treated before it gets to the treatment plant.

For comparison purposes, when reviewing the costs for the alternative water supply projects evaluated in this report, dam construction costs alone associated with the Yellow River Reservoir Project report were estimated by the U.S. Army Corps of Engineers to be $86,000,000 (fiscal year 2003 dollars). This does not include project costs for real estate, wetland mitigation (i.e., ~6,439 acres of wetlands based on National Wetlands Inventory mapping), cultural resources mitigation, operations and maintenance, energy, water intake/pump station facilities, conveyance, and power transmission lines, among others. The very high capital costs associated with these components for this alternative are generally not considered financially supportable and, on a comparative basis with other alternatives, are not economical. Other significant environmental and legal constraints which have been identified by the NWFWMD are those that may not be mitigated.

Estimated project costs for the alternatives evaluated in this feasibility analysis are displayed in the following table. More detailed estimates of capital and total costs, together with estimated unit costs, are provided in Table 7.

	Conceptual Alternatives – Water Production Cost Estimates				
Estimated Unit Cost Category	Pond Creek	Bear Creek	West Dog Creek	Shoal River	Riverbank Filtration
Present Value of Unit Cost ($/1,000 gallon)	$ 1.51	$ 0.82	$ 0.87	$ 0.62	$ 0.83

The NWFWMD will continue to develop surface water as a water supply alternative through implementation of its Region II RWSP and in cooperation with Okaloosa County. The county also expressed a need for the NWFWMD to continue to work cooperatively with other utilities and local governments to develop surface water supply as a county-wide regional solution to future water supply. A number of feasible surface water supply alternatives have conceptually been identified in this report as a solution for future water supply in this region. Cooperation with other stakeholders in the basin, including other utilities and local governments, will be required for any large scale surface water supply facility to be successful in the region. The NWFWMD may play a significant role through its Region II water supply planning process as well as its other programs for water management in the development of this water resource.

Recommendations

The following recommendations are offered for future investigations:

- In coordination with Okaloosa County, meet and coordinate with local utilities and regional water suppliers to refine assumptions used in evaluation of alternative supply options.
- Evaluate conjunctive use management opportunities within the region, particularly with respect to reduced use of the coastal Floridan Aquifer sources, to facilitate coordinated management of surface and groundwater resources.
- Based upon the conceptual engineering, land use, environmental, and financial cost analysis of this feasibility analysis, there are several potential alternative water supplies which have less impact on the natural resources than those associated with Pond Creek Reservoir and the previously studied Yellow River Reservoir Project. Based on the conceptual costs developed in this feasibility analysis, smaller reservoirs such as those studied in this report with surface water supplementation and/or riverbank filtration, have fewer impacts to land use and environmental constraints, as compared to larger reservoirs mentioned above. The direct diversion option (i.e., Alternative #4) was determined to be the least cost alternative and should be considered in future studies.
- For any alternatives not eliminated from consideration following this analysis, conduct detailed field investigations for environmental, cultural, land use and technical constraints.
- Further evaluation of riverbank water supplies should consider the placement of a near-capacity sampling/monitoring well at the location of the anticipated well field. The well should be operated for a period of time to ensure that there is a good influence from the surface water into the well. Samples should be collected of sufficient numbers, over a variety of surface water conditions (i.e., storm and low flow conditions), to ensure that all potential constituents of concern, including Giardia, Cryptosporidium, viruses, total organic compounds, etc., have been obtained. The collected samples will be used to run jar tests to determine chemicals to be added for the greatest effective treatment. It is anticipated that the results of the sampling and jar tests would reduce the treatment necessary, particularly related to operation and maintenance cost for chemical addition, and in terms of sludge removal and treatment. This could significantly reduce both sludge treatment infrastructure costs and operation and maintenance costs.
- For surface water supplies, samples of stream flow should be collected at locations anticipated for the take point for raw water used for treatment. These samples should be taken at various surface water conditions, including high and low flow, to consider all possible treatment requirements related to potential constituents of concern, including Giardia, Cryptosporidium, viruses, total organic compounds, etc., and to more particularly evaluate sludge management requirements for facility needs and operation and maintenance costs necessary for sludge treatment.
- Conduct geotechnical investigations consisting of field and laboratory tests for borings and piezometers along the proposed dam alignments, embankments and anticipated borrow areas, as well as potential sites for riverbank filtration facilities.

- Collect hydrogeologic data collection using exploratory wells to define lithology and physical aquifer characteristics, and aquifer performance test(s) to define aquifer flow characteristics for the Sand-and-Gravel Aquifer within the riverbank filtration study area.
- Continue implementation of the Water Resource Development Work Program of the RWSP to develop the surface water component of the Region II plan.

Acronyms and Abbreviations

ac-ft	acre-feet
CCI	Construction Cost Index
cfs	cubic feet per second
CPI	Consumer Price Index
CR	County Road
EPA	U.S. Environmental Protection Agency
ERP	Environmental Resource Permit
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FEMA	Federal Emergency Management Agency
FGDL	Florida Geographic Data Library
FNAI	Florida Natural Areas Inventory
FWS	U.S. Fish and Wildlife Service
HEP	Habitat Evaluation Procedure
HGM	Hydrogeomorphic
IDF	Inflow Design Flood
IH	Interstate Highway
kWh	kilowatt hour
mgd	million gallons per day
MWRAP	Modified Wetland Rapid Assessment Procedure
NPDWRs	National Primary Drinking Water Regulations
NSDWRs	National Secondary Drinking Water Regulations
NWFWMD	Northwest Florida Water Management District
NWI	National Wetlands Inventory
O&M	operation and maintenance
PMF	Probable Maximum Flood
psi	pounds per square inch
ROW	rights-of-way
RWSP	Regional Water Supply Plan for Santa Rosa, Okaloosa, Walton Counties Region II
SCADA	Supervisory Control and Data Acquisition System
SJRWMD	St. Johns River Water Management District
SR	State Road
TOC	total organic compounds
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
UWAM	Uniform Mitigation Assessment Method
WRAP	Wetland Rapid Assessment Procedure
WTP	water treatment plant

INTRODUCTION

On February 17, 2006, the Northwest Florida Water Management District contracted with PBS&J to provide technical services in water resources planning, engineering and economic analysis in support of the Regional Water Supply Plan for Santa Rosa, Okaloosa, Walton Counties (Region II, RWSP) Water Resources Development task “Surface Water Feasibility Analysis.” This is a continuing task that will be included in the future update of a RWSP for Region II. The specific focus of this task is currently on Okaloosa County, which was initiated following a formal written request by the Okaloosa County Board of Commissioners in a letter dated March 17, 2004. The 2006 RWSP will provide a regional framework for future water supply alternatives development and strategies to ensure adequate water supply beyond year 2020. This report describes the evaluation of a number of previously identified surface water supply alternatives in the RWSP including (1) river bank filtration, and (2) surface water sources, including the Shoal and Yellow Rivers and their tributaries, within Okaloosa County. Reservoirs investigated in this report focus on siting facilities on tributaries to the Shoal River as an alternative water supply to the previously studied Yellow River Reservoir Project and are significantly smaller than the Yellow River Reservoir Project investigated in April 2004 by the U.S. Army Corps of Engineers (USACE) at the request of Okaloosa County.

The objective of this report is to provide the Northwest Florida Water Management District (NWFWMD) with an initial feasibility assessment and conceptual planning level cost estimates to help evaluate the feasibility of surface water alternative supplies in Okaloosa County, Florida. The alternative water supply projects identified in this report are intended to provide a reliable yield of 25 million gallons per day (mgd) to communities in Okaloosa County to satisfy demands beyond 2020. Based on NWFWMD demand projections, it is anticipated that and additional 25 mgd, together with the sustainable use of existing sources, would meet public water supply demands in Okaloosa County to approximately through 2040 and potentially approaching 2050.

The focus of this report is to provide in a conceptual manner the feasibility of riverbank filtration and surface water alternative supplies. A more detailed water supply needs analysis will be required in future studies to address institutional issues, define system integration points and identify where future water supply shortages or supplementation will occur within Okaloosa County. The conceptual water supply facilities evaluated in this report are intended to provide the County and NWFWMD with preliminary yet sufficient information to assess the feasibility of surface water alternative supplies based on general assumptions on system integration points and delivery considerations. Cost comparisons are therefore developed and stated in relative terms and do not address the more detailed level of analysis that may be required for final alternatives selection or to reduce the number of “feasible” alternatives and site selection to one or two. It is anticipated that to decide on a final alternative, local governments, local utilities or regional water authorities working in conjunction with the county and NWFWMD, will address institutional issues, discuss and identify regional needs and water supply integration specific to the alternative supplies investigated in this report to better refine facilities planning and schedule. A key factor in the development of a preferred alternative will likely be the capability of that alternative to reduce current groundwater withdrawals from the Floridan Aquifer along the coast. The conjunctive use of surface water with groundwater along the coast may play a significant long term alternative in protecting the Floridan Aquifer as potable drinking water source.

Alternative water supplies evaluated in this report are limited to surface water and riverbank filtration facilities at selected sites in Okaloosa County, Florida. Specifically this conceptual planning level analysis will focus on the following infrastructure elements:

SURFACE WATER FACILITIES

- **Intake Facilities:** Consist of a diversion structure such as a short diversion channel, head wall, an intake structure with screens, a pump station, an electrical substation and a discharge pipeline to either a surface water treatment plant (WTP) or small tributary reservoir.
- **Tributary Reservoir Facilities:** Reservoirs to be evaluated are formed by on-line channel dams on tributaries to the Shoal River in Okaloosa County, Florida.
- **Surface Water Transmission Facilities:** Consist of an intake structure in a tributary reservoir, a pump station, an electrical substation and a pipeline from the reservoir to a surface WTP. Additionally, transmission facilities will also include a pump station and distribution pipeline from the surface WTP to tie-in on existing distribution system.
- **Surface Water Treatment Plant Facilities:** Treatment plant and supporting facilities (i.e., forebay and operations/maintenance facilities).

RIVERBANK FILTRATION FACILITIES

- **Collector Well Field Facilities:** Defined as shallow groundwater wells penetrating the riverbed soils and electrical power supply network, and piping to water supply treatment system.
- **Water Supply Treatment Facilities:** Treatment plant with an appropriate level of treatment and supporting facilities, including ground storage tanks.
- **Water Supply Transmission Facilities:** Pump station, electrical substation, and distribution pipeline from groundwater treatment plant to tie-in on existing distribution system.

ECOLOGICAL CONSIDERATIONS

Typical water supply infrastructure facilities, as evaluated in this report, can impact both environmental and archeological resources. Reservoirs can inundate several thousand acres and pipelines often must traverse considerable distances. In both cases a variety of permanent and/or temporary potential environmental impacts may result during and after construction. These environmental impacts must be considered during the process of evaluating project alternatives. The NWFWMD has compiled a considerable amount of information (see Attachment A) on constraints associated with environmental and land use characteristics, as well as on the technical criteria for the reservoir sites investigated in this analysis. This compilation and the process of compiling available environmental data along with site logistics data has resulted in the elimination of a number of sites from further consideration. The alternatives chosen for conceptual planning and feasibility analysis as discussed in this report are the result of what appear to be environmentally as well as economically feasible alternative water supplies. However, it is not the intent of this report to focus on the environmental and land use information compiled by the NWFWMD for each alternative. Constraints information compiled by the NWFWMD, in Attachment A for wetland impacts and other ecological and land use constraints will need to be refined through more detailed site investigations once alternatives, to carry forward are determined. This may lead to more refined estimates (possibly reduced impacts) of wetland mitigation costs as well as the key environmental benefits that result from the alternatives the NWFWMD has developed. Potential restorative and preservation activities with the selection of some alternatives may be associated with considerable environmental benefits.

The focus of this report is on conceptual alternative water supply projects which are an alternative to traditional groundwater sources as well as a feasible alternative to the Yellow River Reservoir Project. Attachment A offers a description of the land use, environmental and technical data for each of conceptual alternative supplies outlined in this report as well as similar information made available by the USACE Report on the Yellow River Reservoir Project.

In the Yellow River Reservoir Project report, the USACE identified over 10,025 acres of habitat within the 100-foot contour that would potentially be affected by a proposed impoundment. These include 6,439 acres of wetlands, as estimated by GIS analysis of National Wetlands Inventory (NWI) data. As noted in the report, the USACE's estimate of an $86,000,000 total price tag for an in-line impoundment on the Yellow River does not appear to take into account costs for real estate, wetland mitigation, operations and maintenance, water intake/pump station facilities, conveyance, power transmission lines, or energy, among others. The report further recommended additional analysis to identify other, more cost effective and environmentally acceptable alternatives.

Construction of the Yellow River Reservoir would cause inundation of district lands purchased with state conservation funds which would not be consistent with the statutory purpose of the public acquisition. An additional challenge to the Yellow River Reservoir Project is the potential to significantly impact a federally listed (threatened) anadromous species.

It is within this framework that the alternative surface water supply projects are evaluated.

The subsequent sections discuss the following key environmental issues and considerations used in the development of planning level cost estimates for the conceptual alternative projects:

- Wetland impacts
- Mitigation costs
- Costs associated with construction in environmentally sensitive areas
- Wildlife impacts

- Presence of threatened or endangered species
- Watershed restoration and protection potential

Although not performed in this analysis, during future studies/preliminary design, a detailed environmental assessment will be necessary to evaluate and rank alternative projects in terms of potential environmental impacts. In addition to environmental assessments, permitting and mitigation issues must be addressed, and measures to avoid and minimize impacts will be needed during the design of the facilities. The possibility for net positive environmental benefits with each selected alternative will also be considered.

The following sections describe important considerations relating to environmental impacts and permitting. Planning level cost estimates associated with these concerns are provided in later sections of this report.

IMPACTS TO WETLANDS AND WILDLIFE

Two important environmental features that must be considered when evaluating alternative water supply projects are wetlands and protected wildlife. Impacts to both wetlands and wildlife can be considered either temporary or permanent. Permanent impacts usually require some form of mitigation, while temporary impacts may not. Initial analyses indicates that these types of impacts may be reduced to relatively minor impacts through the use of direct withdrawal approaches and site selection where impacts have already occurred and watershed restoration or protection is needed to facilitate water supply source protection.

WETLANDS IMPACTS

Placement of an underground pipeline in a wetland area typically requires dewatering of the construction area and excavation of a trench. Following placement of the pipe the trench is backfilled to preconstruction grades, and groundwater level recovers. In some instances, construction impacts to herbaceous wetlands may be considered temporary if the wetlands can be fully restored (and perhaps further enhanced over existing degraded conditions) by natural revegetation within a short time following completion of construction.

Specific construction techniques can be used to minimize long-term impacts. These techniques include stockpiling of excavated soils and restoration of preconstruction grades in the disturbed areas with the wetland soils. The size of the construction area should be kept to a practical minimum. Silt barriers should be used to define the construction area and protect against sediment transport to areas outside the construction zone. The topsoil should be excavated and placed adjacent to the trench, with excess material directly loaded into trucks for removal to an upland disposal area. After pipe is buried, the topsoil should be used to restore the area to preconstruction grades. Returning topsoil to the same specific vegetation zone from which it was taken will help to promote natural revegetation.

Alternatives to pipeline burial include trenchless technology (i.e., horizontal directional drilling) and use of elevated pipelines. Use of horizontal directional drilling technology to install the pipelines under wetlands could result in significant reduction of environmental impacts, and also has the advantage of reducing disruptions to navigation, if applicable. Nevertheless, horizontal directional drilling involves increasing risk of failure as pipe diameter increases.

Pipelines may be elevated over wetlands to reduce wetland impacts if existing bridges or other structures are available for attaching the pipeline at the crossing. Elevated pipelines and associated structures would, however, impact wetlands due to construction activities for pipeline installation and construction of service roads necessary to provide access for pipeline maintenance and repairs.

The construction area must be monitored to ensure that the wetland vegetation recovers and that exotic or nuisance species do not become established. If adequate plant cover is not established within one growing season, replanting may be necessary. Impacts to forested wetland systems within the pipeline construction area will be considered permanent, since trees must be permanently removed to provide access to the pipe for continuing maintenance and emergencies.

The most important factor controlling the quantity of permanent wetland impacts is the estimated miles of new service road needed in the wetlands. Once constructed, the pipeline must be accessible by vehicle for service. While the pipeline itself can be constructed below grade and without a permanent surface grade change, any service roads must be above grade to allow wet weather access by service vehicles.

Where practical, preference should be given to pipeline route alternatives located adjacent to existing linear disturbances, such as railroad grades, power line easements, utility service roads, farm roads, and other roadways. This may help to reduce wetlands impacts that result from activities such as construction of additional maintenance and patrol access roads, and stream and wetland crossings. Where roads do not already exist, some new road construction will be necessary. Routes requiring large amounts of new road construction may result in significant permitting difficulties and wetland compensation costs. Similarly, use of existing rights-of-way (ROW) and easements where possible may help to minimize new impacts and control project capital costs.

Pipeline routing for this conceptual analysis has for the most part assumed to follow existing corridors such as railroads and roadways. During preliminary design alternative routes should and will be considered for those conceptual alternatives which are considered feasible.

WILDLIFE IMPACTS

Wildlife impacts can also be temporary. If, for example, a gopher tortoise burrow occurs within the planned construction area, with appropriate permitting the burrow can be excavated and the tortoise relocated to an appropriate area.

Other wildlife impacts may be more permanent. An example of a permanent protected wildlife impact would be the removal of long leaf pine habitat or specific red-cockaded woodpecker nesting trees, or the removal of isolated ephemeral ponds which provide habitat for flatwoods salamander breeding.

Table 1 lists species considered threatened or endangered by the state or federal government, and provides information concerning occurrence or potential occurrence in the study area of Okaloosa County as well as the adjacent Santa Rosa and Walton Counties. All 89 of the animal and plant species noted are listed as threatened or endangered at the state level and 18 of these species are listed as federally endangered or threatened. During this analysis only limited reconnaissance level preliminary field investigations have been undertaken. Table 1 is presented in order to identify those species which may be within the study area and surrounding counties.

Several species are listed for the counties, but based on habitat requirements, are not likely to occur in the project area. The turtles not expected in the project area include loggerhead (*Caretta caretta*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and Kemp's Ridley (*Lepidochelys kempii*). All four species nest on open beaches along the shore and do not occur in the project area. Another reptile, the Gulf salt marsh snake (*Nerodia clarkii clarkii*) is not expected in the proposed project area. The Gulf sturgeon (*Acipenser oxyrinchus desotoi*) is seasonally resident in the Yellow River and has a limited summer resting area in the Shoal River from the Yellow River confluence upstream to approximately Florida Highway Bridge 85. The Okaloosa darter (*Etheostoma okaloosae*) is not expected to occur in the project area.

Birds listed but not expected within the project include the beach foraging piping plover (*Charadrius melodus*), and the beach nesting and foraging snowy plover (*Charadrius alexandrinus*). Mammals not expected to occur in the project area include the Choctawhatchee beach mouse (*Peromyscus polionotus allophrys*) and the Santa Rosa beach mouse (*Peromyscus polionotus leucocephalus*). A more detailed review of habitat requirements once a water supply route is planned can be made and additional species may be eliminated. If appropriate habitat is available, surveys for listed species associated with those habitats should be made to determine their presence.

EVALUATING PIPELINE ROUTE ALTERNATIVES FOR POTENTIAL ENVIRONMENTAL IMPACTS

During future investigations alternative pipeline routes will be evaluated and ranked in order of anticipated environmental impacts. There are several wetland assessment protocols and available databases used by the USACE and the Florida Department of Environmental Protection (FDEP) to develop such rankings. Within Florida, the Uniform Mitigation Assessment Method (UWAM) is the functional assessment method specified under for state agencies and local governments (s. 373.414(18), F.S.; Rule 62-345, F.A.C.). The USACE has also accepted use of UWAM for wetland impact and mitigation permitting. Other example assessment protocols include Wetland Rapid Assessment Procedure (WRAP), Modified Wetland Rapid Assessment Procedure (MWRAP), Habitat Evaluation Procedure

Table 1: Federal and State-Listed Species and County Occurrence in
Walton (W), Okaloosa (O), and Santa Rosa (S) Counties, Florida
(Note: A species is listed for a county if the first letter of the county is provided for that species)

Scientific Name*	Common Name	Federal Status	State Status	County Occurrence		
FISH						
Acipenser oxyrinchus desotoi	Gulf sturgeon	LT	LS	W	O	S
Awaous tajasica	River goby	LT	LS		O	
Etheostoma okaloosae	Okaloosa darter	LE	LE	W	O	
Notropis melanostomus	Blackmouth shiner	N	LE	W		S
Pteronotropis welaka	Bluenose shiner	N	LS	W	O	S
AMPHIBIANS						
Ambystoma cingulatum	Flatwoods salamander	LT	N	W	O	S
Hyla andersonii	Pine barrens treefrog	N	LS	W	O	S
Rana capito	Gopher frog	N	LS	W	O	S
Rana okaloosae	Florida bog frog	N	LS	W	O	S
REPTILES						
Alligator mississippiensis	American alligator	LT	LS	W	O	S
Caretta caretta	Loggerhead	LT	LT	W	O	S
Chelonia mydas	Green turtle	LE	LE	W	O	S
Dermochelys coriacea	Leatherback	LE	LE	W	O	S
Drymarchon corais couperi	Eastern indigo snake	LT	LT	W	O	S
Gopherus polyphemus	Gopher tortoise	N	LS	W	O	S
Lepidochelys kempii	Kemp's ridley	LE	LE	W	O	S
Macroclemys temminckii	Alligator snapping turtle	N	LS	W	O	S
Pituophis melanoleucus mugitus	Florida pine snake	N	LS	W	O	S
BIRDS						
Ammodramus maritimus peninsulae	Scott's seaside sparrow	N	LS	W		
Charadrius alexandrinus	Snowy plover	N	LT	W	O	S
Charadrius melodus	Piping plover	LT	LT	W	O	S
Cistothorus palustris marianae	Marian’s marsh wren	N	LS			S
Egretta caerulea	Little blue heron	N	LS	W	O	S
Egretta thula	Snowy egret	N	LS	W	O	S
Egretta tricolor	Tricolored heron	N	LS	W	O	S
Eudocimus albus	White ibis	N	LS	W	O	S
Falco peregrinus	Peregrine falcon	LE	LE	W	O	S
Falco sparverius paulus	Southeastern American kestrel	N	LT	W	O	S
Haematopus palliatus	American oystercatcher	N	LS	W	O	S
Haliaeetus leucocephalus	Bald eagle	LT	LT		O	
Mycteria americana	Wood stork	LE	LE	W	O	S
Pandion haliaetus	Osprey	N	LS**	W	O	S
Pelecanus occidentalis	Brown pelican	N	LS	W	O	S
Picoides borealis	Red-cockaded woodpecker	LE	LT	W	O	S
Rynchops niger	Black skimmer	N	LS	W	O	S
Speotyto cunicularia floridana	Florida burrowing owl	N	LS	W	O	
Sterna antillarum	Least tern	N	LT	W	O	S
MAMMALS						
Peromyscus polionotus allophrys	Choctawhatchee beach mouse	LE	LE	W		
Tamias striatus	Eastern chipmunk	N	LS	W	O	S
Trichechus manatus	Manatee	LE	LE	W	O	S
Ursus americanus floridanus	Florida black bear	C	LT**	W	O	S
PLANTS						
Arnoglossum diversifolium	Variable-leaved Indian-plantain	N	LT	W		

Table 1 (Concluded)

Scientific Name*	Common Name	Federal Status	State Status	County Occurrence		
Asclepias viridula	Southern milkweed	N	LT	W		
Baptisia calycosa var *villosa*	Hairy wild indigo	N	LT	W	O	S
Calamovilfa curtissii	Curtiss' sandgrass	N	LT	W	O	S
Calycanthus floridus	Sweet shrub	N	LE	W		S
Carex baltzellii	Baltzell's sedge	N	LT	W	O	S
Chrysopsis gossypina ssp. *cruiseana*	Cruise's golden aster	N	LE	W	O	S
Crataegus phaenopyrum	Washington thorn	N	LE	W		
Drosera intermedia	Spoon-leaved sundew	N	LT	W	O	S
Epigaea repens	Trailing arbutus	N	LE	W	O	S
Gentiana pennelliana	Wiregrass gentian	N	LE	W		
Hexastylis arifolia	Heartleaf	N	LT	W	O	S
Hymenocallis henryae	Panhandle spiderlily	N	LE	W		
Hypericum lissophloeus	Smooth-barked St. John's-wort	N	LE	W		
Illicium floridanum	Florida anise	N	LT	W	O	S
Kalmia latifolia	Mountain laurel	N	LT	W	O	S
Lilium iridollae	Panhandle lily	N	LE	W	O	S
Lindera subcoriacea	Bog spicebush	N	LE		O	
Linum westii	West's flax	N	LE		O	
Litsea aestivalis	Pondspice	N	LE		O	
Lupinus westianus	Gulf Coast lupine	N	LT	W	O	S
Macranthera flammea	Hummingbird flower	N	LE	W	O	S
Magnolia acuminata	Cucumber magnolia	N	LE	W		
Magnolia ashei	Ashe's magnolia	N	LE	W	O	S
Magnolia pyramidata	Pyramid magnolia	N	LE	W	O	S
Malaxis unifolia	Green adder's-mouth	N	LE	W	O	
Matelea alabamensis	Alabama spiny-pod	N	LE	W		
Medeola virginiana	Indian cucumber-root	N	LE	W		S
Monotropa hypopithys	Pinesap	N	LE	W	O	
Najas filifolia	Narrowleaf naiad	N	LT			S
Panicum abscissum	Cutthroat grass	N	LE	W		
Pinguicula planifolia	Chapman's butterwort	N	LT	W	O	S
Pinguicula primuliflora	Primrose-flowered butterwort	N	LE	W	O	S
Platanthera integra	Yellow fringeless orchid	N	LE	W	O	S
Polygonella macrophylla	Large-leaved jointweed	N	LT	W	O	S
Rhexia parviflora	Small-flowered meadowbeauty	N	LE	W	O	S
Rhododendron austrinum	Orange azalea	N	LE	W	O	S
Sarracenia leucophylla	White-top pitcherplant	N	LE	W	O	S
Sarracenia rubra	Sweet pitcherplant	N	LT	W	O	S
Sideroxylon lycioides	Gopherwood buckthorn	N	LE			S
Sideroxylon thornei	Thorne's buckthorn	N	LE			S
Stewartia malacodendron	Silky camellia	N	LE	W	O	S
Thalictrum cooleyi	Cooley's meadowrue	LE	LE	W		
Verbesina chapmanii	Chapman's crownbeard	N	LT	W	O	S
Xanthorhiza simplicissima	Yellow-root	N	LE	W		
Xyris longisepala	Karst pond xyris	N	LE	W	O	
Xyris scabrifolia	Harper's yellow-eyed grass	N	LT	W	O	S
INVERTEBRATES						
Medionidus penicillatus	Gulf moccasinshell	LE	N	W		

*Vertebrates, Invertebrates, and Plants: **C** = (confirmed) occurrence status derived from a documented record in the FNAI database; **P** = (potential) occurrence status derived from a reported occurrence for the County or the occurrence lies within the published range of the taxon; **N** = Not Listed. Plants, Natural Communities, and Other: (Confirmed) occurrence status derived from a documented record in the FNAI database or from an herbarium specimen; **R** = (Reported) occurrence status derived from published reports. **LS** = Species of special concern, **LT** = Threatened species, **LE** = Endangered species.

(HEP), and the Hydrogeomorphic (HGM) approach. Available databases include Florida Geographic Data Library (FGDL), NWI, Florida Natural Areas Inventory (FNAI) and FDEP Wetlands.

Generally speaking, alternatives with smaller amounts of high quality wetlands, fewer miles of new service road required, narrower water crossings, and smaller numbers of potentially occurring endangered species are more favorable in terms of minimizing environmental impacts. A previous report prepared by PBS&J in 2000 for the NWFWMD discussed in general terms wetland impacts associated with pipelines.

ENVIRONMENTAL PERMITTING AND REGULATORY AUTHORITIES

The primary environmental permitting issues associated with the construction of pipelines and associated service roads are concerned with wetlands and protected wildlife. A summary of environmental permit requirements is presented in Table 2.

Table 2: Environmental Permit Requirements

Activity	Agency	Type of Permit
Wetlands Impacts	NWFWMD and/or FDEP*	Environmental Resource Permit (ERP)*/(to be determined)
	USACE (with review by EPA and FWS)	Dredge and Fill Permit for Waters of the U.S.
Stormwater Regulation	FDEP*	Stormwater quality per Rule 62-40; ERP rules in place by 2007*
Wildlife Impacts to Federally Listed Species	FWS	Issued with USACE permit through Section 7 Consultation – may require a Habitat Conservation Plan and/or an Incidental Take Permit
Wildlife Impacts to Non-federally Listed Species	Florida Fish and Wildlife Conservation Commission	Incidental Take Permit may be required
Impacts to Specific Communities or Habitat	Okaloosa	Local construction approval of impacts to these systems to be considered during development review process

*ERP requirements will be implemented in northwest Florida, with ERP stormwater rules in place by January 2007 and wetland rules in place by January 2008. The ultimate split in responsibilities between DEP and the NWFWMD are yet to be determined.

A number of state and federal regulatory agencies have the responsibility to review the potential impacts of a proposed project. Each has its own statutory responsibility, which may overlap that of other agencies, and review criteria. Additionally, applicable city and county requirements, such those affecting the construction permitting process, will need to be considered.

The USACE reviews applications for dredging and filling in waters of the U.S. A determination of federal wetland jurisdiction will be needed from the USACE Panama City field office, and likely concurrence with the NWFWMD assuming the applicant is a utility or local governmental entity (likely to be

Okaloosa County), and the resulting wetland boundaries will be used to determine the extent of wetland impacts during the permitting process.

The USACE requires permits for all works in the "Navigable Waters of the U.S." pursuant to Sections 9 and 10 of the Rivers and Harbors Act of 1899, and for certain works in the "Waters of the U.S." pursuant to Section 404 of the Clean Water Act. Under a Memorandum of Agreement, the USACE and U.S. Environmental Protection Agency (EPA) jointly review dredge and fill permit applications. In addition, other federal resource agencies, including the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (for marine habitats only), have review authority over environmental impacts associated with wetland and wildlife issues. While the USACE has ultimate responsibility for federal permitting decisions, EPA has statutory veto authority over permits issued by the USACE.

The USACE requires minimization and avoidance of wetland impacts to the maximum extent practical. The agency also requires the applicant to demonstrate the absence of practical alternatives (other reasonable routes) which would avoid and minimize wetlands impacts, and an analysis of alternatives would likely be required to justify wetland impacts. As part of a public-interest review, the USACE sends notice of projects to the public and to federal resource agencies for comment. Through this process, issues are raised for the applicant to address to the satisfaction of the USACE.

COST INFORMATION AND ELEMENTS

The cost estimates developed for this analysis are conceptual planning-level estimates for system components. Cost information for some facilities is consistent with ongoing water supply planning efforts by the St. Johns River Water Management District (SJRWMD). Specifically, water supply cost components as published by the SJRWMD in 1997 (SJ97-SP3). Additionally, cost estimates for dam embankments and spillways were based on conceptual level designs, unit costs and PBS&J experience.

To facilitate the cost estimating procedure for the NWFWMD, selected unit costs were adapted from the SJRWMD cost estimates by updating construction and nonconstruction capital costs for inflation. Land costs where provided by the NWFWMD. PBS&J believes the updated SJRWMD report costs are appropriate for planning level use in Region II.

The SJRWMD cost estimates were given in 1996 dollars, and include total capital costs, operation and maintenance (O&M) costs, and equivalent annual costs. The time value of money and estimated service life of components were consistent with the procedures established for water supply planning by the SJRWMD. Cost information was updated to year 2006 dollars using Engineering News Record Construction Costs Indices from 1996 to March 2006.

TOTAL CAPITAL COST

Estimated total capital costs are based on the individual costs for the system components needed to implement a particular conceptual alternative project. The total capital costs for each system component were the sum of the construction, nonconstruction, land, and land acquisition costs, including environmental impact costs.

CONSTRUCTION COSTS

Estimated construction costs are amounts that a qualified contractor is likely to charge for construction of facilities. Included are material, equipment, construction labor costs, taxes, overhead and profit.

CONSTRUCTION CONTINGENCY COSTS

A 25% construction contingency is included in the total capital cost estimate to account for unforeseen costs and undefined details that may be associated with a specific alternative project.

NONCONSTRUCTION COSTS

Estimated nonconstruction costs consist of project management costs, including legal, administrative, and permitting/regulatory coordination tasks, surveying, geotechnical investigation, ROW/land acquisition and engineering design. Permitting and regulatory coordination tasks relating to environmental impacts specific to pipeline projects are not included in these cost estimates, and are considered separately (see below). Estimated costs for project management, bond issuance (2%) and engineering design are 10% and 15% of estimated construction costs, respectively, for a total of 25% of estimated construction costs.

ENVIRONMENTAL IMPACT-RELATED COSTS

Costs associated with environmental impacts can include delineation of wildlife habitat and wetlands, mitigation and permitting associated with impacts to wildlife habitat and wetlands, and construction in environmentally sensitive areas. Costs for wetlands delineation and mitigation were estimated based on NWI mapping estimates of wetland area for reservoir sites. To estimate and compare mitigation costs, the NWI wetland area for each conceptual reservoir was multiplied by $95,955. This figure is the fiscal year (FY) 2007–2008 per impact acre cost for mitigation used for transportation impacts pursuant to section 373.4137, F.S.

LAND AND LAND ACQUISITION COSTS

Land and land acquisition cost estimates were developed based on pipeline length for urban, suburban and rural scenarios. In Region II, many potential pipeline route alternatives would likely be located in rural areas, which would be expected to have lower land costs than urban or suburban areas. It should be noted, however, that in rural areas mitigation for relatively pristine wetlands may be necessary, and permitting problems associated with public lands may be encountered. A route alternative selection process should also consider existing easements or ROW where it may be possible to place utilities. Selection of routes where utilities can be placed in existing easements or ROW may help to reduce the capital costs of the project.

OPERATION AND MAINTENANCE COSTS

O&M costs include all labor and materials, excluding energy, required to run the facility and keep it operational, including periodic repair and/or replacement of facility equipment. Based on regional planning cost assumptions (Texas), O&M costs are estimated to be 1% of the total estimated construction costs for pipelines, distribution facilities, tanks, and wells, 1.5% of the total estimated construction costs for dams and reservoirs, and 2.5% of the total estimated construction costs for intake structures and pump stations. WTP annual O&M cost estimates are based on PBS&J databases and is estimated to be at 8% of construction costs or $2,282,000 for a 25-mgd facility.

PUMPING ENERGY COSTS

Power costs are calculated on an annual basis, using calculated horsepower input and an assumed power purchase cost of $0.08 per kilowatt hour (kWh).

DEBT SERVICE

Debt service is the estimated annual payment that can be expected for repayment of borrowed funds based on the total project cost, the project finance rate, and the finance period in years. These were estimated assuming annual payments that include both interest and principle and the following economic criteria:

Term for Bonds (years)	=	30
Interest Rate (%/year)	=	5.6% (current U.S. Treasury Rate)

ANNUAL COSTS

Annual cost estimates were based on a debt service for the capital costs amortized over 30 years at an annual interest rate of 5.6% (2006 U.S. Treasury rate) with zero salvage value assumed at the end of 30-year period and O&M and energy costs. Capital costs were inflated at 4.5% per year from 2006 to 2012, when construction of facilities is assumed to begin, and completed in 2015 with operations beginning in 2015. O&M and energy costs were inflated at 4.5% annually (Engineering News Record). While not used in the economic analysis of this report, for reference purposes only, the estimated service life of system components are as shown in Table 3. For simplifying assumptions, we assume an overall average service life of 30 years, such that there is zero salvage value at the end of 30 years.

UNIT COSTS

Unit costs were developed for each year of the bond term (i.e., 30 years) by the ratio of total annual costs to the project yield, including inflation for both O&M and energy consumption. An inflation rate of 3.5% (2006 Consumer Price Index [CPI]) was used to develop a present value unit cost (see the Life Cycle costs for conceptual alternatives in Attachment D).

Table 3: Component Service Life

Component Type	Service Life
Land	Permanent
Water conveyance structures (including pipelines, collection and distribution systems, interceptors, force-mains, drop shafts, tunnels, spillways, etc.)	50 years
Other structures (including buildings, concrete tankage, pumping station structures, and site improvements, etc.)	40 years
Process and auxiliary equipment (including treatment equipment such as clarifier mechanisms and filters, steel process tankage, chemical storage facilities, standby electrical generating equipment, pumps and motors, instrumentation and control facilities, mechanical equipment such as compressors, aeration systems, chlorinators, other electrical equipment in regular service, etc.)	20 years

Source: SJRWMD Special Publication SJ97-SP15.

CONCEPTUAL ALTERNATIVE PROJECTS

The factors affecting the conceptual alternative projects are discussed below, including the assumptions used for specific alternatives. Facility locations and sites for the management strategies investigated in this feasibility analysis do not represent the full range of alternatives that will be required to evaluate in order to develop cost effective and environmentally acceptable solutions, but rather to provide the NWFWMD with some preliminary planning information on the technical and financial implications and/or considerations to assess the feasibility of the management strategies.

WATER SUPPLY SOURCES

Water supply sources for this analysis were identified through discussions with the NWFWMD. Water supply sources discussed later in this section include the Shoal River for surface water supplies and the Yellow River for riverbank filtration facilities. Diversions and yields for Shoal River water supplies were evaluated upstream of U.S. Highway (US) 90. River bank filtration facilities were evaluated on the western floodplain on the Yellow River in western Okaloosa County south of Interstate Highway (IH) 10.

In all conceptual alternatives evaluated in this feasibility analysis the delivery of additional supplies was assumed to be constant throughout the year with no peaking considerations. This assumes that local governments and regional water authorities would provide peaking needs from their own existing or future groundwater supplies. While the NWFWMD considered this assumption to be appropriate for this feasibility analysis, future studies will have to evaluate and coordinate with the regional water suppliers whether this is a reasonable assumption and/or evaluating the benefits of conjunctive use.

Discussions between the NWFWMD and Okaloosa County Water & Sewer indicated the region north east of the city of Crestview, as an area where water supply shortfalls were expected beyond the year 2020. For this feasibility analysis it is assumed that treated water, either from Riverbank filtration or surface water sources, will be delivered at a point approximately 1 mile south of the Bob Sikes Airport, near the intersection of James Lee Boulevard (i.e., US 90) and Okaloosa Lane. The Bob Sikes Airport is northeast of Crestview. The preliminary delivery point was selected based on the region of expected growth and use of the alternative supplies and may change during future investigations based on input from regional water suppliers.

The NWFWMD has performed a preliminary hydrogeologic and hydrologic analyses to assess the reliable supplies from riverbank filtration and surface water supplies. While not within the scope of this investigation the yield analysis for the surface water supplies was performed by district staff taking into consideration instream environmental pass through flows. Based on NWFWMD preliminary analysis, the reliable yield for both surface (i.e., Yellow and Shoal Rivers) and riverbank filtration is 25 mgd. A description of each conceptual alternative projects, water supply sources and other pertinent information is provided in the following sections. Any impact from this level of withdrawal relative to available low flow statistics on the main stem rivers is anticipated to be minimal. However, more detailed hydrologic and hydrodynamic analyses will likely need to be conducted by the NWFWMD to document the dependability of the surface water sources and their sustainability or future limits on water availability relative to the freshwater needs of natural systems.

The NWFWMD has identified multiple tributary reservoir sites in Okaloosa County and selected three tributary reservoir sites for analysis in order to establish a representative range of project costs. While this analysis only focused on three sites to assess feasibility, future studies should evaluate and compare the technical, environmental and financial constraints of other reasonable and practical alternatives identified by the NWFWMD and their consultants. For this feasibility analysis it was determined that conceptual alternative projects would be developed using three of the eight reservoir sites identified by the NWFWMD: Pond Creek, West Dog, and Bear Creek. For initial comparison purposes the district also included consideration of a main stem Yellow River Reservoir Project as a surface water supply source. As mentioned previously this was a surface water supply alternative considered by Okaloosa County and studied by the USACE in 2004.

It is assumed that the surface water reservoirs may be able to provide a portion of the yield from within their own watersheds without supplementing with run-of-river diversions. However, early in the analysis, it was agreed that with the exception of Pond Creek reservoir, facilities will be sized assuming that the yield will be augmented by run-of-river diversions. This is a conservative assumption considering that West Dog and Bear Creek reservoirs have small watersheds and have minimal yields on their own right. While the preliminary yield analysis for Pond Creek reservoir indicated a yield of 25 mgd without supplemental run-of-river diversions during the critical period, the project team assumed that 15 mgd would be a reasonable yield to size facilities considering the uncertainties of the preliminary reservoir yield analysis. Future investigations should include refining the Pond Creek yield analysis. The yield analysis prepared by the NWFWMD for run-of-river diversions is considered acceptable and reasonable for this level of analysis.

All reservoirs investigated in this feasibility analysis offer a degree of redundancy in delivery of surface water supplies with the additional storage they provide. Additionally, system storage provides for water supply reliability in the region during hurricanes and tropical storms which could negatively impact coastal water supply facilities.

WATER QUALITY EVALUATION FOR WATER SUPPLY SOURCES

A brief water quality analysis was performed on data from the Shoal and Yellow Rivers to assess the level of treatment that would be required for the water from the potential water supply sources discussed in the above section. Details of this water quality evaluation and the resulting proposed treatment are provided in the Technical Memorandum, prepared by PBS&J, included in Attachment B. Below is a summary of the data evaluated in the water quality analysis and the conclusions of the evaluation.

The potential water supply sources identified in this analysis were surface water from the Shoal River and groundwater from an aquifer influenced by the Yellow River. There were four sites considered for raw surface water intake along the Shoal River and one site along the banks of the Yellow River identified as a potential location for a wellfield to extract groundwater via riverbank filtration. Data provided on the water quality of the Shoal River was evaluated to propose treatment techniques for water from the four surface water intake sites identified for Alternatives 1 through 4. Due to the limited amount of groundwater quality data, surface water quality data for the Yellow River was also evaluated as part of the treatment assessment for the groundwater extracted via riverbank filtration, proposed as Alternative 5. The water quality analysis of the Yellow River surface water and the groundwater from the Sand-and-Gravel Aquifer showed that these two sources have similar characteristics and could be used in conjunction to develop a treatment process necessary to meet the quality standards for distribution and consumption.

Surface water quality data was provided to PBS&J from three separate sources for two sites on the Shoal River and three sites along the Yellow River, and groundwater quality data was provided for four wells drawing from the Sand-and-Gravel Aquifer. Data from the Pensacola Bay System Tributary Sampling Program conducted by the NWFWMD was supplied for a site along the Shoal River at the crossing of US 90 and two sites along the Yellow River near Milligan and at the crossing of State Road (SR) 2. A summary of NWFWMD historical records provided historical water quality data for the Shoal River at the crossing of SR 85 and the Yellow River at the crossing of SR 87. Records provided from the EPA STORET database included historical data for the Yellow River at the SR 2 site. Groundwater data from four wells drawing from varying locations in the Sand-and-Gravel Aquifer was provided from a sampling period in August 2003.

A review of the water quality data provided in comparison to the National Primary Drinking Water Regulations (NPDWRs) and the National Secondary Drinking Water Regulations (NSDWRs) revealed that the surface water from both the Shoal and Yellow Rivers exceeds limits set by the NPDWRs for total fecal coliform count and limits set by the NSDWRs for color. In addition to the coliform and color concerns, surface water quality data collected during high flows along the Shoal River indicate low pH values that fall below the standards set in the NSDWRs. The limited well data for the groundwater from the Sand-and-Gravel Aquifer showed levels of total suspended solids (TSS), turbidity, and pH that would require treatment. The color values were lower for the groundwater compared with surface water, but the color present in the groundwater will still require treatment. Low values of alkalinity and the presence of coliforms were also noted in the water quality analysis of the well data provided from the Sand-and-Gravel Aquifer.

Based on the water quality data evaluated and the analysis conducted with respect to the NPDWRs and NSDWRs, the analysis determined that the constituents of concern noted for the surface water of the Shoal and Yellow Rivers, and the groundwater from the Sand-and-Gravel Aquifer, could be treated and brought to drinking water standards using chemical disinfection and conventional treatment methods.

CONCEPTUAL ALTERNATIVE PROJECTS

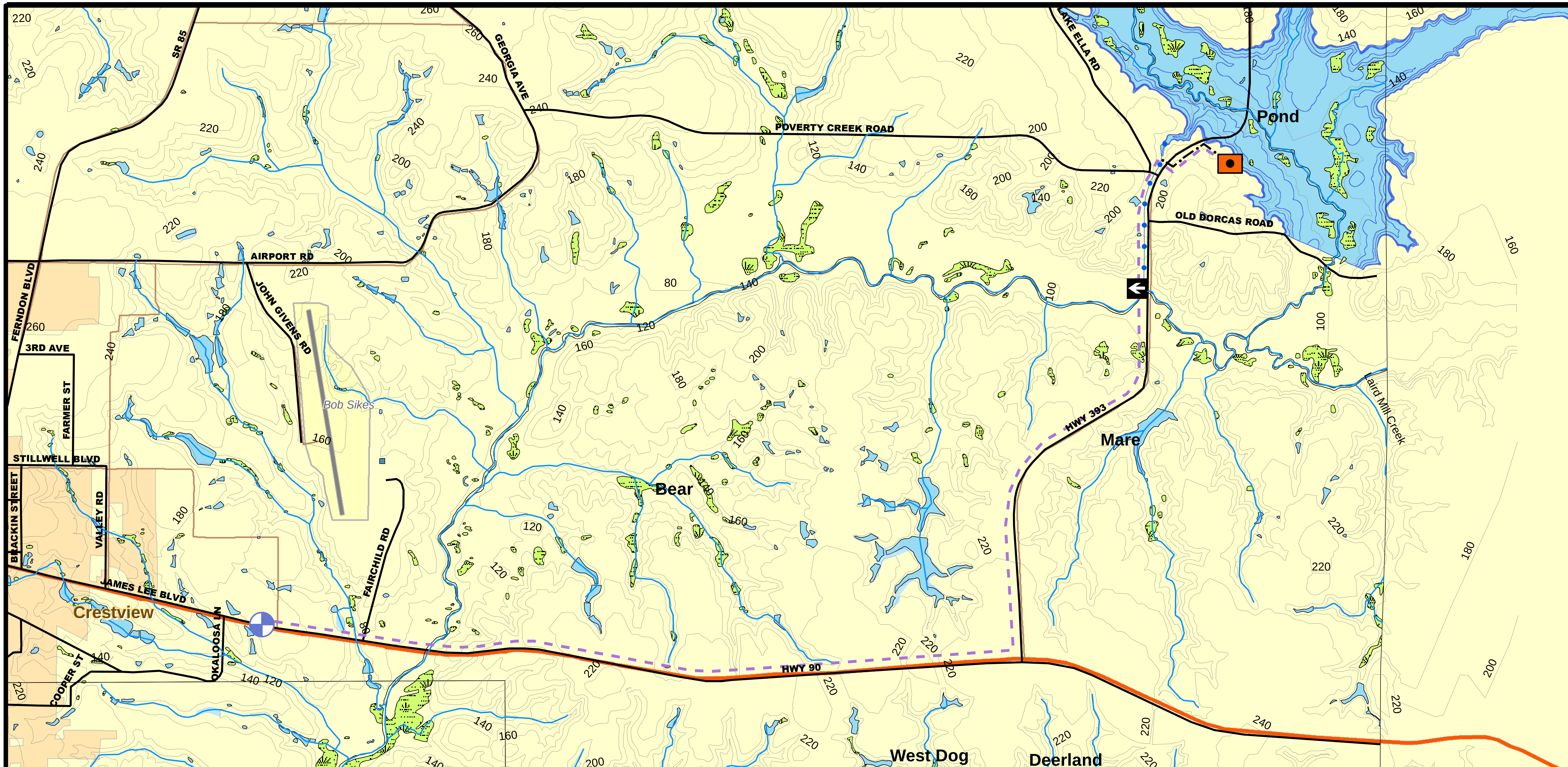
In general, cost estimates for electrical substations and maintenance warehouse (as well as supporting ancillary facilities such as access roads) are included as part of the conceptual costs estimates for pumping stations and the WTP. The following sections describe each of the five conceptual alternative projects.

Alternative #1 – Pond Creek Reservoir

Conceptual Alternative #1 (CA1) is shown on Figure 1 and involves the following facilities:

- ***Shoal River intake structure and pumping station*** – The pump station would be a concrete structure constructed on the north bank of the Shoal River and on the western side of County Road (CR) 393. Conceptually, a concrete-lined trapezoidal intake channel about 100 feet in length would be constructed between the Shoal River and the pumping station. A silt wall at the upstream point of the intake channel would permit the bedload to pass without significant sediment conveyed into the intake channel. The invert channel would slope from the silt wall (i.e., at the river) down to the pump station at a slope of approximately 3%. The sides of the concrete channel would rise at a 1:1 slope to a 20 bench which would serve as a maintenance roadway for the channel.

  The pumping station must accommodate a wide range of flows, up to the peak diversion rate, 10 mgd firm capacity. Firm capacity is defined as the total capacity of the pumping station assuming the largest pump is out of service. Pumps will operate individually, or in combinations up to the total number of pumps, not including one installed spare. The number of pumps will be defined during preliminary design but will likely be three or four pumps. Vertical turbine pumps, are envisioned; however, horizontal split case pumps could be used in a dry well configuration. A water agitation system would be required for maintaining solids in suspension. The station should be configured to accommodate pumps and screens during the preliminary design phase. Additionally, a disinfection facility is needed for slime control.



Legend (Preliminary Routes and Facility Sites)

- Bypass (Diameter = 24 inch, Length = .6 mi)
- Intake (Diameter = 24 inch, Length = 1.1 mi)
- Transmission Pipeline (D= 36 inch, L = 10.6 mi)
- Water Treatment Plant
- Delivery Point
- Intake Facility
- Marsh, wetland, swamp, bog
- 20 ft Elevation Contours

0 0.75 1.5 Miles

N

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Figure 1 - Alternative 1
Shoal River Intake to Pond Storage

Prepared for: NWF WMD	
Job No.: 091812.01	Scale: 1:47,520
Prepared by: D. Harris	Date: April, 2006
File: Alternative 1.mxd	

- ***Raw water pipeline and Bypass***– The raw water pipeline would convey 10 mgd at a constant rate via a 1.1-mile-long, 24-inch-diameter pipeline along the eastern ROW of CR 393 to an outlet structure (i.e., stilling basin) at Pond Creek Reservoir. The pipeline is assumed to be constructed within a 30-foot easement. To provide for operational flexibility a 0.6-mile-long, 24-inch-diameter bypass pipeline would bypass flows directly to the treatment plant.

- ***Dam & Reservoir*** – An earthen dam structure was evaluated on Pond Creek in the approximate location selected for the hydrologic analysis, which was conducted by NWFWMD. This location is approximately 500 feet upstream of Old Dorcas Road, which is assumed to have a low water crossing at Pond Creek, and for this analysis the roadway is assumed to remain; however, future studies will confirm this.

  The NWFWMD developed area-capacity relationships for each proposed reservoir site. The preliminary results presented in the NWFWMD's analysis indicate the feasibility of a reservoir on Pond Creek with a storage capacity of approximately 36,000 acre-feet (ac-ft) at a corresponding normal-pool reservoir depth of 30 feet. Accordingly, conceptual designs were prepared to estimate the approximate costs to build a dam and spillway to meet these storage conditions using federal dam safety guidelines at the selected location on Pond Creek.

  The conceptual design for the Pond Creek Dam includes enough additional dam height to provide a spillway capable of safely passing the full probable maximum flood (PMF) generated within the contributing Pond Creek Watershed. The following dam characteristics for the Pond Creek Reservoir were assumed for conceptual design:

Pond Creek Reservoir Conceptual Data

Contributing Drainage Area (square miles)	160
Storage Capacity at Normal Operating Level (NOL) (ac-ft)	36,000
Length of Dam (feet)	3,130
Top of Dam Elevation (feet)	130
Dam Height above Creek Flowline (feet)	40
NOL Elevation – feet	120
Reservoir surface area at NOL (acres)	2,600
Emergency Spillway Elevation (feet)	123
Emergency Spillway Width (feet)	1,830
Embankment Side Slopes (horizontal:vertical)	3.5:1

Note: Uncontrolled, concrete-armored spillways were assumed for cost estimating purposes.

The reservoir feasibility evaluation is based upon a dam with 3.5:1 side slopes (horizontal to vertical) and an integrated concrete service and emergency spillway. The dam assumed for this analysis has a zoned earthen embankment. The typical section consists of an impermeable clay core with semi-permeable fill on the outer embankment slopes. On site soils were assumed to be suitable for all embankment materials. The clay core extends along the dam's entire longitudinal axis, and it was assumed that this core would be keyed into an impermeable formation 10 feet below the existing creek flowline. Costs for a gravel drainage system are included between the downstream interface with the clay core and the toe of the dam to provide seepage control and prevent saturation and instability of the outer embankment soils. A 20-foot-wide dam crest was assumed for maintenance access with a 15-foot-wide gravel road base. The embankment slopes were assumed to have rock rip-rap (18-inch median rock size) for the entire upstream slope and native grass seeding on the downstream slope.

The actual dam and spillways would be designed to meet Federal Guidelines for Dam Safety, Federal Emergency Management Agency (FEMA) 94, October 1998. These guidelines state that the maximum freeboard requirements are typically associated with the PMF. However, these guidelines also recommend that the final spillway configurations be determined based upon a detailed analysis of extreme events (i.e., wave action, peak discharge, etc.) over a range of reservoir operation levels to minimize risk of failure and optimize design cost-effectiveness. For this planning level analysis the full PMF was assumed to represent the Inflow Design Flood (IDF) for the proposed Pond Creek Reservoir. A total of 3 feet was assumed between the NOL and the flowline of the emergency spillway to minimize losses caused by wave action. A total freeboard of 1 foot is assumed during the IDF. Per federal guidelines, coincident maximum wave and IDF events were assumed to have an extremely low probability of occurrence, and therefore these events were considered separately in layout of the proposed spillway configurations.

According to the NWFWMD's hydrologic model results, the full PMF would produce a peak discharge of approximately 80,500 cubic feet per second (cfs). This peak discharge was assumed to represent the IDF for Pond Creek Reservoir. For the planning level cost estimate, the assumed emergency spillway length is 1,830 feet. This spillway size was determined assuming the spillway functions as a broad-crested weir. The maximum flow depth of the assumed peak discharge through this spillway is 6 feet. The top of the dam was assumed to be 7 feet above the emergency spillway elevation, allowing an additional foot over the IDF water surface elevation. A concrete-lined stilling basin for spillway energy dissipation was included in the cost of the spillway. The assumed basin dimensions are 4 feet deep and 50 feet long, starting at the down stream toe of the spillway.

The available soils data suggest that the inundation areas of the proposed Pond Creek Reservoir would not contribute to excessive losses due to infiltration. Additionally, since no geotechnical information is available for the proposed site, it is assumed that sufficient amounts of clay are available on site for construction of the embankment core. Future studies will include an appropriate geotechnical investigation.

Environmental and cultural constraints have not been assessed during this conceptual planning analysis and will be evaluated during future studies. It should be noted that a portion of the Pond Reservoir inundates the Upper Shoal River Florida Forever Project in Walton County. As of November 2004, according to the FNAI the Upper Shoal River Project had not acquired any property of the anticipated 14,545 acres. The added inundation associated with the IDF (i.e., the maximum reservoir rim elevation) is also assumed to be acceptable in terms of potential environmental impacts at this time.

- ***Reservoir intake structure, pumping station and pipeline*** – Several options for a reservoir intake will be analyzed during preliminary design. These include floating intakes, free standing intake, single port intake, multi-port intake (i.e., multi-tiered) and potentially lake destratification equipment. The conceptual intake facility considered during this feasibility analysis is comprised of a 20-foot diameter concrete lined vertical shaft approximately 50 feet deep near the shore of the reservoir with two, 4-foot diameter horizontal tunnels at different elevations to allow operational flexibility in addressing water quality issues. Each tunnel is planned to have a gate located at the vertical shaft and a bar and fish screen where the tunnel enters the reservoir. Evenly spaced vertical turbine pumps would extend vertically to the bottom of the shaft. A short 36-inch-diameter pipeline would serve as a discharge header into the WTP.

- ***Water Treatment Plant*** – The WTP will have a capacity of 25 mgd. Specific details describing the WTP are included in a Technical Memorandum, prepared by PBS&J, included in Attachment B.

  Selection of the water treatment process considered the results of water quality analysis as discussed previously for the Shoal River. The results of the water quality analysis show that for the four surface water alternatives, water treatment facilities located on the Shoal River, the treatment process will be identical for the three reservoir sites, Conceptual Alternatives 1 through 3 and Conceptual Alternative 4, Shoal River Direct Diversion. The water quality data analysis was from a single location, and therefore there is no distinction in water treatment expected from alternative to alternative, resulting in all alternatives having identical treatment components. Additionally, specific requirements for reverse osmosis, ozone, peroxide, and ultraviolet radiation were not considered necessary at this planning level and should be consideration during preliminary design.

  The following is a description of the anticipated treatment components:

  - **Primary disinfection** – Chlorination and ammonia addition to produce chloramines for initial biological pathogen kill;
  - **Primary Treatment Clarifier** – Rapid mix coagulation, flocculation, use of slaker lime feed, alum for color removal, and turbidity reduction, addition of liquid polymer for clarification aid;
  - **Filtration** – Gravity multimedia filters to reduce biological pathogen and turbidity, air scour backwash, and the addition of polymer for polishing aid;
  - **Chlorine Contact Basin/Clearwell** – Provide a baffled clearwell to introduce chloramines (chlorine and ammonia) to finished water if necessary for secondary disinfection;
  - **Chemical Systems**
    - Lime feed – Dry system for slaker feed
    - pH control – Carbon dioxide package system
    - Chlorine and ammonia (liquid ammonia sulfate) for primary and secondary disinfection
    - Liquid alum system and/or polymer for coagulate aid and filtration aid for color
  - **Backwash facilities** – Blower system for air scour; backwash storage pond and decant pump station and return piping;
  - **Sludge handling** – Dewatering thickener, pump station, belt press, and offsite disposal;
  - **Process control and instrumentation system** – Including Intelligent Instrumentation and Supervisory Control and Data Acquisition System (SCADA).

  Specific state-of-the-art technologies, including Reverse Osmosis, ozone, peroxide and ultraviolet radiation, were not considered necessary based on the water quality data. Additional analysis for total organic compounds (TOC) production, brackish water, salinity (chloride), pH excursions and turbidity (TSS) should all be given the greatest consideration in preliminary design to ensure that membrane technology and other treatment alternatives are not necessary.

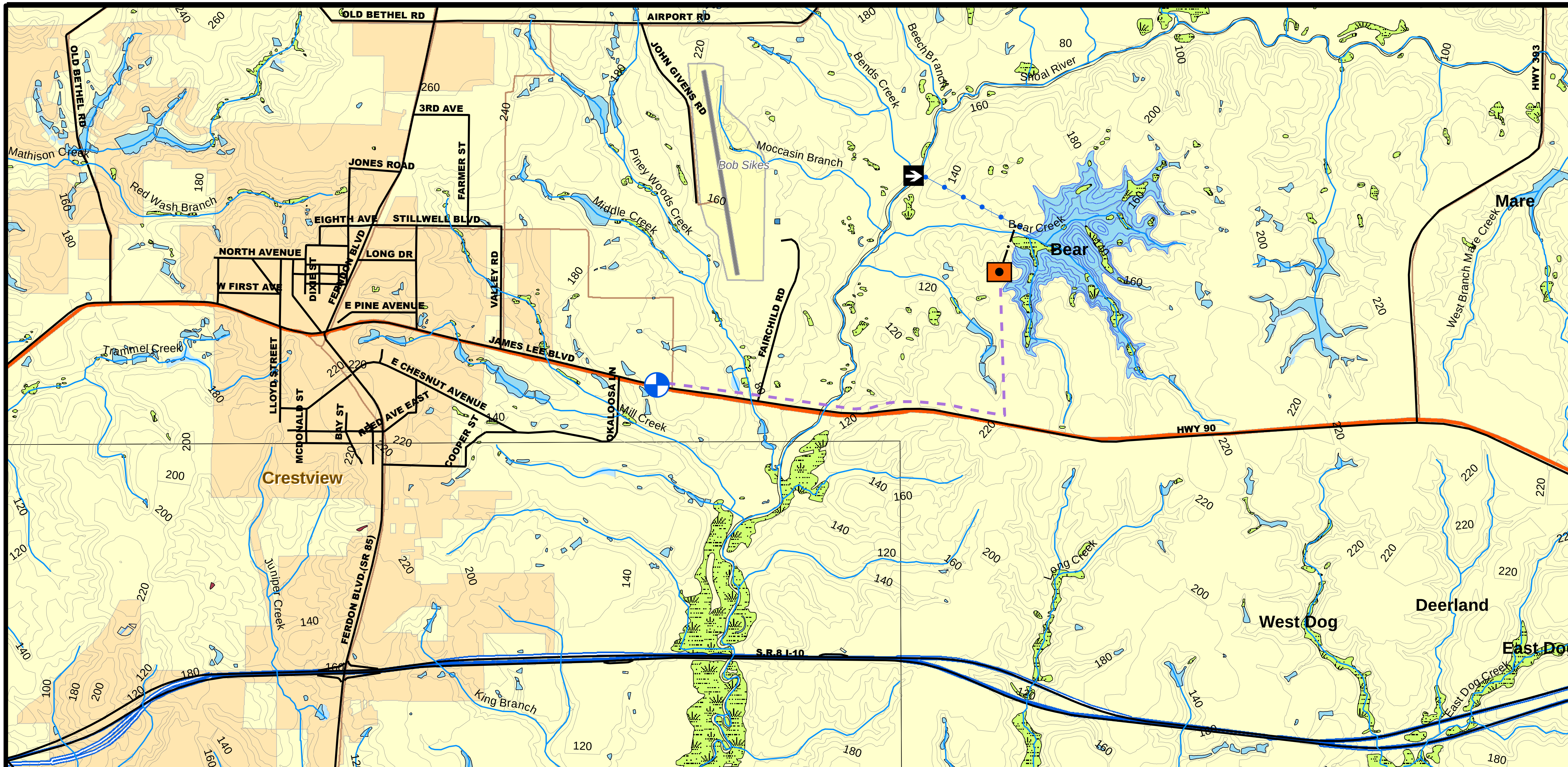
- ***High Service Pumping Station*** – The high service pumping station located at the WTP site will pump 25 mgd (firm capacity) toward the delivery point, from the WTP clear well. The pump station must accommodate a constant transmission rate of 25 mgd. All pumps will operate continuously, with the exception of one installed spare available for redundancy and for substitution for and operating pump during maintenance. Horizontal split-case pumps are considered, with a typical piping layout. During preliminary design other types of pumps should be considered. This station will be enclosed in a building to allow maintenance under all weather conditions. Included at this station is a control room for the entire supply system. Chlorine injection is also a consideration for slime control. A chlorine storage and feed room is provided within the building.
- ***Transmission pipeline to Delivery point*** – The potable water pipeline would convey 25 mgd at a constant rate, from the WTP to the delivery point, via a 10.6-mile-long, 36-inch-diameter pipeline south along the western ROW of CR 393 to US 90 and then westward along the northern ROW of US 90 to the delivery point near Okaloosa Lane. The pipeline is assumed to be constructed within a 30-foot easement. The pipeline will cross most streams/creeks by open cut construction except for the Shoal River crossings and other major streams. At those locations where open cut construction is not feasible, considerations for pipeline suspension from bridges and/or trenchless construction techniques should be evaluated during preliminary design. For the purposes of this feasibility analysis it is assumed that trenchless construction (i.e., Jack & Bore, Microtunneling) will be used at all major stream/river crossings. It is assumed that the delivery pressure will be 25 pounds per square inch (psi).

Alternative #2 – Bear Creek Reservoir

Conceptual Alternative #2 (CA2) is shown on Figure 2 and involves the following facilities:

- ***Shoal River intake structure and pumping station*** – The pump station would be a concrete structure constructed on the east bank of the Shoal River approximately 2 miles north of the US 90 bridge. Conceptually, a concrete-lined trapezoidal intake channel about 100 feet in length would be constructed between the Shoal River and the pumping station. A silt wall at the upstream point of the intake channel would permit the bedload to pass without significant sediment conveyed into the intake channel. The invert channel would slope from the silt wall (i.e., at the river) down to the pump station at a slope of approximately 3%. The sides of the concrete channel would rise at a 1:1 slope to a 20 bench which would serve as a maintenance roadway for the channel.

  The pumping station must accommodate a wide range of flows, up to the peak diversion rate, 25 mgd firm capacity. Firm capacity is defined as the total capacity of the pumping station assuming the largest pump is out of service. Pumps will operate individually, or in combinations up to the total number of pumps, not including one installed spare. The number of pumps will be defined during preliminary design but will likely be three or four pumps. Vertical turbine pumps, are envisioned; however, horizontal split case pumps could be used in a dry well configuration. A water agitation system would be required for maintaining solids in suspension. The station should



Legend (Preliminary Routes and Facility Sites)

- Bypass (Diameter = 36 inch, Length = .4 mi)
- Intake (Diameter = 36 inch, Length = .9 mi)
- Transmission Pipeline (Diameter= 36 inch, Length = 3.6 mi)
- Water Treatment Plant
- Delivery Point
- Intake Facility
- Marsh, wetland, swamp, bog
- 20 ft Elevation Contours

0 0.75 1.5 Miles

N

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Figure 2 - Alternative 2

Shoal River Intake to Bear Storage

Prepared for: NWF WMD	
Job No.: 091812.01	Scale: 1:47,520
Prepared by: D. Harris	Date: April, 2006
File: Alternative 2.mxd	

be configured to accommodate pumps and screens during the preliminary design phase. Additionally, a disinfection facility is needed for slime control.

- ***Raw water pipeline and Bypass***– The raw water pipeline would convey 25 mgd at a constant rate via a 0.9-mile-long, 36-inch-diameter pipeline to an outlet structure (i.e., stilling basin) at Bear Creek Reservoir. The pipeline is assumed to be constructed within a 30-foot easement. To provide for operational flexibility a 0.4-mile-long, 36-inch-diameter bypass pipeline would bypass flows directly to the treatment plant.

- ***Dam & Reservoir*** – An earthen dam structure was evaluated on Bear Creek in the approximate location selected for the hydrologic analysis, which was conducted by NWFWMD. The NWFWMD developed an area-capacity relationship for this reservoir site and the preliminary results indicate the feasibility of a reservoir with a storage capacity of approximately 3,000 ac-ft at a corresponding normal-pool reservoir depth of 30 feet. Accordingly, conceptual designs were prepared to estimate the approximate costs to build a dam and spillway to meet these storage conditions using federal dam safety guidelines at the selected location on Bear Creek.

  The conceptual design for the Bear Creek Dam includes enough additional dam height to provide a spillway capable of safely passing the full PMF generated within the contributing watershed. The following dam characteristics for the Bear Creek Reservoir were assumed for conceptual design:

Bear Creek Reservoir Conceptual Data

Contributing Drainage Area (square miles)	3.8
Storage Capacity at NOL (ac-ft)	3,000
Length of Dam (feet)	1,700
Top of Dam Elevation (feet)	140
Dam Height above Creek Flowline (feet)	40
NOL Elevation – feet	130
Reservoir surface area at NOL (acres)	250
Emergency Spillway Elevation (feet)	133
Emergency Spillway Width (feet)	115
Embankment Side Slopes (horizontal:vertical)	3.5:1

Note: Uncontrolled, concrete-armored spillways were assumed for cost estimating purposes.

The reservoir feasibility evaluation is based upon a dam with 3.5:1 side slopes (horizontal to vertical) and an integrated concrete service and emergency spillway. The dam assumed for this analysis has a zoned earthen embankment. The typical section consists of an impermeable clay core with semi-permeable fill on the outer embankment slopes. On site soils were assumed to be suitable for all embankment materials. The clay core extends along the dam's entire longitudinal axis, and it was assumed that this core would be keyed into an impermeable formation 10 feet below the existing creek flowline. Costs for a gravel drainage system are included between the downstream interface with the clay core and the toe of the dam to provide seepage control and prevent saturation and instability of the outer embankment soils. A 20-foot wide dam crest was assumed for maintenance access with a 15-foot-wide gravel road base. The embankment slopes were assumed to have rock rip-rap (18-inch median rock size) for the entire upstream slope and native grass seeding on the downstream slope.

For this planning level analysis the full PMF was assumed to represent the IDF for the proposed Bear Creek Reservoir (see discussion of assumptions for Alternative 1, Pond Creek Reservoir). A total of 3 feet was assumed between the NOL and the flowline of the emergency spillway to minimize losses caused by wave action. A total freeboard of 1 foot is assumed during the IDF.

According to the NWFWMD's hydrologic model results, the full PMF would produce a peak discharge of approximately 4,900 cfs. This peak discharge was assumed to represent the IDF for Pond Creek Reservoir. For the planning level cost estimate, the assumed emergency spillway length is 115 feet. This spillway size was determined assuming the spillway functions as a broad-crested weir. The maximum flow depth of the assumed peak discharge through this spillway is 6 feet. The top of the dam was assumed to be 7 feet above the emergency spillway elevation, allowing an additional foot over the IDF water surface elevation. A concrete-lined stilling basin for spillway energy dissipation was included in the cost of the spillway. The assumed basin dimensions are 4 feet deep and 50 feet long, starting at the down stream toe of the spillway.

The available soils data suggest that the inundation areas of the proposed Bear Creek Reservoir would not contribute to excessive losses due to infiltration. Additionally, since no geotechnical information is available for the proposed site, it is assumed that sufficient amounts of clay are available on site for construction of the embankment core. Future studies will include an appropriate geotechnical investigation.

Environmental and cultural constraints have not been assessed during this conceptual planning analysis and will be evaluated during future studies. The added inundation associated with the IDF (i.e., the maximum reservoir rim elevation) is also assumed to be acceptable in terms of potential environmental impacts.

- ***Reservoir intake structure, pumping station and pipeline*** – Several options for a reservoir intake will be analyzed during preliminary design. These include floating intakes, free standing intake, single port intake, multi-port intake (i.e., multi-tiered), and potentially lake destratification equipment. The conceptual intake facility considered during this feasibility analysis is comprised of a 20-foot diameter concrete lined vertical shaft approximately 50 feet deep near the shore of the reservoir with two, 4-foot diameter horizontal tunnels at different elevations to allow operational flexibility in addressing water quality issues. Each tunnel is planned to have a gate located at the vertical shaft and a bar and fish screen where the tunnel enters the reservoir. Evenly spaced vertical turbine pumps would extend vertically to the bottom of the shaft. A short 36-inch-diameter pipeline would serve as a discharge header into the WTP.
- ***Water Treatment Plant*** – The WTP will have a capacity of 25 mgd. Specific details describing the WTP are included in a Technical Memorandum, prepared by PBS&J, included in Attachment B. The WTP for Alternative 2 will be identical to Alternative 1. See Alternative 1 – Pond Creek Reservoir for a brief description of the water treatment facilities.
- ***High Service Pumping Station*** – The high service pumping station located at the WTP site will pump 25 mgd (firm capacity) toward the delivery point, from the WTP clear well. The pump station must accommodate a constant transmission rate of 25 mgd. All pumps will operate continuously, with the exception of one installed spare available for redundancy and for substitution for and operating pump during maintenance. Horizontal split-case pumps are considered, with a typical piping layout. During preliminary design other types of pumps should be considered. This station will be enclosed in a building to allow maintenance under all weather

conditions. Included at this station is a control room for the entire supply system. Chlorine injection is also a consideration for slime control. A chlorine storage and feed room is provided within the building.

- ***Transmission pipeline to Delivery point*** – The potable water pipeline would convey 25 mgd at a constant rate, from the WTP to the delivery point, via a 3.6-mile-long, 36-inch-diameter pipeline south over land to US 90 and then westward along the northern ROW of US 90 to the delivery point near Okaloosa Lane. The pipeline is assumed to be constructed within a 30-foot easement. The pipeline will cross most streams/creeks by open cut construction except for the Shoal River crossings and other major streams. At those locations where open cut construction is not feasible, considerations for pipeline suspension from bridges and/or trenchless construction techniques should be evaluated during preliminary design. For the purposes of this feasibility analysis it is assumed that trenchless construction (i.e., Jack & Bore, Microtunneling) will be used at all major stream/river crossings. It is assumed that the delivery pressure will be 25 psi.

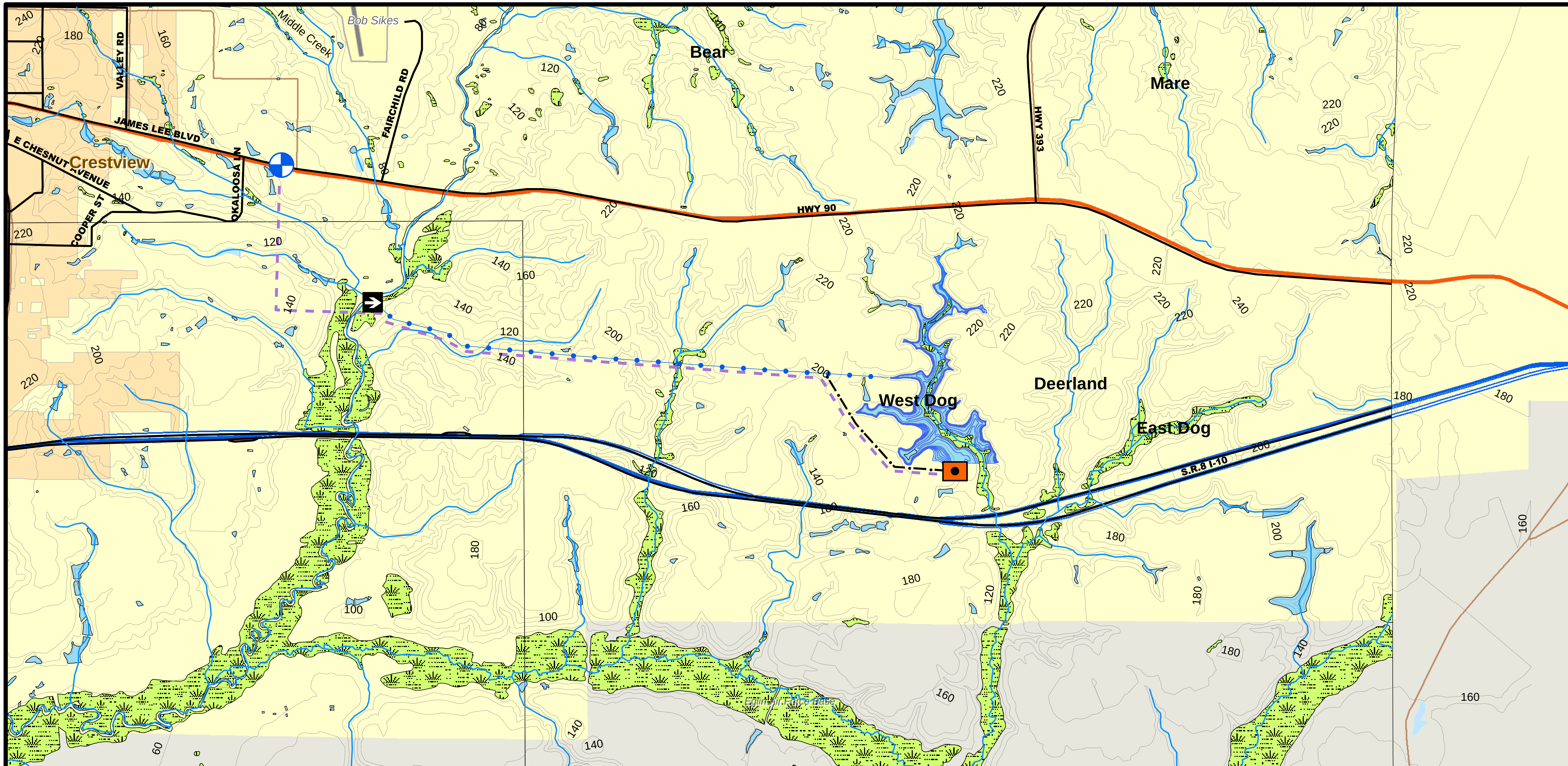
Alternative #3 – West Dog Reservoir

Conceptual Alternative #3 (CA3) is shown on Figure 3 and involves the following facilities:

- ***Shoal River intake structure and pumping station*** – The pump station would be a concrete structure constructed on the east bank of the Shoal River, south and adjacent to the Louisville and Nashville Railroad bridge. Conceptually, a concrete-lined trapezoidal intake channel about 100 feet in length would be constructed between the Shoal River and the pumping station. A silt wall at the upstream point of the intake channel would permit the bedload to pass without significant sediment conveyed into the intake channel. The invert channel would slope from the silt wall (i.e., at the river) down to the pump station at a slope of approximately 3%. The sides of the concrete channel would rise at a 1:1 slope to a 20 bench which would serve as a maintenance roadway for the channel.

  The pumping station must accommodate a wide range of flows, up to the peak diversion rate, 25 mgd firm capacity. Firm capacity is defined as the total capacity of the pumping station assuming the largest pump is out of service. Pumps will operate individually, or in combinations up to the total number of pumps, not including one installed spare. The number of pumps will be defined during preliminary design but will likely be three or four pumps. Vertical turbine pumps, are envisioned; however, horizontal split case pumps could be used in a dry well configuration. A water agitation system would be required for maintaining solids in suspension. The station should be configured to accommodate pumps and screens during the preliminary design phase. Additionally, a disinfection facility is needed for slime control.

- ***Raw water pipeline and Bypass***– The raw water pipeline would convey 25 mgd at a constant rate via a 3.9-mile-long, 36-inch-diameter pipeline along the southern ROW of Louisville and Nashville Railroad to an outlet structure (i.e., stilling basin) at West Dog Reservoir. The pipeline is assumed to be constructed within a 30-foot easement. To provide for operational flexibility a 1.3-mile-long, 36-inch-diameter bypass pipeline would bypass flows directly to the treatment plant. Open-cut construction is assumed for the majority of the pipeline route with the exception of the Long Creek crossing where trenchless construction would be required.



Legend (Preliminary Routes and Facility Sites)

- Bypass (Diameter = 36 inch, Length = 1.3 mi)
- Intake (Diameter = 36 inch, Length = 3.9 mi)
- Transmission Pipeline (Diameter = 36 inch, Length = 6.5 mi)
- Water Treatment Plant
- Delivery Point
- Intake Facility
- Marsh, wetland, swamp, bog
- 20 ft Elevation Contours

0 0.75 1.5 Miles

N

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Figure 3 - Alternative 3
Shoal River Intake to West Dog Storage

Prepared for: NWF WMD	
Job No.: 091812.01	Scale: 1:47,520
Prepared by: D. Harris	Date: April, 2006
File: Alternative 3.mxd	

- ***Dam & Reservoir*** – An earthen dam structure was evaluated on West Dog Creek in the approximate location selected for the hydrologic analysis, which was conducted by NWFWMD. The NWFWMD developed an area-capacity relationship for this reservoir site and the preliminary results indicate the feasibility of a reservoir with a storage capacity of approximately 850 ac-ft at a corresponding normal-pool reservoir depth of 25 feet. Accordingly, conceptual designs were prepared to estimate the approximate costs to build a dam and spillway to meet these storage conditions using federal dam safety guidelines at the selected location on West Dog Creek.

  The conceptual design for the West Dog Creek Dam includes enough additional dam height to provide a spillway capable of safely passing the full PMF generated within the contributing watershed. The following dam characteristics for the West Dog Creek Reservoir were assumed for conceptual design:

West Dog Creek Reservoir Conceptual Data

Contributing Drainage Area (square miles)	2.7
Storage Capacity at NOL (ac-ft)	850
Length of Dam (feet)	1,470
Top of Dam Elevation (feet)	160
Dam Height above Creek Flowline (feet)	35
NOL Elevation – feet	150
Reservoir surface area at NOL (acres)	70
Emergency Spillway Elevation (feet)	153
Emergency Spillway Width (feet)	85
Embankment Side Slopes (horizontal:vertical)	3.5:1

Note: Uncontrolled, concrete-armored spillways were assumed for cost estimating purposes.

The reservoir feasibility evaluation is based upon a dam with 3.5:1 side slopes (horizontal to vertical) and an integrated concrete service and emergency spillway. The dam assumed for this analysis has a zoned earthen embankment. The typical section consists of an impermeable clay core with semi-permeable fill on the outer embankment slopes. On site soils were assumed to be suitable for all embankment materials. The clay core extends along the dam's entire longitudinal axis, and it was assumed that this core would be keyed into an impermeable formation 10 feet below the existing creek flowline. Costs for a gravel drainage system are included between the downstream interface with the clay core and the toe of the dam to provide seepage control and prevent saturation and instability of the outer embankment soils. A 20-foot wide dam crest was assumed for maintenance access with a 15-foot-wide gravel road base. The embankment slopes were assumed to have rock rip-rap (18-inch median rock size) for the entire upstream slope and native grass seeding on the downstream slope.

For this planning level analysis the full PMF was assumed to represent the IDF for the Proposed West Dog Creek Reservoir (see discussion of assumptions for Alternative 1, Pond Creek Reservoir). A total of 3 feet was assumed between the NOL and the flowline of the emergency spillway to minimize losses caused by wave action. A total freeboard of 1 foot is assumed during the IDF.

According to the NWFWMD's hydrologic model results, the full PMF would produce a peak discharge of approximately 3,700 cfs. This peak discharge was assumed to represent the IDF for Pond Creek Reservoir. For the planning level cost estimate, the assumed emergency spillway length is 85 feet. This spillway size was determined assuming the spillway functions as a broad-crested weir. The maximum flow depth of the assumed peak discharge through this spillway is 6 feet. The top of the dam was assumed to be 7 feet above the emergency spillway elevation, allowing an additional foot over the IDF water surface elevation. A concrete-lined stilling basin for spillway energy dissipation was included in the cost of the spillway. The assumed basin dimensions are 4 feet deep and 50 feet long, starting at the down stream toe of the spillway.

The available soils data suggest that the inundation areas of the proposed West Dog Creek Reservoir would not contribute to excessive losses due to infiltration. Additionally, since no geotechnical information is available for the proposed site, it is assumed that sufficient amounts of clay are available on site for construction of the embankment core. Future studies will include an appropriate geotechnical investigation.

Environmental and cultural constraints have not been assessed during this conceptual planning analysis and will be evaluated during future studies. The added inundation associated with the IDF (i.e., the maximum reservoir rim elevation) is also assumed to be acceptable in terms of potential environmental impacts.

- ***Reservoir intake structure, pumping station and pipeline*** – Several options for a reservoir intake will be analyzed during preliminary design. These include floating intakes, free standing intake, single port intake, multi-port intake (i.e., multi-tiered), and potentially lake destratification equipment. The conceptual intake facility considered during this feasibility analysis is comprised of a 20-foot diameter concrete lined vertical shaft approximately 50 feet deep near the shore of the reservoir with two, 4-foot diameter horizontal tunnels at different elevations to allow operational flexibility in addressing water quality issues. Each tunnel is planned to have a gate located at the vertical shaft and a bar and fish screen where the tunnel enters the reservoir. Evenly spaced vertical turbine pumps would extend vertically to the bottom of the shaft. A short 36-inch-diameter pipeline would serve as a discharge header into the WTP.
- ***Water Treatment Plant*** – The WTP will have a capacity of 25 mgd. Specific details describing the WTP are included in a Technical Memorandum, prepared by PBS&J, included in Attachment B. The WTP for Alternative 3 will be identical to Alternative 1. See Alternative 1 – Pond Creek Reservoir for a brief description of the water treatment facilities.
- ***High Service Pumping Station*** – The high service pumping station located at the WTP site will pump 25 mgd (firm capacity) toward the delivery point, from the WTP clear well. The pump station must accommodate a constant transmission rate of 25 mgd. All pumps will operate continuously, with the exception of one installed spare available for redundancy and for substitution for and operating pump during maintenance. Horizontal split-case pumps are considered, with a typical piping layout. During preliminary design other types of pumps should be considered. This station will be enclosed in a building to allow maintenance under all weather conditions. Included at this station is a control room for the entire supply system. Chlorine injection is also a consideration for slime control. A chlorine storage and feed room is provided within the building.

- ***Transmission pipeline to Delivery point*** – The potable water pipeline would convey 25 mgd at a constant rate, from the WTP to the delivery point, via a 6.5-mile-long, 36-inch-diameter pipeline west and north to parallel the raw water intake pipeline along the ROW of the Louisville and Nashville Railroad, crossing the Shoal River and then north to the delivery point near Okaloosa Lane. The pipeline is assumed to be constructed within a 30-foot easement. The pipeline will cross most streams/creeks by open cut construction except for the Shoal River crossings, major streams and the Louisville and Nashville Railroad. At those locations where open cut construction is not feasible, considerations for pipeline suspension from bridges and/or trenchless construction techniques should be evaluated during Preliminary design. For the purposes of this feasibility analysis it is assumed that trenchless construction (i.e., Jack & Bore, Microtunneling) will be used at all major stream/river/railroad crossings. It is assumed that the delivery pressure will be 25 psi.

Alternative #4 – Shoal River Direct Diversion

Conceptual Alternative #4 (CA4) is shown on Figure 4 and involves the following facilities:

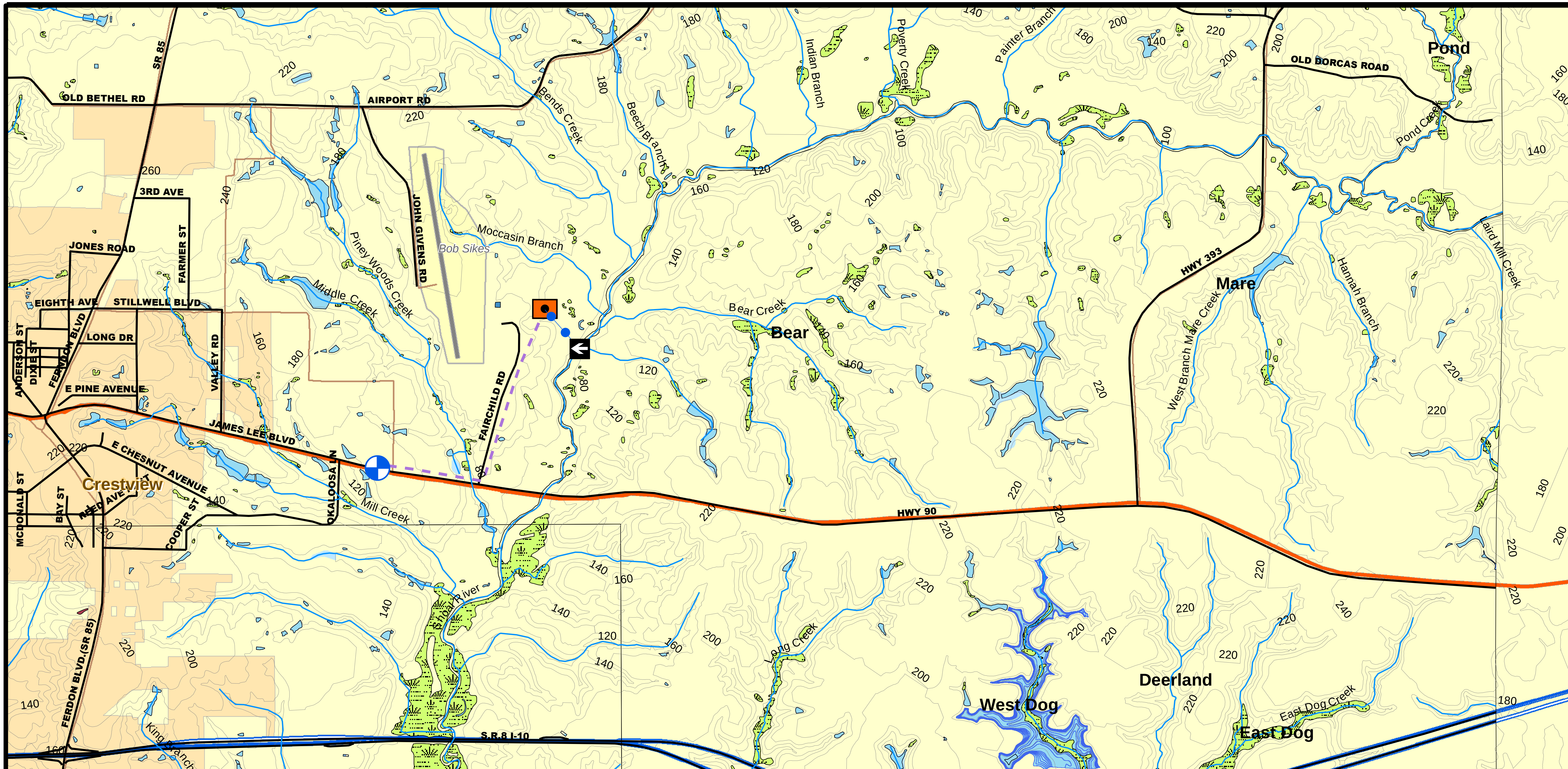
- ***Shoal River intake structure and pumping station*** – The pump station would be a concrete structure constructed on the west bank of the Shoal River south of the Bear Creek confluence. Conceptually, a concrete-lined trapezoidal intake channel about 100 feet in length would be constructed between the Shoal River and the pumping station. A silt wall at the upstream point of the intake channel would permit the bedload to pass without significant sediment conveyed into the intake channel. The invert channel would slope from the silt wall (i.e., at the river) down to the pump station at a slope of approximately 3%. The sides of the concrete channel would rise at a 1:1 slope to a 20 bench, which would serve as a maintenance roadway for the channel.

  The pumping station must accommodate a wide range of flows, up to the peak diversion rate, 25 mgd firm capacity. Firm capacity is defined as the total capacity of the pumping station assuming the largest pump is out of service. Pumps will operate individually, or in combinations up to the total number of pumps, not including one installed spare. The number of pumps will be defined during preliminary design but will likely be three or four pumps. Vertical turbine pumps, are envisioned; however, horizontal split case pumps could be used in a dry well configuration. A water agitation system would be required for maintaining solids in suspension. The station should be configured to accommodate pumps and screens during the preliminary design phase. Additionally, a disinfection facility is needed for slime control.

- ***Raw water pipeline***– The raw water pipeline would convey 25 mgd at a constant rate via a 0.4-mile-long, 36-inch-diameter pipeline to the WTP. The pipeline is assumed to be constructed within a 30-foot easement.

- ***Water Treatment Plant*** – The WTP will have a capacity of 25 mgd. Specific details describing the WTP are included in the Technical Memorandum, prepared by PBS&J, included in Attachment B. The WTP for Alternative 4 will be identical to Alternative 1. See Alternative 1 – Pond Creek Reservoir for a brief description of the water treatment facilities.

- ***High Service Pumping Station*** – The high service pumping station located at the WTP site will pump 25 mgd (firm capacity) toward the delivery point, from the WTP clear well. The pump station must accommodate a constant transmission rate of 25 mgd. All pumps will operate continuously, with the exception of one installed spare available for redundancy and for



Legend (Preliminary Routes and Facility Sites)

- Intake (Diameter = 36 inch, Length = .4 mi)
- Transmission Pipeline (Diameter = 36 inch, Length = 2.1 mi)
- Water Treatment Plant
- Delivery Point
- Intake Facility
- Marsh, wetland, swamp, bog
- 20 ft Elevation Contours

0 0.75 1.5 Miles

N

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Figure 4 - Alternative 4

Shoal River Intake
No Storage Option

Prepared for: NWF WMD	
Job No.: 091812.01	Scale: 1:47,520
Prepared by: D. Harris	Date: April, 2006
File: Alternative 4.mxd	

substitution for and operating pump during maintenance. Horizontal split-case pumps are considered, with a typical piping layout. During preliminary design other types of pumps should be considered. This station will be enclosed in a building to allow maintenance under all weather conditions. Included at this station is a control room for the entire supply system. Chlorine injection is also a consideration for slime control. A chlorine storage and feed room is provided within the building.

- ***Transmission pipeline to Delivery point*** – The potable water pipeline would convey 25 mgd at a constant rate, from the WTP to the delivery point, via a 2.1-mile-long, 36-inch-diameter pipeline south along the eastern ROW of Fairchild Road and then westward along the northern ROW of US 90 to the delivery point near Okaloosa Lane. The pipeline is assumed to be constructed within a 30-foot easement. The pipeline will cross most streams/creeks by open cut construction except for the Piney Woods Creek crossings and/or other major streams. At those locations where open cut construction is not feasible, considerations for pipeline suspension from bridges and/or trenchless construction techniques should be evaluated during preliminary design. For the purposes of this feasibility analysis it is assumed that trenchless construction (i.e., Jack & Bore, Microtunneling) will be used at all major stream/river crossings. It is assumed that the delivery pressure will be 25 psi.

Alternative #5 – Riverbank Filtration

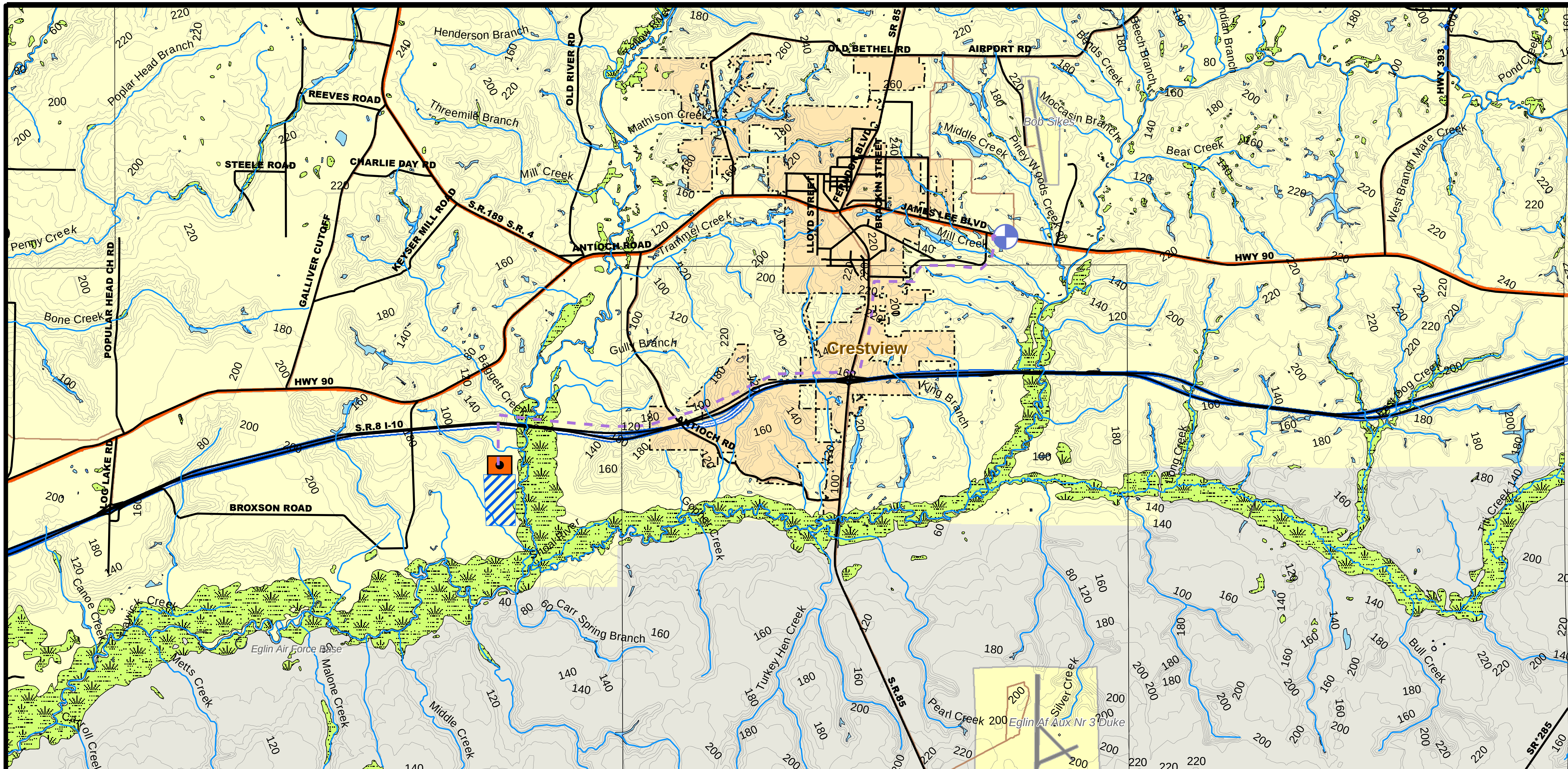
Conceptual Alternative #5 (CA5) is shown on Figure 5 and involves the following facilities:

- ***Groundwater well field*** – The groundwater well field will have a capacity of 25 mgd. Specific details describing the Riverbank filtration well field components/evaluation are included in the Technical Memorandum, prepared by PBS&J, included in Attachment C

  Collector wells (Ranney) may be the most cost effective alternative when considering long-term costs of O&M, largely due to the reduced requirement for pumps, piping, valves and related infrastructure. Conceptually, preliminary estimates indicate four collector wells would be capable of producing 25 mgd. An individual collector well in the study area is conceptualized as a 13-foot diameter caisson set to approximately 40 feet below land surface. The caisson would have four 6-inch-diameter screened laterals 200 feet in length, between 5 to 40 feet below land surface. The total land requirement for the four collector wells, laterals, and wellfield pipelines is assumed to require 50 acres for cost estimating purposes.

- ***Raw water pipelines from Collector wells to Ground Storage Tank*** – Each of the four collector wells will have a 0.5-mile-long, 20-inch-diameter water pipeline which would convey 6.25 mgd at a constant rate to a Ground Storage tank located at the headworks of the WTP. Each pipeline is assumed to be constructed within a 30-foot easement.

- ***Ground Storage Tank*** – For ease of operation the water supplies from the well field will be pumped into a ground storage facility at the water treatment site. The ground storage tank is anticipated to be 7 million gallons or the equivalent of one of the four collector wells being out of operation for one day's service. Greater capacity may be considered based on expectations of outages of the well pumps. The ground storage tank should be located on the property site or and an adjacent site at an elevation to gravity feed from the tank to the WTP to avoid a booster pump



Legend (Preliminary Routes and Facility Sites)

- Transmission Pipeline (D= 36 inch, L = 9.9 mi)
- Water Treatment Plant & Ground Storage Tank
- Collector Well Field
- Marsh, wetland, swamp, bog
- Delivery Point
- 20 ft Elevation Contours

0 0.75 1.5 Miles

N

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Figure 5 - Alternative 5
In-Bank Filtration

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Job No.: 091812.01	Scale: 1:47,520
Prepared by: D. Harris	Date: April, 2006
File: Alternative 5.mxd	

station. This could also be accomplished with an elevated storage tank, though this is more expensive and potentially more controversial from an aesthetic perspective.

- ***Water Treatment Plant*** – The WTP will have a capacity of 25 mgd. Specific details describing the WTP are included in a Technical Memorandum, prepared by PBS&J, included in Attachment B. The WTP for Alternative 5 will be identical to Alternative 1, with the exception that the source water is the Yellow River and since there is no major distinction in water quality the preliminary treatment process is considered the same based on the available information to date. Until future studies include test well sampling and analysis, this assumption is conservative since the expected treatment process could be significantly different and/or reduced. See Alternative 1 – Pond Creek Reservoir for a brief description of the water treatment facilities.
- ***High Service Pumping Station*** **–** The high service pumping station located at the WTP site will pump 25 mgd (firm capacity) toward the delivery point, from the WTP clear well. The pump station must accommodate a constant transmission rate of 25 mgd. All pumps will operate continuously, with the exception of one installed spare available for redundancy and for substitution for and operating pump during maintenance. Horizontal split-case pumps are considered, with a typical piping layout. During preliminary design other types of pumps should be considered. This station will be enclosed in a building to allow maintenance under all weather conditions. Included at this station is a control room for the entire supply system. Chlorine injection is also a consideration for slime control. A chlorine storage and feed room is provided within the building.
- ***Transmission pipeline to Delivery point*** – The potable water pipeline would convey 25 mgd at a constant rate, from the WTP to the delivery point, via a 9.9-mile-long, 36-inch-diameter pipeline north to IH 10 and eastward along the northern ROW of IH 10 to SR 85 and then northward along the eastern ROW of SR 85 to Cooper Street eastward to Okaloosa Lane and thence the delivery point. The pipeline is assumed to be constructed within a 30-foot easement. The pipeline will cross most streams/creeks by open cut construction except for the Shoal River crossings and other major streams. At those locations where open cut construction is not feasible, considerations for pipeline suspension from bridges and/or trenchless construction techniques should be evaluated during Preliminary design. For the purposes of this feasibility analysis it is assumed that trenchless construction (i.e., Jack & Bore, Microtunneling) will be used at all major stream/river crossings. It is assumed that the delivery pressure will be 25 psi.

UNIT COST ESTIMATES

Cost estimates are typically prepared at various points during project planning and design and the expected level of accuracy is directly proportional to the level of engineering effort applied and known details. Each category of estimate must be carefully prepared from the conceptual level to the facilities plan level, preliminary design and final engineers' estimate. In general there are three major cost categories:

- Category 1: Conceptual estimate
- Category 2: Preliminary estimate
- Category 3: Detailed estimate

The accuracy of construction cost estimates should increase as the project moves from planning through design and to the final estimate prepared at the completion of 100% design documents. It can also be expected that conceptual estimates would have a relatively wider accuracy range relative to the construction contract amount because few design features and details have been addressed and/or analyzed during conceptual planning effort. In comparison, the final Engineer's Estimate should be more accurate due to the additional level of detail that is known when the design is completed.

Planning level unit cost estimates were prepared for the following facility components and estimates for environmental mitigation:

- Pipelines
- Pumping Station and Intakes
- Groundwater Wells
- Ground Storage Tank
- Surface and Ground Water Treatment
- High Service Pumping Station
- Dams and Reservoirs

To facilitate development of cost estimates for each of these components, cost estimates prepared for similar facilities in the SJRWMD were reviewed, along with local utilities cost information from the following reports relating to pipeline projects in Region II:

- *Water Resource Facilities Plan for Okaloosa County, Florida* (PolyEngineering of Florida, Inc., 1998)
- *Regional Water Supply System for City of Gulf Breeze, Holley-Navarre Water System, Inc., and Midway Water System, Inc.* (Baskerville-Donovan, Inc., and Fabre Engineering, Inc., c. 1997) (Fairpoint Project)
- *Water Facilities Plan for the WRP, Inc., Remote Well Field and Water Transmission Main Phase I* (Baskerville-Donovan, Inc., 1999)

Using this information, PBS&J staff experience with similar projects, State of Texas regional planning cost estimates, and internal cost databases, the following cost parameters associated with each of the components mentioned above were developed:

- Construction costs
- Total capital costs
- O&M costs

The cost estimates include related land and land acquisition costs, as appropriate. Methods used to generate the cost estimates are described below, and the estimates are summarized in (see Attachment D).

CONSTRUCTION COSTS

Unit Construction Cost Estimates for Pipelines

Pipeline Design and Construction Considerations. Pipeline construction costs are influenced by pipe materials, bedding requirements, geologic conditions, urbanization, terrain, and special crossings. For this feasibility analysis, conceptual planning level unit costs were compiled from internal PBS&J cost databases. Pipeline construction unit costs were compiled and are shown in Table 4, which shows unit costs based on the pipe diameter and level of urban development. In the case of a high-pressure pipeline (>150 psi), the pipe unit cost should be increased by 15% for the length of pipe designated as high pressure class pipe; however, it is not anticipated that higher pressure pipelines will be required in the conceptual alternative projects presented in this report. The unit costs listed in Table 4 include installed cost of the pipeline and appurtenances, such as markers, valves, thrust restraint systems, corrosion monitoring and control equipment, air and vacuum valves, blow-off valves, erosion control, revegetation of ROW, fencing, and gates.

Table 4: Pipeline Construction Unit Costs

Pipe Diameter (inches)	Pipe Material	Unit Cost ($)/feet Rural Const.	Unit Cost ($)/feet Urban Const.
16	PVC/DIP	65	90
20	PVC/DIP	85	110
24	PVC/DIP	100	125
30	DIP	126	155
36	DIP	155	205
42	DIP	200	255
48	DIP	235	290

Unit Construction Cost Estimates for Pumping Stations and Intakes

The cost of a pump station depends upon a wide range of design conditions, including flow, pumping head, type of pumps, site conditions, desired usage, and structural design. In compiling and developing a conceptual estimate of the cost of a pump station for this analysis, the focus was not to determine the pump type or details of the station design, but rather to estimate the cost of a general station capable of pumping the desired flow rate at the necessary head conditions. Pump station project cost estimates and construction records were based on State of Texas (Region L) regional planning cost estimates by PBS&J. The construction unit costs in Table 5 display the costs for pump stations for the range of horsepower requirements, based on the maximum discharge and design head anticipated for this feasibility analysis.

Table 5: Pumping Station Costs

Pump Station (HP)	Adjusted to 3/2006 Pump Station Cost ($ million)
< 300	0.94
300	0.94
400	1.18
500	1.37
600	1.57
700	1.77
800	1.96
900	2.16
1,000	2.36
1,100	2.51
1,200	2.66
1,300	2.81
1,400	2.97
1,500	3.12

Pump stations are typically classified as transmission or intake type structures, depending on the source of the water. Intake stations normally pump water from a raw water source, such as a river or reservoir, and therefore require an intake structure to insure that proper flow conditions into the station are permitted. Transmission stations normally act as high services in a plant or pipeline and do not require intake structures since the inlet pipe flow conditions are fairly constant. Based on Region L (State of Texas) regional planning cost estimates, the total cost for the intake structure of a pump station has been estimated as an additional 50% of the pump station construction cost. While 25% is structural and site modifications, the other 25% is to account for trash rack screens and miscellaneous rack cleaning equipment.

The cost of providing electrical power to each pump station can be a significant cost for sites which are remote from available service. It is assumed for the purposes of this analysis that electrical service is readily available in the region where facilities are located. All other electrical costs, with the exception of standby power, are included in the base pump station regional planning construction cost estimates. Standby power, normally either a diesel generator or a dual power feed, is necessary to ensure that the pump station can remain operational in the event of a power failure. Standby power is an optional feature that has been estimated as an additional 35% of the base pump station construction cost.

Unit Construction Cost Estimates for Groundwater Wells (Ranney-Collector Wells)

In general, costs for individual vertical wells are the least expensive of the three options evaluated below. However, collector wells may be the most cost effective selection when considering long-term costs of O&M because of fewer number of pumps and less piping and valves to tie into water systems. Total construction cost estimates in Table 6 were based on multiple cost estimates provided by vendors.

Table 6: Summary of Construction Cost Comparisons

Well Type	Construction Cost	Equipment and Appurtenances	O&M Cost per year	Total Cost for 1 mgd	Total Cost for 12 mgd	Total Cost for 25 mgd
Vertical Well	$125,000	$100,000	$35,453	$260,453	$3,125,436	$6,511,325
Horizontal Well	$200,000	$100,000	$35,453	$335,453	$4,025,436	$8,386,325
Collector Well	$170,833	$100,000	$35,453	$306,286	$3,675,432	$7,657,150

Construction Cost Estimates for Water Treatment (Surface and Groundwater)

Construction cost estimates for the WTP are based on a preliminary review of surface water quality data and limited water quality data from wells in the Sand-and-Gravel Aquifer. Our preliminary analysis of the limited Sand-and-Gravel Aquifer well data, indicates that the water treatment process and facilities will not change significantly between surface and riverbank filtration supplies. During preliminary design, additional well samples should be obtained in the targeted well field region. WTP construction cost estimates were prepared based on estimates developed for the SJRWMD, Special Publication SJ97-SP15 prepared by CH2M Hill in 1997. PBS&J adjusted these costs to account for only those facilities provided in this report, and updated to reflect March 2006 costs. PBS&J also utilized several planning level studies prepared by HDR in 2002 for Texas, including Region L (San Antonio), Region C (Dallas/Fort Worth), and Region H (Houston). These costs were updated applying Construction Cost Index (CCI) from Engineering News Record, and comparing this to PBS&J's 2005 cost estimation prepared for a new conventional 10-mgd WTP expansion for the Lower Colorado River Authority in Austin, Texas.

During preliminary design, each possible surface water source location identified should have additional water sampling performed and lab samples run. These tests should occur over varying periods of high and low flow to be sure all aspects of treatment concerns are identified. Future studies should obtain specific test well samples as the treatment requirements could vary significantly and affect water treatment costs and methodologies. In general, based on this preliminary review, there are no major distinctions in water quality between the Shoal and Yellow Rivers and therefore, the conceptual level cost estimates are identical for each source, and the construction costs estimate for a 25-mgd surface WTP is $28,400,000, excluding land costs.

Construction Cost Estimates for Dams and Reservoirs

Construction costs estimates for dams and reservoirs are unique for each site and are based on specific requirements of the project for the site. Cost estimates for these structures involve determining approximate material volumes (i.e., cut and fill, seepage and erosion control, reinforced concrete, etc.) that will be used, and an estimate of the cost for the spillway, outlet works, and other structures. Conceptual cost estimates for the three dams and reservoirs evaluated in this analysis were based on estimated unit costs for construction of facilities and are shown in Attachment D.

Cost Assumptions for Environmental Impacts

Wetland Impact Mitigation Costs. Wetland impacts defined in this analysis were developed by the NWFWMD and are based on information obtained from the NWI (FGDL, 1999), riverine (streams), lacustrine (lakes), and palustrine (inland shallow ponds, marshes, and forested wetlands) areas.

Mitigation costs for wetlands impacts were estimated at $95,955 per acre based on current information obtained from the NWFWMD. This is the approximate amount that is paid to the NWFWMD by the Florida Department of Transportation (FDOT) for mitigation of wetlands impacted by road projects.

Wildlife Habitat Mitigation Costs. Because a federal action is involved through USACE wetlands permitting, the FWS and/or the National Marine Fisheries Service also review USACE wetlands permit applications. Through this review process, either of these two entities may request a consultation under Section 7 of the Endangered Species Act, in which case further analysis of potential impacts to listed species may be required. Costs associated with such an analysis will depend upon several variables, including species involved, severity of impacts, magnitude of impacts, and possible mitigation required for the proposed project. Due to the wide variability of these projects, cost estimates for these measures should be prepared on a project-specific basis when needed and are not included in this conceptual planning analysis.

TOTAL CAPITAL COSTS

Total capital costs include construction and other project related costs, which are costs incurred in a project that are not directly associated with construction activities. These other project related costs include costs for engineering, legal, financing, contingencies, land, easements, and environmental services.

For this conceptual planning level analysis the engineering, surveying, geotechnical, legal, financing and environmental services costs will be based on a percentage of 25%. Additionally, a 25% contingency allowance is assumed to account for unknown circumstances and for any variances in design components. Unit costs for land were based on a preliminary search for recent land sales in Okaloosa County and should be refined in future phases.

Inevitably during the development of large scale water supply projects such as this, there will be conflicts with existing utilities (i.e., pipelines, roadways, erosion control, and drainage features) that will require relocations and/or consideration. During this analysis phase there has been no analysis in quantifying these conflicts or estimating the resulting probable costs. Based on similar projects the estimated costs for conflict resolution will be assumed to be 10% of construction costs.

OPERATING AND MAINTENANCE COSTS

As mentioned in previous sections the estimated operations and maintenance costs will vary and be based on a percentage of constructions costs for each facility component (i.e., pipelines, pumping station, WTP, and collector wells). Estimated O&M costs were based on State of Texas regional planning guidelines and are estimated to be 1% of the total estimated construction costs for pipelines, distribution facilities, tanks, and wells, 1.5% of the total estimated construction costs for dams and reservoirs, 2.5% of the total estimated construction costs for intake structures and pump stations. O&M for the WTP are based on PBS&J estimates and are expected to be 8% of construction costs.

ANNUAL COSTS

The estimated annual cost for each conceptual alternative includes total capital, energy, and O&M costs.

UNIT COSTS

Unit costs were developed for each year of the bond term (i.e., 30 years) by the ratio of total annual costs to the project yield, including inflation for both O&M and energy consumption. Additionally, an annualized present value unit cost was prepared for comparison to the cost of supplies in present terms.

SUMMARY OF RESULTS

Planning level cost estimates for each conceptual alternative project are provided showing total construction and nonconstruction costs, total project costs (the sum of construction costs and other project costs), and total annual project costs. The unit cost of each alternative per unit of water delivered (total project cost per 1,000 gallons of water delivered) is also presented for further comparison. Table 7 presents the conceptual cost estimates for each of the five conceptual alternative projects. Additional detailed cost tables are presented in Attachment D of this report.

For comparison purposes, when reviewing the costs for the alternative water supply projects evaluated in this report, costs associated with the Yellow River Reservoir Project report were estimated to be approximately $86,000,000 (FY 2003 dollars). The Yellow River Reservoir Project costs did not appear to take into account costs for real estate, wetland mitigation (i.e. ~ 6,439 acres of wetlands (based on NWI mapping), cultural resources mitigation, operations and maintenance, energy, water intake/pump station facilities, conveyance, power transmission lines, among others.

Table 7: Summary of Costs

Item	Conceptual Level Costs Alternative # 1 Pond Creek	Alternative # 2 Bear Creek	Alternative # 3 West Dog Creek	Alternative # 4 Shoal River	Alternative # 5 Riverbank Filtration
River Intake and Pump Station	$ 2,943,968	$ 1,766,381	$ 2,943,968	$ 2,355,175	$ –
Dam and Spillway	$ 15,000,000	$ 5,100,000	$ 3,800,000	$ –	$ –
Reservoir Pump Station	$ 3,238,365	$ 2,943,968	$ 2,649,571	$ –	$ –
Water Treatment Plant	$ 28,400,000	$ 28,400,000	$ 28,400,000	$ 28,400,000	$ 28,400,000
Pipelines	$ 9,572,640	$ 4,010,160	$ 10,311,840	$ 2,046,000	$ 10,829,280
High Service Pumping Station	$ 2,661,347	$ 1,766,381	$ 2,355,175	$ 1,570,116	$ 2,661,347
Groundwater Wells	$ –	$ –	$ –	$ –	$ 7,657,150
7 MG Ground Storage Tank	$ –	$ –	$ –	$ –	$ 3,179,486
Subtotal Construction Costs	$ 61,816,320	$ 43,986,890	$ 49,723,994	$ 34,371,291	$ 52,727,263
Conflict Resolution at 10%	$ 6,181,632	$ 4,398,689	$ 4,972,399	$ 3,437,129	$ 5,272,726
Contingencies and Non Construction Costs at 50%*	$ 30,908,160	$ 21,993,445	$ 24,861,997	$ 17,185,645	$ 26,363,631
Land Costs and Easements	$ 24,716,273	$ 2,186,182	$ 1,371,455	$ 340,909	$ 880,727
Environmental Mitigation	$ 83,049,150	$ 12,330,232	$ 5,229,554	$ 479,776	$ 3,358,429
Total Capital Costs	$ 206,672,000	$ 84,895,000	$ 86,159,000	$ 55,815,000	$ 88,603,000
Annual Operations & Maintenance Costs	$ 2,813,818	$ 2,550,520	$ 2,623,471	$ 2,390,592	$ 2,482,279
Annual Energy – Pumping Costs	$ 1,592,962	$ 1,079,053	$ 1,363,454	$ 680,681	$ 1,067,028
Average Annual Unit Cost ($/1,000 gal)**	$ 3.18	$ 1.77	$ 1.86	$ 1.35	$ 1.79
Present Value of Unit Cost ($/1,000 gal)***	$ 1.51	$ 0.82	$ 0.87	$ 0.62	$ 0.83

* 25% Contingency and 25% Non Construction Costs (i.e. Engineering/Geotechnical/Surveying/Legal/Bond Issuance and Administration)

** Average Annual costs based on 30 years.

** Present Value of Unit Costs based on 3.5 % inflation rate (2006 CPI).

RECOMMENDATIONS

The following recommendations are offered for future investigations:

- In coordination with Okaloosa County, meet with and coordinate with local utilities and regional water suppliers to refine assumptions used in evaluation of alternative supply options.
- Evaluate conjunctive use management opportunities within the region particularly with respect to reduced use of the coastal Floridan Aquifer sources, to facilitate coordinated management of surface and groundwater resources.
- Based upon the conceptual engineering, land use, environmental and financial cost analysis of this feasibility analysis, there are several potential alternative water supplies which have less impacts on the natural resources than those associated with Pond Creek Reservoir, and the previously studied Yellow River Reservoir Project. Based on the conceptual costs developed in this feasibility analysis, smaller reservoirs such as those studied in this report with surface water supplementation and/or riverbank filtration, have fewer impacts to land use and environmental constraints, as compared to larger reservoirs mentioned above. The direct diversion option (i.e.

Alternative #4) was determined to be the least cost alternative and should be considered in future studies.

- For any alternatives not eliminated from consideration following this analysis, conduct detailed field investigations for environmental, cultural, land use and technical constraints.
- Further evaluation of riverbank water supplies should consider the placement of a near-capacity sampling/monitoring well at the location of the anticipated well field. The well should be operated for a period of time to ensure that there is a good influence from the surface water into the well. Samples should be collected of sufficient numbers, over a variety of surface water conditions (i.e., storm and low flow conditions), to ensure that all potential constituents of concern, including Giardia, Cryptosporidium, viruses, TOCs, etc., have been obtained. The collected samples will be used to run jar tests to determine chemicals to be added for the greatest effective treatment. It is anticipated that the results of the sampling and jar tests would reduce the treatment necessary, particularly related to O&M cost for chemical addition, and in terms of sludge removal and treatment. This could significantly reduce both sludge treatment infrastructure costs and O&M costs.
- For surface water supplies, samples of stream flow should be collected at locations anticipated for the take point for raw water used for treatment. These samples should be taken at various surface water conditions, including high and low flow, to consider all possible treatment requirements related to potential constituents of concern, including Giardia, Cryptosporidium, viruses, TOCs, etc., and to more particularly evaluate sludge management requirements for facility needs and O&M costs necessary for sludge treatment.
- Conduct geotechnical investigations consisting of field and laboratory tests for borings and piezometers along the proposed dam alignments, embankments and anticipated borrow areas, as well as potential sites for riverbank filtration facilities.
- Collect hydrogeologic data collection using exploratory wells to define lithology and physical aquifer characteristics, and aquifer performance test(s) to define aquifer flow characteristics for the Sand-and-Gravel Aquifer within the riverbank filtration study area.
- Continue implementation of the Water Resource Development Work Program of the RWSP to develop the surface water component of the Region II plan.

RISKS/UNCERTAINTIES/FATAL FLAWS

Similar to all other water supply feasibility studies, until additional site-specific investigations have been performed and additional analysis have occurred, there are certain risks associated with the assumptions used in this conceptual analysis. As alternative supplies are investigated and more-detailed information is acquired, a more-refined engineering and ecological analysis can be performed, which in turn will increase the accuracy of construction cost estimates. Thus, the final Engineer’s Estimate will be more accurate due to the additional level of detail that is known when the design is completed.

Attachment A

Site Screening Summary

Attachment A

Screening Evaluation of Alternative Water Supply Source Areas within Okaloosa County

INTRODUCTION

This appendix describes the screening process and methods followed for identifying sub-basins and sites suitable for fresh surface water supply source development in Okaloosa County, Florida. The intent of the analysis is to support decision-making in consideration of the environmental and technical feasibility of future alternative water supply sources. The focus on Okaloosa County is based upon several factors. This county is within the Northwest Florida Water Management District's ("District" or "NWFWMD") planning area for the Region II Regional Water Supply Plan (RWSP) (NWFWMD 2000; 2006). In this region, the Governing Board of the District determined that water supply planning pursuant to section 373.0361, Florida Statutes, is needed to meet the region's future water demands. Given this and the underlying water resource challenges, long-term alternative water supplies must be identified and developed in cooperation with local governments and utilities. Additionally, the Chairman of the Okaloosa County Commission requested in 2004 that the NWFWMD assist the county in identifying viable, long-term alternative water supply sources. Existing alternative water supply sources are already in production within the other two counties Region II, Santa Rosa and Walton counties. It is also noteworthy that Okaloosa County has constructed a major water transmission pipeline from the northern portion of the county to the coastal region.

ALTERNATIVE WATER SUPPLY SOURCES

The U.S. Army Corps of Engineers (2004) previously evaluated the feasibility of constructing a dam across the Yellow River to develop a large in-line reservoir as a surface water supply source. The Corps concluded that construction of such a dam and reservoir is physically feasible. However, the Corps also noted that the project would be costly and would cause significant environmental impacts. The Corps recommended that "additional comprehensive study be conducted to evaluate alternative measures," including to identify alternatives that may be more cost effective and environmentally acceptable. The County requested that the subsequent alternatives analysis conducted by the District incorporate the Yellow River Dam proposal as a basis of comparison in determination of a preferred alternative.

Some of the constraints associated with the Yellow River reservoir proposal include the following:

- Extensive wetland impacts. The Corps' report provided an estimate that the reservoir area evaluated, at the 100-foot contour, would impact approximately 10,026 acres of habitat, of which 6,439 acres are wetland as classified by the National Wetlands Inventory (NWI). Wetland mitigation required under state and federal regulations to compensate for this level of impact would be difficult to identify and exceptionally costly (over $600,000,000 given the methods used to estimate mitigation costs for the other alternatives evaluated in the accompanying feasibility analysis).

- Other significant environmental impacts. In impounding a major river, the project would eliminate extensive riverine and riparian habitat and affect the viability of a population of the federally listed (threatened) Gulf sturgeon (Acipenser oxyrinchus desotoi), as well as other species of fish and invertebrates.
- High cost relative to other potential alternatives. The Corps estimated costs at $86,000,000. However, this estimate does not take into account costs for real estate, wetland mitigation, operations and maintenance, water intake/pump station facilities, additional conveyance, power transmission lines, water treatment, or energy. These factors are incorporated into the estimates provided for the tributary reservoir and riverbank filtration alternatives discussed in the accompanying feasibility and cost analysis.
- The proposal would impact Northwest Florida Water Management District lands in a manner not consistent with the statutory purpose of the public acquisition.

There are also other issues associated with the use of the Yellow River that merit consideration. Given that the majority of the watershed (exclusive of the Shoal River) is within Alabama, most of the land use upstream of any water supply facility would be outside of the control of Okaloosa County and the state of Florida. Additionally, use of the Yellow River for a water supply source is under consideration in Alabama (Cook et al. 2002). Thus, the long-term, future flow and demand from the uppermost reaches of the river north of Okaloosa County is less certain.

Given these issues and the need to identify feasible alternative water supply sources for Okaloosa County, the Northwest Florida Water Management District identified and set out to evaluate the feasibility and estimated costs associated with several potential alternative water supply sources, including direct withdrawal from one of the major rivers, development of one or more small reservoirs on tributaries of the Yellow and/or Shoal rivers, and construction of riverbank filtration wells. Such alternatives could be used together and/or in conjunction with sustainable ground water withdrawals.

Sub-basin yields of small conceptual tributary reservoirs, such as those evaluated, would be sufficient to reduce reliance on the adjacent main stem river during wet weather conditions. It would be expected that the inflow to such reservoirs would need to be augmented by supplementary withdrawal from either the Yellow or Shoal River. They would be designed to provide some storage that would be available for use during periods of low flow or times when river water quality is less desirable.

Among other broad alternatives, desalination is encompassed within the RWSP as potential long-term strategies. As indicated in the RWSP (NWFWMD 2000; 2006), however, this alternative appears not to be cost effective at present.

WATERSHED DESCRIPTION

The Yellow River watershed represents the major non-Floridan Aquifer fresh water resource within Okaloosa County. The overall watershed covers 878,118 acres, with 63% within Florida and the remainder within Alabama (Figure 1). The primary tributary of the Yellow River is the Shoal River. The Shoal River watershed covers approximately 318,386 acres, about 96% of which is within Florida. Excluding the Shoal River, the Yellow River watershed covers about 559,732 acres, 57% of which is in Alabama. Approximately 167,340 acres within Florida's portion of the Yellow River watershed are public lands, encompassing about 31% of the watershed area within the state. These include 137,756 acres of Department of Defense land and 29,584 acres of District, state forest, and other state conservation land. Within Alabama, approximately 21,105 acres of the watershed, or 6% of the watershed area in that state, are within the Conecuh National Forest.

As described in the Surface Water Improvement and Management (SWIM) plan for the Pensacola Bay System (NWFWMD 1997), the Yellow River extends approximately 92 miles from Covington County, Alabama, to Blackwater Bay in Santa Rosa County, Florida. The river's extent through the Western Highlands region creates substantial bluffs in some areas. The river has an extensive floodplain and associated forest. The Shoal River originates in Walton County, with a relatively small area (11,637 acres) of the Pond Creek sub-basin extending north into Alabama. The lower Yellow River, along with portions of Blackwater and East bays, are within the Yellow River Marsh Aquatic Preserve. The Shoal River and waters within the aquatic preserve are designated as Outstanding Florida Waters (OFWs).

STREAM FLOW CHARACTERIZATION

Table 1 lists streamflow statistics over the period of record for established monitoring stations in Okaloosa County.

Table 1. Stream Flow Statistics for Major Rivers within Okaloosa County

Stream (Gauging Station Number)	Period of Record	Average (MGD)	30Q2 (MGD)	7Q10 (MGD)	Drainage Area (Mi^2)
Blackwater River near Baker (02370000)	04/01/1950 to 09/30/2003	224	63	41	205
Shoal River near Crestview (02369000)	08/01/1938 to 09/30/2003	717	302	185	474
Yellow River at Milligan (02368000)	08/01/1938 to 09/30/2003	745	210	107	624
*Yellow River near Holt (02369500)	08/01/1938 to 09/30/2003	1,586	559	318	1,210

Source: U.S. Geological Survey

*Calculated based on drainage basin area-ratio

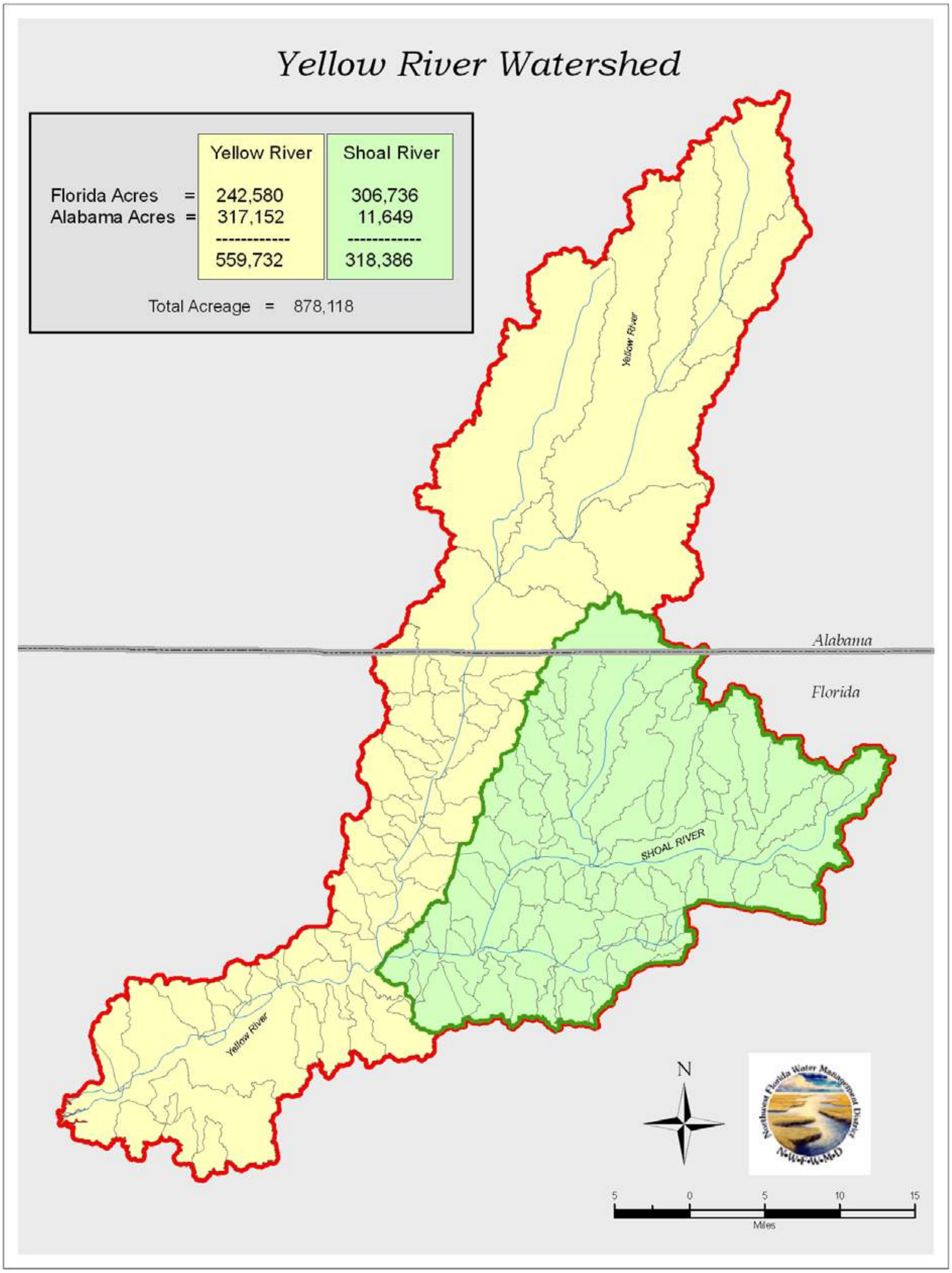

Figure 1. Yellow River Watershed

ALTERNATIVE SOURCE SCREENING

Conceptual Reservoirs

The analysis began with delineation of sub-basins within Okaloosa County based on the hydrologic unit classification system of the U.S. Geological Survey. Seventy-five sub-basins were delineated and evaluated. These are listed in Attachment 1 to this appendix. Additionally, geological and hydrologic characteristics of the major river floodplains in northern Okaloosa County were evaluated for the purpose of identifying areas suitable for development of riverbank filtration wells.

Initially it was realized that most of the small sub-basins in the northern portion of the county would not be given further consideration due to logistical and geographic considerations. Small watersheds eliminated included those that were far from main stem rivers or those that drain in more or less easterly or westerly directions and do not provide for a natural conveyance southward. Pond Creek, which conveys large amounts of water south under natural gravity flow to the mid-county region, was retained in the analysis for comparison purposes. Other small undeveloped watersheds, which would require large pipelines at considerable cost and environmental impact to move water south towards major demand centers in the mid-county region, were not considered feasible.

Following initial identification and screening of sub-basins, Eglin Air Force Base (AFB) and areas to the south were also eliminated from consideration. This was based upon previously identified constraints associated with military lands, location of areas of anticipated future demand, and the above-mentioned water pipeline the county has constructed, connecting northern Okaloosa County with the coastal region.

A number of preliminary screening criteria were identified. In general, it was concluded that sites and sub-basins considered for alternative water supply sources should be:

- proximate to the main stem of a major river, so as to provide the opportunity for augmentation as necessary;
- proximate to areas of expected future increasing demand;
- of sufficient size to support a reservoir with adequate storage;
- non-urban and not include major sources of water quality degradation;
- outside of military lands;
- outside of the coastal area to avoid storm surge area and tidal influence; and
- able to provide for an outlet or in-take point in the approximate middle latitudes of the county.

Consideration of these factors, as well as the county's north-south water supply pipeline, suggested the portion of the county north of Eglin AFB, but south of latitude 30 degrees 50 minutes north, as the logical area of focus.

For identifying alternative locations suitable for potential reservoirs, subsurface geology, soils, topography, land use and ownership, and stream-flow magnitudes were evaluated. Stream flows were identified based on long-term monitoring data. Where actual data were unavailable, flows were estimated based on basin areas and statistical relationships with nearby streams for which long-term data were available.

To further narrow sites that would be evaluated in detail for potential tributary reservoir development, sub-basins were eliminated if they were considered too small in terms of flow, remote from potential demand areas or sources of augmentation (i.e., major rivers), heavily sub-divided into separate parcels, or subject to relatively intensive land use. For sub-basins remaining under consideration, potential reservoir locations were conceptualized. Soil data were also closely evaluated to ensure sites would be able to support reservoir development.

Stage-storage and stage-area relationships needed for the yield analyses were developed through geographic and statistical analysis. Stream low-flows were analyzed to identify potential safe yields from basins and conceptual reservoirs. The 7Q10 statistic was used to proximate the low flow over the period of record-and to identify the drought of record. The 7Q10 is defined as a seven day moving average representing the low flow expected on a one-in-ten year return interval—i.e., with a ten percent or lower probability in any given year that the flow will be that low or lower. The 2Q30 statistic was also calculated for each basin as an initial estimate of yield of a sub-basin during average low flow conditions. The difference between 7Q10 and 2Q30 was considered a reasonable yield estimate to provide a downstream flow requirement.

Conceptual tributary reservoir sites were located at least two contours (USGS Quads) off the adjacent main river to minimize the likelihood of effects from major riverine flood events. Additional criteria considered in identifying prospective tributary reservoirs included the following:

- A suitable dam site must exist. The cost of the dam is often the controlling factor in selection of a site.
- The expected cost of real estate for the reservoir, including roads, railroads, cemeteries, and dwelling relocations, must not be excessive.
- The reservoir site must have adequate capacity.
- A deep reservoir is preferable to a shallow one because of lower land cost, less evaporation, and less aquatic plant growth.
- Tributary areas that are unusually productive of sediment should be avoided.
- The quality of stored water must be satisfactory.
- Reservoir banks/adjacent hill slopes should be stable.
- Environmental impacts should be minimal and have significant potential for watershed resource restoration.

- Information on recurrence of low flows is particularly important in designing surface-water supply systems, because the lowest discharge usually establishes the limits of supply without storage.
- Reservoir storage may provide up to 200 days of water supply without additional inflow augmentation.

Table 2 lists sub-basins considered at this stage, to include estimated surface area and storage associated with conceptual reservoirs, and a qualitative evaluation of general sub-basin characteristics. Surface area and storage figures are based on an assumed 25-foot maximum water level.

For development of feasibility analysis and planning level cost estimates, the final set of sub-basins of interest were narrowed by eliminating those that were too small to provide significant storage and, for cost effectiveness reasons, those that were considered too far north of the transmission pipeline and potential distribution points.

An important qualitative factor is the evaluation of existing environmental alteration of the sub-basins under consideration. In addition to being a means of avoiding unnecessary environmental impacts, focusing on areas where the landscape has already been substantially altered would provide an opportunity for watershed resource and habitat restoration and subsequent protection. This helps protect long-term source water quality and provides for ecological restoration and integrity. Together with mitigation of any unavoidable wetland impacts and watershed protection efforts, this approach would potentially provide for a net environmental benefit.

Following the quantitative and qualitative assessments described above, the sub-basins that appeared most viable for further consideration were:

- Pond Creek (inclusive of Juniper Creek and other contributing sub-basins);
- Bear Creek; and
- West Dog Creek.

The characteristics of these study areas provide a reasonable range of the expected conditions one would need to evaluate in siting a water supply reservoir in Okaloosa County. As such, they do not rule out other areas which would have similar characteristics. The analytical results from proximate areas, for example, would be transferable to the Baggett, Mare, and Long creek basins, among others. Feasibility analysis and planning level cost estimates were therefore developed for conceptual reservoirs within the Bear, West Dog, and Pond creek basins, as well as for development of riverbank filtration wells along the Yellow River.

Table 2. Sub-basin Screening for Conceptual Reservoir Sites

Sub-basin	Reservoir Surface Area (Acres)	Net Storage (ft^3)	Days Net Storage @ 25 mgd withdrawal	Parcel Evaluation[1]	Proximity to Right-of-Way[2]	Topography[3]	Distance to Main River[4]	Comments
Baggett Creek	103.2	39,823,605	12	Fair	Excellent	Excellent	Excellent	Landfill within sub-basin
Bear Creek	180.3	83,568,147	25	Excellent	Excellent	Excellent	Excellent	
Deerland Branch	50.4	23,476,059	7	Excellent	Excellent	Excellent	Excellent	
Dog Creek	100.0	41,571,084	12	Excellent	Excellent	Excellent	Excellent	Major development apparently underway
Juniper Creek	207.5	70,682,653	21	Excellent	Good	Good	Excellent	Too far north of transmission pipeline. Considered with Pond Creek
Long Creek	67.0	24,007,150	7	Excellent	Excellent	Excellent	Excellent	Planned wastewater treatment plant. Revised site location could make basin viable for consideration
Mare Creek	70.1	27,549,929	8	Fair	Excellent	Excellent	Excellent	Considered due to existing alteration and proximity to augmentation
Pond Creek	2,118.8	1,043,042,562	312	Poor	Good	Fair	Excellent	Enters Walton County
West Dog Creek	71.1	37,090,102	11	Excellent	Excellent	Excellent	Excellent	Considered due to existing alteration and proximity to augmentation

[1]Low number of parcels and large parcels considered positive trait (Excellent) for public resource acquisition.
[2]Based on proximity to major roadways and utility corridors.
[3]Topography conducive to impoundment placement and water storage.
[4]Proximate to major river for efficient augmentation as necessary.

Riverbank Filtration System

Hydrogeologic analysis of floodplains along the Yellow River, Shoal River, and Titi Creek concluded in identifying the Yellow River floodplain downstream of the confluence with the Shoal River as being the area most favorable for construction of a riverbank filtration water supply system. This area was therefore included within the feasibility analysis and the development of planning level cost estimates.

The geology along the Yellow River floodplain is the most important criteria for determining an appropriate site for a riverbank filtration system. The Alum Bluff Group is near the surface, or relatively shallow, in the eastern part of Okaloosa County. The Alum Bluff Group sediments "…range from clayey sands and gravels to greenish, stiff, micaceous clays…" (Florida Geological Survey [FGS] 2001) and therefore would not make a good matrix for a riverbank filtration system. These sediments dip slightly to the southwest and underlie the Citronelle Formation in the western part of the county. The Citronelle Formation is at the surface west of the confluence of the Yellow River and Shoal River and consists of "…sands and gravels with varying amounts of clay…" (FGS 2001). The Citronelle Formation would make an excellent matrix for a riverbank filtration system. From the confluence of the Yellow and Shoal rivers, the Citronelle Formation thickens from about 20 feet to 100 feet at the Okaloosa-Santa Rosa County line. Therefore, the Citronelle Formation may serve as a matrix for lateral movement of Yellow River water to riverbank filtration wells. Also, the Alum Bluff clays under the Citronelle Formation would prevent vertical movement of groundwater from deeper aquifers during pumping of this proposed system.

ENVIRONMENTAL SCREENING

The screening analysis of environmental and cultural elements consisted of a geographic information system (GIS)-based analysis of existing coverages and a review of selected literature sources (Table 3). More detailed, field-level investigations for environmental, cultural, land use, and technical constraints would be required for any alternatives selected for further consideration based on the results of this feasibility analysis.

Screening criteria were identified based on review of existing data sets and consideration of Villalon (2005) and the Florida Department of Transportation's online Environmental Screening Tool (EST). The EST, developed in support of the Efficient Transportation Decision-Making (ETDM) initiative, was also consulted to help screen for constraints and identify available data sources. The EST is supported by the Federal Highway Administration to make planning level decisions intended to minimize or avoid environmental impacts caused by construction of highways in Florida.

Discussion of wetlands, land use, cultural elements, threatened and endangered species, and environmental contaminants screening follows.

Table 3. Analytical Elements and Primary Data Sources

Environmental and Cultural Elements	*Data Sources*
Basins	Florida Department of Environmental Protection (FDEP) (1998)
Sinkholes	FDEP (2005)
1st Magnitude Springs	FDEP (2001)
Wetlands	National Wetlands Inventory (NWI) (1971-1992)
Land Use	FDEP (1995)
Future Land Use	Okaloosa County (2006), Walton County (2005)
National Register of Historic Places	Florida Bureau of Archaeological Research
State Historic Preservation Officer (SHPO) Structures	Bureau of Archaeological Research SHPO data
SHPO Cemeteries	Bureau of Archaeological Research SHPO data
Cemeteries	University of Florida GeoPlan Center (2005)
SHPO Bridges	Bureau of Archaeological Research SHPO data (2005)
SHPO Resource Groups	Bureau of Archaeological Research (2005)
Points of Interest	University of Florida GeoPlan Center (1994)
Roads	Florida Department of Transportation
Visual	USGS DOQQ
Trails	Florida Greenways and Trails
Soil Service Geographic (SSURGO) data	U. S. Dept. of Agriculture (USDA) Natural Resources Conservation Service (NRCS)
Parcel data	Okaloosa County (2005); Walton County (2006)
Flood Insurance Rate Maps digital representation "Q3 Data"	Federal Emergency Management Agency (FEMA) (1996)
Digital Flood Insurance Rate Map (DFIRM)	FEMA (2002)
Areas of Conservation Interest A	Florida Natural Areas Inventory (FNAI) (1995)
Areas of Conservation Interest B	FNAI (1995)
Areas of Conservation Interest C	FNAI (1995)
Florida Managed Areas	FNAI (2006)
Florida Forever BOT Projects	FNAI (2006)
Eagle Nests	Florida Fish & Wildlife Conservation Commission (FWC) (2003)
FL Ecological Greenways Network Critical Linkages and Prioritization Results	University of Florida GeoPlan Center (2002)
Threatened and Endangered Species	FNAI data request (2006)
Priority Ecological Areas	University of Florida GeoPlan Center (2005)
Biodiversity Hot Spots	FWC (1989)
Strategic Habitat Conservation Areas	FWC (2000)
Priority Wetland Habitats	FWC (1998)
Greenways Project Paddling Trails	University of Florida GeoPlan Center (1998)
Greenways Multi-Use Trails Modified	University of Florida GeoPlan Center (1998)
Brownfields	FDEP (2004)
Petroleum Tanks	FDEP (2003)
Hazardous Material Sites	Florida Department of Transportation (1997)
Solid Waste Facilities	FDEP (1997)
Superfund Hazardous Waste Sites	U. S. Environmental Protection Agency (2002)

Conceptual Study Areas

As discussed above, the conceptual study areas chosen for further analysis are:

- Pond Creek Reservoir;
- Bear Creek Reservoir;
- West Dog Creek Reservoir; and
- Riverbank Filtration Area.

Pond Creek Reservoir

The Pond Creek basin covers 102,193 acres within Okaloosa County, Walton County, and southern Alabama. The conceptual reservoir site covers 2,593 acres within Okaloosa and Walton counties. Land use in the Pond Creek reservoir is predominately characterized by upland forests and wetlands, which together comprise approximately 91 percent of the total area. Other land uses include agriculture, barren land, rural residential, water, transportation, commercial, and utilities. Alteration within the sub-basin is apparent, which may provide opportunities for restoration. The wetland quality within the basin has not been evaluated in detail, but it is anticipated that it has been impacted by adjacent land use practices. Neither the basin nor the reservoir footprint includes public lands.

Bear Creek Reservoir

The Bear Creek basin covers 2,432 acres within Okaloosa County. Of this area, the conceptual reservoir site covers 246 acres. Land use within the Bear Creek reservoir imprint is characterized by upland forests and wetlands, with some rural residential and additional alteration evident, particularly in the western portion of the basin. Additional watershed protection and restoration could help enhance and maintain water quality. Neither the basin nor the reservoir footprint includes public lands.

West Dog Creek Reservoir

The West Dog Creek basin covers 1,718 acres within Okaloosa County. It is evident that this basin has been heavily altered and impacted due to past land use practices. Thus, it would appear to be a good candidate for environmental and watershed resource restoration. The conceptual reservoir site covers approximately 100 acres. Land use and land cover within the reservoir imprint includes wetlands, with some agriculture and upland forest. Neither the basin nor the reservoir footprint includes public lands. The quality of the wetlands has not been evaluated in detail, but it is anticipated that they have been impacted by adjacent land use practices. Thus, overall watershed resource restoration potential appears high if the overall sub-basin were ultimately managed for water quality protection.

Riverbank Filtration Area

Approximately 7,000 acres located along the northern banks of the Yellow River below the confluence of the Shoal River within Okaloosa County were evaluated as being the area most likely to be feasible for construction of a riverbank filtration (RBF) facility. The actual site of an RBF facility has not been determined, but it was estimated only 70 acres of land, including below grade construction, would be required for actual construction of this type of facility. Wetlands and upland forest together comprise about 92 percent of the total area evaluated. Approximately 2,482 acres are in public lands. As the only real requirement for the RBF site is that the Citronelle Formation below it be reasonably thick sand with a good hydraulic connection with the river bottom sediments, site selection could be conducted to avoid or minimize environmental impacts.

Land Use and Land Cover

Figure 2 illustrates generalized land use and land cover for the Yellow River watershed. The data was developed by the state of Florida from 1994-1995 National Aerial Photography Program color-infrared imagery and indicate that much of the area consists of silviculture, other forestland, and wetlands. Rural residential and agricultural land uses are also significant within the watershed, and the city of Crestview is the primary urbanized area. Sub-basin level land use is presented in Attachment 1 to this appendix (Table 14) and classified according to the Florida Land Use, Cover, and Forms Classification System (FLUCCS) (FDOT 1999). Alabama land use and land cover data shown in Figure 2 are based upon Landsat Thematic Mapper imagery (late 1980s through 1990s) processed by the U.S. Geological Survey.

Land use and land cover data for the respective conceptual reservoir and riverbank filtration study areas are presented in the following tables. Existing land use/land cover results were calculated from GIS analysis of FLUCCS 95 data for the basin and reservoir extents, respectively. Future land use data were provided by Okaloosa and Walton counties.

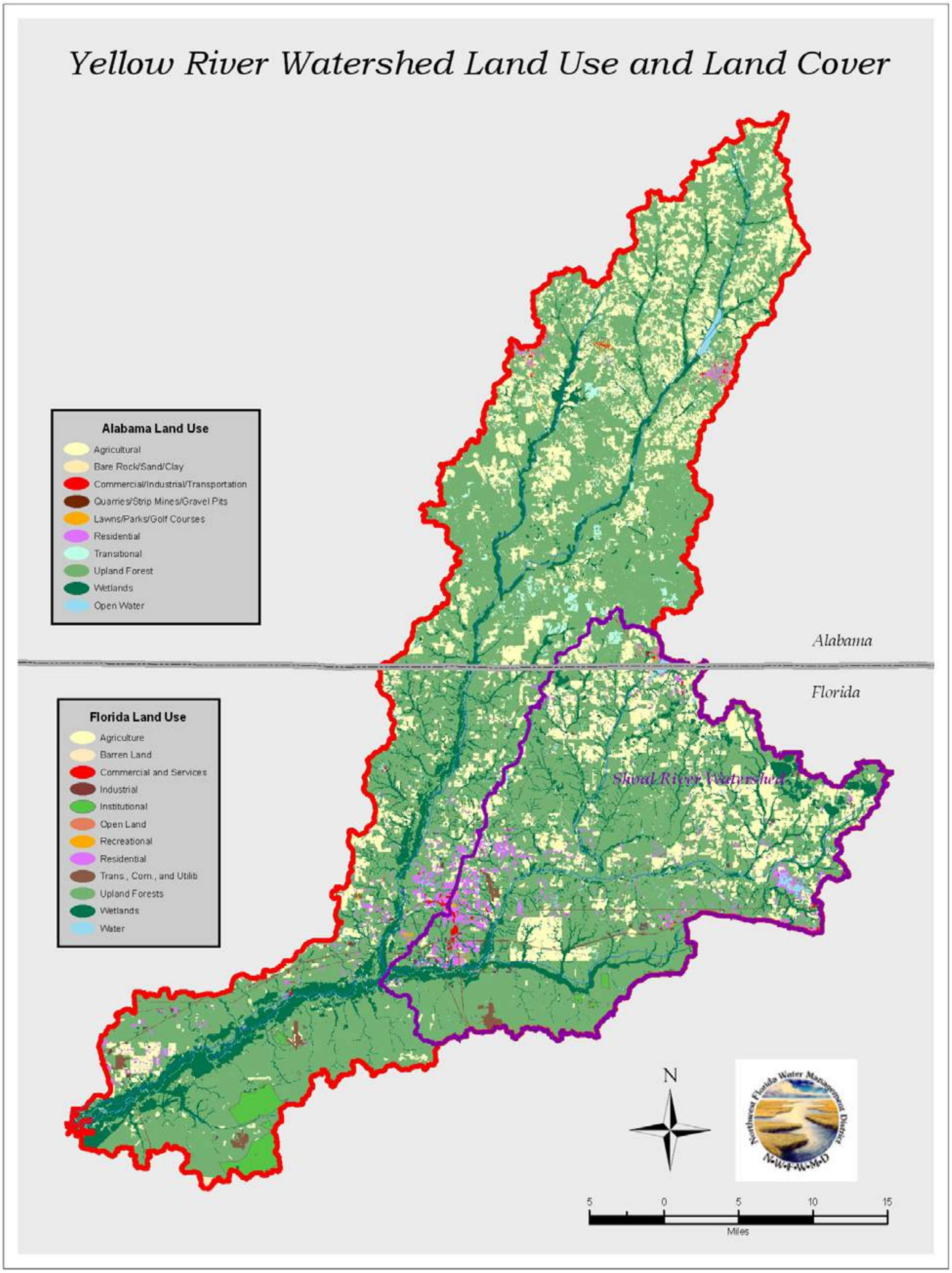

Figure 2. Yellow River Watershed Land Use and Land Cover

Table 4. Existing Generalized Land Use and Land Cover (acres)

Study Area	Basin/Study Area							Conceptual Reservoir Area					
	Agri-culture	Barren	TCU	Upland Forest	Urban	Water	Wetland	Agricul-ture	Barren	TCU	Upland Forest	Water	Wetland
W. Dog	1,217	0	0	271	55	20	154	14	0	0	2	0	58
Bear	326	9	37	1,698	128	20	216	0	0	0	136	0	109
Pond	21,013	104	147	55,626	1,517	1,039	10,306	107	28	15	1,409	66	953
RBF	67	1	15	2,296	178	174	4132	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

RBF – Riverbank Filtration (actual footprint estimated at 70 acres)

TCU – Transportation, Communications, and Utilities

Urban – Residential, Commercial, Industrial, and Institutional

Table 5. Future Land Use (acres)

Study Area	Basin/Study Area						Conceptual Reservoir Area					
	Munici-pal	Residential	Commer-cial	Agricul-ture	Industrial	Conser-vation	Municipal	Residential	Commer-cial	Agricul-ture	Industrial	Conser-vation
W. Dog	0	108.6	0	1,279	332	0	0	0	0	1,279	70	0
Bear	0	534	0	1,888	10	0	0	54	0	191	0	0
Pond	3,996	6,120	107	80,376	0	0	0	0	0	2,566	0	0
RBF	0	732	0	3,497	0	2,465	N/A	N/A	N/A	N/A	N/A	N/A

Numbers of parcels within analysis areas are presented in Table 6.

Table 6. Parcels within the Study Area

Study Area	Basin/Study Area		Conceptual Reservoir Area	
	Parcels	Owners	Parcels	Owners
West Dog Creek	70	45	3	1
Bear Creek	282	190	16	14
Pond Creek	3,504	2,280	154	119+
Riverbank Filtration Area	567	425	n/a	n/a

Farmland

Area of agricultural lands, based on existing FLUCCS data, is listed above in Table 4 for the analysis areas. Natural Resource Conservation Service (NRCS) soils data indicate that 11 acres of the Pond Creek conceptual impoundment area, one acre of the Bear Creek conceptual impoundment area, and eight acres of the RBF analysis area are classified as Prime Farmland. It should be noted that, due to the limited area of potential impact, losses of prime farmlands due to implementation of the RBF alternative should be avoidable.

Cultural Resources

The State Historic Preservation Officer (SHPO) GIS database was consulted to identify listed and proposed cultural and historic resources within the analysis areas. No resources were identified within the conceptual impoundment areas. Four historic cemeteries and a number of potential historic structures were identified within the Pond Creek basin. One historic bridge was identified within the RBF analysis area.

Wetlands

Wetland estimates for the conceptual reservoirs are based on GIS analysis of National Wetland Inventory (NWI) data within the estimated maximum flooded area. Digital ortho quarter-quad (DOQQ) aerial photograph images were also reviewed for consistency with the NWI coverage. Wetland impacts for riverbank filtration are estimated by assuming that half of the area needed for the wellfield, pumping station, and treatment plant (a total of 70 acres) would be wetland. Wetland area is illustrated in Figure 3 and listed in Table 7.

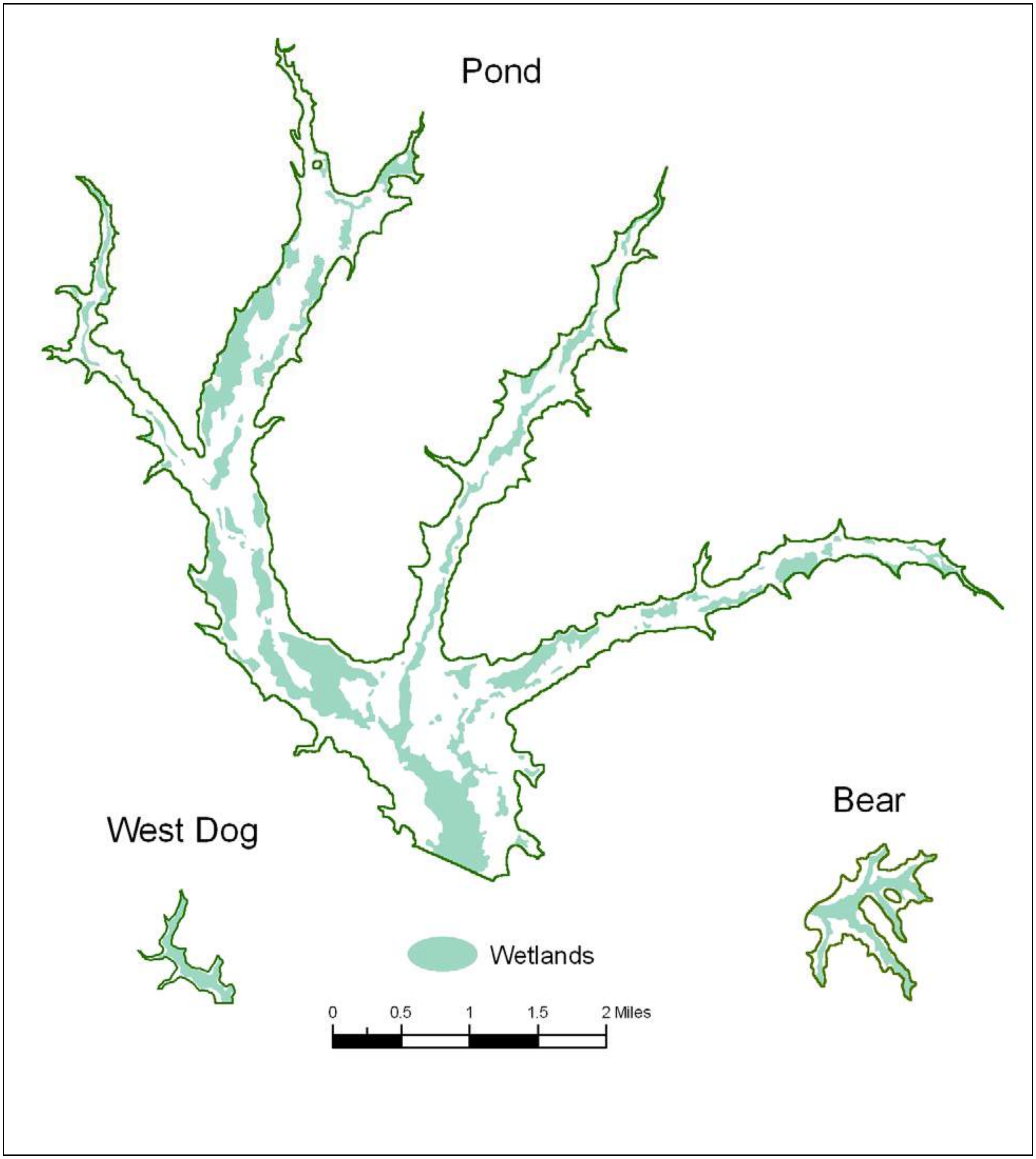

Figure 3. NWI Wetlands within Conceptual Reservoir Areas

Reservoir placement is not shown geographically.

Table 7. Estimated Wetlands within Assessment Areas

Wetland Type	NWI Area (Acres)			
	Pond Creek	West Dog	Bear	RBF
Palustrine	842	52	126	35
Riverine	21	0	0	0
Total	863	52	126	35

Threatened and Endangered Species

To screen for the presence of listed species, a data request was filed with the Florida Natural Areas Inventory. Supplementary literature was also consulted, including Bass et al. (2004) and Hoehn (1998).

Overall Project Area

Listed species currently documented within the study region of northern Okaloosa County are displayed in Table 8.

Table 8. Listed Species Documented within Northern Okaloosa County

Scientific Name	Common Name	Federal Status	State Status
Fish			
Acipenser oxyrinchus desotoi	Gulf sturgeon	LT	LS
Pteronotropis welaka	Bluenose shiner	N	LS
Notropis melanostomus	Blackmouth shiner	N	LE
Amphibians			
Ambystoma cingulatum	Flatwoods salamander	LT	N
Hyla andersonii	Pine barrens treefrog	N	LS
Rana capito	Gopher frog	N	LS
Rana okaloosae	Florida bog frog	N	LS
Reptiles			
Alligator mississippiensis	American Alligator	N	LS
Drymarchon corais couperi	Eastern indigo snake	LT	LT
Gopherus polyphemus	Gopher tortoise	N	LS
Macroclemys temminckii	Alligator snapping turtle	N	LS
Pituophis melanoleucus mugitus	Florida pine snake	N	LS
Birds			
Egretta caerulea	Little blue heron	N	LS
Egretta thula	Snowy egret	N	LS
Egretta tricolor	Tricolored heron	N	LS
Eudocimus albus	White ibis	N	LS
Falco peregrinus	Peregrine Falcon	N	LE
Falco sparverius paulus	Southeast American Kestrel	N	LT
Haliaeetus leucocephalus	Bald Eagle	N	LT

Scientific Name	Common Name	Federal Status	State Status
Pandion haliaetus	Osprey	N	LS
Picoides borealis	Red-cockaded woodpecker	LE	LT
Mammals			
Sciurus niger shermani	Sherman's Fox Squirrel	N	LS
Tamias striatus	Eastern chipmunk	N	LS
Ursus americanus floridanus	Florida black bear	N	LT
Plants			
Andropogon arctatus	Pine-woods Bluestem	N	LT
Aristida simpliciflora	Southern three-awned grass	N	LE
Baptisia calycosa var *villosa*	Hairy wild indigo	N	LT
Calamovilfa curtissii	Curtiss' Sandgrass	N	LT
Calycanthus floridus	Sweet shrub	N	LE
Carex baltzellii	Baltzell's sedge	N	LT
Drosera intermedia	Spoon-leaved sundew	N	LT
Coelorachis tuberculosa	Piedmont jointgrass	N	LT
Epigaea repens	Trailing arbutus	N	LE
Hexastylis arifolia	Heartleaf	N	LT
Ilex amelanchier	Serviceberry Holly	N	LT
Juncus gymnocarpus	Coville's Rush	N	LE
Kalmia latifolia	Mountain laurel	N	LT
Lachnocaulon digynum	Bog button	N	LT
Lilium iridollae	Panhandle lily	N	LE
Lindera subcoriacea	Bog Spicebush	N	LT
Litsea aestivalis	Pondspice	N	LE
Macranthera flammea	Hummingbird flower	N	LE
Magnolia ashei	Ashe's magnolia	N	LE
Magnolia pyramidata	Pyramid magnolia	N	LE
Magnolia tripetala	Umbrella magnolia	N	LE
Panicum nudicaule	Naked-stemmed panic grass	N	LT
Platanthera integra	Yellow Fringeless Orchid	N	LE
Quercus arkansana	Arkansas oak	N	LE
Rhexia parviflora	Small-flowered meadowbeauty	N	LE
Rhododendron austrinum	Orange azalea	N	LE
Rhynchospora crinipes	Hairy-peduncled Beakrush	N	LE
Sarracenia leucophylla	White-top pitcherplant	N	LE
Sarracenia rubra	Sweet pitcherplant	N	LT
Stewartia malacodendron	Silky camellia	N	LE
Xyris scabrifolia	Harper's yellow-eyed grass	N	LT

LS = Species of Special Concern LT = Threatened LE = Endangered

One federally-listed species of fish is documented within the Yellow and Shoal rivers. The Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) is seasonally resident in the Yellow River and the lower Shoal River (50 CFR 17; 50 CFR 226). The Gulf sturgeon is an anadromous species that inhabits river systems in northwest Florida during the warmer months and overwinters in nearby coastal waters. Bass et al. (2004)

and Hoehn (1998) indicate the presence of the state-listed bluenose shiner (*Pteronotropis welaka*) and potential presence of the blackmouth shiner (*Notropis melanostomus*) within the Yellow and Shoal rivers watershed.

West Dog Creek

No occurrences have been documented with the West Dog Creek watershed.

Bear Creek

No occurrences have been documented with the Bear Creek watershed.

Pond Creek

The pine barren treefrog has been documented within the Pond Creek conceptual reservoir area.

Table 9. Listed Species Documented within the Pond Creek Conceptual Reservoir Area

Scientific Name	Common Name	Federal Status	State Status
Hyla andersonii	Pine barren tree frog	N	LS

Nine listed occurrences have been documented within the contributing Pond Creek sub-basin (Table 10).

Table 10. Listed Species Documented within the Pond Creek Sub-Basin

Scientific Name	Common Name	Federal Status	State Status
Tamias striatus	Eastern chipmunk	N	LS
Drymarchon corais couperi	Eastern indigo snake	LT	LT
Hyla andersonii	Pine barrens treefrog	N	LS
Egretta caerulea	Little blue heron	N	LS
Lilium iridollae	Panhandle lily	N	LE
Juncus gymnocarpus	Coville's Rush	N	LE
Platanthera integra	Yellow fringeless orchid	N	LE
Sarracenia leucophylla	White-top pitcherplant	N	LE
Xyris scabrifolia	Harper's yellow-eyed grass	N	LT

Riverbank Filtration Area

Within the riverbank filtration study area, three listed species have been documented, including two plants and one amphibian (Table 11). Unlike the reservoir alternatives, however, implementation of the RBF alternative should be able minimize or completely avoid impacting listed species within the evaluation area due to the small footprint of any facilities, below grade placement of the collector wells, and the ability to site the facilities to minimize or avoid impacts.

Table 11. Listed Species Documented within the Riverbank Filtration Study Area

Scientific Name	Common Name	Federal Status	State Status
Hyla andersonii	Pine barrens treefrog	N	LS
Ilex amelanchier	Serviceberry holly	N	LT
Rhododendron austrinum	Orange azalea	N	LE

Public Lands

The areas of analysis are generally lacking in public lands with the exception of the riverbank filtration area. Over 60 percent of the riverbank filtration area evaluated consists of private lands, however. Thus, if the geological characteristics of the area support riverbank filtration wells, it is assumed that sufficient area would be available to locate them outside of existing conservation or military lands.

Table 12. Public Lands within the Study Area (acres)

Study Area	Basin/Study Area	Conceptual Reservoir Area
West Dog Creek	0	0
Bear Creek	0	0
Pond Creek	0	0
Riverbank Filtration Area	2,465 (NWFWMD); 17 (Eglin AFB)	N/A

There is one proposed state land acquisition (Florida DEP) within the Pond Creek reservoir area. This is the "Upper Shoal River" project within Walton County. This 75 acre portion of the site represents approximately 3% of the total reservoir site. About 9,850 acres is within the Pond Creek Basin. A small portion (79 acres) of the Riverbank Filtration Area is proposed by the state as part of the "Yellow River Ravines" Florida Forever project acquisition area. Also in this area, 3,871 acres have been designated additional potential NWFWMD acquisition.

Environmental Contaminants

Known environmental contaminant sites are displayed in Table 13 and illustrated in Figure 4. The majority of the elements of concern identified are located within the Pond Creek basin.

Table 13. Environmental Contaminants within the Study Area

Study Area	Basin/Study Area			Conceptual Reservoir Area		
	Hazardous Materials	Petroleum Tanks	Solid Waste Facilities	Hazardous Materials	Petroleum Tanks	Solid Waste Facilities
W. Dog	0	4	0	0	0	0
Bear Creek	0	0	0	0	0	0
Pond Creek	1	24	2	0	0	0
RBF	0	0	1	N/A	N/A	N/A

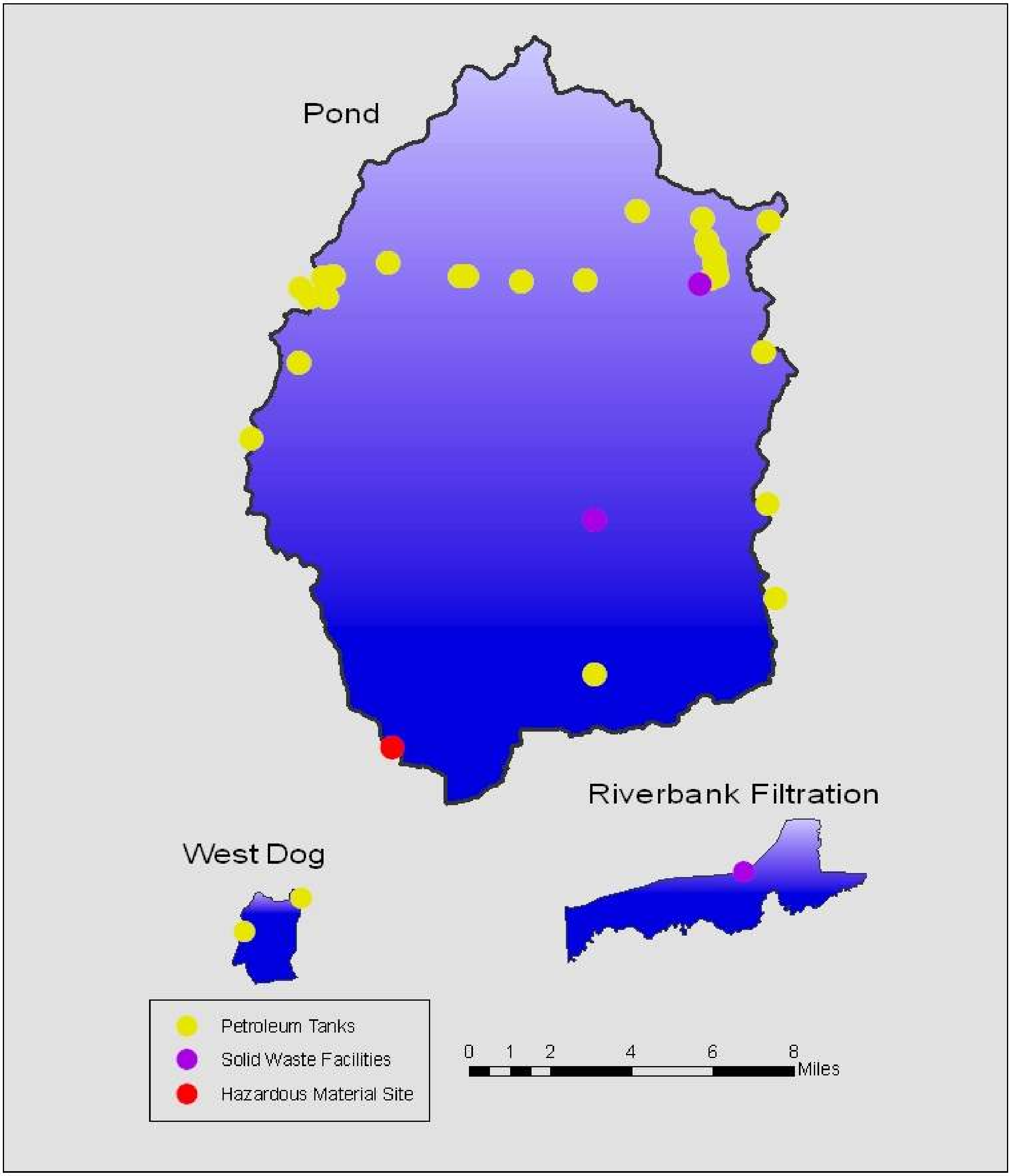

Figure 4. Contaminant Sites – West Dog and Pond Creek Basins and Riverbank Filtration Study Area

Minimum Flows and Levels and Reservations

The District's Minimum Flows and Levels (MFL) priority list and schedule is updated annually. The current schedule, which may be found at http://www.nwfwmd.state.fl.us/rmd/mfl/mfl.htm and in the District's Consolidated Annual Report (NWFWMD 2006b), provides for a minimum flow to be completed for the Yellow River in 2008. Proposed surface and ground water withdrawals are subject to rigorous analysis through the District's consumptive use permitting program (Chapter 40A-2, F.A.C.). Through this process, the District ensures that approved consumptive uses of water are reasonable-beneficial and consistent with the public interest and that they do not interfere with existing legal uses. In place of MFLs, the Governing Board may also establish reservations of water resources for the protection of fish and wildlife resources and the public interest under Chapter 40A-2, F.A.C.

Watershed Resource Protection

Development of a tributary reservoir or other alternative water supply source provides a need and opportunity for enhanced watershed resource protection. In particular, if a tributary reservoir is developed, a number of management approaches should be followed to protect the quality of the water supply and the public investment. Among these are:

- Protect water quality through sub-watershed protection. Strategies may include protecting or restoring wetland and riparian habitats along with protecting or restoring forestland within the contributing drainage basin. These may be accomplished through public land acquisition (fee or less-than-fee), a variety of growth management approaches, and habitat restoration projects.
- Protect water quality in the main stem river used to augment the reservoir. This can be pursued through land acquisition, land use planning, and other watershed management approaches.
- Manage public use of the reservoir in a way that protects the purpose of the resource. For example, activities that would degrade water quality or introduce invasive exotic plants should be avoided.

Along with protecting water quality within the water supply source, such measures would also help to achieve related objectives. For example, protection and restoration of wetland systems can help to provide mitigation for any unavoidable wetland impacts associated with construction of a reservoir or other facilities. The effort may provide an opportunity for an overall environmental benefit and help to achieve interrelated resource objectives, such as those associated with the OFW designation of the Shoal River and the SWIM program for the greater Pensacola Bay System watershed.

REFERENCES

Primary data sources used in this screening analysis are listed in Table 2. Additional sources consulted include the following:

50 CFR Part 17 and 50 CFR Part 226. 2003. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Gulf Sturgeon; Final Rule. Federal Register, March 19, 2003.

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Attachment 1. Sub-Basin Level Land Use and Land Cover

Table 14. Sub-Basin Level Land Use and Land Cover

Watershed	Sub-basin	Agriculture	Disturbed	Reservoir	Urban & Built Up	Vegetated	Total Area (Acres)	Total Area (Sq Mi)	Estimated 7Q10 (CFS)
Yellow	**Baggett Creek**								
	Acres	1224.12	15.03	50.90	237.20	2653.81	4181.07	6.53	3
		29.3%	0.4%	1.2%	5.7%	63.5%	100%		
Yellow	**Baily Branch**								
	Acres	430.08	0.00	59.45	12.57	338.66	840.76	1.31	1
		51.2%	0.0%	7.1%	1.5%	40.3%	100%		
Shoal	**Battle Creek**								
	Acres	125.21	0.00	17.91	138.34	1682.60	1964.07	3.07	1
		6.4%	0.0%	0.9%	7.0%	85.7%	100%		
Yellow	**Bear Branch**								
	Acres	62.16	0.00	49.60	37.82	1483.75	1633.34	2.55	1
		3.8%	0.0%	3.0%	2.3%	90.8%	100%		
Shoal	**Bear Creek**								
	Acres	139.49	8.93	21.23	166.80	2580.99	2917.44	4.56	2
		4.8%	0.3%	0.7%	5.7%	88.5%	100%		
Shoal	**Bee Branch**								
	Acres	665.92	0.00	19.94	20.30	818.85	1525.02	2.38	1
		43.7%	0.0%	1.3%	1.3%	53.7%	100%		
Shoal	**Beech Tree Creek**								
	Acres	0.00	9.89	1.16	0.00	1690.58	1701.63	2.66	1
		0.0%	0.6%	0.1%	0.0%	99.4%	100%		
Shoal	**Bends Creek**								
	Acres	671.38	16.25	53.12	924.98	2351.10	4016.82	6.28	3
		16.7%	0.4%	1.3%	23.0%	58.5%	100%		

Watershed	Sub-basin	Agriculture	Disturbed	Reservoir	Urban & Built Up	Vegetated	Total Area (Acres)	Total Area (Sq Mi)	Estimated 7Q10 (CFS)
Yellow	**Big Creek**								
	Acres	908.84	7.08	32.57	85.48	5277.35	6311.32	9.86	5
		14.4%	0.1%	0.5%	1.4%	83.6%	100%		
Titi	**Big Fork**								
	Acres	2245.43	7.62	46.21	217.24	3539.58	6056.09	9.46	5
		37.1%	0.1%	0.8%	3.6%	58.4%	100%		
Yellow	**Big Horse Creek**								
	Acres	1747.54	9.06	72.33	6592.93	231.47	8653.32	13.52	6
		20.2%	0.1%	0.8%	2.1%	76.8%	100%		
Shoal	**Bottle Branch**								
	Acres	63.82	166.03	23.95	256.40	3858.27	4368.47	6.83	3
		1.5%	3.8%	0.5%	5.9%	88.3%	100%		
Yellow	**Buckhannon Branch**								
	Acres	222.37	0.00	2.89	33.64	1247.19	1506.10	2.35	1
		14.8%	0.0%	0.2%	2.2%	82.8%	100%		
Yellow	**Burnt Grocery Creek**								
	Acres	58.19	6.01	157.47	5054.64	5741.30	11017.61	17.22	8
		1.1%	0.1%	0.2%	7.2%	91.4%	100%		
Yellow	**Cambells Mill Creek**								
	Acres	473.43	0.00	18.21	79.01	2134.35	2705.00	4.23	2
		17.5%	0.0%	0.7%	2.9%	78.9%	100%		
Shoal	**Carney Creek**								
	Acres	3538.69	5.69	34.99	59.04	5044.91	8683.33	13.57	6
		40.8%	0.1%	0.4%	0.7%	58.1%	100%		
Shoal	**Clear Creek**								
	Acres	1.26	3.38	14.36	58.21	800.38	877.59	1.37	1

Watershed	Sub-basin	Agriculture	Disturbed	Reservoir	Urban & Built Up	Vegetated	Total Area (Acres)	Total Area (Sq Mi)	Estimated 7Q10 (CFS)
		0.1%	0.4%	1.6%	6.6%	91.2%	100%		
Yellow	**Canoe Creek**								
	Acres	146.59	12.20	7.25	124.28	741.88	1032.20	1.61	1
		14.2%	1.2%	0.7%	12.0%	71.9%	100%		
Yellow	**Cotton Creek**								
	Acres	957.91	1.21	8.26	71.49	1478.98	2517.86	3.93	2
		38.0%	0.0%	0.3%	2.8%	58.7%	100%		
Shoal	**Cypress Pond Branch**								
	Acres	58.27	0.52	0.00	4.47	1437.22	1500.49	2.34	1
		3.9%	0.0%	0.0%	0.3%	95.8%	100%		
Yellow	**Davis Mill Creek**								
	Acres	462.39	43.86	31.17	313.95	1125.25	1976.61	3.09	1
		23.4%	2.2%	1.6%	15.9%	56.9%	100%		
Yellow	**Dead River**								
	Acres	1170.70	109.06	39.70	839.52	3970.11	6129.09	9.58	5
		19.1%	1.8%	0.6%	13.7%	64.8%	100%		
Yellow	**Deadfall Creek**								
	Acres	572.91	15.19	76.93	123.82	5623.59	6412.44	10.02	5
		8.9%	0.2%	1.2%	1.9%	87.7%	100%		
Yellow	**Gainer Creek**								
	Acres	0.00	0.00	0.00	44.68	1765.04	1809.72	2.83	1
		0.0%	0.0%	0.0%	2.5%	97.5%	100%		
Shoal	**Green Branch**								
	Acres	529.62	0.00	13.56	138.00	1241.02	1922.20	3.00	1
		27.6%	0.0%	0.7%	7.2%	64.6%	100%		
Yellow	**Gully Branch**								
	Acres	5.82	0.00	3.82	178.70	647.18	835.52	1.31	1
		0.7%	0.0%	0.5%	21.4%	77.5%	100%		

Watershed	Sub-basin	Agriculture	Disturbed	Reservoir	Urban & Built Up	Vegetated	Total Area (Acres)	Total Area (Sq Mi)	Estimated 7Q10 (CFS)
Titi	**Gum Creek 1**								
	Acres	56.71	27.16	8.13	132.14	1737.15	1961.29	3.06	1
		2.9%	1.4%	0.4%	6.7%	88.6%	100%		
Yellow	**Gum Creek 2**								
	Acres	1444.51	0.00	16.92	105.80	2594.69	4161.93	6.50	3
		34.7%	0.0%	0.4%	2.5%	62.3%	100%		
Shoal	**Gum Creek 3**								
	Acres	4602.16	33.75	161.23	548.01	12097.05	17442.21	27.25	13
		26.4%	0.2%	0.9%	3.1%	69.4%	100%		
Shoal	**Holly Lake Outlet**								
	Acres	80.53	13.89	666.01	638.18	1092.21	2490.82	3.89	2
		3.2%	0.6%	26.7%	25.6%	43.8%	100%		
Titi	**Honey Creek**								
	Acres	0.00	25.03	0.00	0.00	87.07	112.09	0.18	0
		0.0%	22.3%	0.0%	0.0%	77.7%	100%		
Shoal	**Horsehead Creek**								
	Acres	2500.37	13.68	94.33	81.38	7281.36	9971.11	15.58	7
		25.1%	0.1%	0.9%	0.8%	73.0%	100%		
Yellow	**Julian Mill Creek**								
	Acres	106.37	17.68	0.00	129.92	1956.95	2210.93	3.45	2
		4.8%	0.8%	0.0%	5.9%	88.5%	100%		
Shoal	**Juniper Creek 1**								
	Acres	31.09	57.64	9.82	745.96	1959.90	2804.41	4.38	2
		1.1%	2.1%	0.4%	26.6%	69.9%	100%		
Shoal	**Juniper Creek 2**								

Watershed	Sub-basin	Agriculture	Disturbed	Reservoir	Urban & Built Up	Vegetated	Total Area (Acres)	Total Area (Sq Mi)	Estimated 7Q10 (CFS)
	Acres	719.17	0.00	20.89	95.86	1513.21	2349.13	3.67	2
		30.6%	0.0%	0.9%	4.1%	64.4%	100%		
Shoal	**Juniper Creek 3**								
	Acres	249.62	92.24	32.55	55.15	7397.88	7827.44	12.23	6
		3.2%	1.2%	0.4%	0.7%	94.5%	100%		
Shoal	**King Branch**								
	Acres	14.55	39.03	12.57	429.77	872.40	1368.31	2.14	1
		1.1%	2.9%	0.9%	31.4%	63.8%	100%		
Shoal	**Kirkland Branch**								
	Acres	1.42	6.48	13.21	0.00	2100.32	2121.42	3.31	2
		0.1%	0.3%	0.6%	0.0%	99.0%	100%		
Shoal	**Laird Mill Creek**								
	Acres	63.47	8.74	5.31	86.38	1918.02	2081.93	3.25	2
		3.0%	0.4%	0.3%	4.1%	92.1%	100%		
Shoal	**Lake Jackson Drain**								
	Acres	1681.99	4.98	314.03	402.54	2264.71	4668.24	7.29	3
		36.0%	0.1%	6.7%	8.6%	48.5%	100%		
Shoal	**Little Creek**								
	Acres	1468.24	0.00	69.02	153.17	3439.17	5129.60	8.02	4
		28.6%	0.0%	1.3%	3.0%	67.0%	100%		
Yellow	**Little Horse Creek**								
	Acres	168.32	0.00	5.88	4.90	1423.49	1602.59	2.50	1
		10.5%	0.0%	0.4%	0.3%	88.8%	100%		
Titi	**Long Creek 1**								
	Acres	1582.33	0.00	12.57	61.81	697.71	2354.41	3.68	2
		67.2%	0.0%	0.5%	2.6%	29.6%	100%		

Watershed	Sub-basin	Agriculture	Disturbed	Reservoir	Urban & Built Up	Vegetated	Total Area (Acres)	Total Area (Sq Mi)	Estimated 7Q10 (CFS)
Shoal	**Long Creek 2**								
	Acres	2155.07	21.18	103.78	230.45	13411.89	15922.37	24.88	12
		13.5%	0.1%	0.7%	1.4%	84.2%	100%		
Shoal	**Mack Branch**								
	Acres	148.21	0.00	35.40	14.27	640.62	838.50	1.31	1
		17.7%	0.0%	4.2%	1.7%	76.4%	100%		
Shoal	**Mare Creek**								
	Acres	9.61	7.48	26.24	69.67	1938.25	2051.25	3.21	2
		0.5%	0.4%	1.3%	3.4%	94.5%	100%		
Yellow	**Mathison Creek**								
	Acres	384.31	0.60	120.35	1427.58	1903.20	3836.04	5.99	3
		10.0%	0.0%	3.1%	37.2%	49.6%	100%		
Yellow	**Mill Creek 1**								
	Acres	556.12	8.69	17.29	378.05	2191.67	3151.82	4.92	2
		17.6%	0.3%	0.5%	12.0%	69.5%	100%		
Yellow	**Mill Creek 2**								
	Acres	283.12	0.00	14.86	35.92	1793.55	2127.45	3.32	2
		13.3%	0.0%	0.7%	1.7%	84.3%	100%		
Shoal	**Mossy Head Branch**								
	Acres	9.17	9.97	107.93	267.93	2267.07	2662.07	4.16	2
		0.3%	0.4%	4.1%	10.1%	85.2%	100%		
Yellow	**Murder Creek**								
	Acres	1881.73	21.43	136.93	273.05	8024.46	10337.60	16.15	8
		18.2%	0.2%	1.3%	2.6%	77.6%	100%		
Shoal	**Narrows Creek**								
	Acres	777.32	27.13	97.28	801.11	4900.13	6602.98	10.32	5
		11.8%	0.4%	1.5%	12.1%	74.2%	100%		
Shoal	**Pine Log Creek**								

Watershed	Sub-basin	Agriculture	Disturbed	Reservoir	Urban & Built Up	Vegetated	Total Area (Acres)	Total Area (Sq Mi)	Estimated 7Q10 (CFS)
	Acres	2241.47	3.17	106.51	89.32	13055.96	15496.43	24.21	12
		14.5%	0.0%	0.7%	0.6%	84.3%	100%		
Shoal	**Piney Woods Creek**								
	Acres	320.30	16.55	93.51	989.10	1599.37	3018.82	4.72	2
		10.6%	0.5%	3.1%	32.8%	53.0%	100%		
Yellow	**Polley Creek**								
	Acres	125.82	0.00	8.84	52.62	3178.51	3365.79	5.26	3
		3.7%	0.0%	0.3%	1.6%	94.4%	100%		
Shoal	**Pond Creek**								
	Acres	5731.17	8.33	187.45	434.83	14236.65	20598.44	32.19	15
		27.8%	0.0%	0.9%	2.1%	69.1%	100%		
Shoal	**Poverty Creek**								
	Acres	775.98	2.48	124.87	448.37	6323.58	7675.29	11.99	6
		10.1%	0.0%	1.6%	5.8%	82.4%	100%		
Yellow	**Reservoir Outlet**								
	Acres	169.95	62.46	38.47	54.11	960.46	1285.46	2.01	1
		13.2%	4.9%	3.0%	4.2%	74.7%	100%		
Shoal	**Rum Still Branch**								
	Acres	613.68	0.00	24.84	68.47	1134.44	1841.43	2.88	1
		33.3%	0.0%	1.3%	3.7%	61.6%	100%		
Shoal	**Shoal River**								
	Acres	6370.88	305.75	851.54	4998.82	37607.35	50134.34	78.33	37
		12.7%	0.6%	1.7%	10.0%	75.0%	100%		
Titi	**Silver Creek 1**								
	Acres	0.00	22.64	1.98	25.76	105.53	155.91	0.24	0
		0.0%	14.5%	1.3%	16.5%	67.7%	100%		
Yellow	**Silver Creek 2**								

Watershed	Sub-basin	Agriculture	Disturbed	Reservoir	Urban & Built Up	Vegetated	Total Area (Acres)	Total Area (Sq Mi)	Estimated 7Q10 (CFS)
	Acres	737.27	27.79	54.00	562.00	3623.02	5004.08	7.82	4
		14.7%	0.6%	1.1%	11.2%	72.4%	100%		
Shoal	**Spring Branch**								
	Acres	570.98	0.00	5.37	41.56	301.53	919.44	1.44	1
		62.1%	0.0%	0.6%	4.5%	32.8%	100%		
Titi	**Titi Creek**								
	Acres	1582.19	39.80	86.41	143.47	1679.52	3531.39	5.52	3
		44.8%	1.1%	2.4%	4.1%	47.6%	100%		
Yellow	**Trawick Creek**								
	Acres	225.31	32.23	12.62	290.90	2833.63	3394.68	5.30	3
		6.6%	0.9%	0.4%	8.6%	83.5%	100%		
Shoal	**Turkey Creek**								
	Acres	2604.79	28.61	140.18	167.28	7729.83	10670.69	16.67	8
		24.4%	0.3%	1.3%	1.6%	72.4%	100%		
Shoal	**Unnamed Branch**								
	Acres	1027.38	0.00	28.50	15.86	699.15	1770.88	2.77	1
		58.0%	0.0%	1.6%	0.9%	39.5%	100%		
Yellow	**Unnamed Creek**								
	Acres	67.05	2.16	1.76	0.02	1511.81	1582.80	2.47	1
		4.2%	0.1%	0.1%	0.0%	95.5%	100%		
Shoal	**Unnamed Outlet**								
	Acres	547.62	0.00	64.03	13.58	816.32	1441.55	2.25	1
		38.0%	0.0%	4.4%	0.9%	56.6%	100%		
Shoal	**Unnamed Stream**								
	Acres	375.22	0.00	1.73	4.76	393.61	775.32	1.21	1
		48.4%	0.0%	0.2%	0.6%	50.8%	100%		

Watershed	Sub-basin	Agriculture	Disturbed	Reservoir	Urban & Built Up	Vegetated	Total Area (Acres)	Total Area (Sq Mi)	Estimated 7Q10 (CFS)
Shoal	**Ward Mill**								
	Acres	21.18	0.00	95.24	121.88	1550.69	1788.99	2.80	1
		1.2%	0.0%	5.3%	6.8%	86.7%	100%		
Shoal	**Watson Bay Branch**								
	Acres	1021.44	0.00	33.42	98.55	1694.34	2847.76	4.45	2
		35.9%	0.0%	1.2%	3.5%	59.5%	100%		
Yellow	**Wilkenson Creek**								
	Acres	91.31	10.79	21.45	239.04	1972.78	2335.38	3.65	2
		3.9%	0.5%	0.9%	10.2%	84.5%	100%		
Shoal	**Williams Branch**								
	Acres	235.38	64.91	3.11	180.96	993.06	1477.42	2.31	1
		15.9%	4.4%	0.2%	12.2%	67.2%	100%		
Yellow	**Upper Yellow River**								
	Acres	4352.05	248.57	1441.61	2937.09	51464.18	60443.50	94.44	45
		7.2%	0.4%	2.4%	4.9%	85.1%	100%		

Attachment B

Water Quality Analysis and Surface Water Quality Treatment Requirements

DRAFT TECHNICAL MEMORANDUM

To: **Ron Bartel (NWFWMD)**

From: **Scott Trainer, P.E.* (PBS&J)**
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C: **William C. Lynn (PBS&J)**
Robert A. Morrell, P.E. (PBS&J)
Augusto Villalon, P.E. (PBS&J)

Date: **June 6, 2006**

Subject: **Surface Water Supply Facilities Planning and Feasibility Analyses**
Water Quality Analysis and Surface Water Treatment Requirements

INTRODUCTION

The scope of this study is for PBS&J to provide a planning level analysis of surface water and to provide conceptual level cost estimates to the Northwest Florida Water Management District for meeting water demands beyond 2020 for communities in Okaloosa County. Water supply is from four separate alternative withdrawal locations from the Shoal River and one alternative location from in-bank wells along the Yellow River, all of which are located in Okaloosa County, Florida.

The water supply for each alternative withdrawal location is limited to 25 million gallons per day (MGD) average flow, with no intended peaking rates. This study is limited to the water treatment plant and an on-site ground storage tank and does not include any intake and conveyance facilities, nor any pumping facilities into or from the water treatment plant. This study also provided an analysis of water quality data, comparing it with the EPA's primary and secondary drinking water standards for public water systems, the results of which were used to determine the appropriate water treatment process.

PURPOSE OF WATER QUALITY ANALYSIS

Treatment processes are selected based on characteristics of the raw water to be treated and the level of treatment required. Specific water quality constituents, among many to consider when choosing an appropriate treatment process include total dissolved solids (TDS), turbidity, color, and pesticides. TDS present in water consists mainly of dissolved inorganic salts, and gases. High levels of TDS can be a sign of increased hardness of water, which could indicate the need for a water softening process as part of the water treatment train. Increased levels of TDS and chlorides can also indicate brackishness (saltiness) of water, meaning that an expensive desalination treatment process such as reverse osmosis may need to be considered. Turbidity measures the cloudiness of water and in high levels can be an indicator of the presence of harmful microorganisms such as viruses and parasites, which can interfere with disinfection of the water and can indicate the presence of Total Organic Carbons (TOCs), which would affect the type of disinfection process and is also an indicator of disinfection by-products. High levels of total and fecal coliform counts can also be an indication of the potential presence of a variety of pathogenic microorganisms, as well as high levels of TOCs. Highly turbid waters can also present the need for chemical coagulation to be a part of the treatment train to bind and settle out the suspended material causing turbidity. The color of water is measured in order to give an indication of the level of treatment required to remove the color from the water. Colored waters exist where the water is in contact with organic matter in various stages of decomposition and the by-products of decomposition, such as tannins, humic acid, and humates, are readily present to infuse the water with color. Chemical coagulation is generally incorporated into the treatment process to reduce high levels of color. Pesticides are of concern due to the associated health hazards. The presence of high levels of pesticides in raw water could potentially cause the need for specialized treatment techniques to reduce the levels to regulatory limits.

Based on the proposed water sources—four alternative surface water intake sites from the Shoal River and one alternate in-bank filtration site from wells along the Yellow River, surface water quality data from the Shoal and Yellow Rivers was evaluated to propose an appropriate treatment process for the distribution and consumption of these waters. There was insufficient test wells to properly evaluate the in-bank filtration supply alternative from the Yellow River. However, we did evaluate four small homeowner wells within the Yellow River and Shoal River basins to assist with our evaluation of the in-bank well analysis and the effects of the direct influence of surface water upon the well data. It should be noted that surface water quality of the Yellow River was evaluated to recommend a treatment process for the in-bank filtered groundwater due to limited data on water quality from any full production in-bank test wells under direct influence of surface water along the anticipated Yellow River well field. Further investigation of the water quality characteristics of the groundwater in the proposed area and the effect of in-bank filtration on the groundwater is required before a final treatment process can be developed for these waters. General characteristics of ground water as compared to surface water, as well as the possible influences of in-bank filtration on the groundwater, are discussed further with the presentation of the water quality data for the Yellow River below.

WATER QUALITY DATA SOURCES

Water quality data for the Shoal and Yellow Rivers was provided to PBS&J from four sources; the Pensacola Bay System Tributary Sampling Program conducted by the NWFWMD, a summary of NWFWMD historical records, and historical records from the EPA STORET database and four small homeowner wells along the Shoal and Yellow Rivers within the Sand and Gravel Aquifer.

The objective of the tributary sampling program was to assess the effects of storm events on the water quality of the rivers, so water quality data was provided for dry and wet weather conditions. Judging by the sampling dates of the water quality data provided, the study was conducted from August 1999 to February 2003. Of the six sampling sites evaluated in the tributary sampling program, one was located on the Shoal River and two were located on the Yellow River. The summary of NWFWMD historical water quality records included data for one site on the Shoal River and one site on the Yellow River. The minimum, maximum, and mean values of water quality constituents were provided over a two year period (1992–1994) for the Shoal River and over a seven year (1992-1999) period for the Yellow River. Data representing water quality characteristics from 1966 through 1997 for only one site along the Yellow River was available from the EPA STORET database. Preliminary investigation indicated that current development along the Shoal River watershed has not changed appreciably, and therefore, the dated values provided should still be reasonable parameters to be used at this study level.

The four individual homeowner sampling wells considered include The Dude's Fish Camp (ID No. AAE0549), N. Locke (ID No. AAF8009), E. Roberson (ID No. AAF8010), and F. Steele (ID No. AAE0552) wells. Each of these wells are located in the unconfined section of the Sand and Gravel Aquifer. Because these wells are very low production wells, it is questionable and inconclusive to determine if they are under the direct influence of surface water (UDI). Without creating a sustained draw-down gradient, true water quality data that specifically addresses UDI cannot be assumed from these wells.

SHOAL RIVER SURFACE WATER QUALITY EVALUATION

The water quality data provided for the Shoal River were from sampling sites located at the crossings of US 90 and State Road 85 (SR 85). The site sampled for the tributary sampling program was located at the US 90 intersection along the river and the NWFWMD historical water quality data was gathered at the SR 85 site. The straight line distance between the two sites is approximately 6.5 miles with the US 90 site located northeast of the SR 85 site. The US 90 site was sampled under dry weather conditions in April 2001 and during three storm events occurring in November 2000, March 2001, and February 2003, and water quality data gathered from the SR 85 site was collected from 1992 to 1994.

Table 1 presents the data evaluated in this study for the Shoal River. Several samples were analyzed for the storm events at the US 90 site, thus a range of the values is presented for the wet weather events in Table 1. Also presented in Table 1, for comparison, are the National Secondary Drinking Water Regulations (NSDWRs). These regulations are non-enforceable, but provide a guideline for constituents that may decrease the aesthetic quality (taste, odor, color) of drinking water. The National Primary Drinking Water Regulations (NPDWRs) were also considered in this study, but the constituents generally regulated by the NPDWRs are organics such as toluene, benzene, and vinyl chloride, which were not included in the water quality data provided. The exception to this was total and fecal coliforms, which were evaluated in the water quality analysis and are included in the NPDWRs.

The water quality data presented in Table 1 shows that the Shoal River only exceeds the guidelines set by the NSDWRs for pH and color. During the March 2001 and February 2003 storm events at the US 90 site,

Table 1
Shoal River Water Quality Data

Constituents (units)	Shoal River at US90 *Water Quality Data from Tributary Monitoring Study*				Shoal River at SR85 *Historical Data from the NWFWD*		National Secondary Drinking Water Regulations (NSDWRs)
	Dry Weather (April 2001)	Wet Weather (November 2000)	Wet Weather (March 2001)	Wet Weather (February 2003)	Highest	Mean	
Alkalinity (mg/L)	4.4	3 - 6	0.7 - 2.4	2.4 - 4.1	N/A	N/A	N/A
Ammonia (mg-N/L)	0.016	0.01	0.01 - 0.013	0.01	0.02	0.019	N/A
Nitrate+nitrite (mg-N/L)	0.25	0.088 - 0.13	0.041 - 0.13	0.17 - 0.28	N/A	N/A	N/A
Total Kjeldahl Nitrogen (mg/L)	0.27	0.29 - 0.5	0.38 - 0.71	0.33 - 0.2	0.38	0.22	N/A
Total Phosphorus (mg-P/L)	0.022	0.023 - 0.42	0.018 - 0.086	0.015 - 0.036	0.03	0.021	N/A
Ortho-phosphate (mg-P/L)	0.008	0.004	0.004 - 0.016	0.004	N/A	N/A	N/A
Total Dissolved Solids (mg/L)	53	36 - 39	30 - 59	24 - 32	N/A	N/A	500 mg/L
Total Suspended Solids (mg/L)	5	5 - 22	10 - 69	5 - 22	N/A	N/A	N/A
Turbidity (NTU)	3.4	3.3 - 16	11 - 99	4.4 - 15	9.6	6	N/A
Chloride (mg/L)	N/A	N/A	N/A	N/A	3.6	2.75	250 mg/L
Magnesium (mg/L)	N/A	N/A	N/A	N/A	0.7	0.68	N/A
Calcium (mg/L)	N/A	N/A	N/A	N/A	1.5	1.28	N/A
Total Organic Carbon (mg/L)	N/A	N/A	N/A	N/A	11	5.1	N/A
Metals							
Cadmium (ug/L)	0.025	0.5	0.5	0.5	N/A	N/A	N/A
Chromium (ug/L)	0.7	0.7 - 0.9	0.91 - 3.7	2	N/A	N/A	N/A
Copper (ug/L)	1.5	4.5 - 6.4	2 - 9.1	6.8 - 11	N/A	N/A	1.0 mg/L
Lead (ug/L)	0.37	3	3 - 3.5	5	N/A	N/A	N/A
Nickel (ug/L)	2	2	2	2	N/A	N/A	N/A
Zinc (ug/L)	24	3.6 - 2	3.3 - 6.5	4 - 6.3	N/A	N/A	5.0 mg/L
Physical parameters							
Dissolved Oxygen (mg/L)	4.6	9 - 7.1	6.5 - 8.76	9.49 - 10.38	N/A	N/A	N/A
pH	7.5	6.4 - 6.8	4.81 - 6.84	4.8 - 9.38	6.74	6.19	6.5 - 8.5
Sp. Conductance (umho/cm)	30	30.2 - 35.3	20.5 - 26.6	27 - 30	N/A	N/A	N/A
Temperature (^{o}C)	24.5	15.9 - 23	13.79 - 16.87	13.09 - 15.9	N/A	N/A	N/A
Color (PCU)	N/A	N/A	N/A	N/A	120	58.57	15 PCU
Biological Parameters							
Fecal coliforms (#/100mL)	40	0 - 115	84 - 900	N/A	N/A	N/A	N/A
Total coliforms (#/100mL)	240	0- 570	230 - 2700	N/A	N/A	N/A	N/A

Notes:

Units expressed as mg-N/L represent the mass of the consituent as nitrogen per liter of water.

Units expressed as mg-P/L represent the mass of the consituent as phosphorus per liter of water.

the pH fell below 6.5, and for the February 2003 event the pH rose above 8.5. These variances in pH were most likely due to runoff during the rainfall events. The historical data at the SR 85 site shows a mean pH of 6.19, which is only slightly lower than the NSDWR guideline. pH control is relatively inexpensive and can easily be maintained with a carbon dioxide package system. Color data was not provided for the US 90 site, but the historical data at the SR 85 site indicates that the mean value for color was almost quadruple the limit set in the NSDWR guidelines and the highest color value was almost ten times the NSDWR limit. Of the other common constituents of concern discussed in the introduction, TDS levels are well below 500 mg/L, and turbidity levels are below 100 NTUs for the Shoal River, which indicates that additional processes beyond conventional treatment will not likely be necessary to treat these constituents. Water quality data for pesticides was not provided for the Shoal River and thus could not be quantified for this study.

The NPDWRs standards do not allow the presence of total and fecal coliforms in water, thus, based on the data provided in Table 1, the regulations are violated by the raw water of the Shoal River. Chemical disinfection and conventional treatment processes suggested for treatment of the Shoal River, are sufficient means of completely removing these total and fecal coliforms.

YELLOW RIVER SURFACE WATER QUALITY DATA EVALUATION

Water quality data from three sites along the Yellow River and the individual wells within the Sand and Gravel Aquifer was evaluated for this study. Data from the tributary sampling program was provided for two sites, one at the crossing of State Road 2 (SR 2) and another near Milligan. Straight line distance between these sites is approximately 11.5 miles with the SR 2 site located northeast of the Milligan site. The study analyzed both dry and wet weather water quality characteristics at these sites. For dry weather water quality analysis monthly samples were obtained for one year from the SR 2 site for a total of twelve samples (August 1999-July 2000), and only one sample was obtained from the site near Milligan in April 2001. The Yellow River sites were also sampled during three separate storms occurring at the end of March 2000, mid June 2001, and the beginning of August 2001. The historical water quality data provided by the NWFWMD was collected at the crossing of State Road 87 (SR 87), which is located southwest of the Milligan site. The data from the SR 87 site includes water quality information gathered between 1992 and 1999. Historical data recorded between the years 1966 through 1997 provided in the EPA STORET database was collected from a site at the crossing of SR 2, which is the same location as the SR 2 site evaluated in the tributary sampling program. It should be noted that the Yellow River water quality data evaluated for this study is dated; however, preliminary evaluations indicate that current development along the watershed of the Yellow River has not appreciably changed, and therefore, the dated study values should be reasonable parameters to be used at this study level.

Due to similarity in site location, the tributary sampling data for the SR 2 site and EPA STORET historical data are presented together in Table 2, and the tributary sampling data for the site near Milligan and the NWFWMD historical data from the SR 87 site are presented together in Table 3.

Table 2
Water Quality Data from the Yellow River SR 2
Sampling Program Site and the EPA STORET Data

	Yellow River at SR2 *Water Quality Data from Tributary Monitoring Study*				Yellow River at SR2 *Historical Data (1966-1997) from EPA STORET Database*			National Secondary Drinking Water Regulations (NSDWRs)
Constituents (units)	**Dry Weather (August 1999 - July 2000)**	**Wet Weather (March 2000)**	**Wet Weather (June 2001)**	**Wet Weather (August 2001)**	**Min Value**	**Mean Value**	**Max Value**	
Alkalinity (mg/L)	38.25	0 - 19	7.3 - 29	9.8 - 25	10	21	45	N/A
Ammonia (mg-N/L)	0.02	0.015 - 0.022	0.14 - 0.045	0.01 - 0.022	<0.1	<0.1	0.27	N/A
Nitrate+nitrite (mg-N/L)	0.11	0.063 - 0.11	0.016 - 0.08	0.038 - 0.082	<0.02	0.14	0.29	N/A
Total Kjeldahl Nitrogen (mg/L)	0.24	0.32 - 0.61	0.39 - 0.7	0.48 - 0.67	N/A	N/A	N/A	N/A
Total Phosphorus (mg-P/L)	0.02	0.039 - 0.067	0.015 - 0.074	0.037 - 0.1	N/A	N/A	N/A	N/A
Ortho-phosphate (mg-P/L)	0.00	0.004 - 0.008	0.004 - 0.014	0.009 - 0.023	N/A	N/A	N/A	N/A
Total Dissolved Solids (mg/L)	54.42	48 - 71	41 - 69	35 - 200	<10	52	67	500 mg/L
Total Suspended Solids (mg/L)	7.75	4 - 28	4 - 38	9 - 56	N/A	N/A	N/A	N/A
Turbidity (NTU)	3.97	0 - 14	6.3 - 24	9.3 - 37	<0.5	10	60	N/A
Chloride (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	250 mg/L
Magnesium (mg/L)	N/A	N/A	N/A	N/A	0.4	1.35	2.2	N/A
Calcium (mg/L)	N/A	N/A	N/A	N/A	1.7	6.4	12	N/A
Total Organic Carbon (mg/L)	N/A	N/A	N/A	N/A	<1	4.2	10	N/A
Metals								
Cadmium (ug/L)	N/A	0.4	0.5	0.75	N/A	N/A	N/A	N/A
Chromium (ug/L)	N/A	0.9 - 1.5	0.7 - 2.9	0.75 - 2	N/A	N/A	N/A	N/A
Copper (ug/L)	N/A	2 - 6.1	1.5 - 12.6	3.4 - 7.5	N/A	N/A	N/A	1.0 mg/L
Lead (ug/L)	N/A	2 - 2.3	3	5	N/A	N/A	N/A	N/A
Nickel (ug/L)	N/A	1.3 - 1.6	2	1.5	N/A	N/A	N/A	N/A
Zinc (ug/L)	N/A	1.5 - 10	4 - 6.6	4 - 6.2	N/A	N/A	N/A	5.0 mg/L
Physical parameters								
Dissolved Oxygen (mg/L)	8.56	7.7 - 7.8	5.1 - 6.8	4.4 - 5.9	6.4	7.45	11.1	N/A
pH	7.51	7.3 - 7.44	6.7 - 7.6	7.3 - 8.04	4.95	6.56	7.4	6.5 - 8.5
Sp. Conductance (umho/cm)	86.83	45 - 48	39.1 - 70.4	36.1 - 59.7	23	62.5	145	N/A
Temperature (^{o}C)	20.25	17.9 - 18.6	24.1 - 29	25.2 - 29.1	5.5	19.25	27.7	N/A
Color (PCU)	N/A	N/A	N/A	N/A	10	52.5	160	15 PCU
Biological Parameters								
Fecal coliforms (#/100mL)	93.2	350	560 - 1300	3700	N/A	N/A	N/A	N/A
Total coliforms (#/100mL)	685.8	1700	8000 - 13000	2500	N/A	N/A	N/A	N/A

Notes:

Units expressed as mg-N/L represent the mass of the consituent as nitrogen per liter of water.

Units expressed as mg-P/L represent the mass of the consituent as phosphorus per liter of water.

Table 3
Water Quality Data from the Yellow River Milligan and SR 87 Sites

Constituents (units)	Yellow River at Milligan *Water Quality Data from Tributary Monitoring Study*				Yellow River at SR87 *Historical Data (1992-1999) from the NWFWD*		National Secondary Drinking Water Regulations (NSDWRs)
	Dry Weather (April 2001)	**Wet Weather (March 2000)**	**Wet Weather (June 2001)**	**Wet Weather (August 2001)**	**Highest**	**Mean**	
Alkalinity (mg/L)	27	0 - 14	6.1 - 26	8.3 - 25	N/A	N/A	N/A
Ammonia (mg-N/L)	0.028	0.011 - 0.035	0.01 - 0.042	0.013 - 0.02	0.02	0.017	N/A
Nitrate+nitrite (mg-N/L)	0.13	0.067 - 0.14	0.009 - 0.071	0.036 - 0.094	N/A	N/A	N/A
Total Kjeldahl Nitrogen (mg/L)	0.28	0.31 - 0.58	0.33 - 0.69	0.31 - 0.65	1.8	0.43	N/A
Total Phosphorus (mg-P/L)	0.033	0.37 - 0.075	0.015 - 0.064	0.037 - 0.063	0.03	0.02	N/A
Ortho-phosphate (mg-P/L)	0.011	0.004 - 0.006	0.005 - 0.012	0.007 - 0.024	N/A	N/A	N/A
Total Dissolved Solids (mg/L)	66	59 - 89	36 - 65	33 - 170	N/A	N/A	500 mg/L
Total Suspended Solids (mg/L)	6	4 - 39	4 - 42	7 - 31	N/A	N/A	N/A
Turbidity (NTU)	5.4	0 - 14	7 - 31	9.6 - 28	10	7.94	N/A
Chloride (mg/L)	N/A	N/A	N/A	N/A	3.4	3.025	250 mg/L
Magnesium (mg/L)	N/A	N/A	N/A	N/A	0.97	0.97	N/A
Calcium (mg/L)	N/A	N/A	N/A	N/A	3.43	2.58	N/A
Total Organic Carbon (mg/L)	N/A	N/A	N/A	N/A	7.7	4.99	N/A
Manganese (mg/L)	N/A	N/A	N/A	N/A	0.04	0.04	0.05
Total Hardness (as $CaCO_3$)	N/A	N/A	N/A	N/A	37	22.4	N/A
Metals							
Cadmium (ug/L)	0.025	0.4	0.5	0.75	N/A	N/A	N/A
Chromium (ug/L)	1.3	0.7 - 1.2	0.7 - 1.7	1.5 - 2	0.025 mg/L	0.025 mg/L	N/A
Copper (ug/L)	3.9	2 - 7.7	6.3 - 18.9	2 - 8.6	0.025 mg/L	0.025 mg/L	1.0 mg/L
Lead (ug/L)	1.34	2 - 2.3	3 - 3.7	5	0.005 mg/L	0.005 mg/L	N/A
Nickel (ug/L)	2	1.3	2	1.5	0.05 mg/L	0.05 mg/L	N/A
Zinc (ug/L)	2.4	1.7 - 10	4 - 6.8	4 - 5.4	0.01 mg/L	0.01 mg/L	5.0 mg/L
Physical parameters							
Dissolved Oxygen (mg/L)	4.8	0 - 7.8	4.4 - 6.7	4.5 - 5.5	N/A	N/A	N/A
pH	7.85	7.7 - 7.8	6.65 - 7.7	7.5 - 8.2	6.62	6.5	6.5 - 8.5
Sp. Conductance (umho/cm)	69.5	0 - 47	64.3 - 34.7	35 - 60.8	N/A	N/A	N/A
Temperature (^oC)	25.3	18.8 - 19.1	24.4 - 30.3	26.1 - 28.8	N/A	N/A	N/A
Color (PCU)	N/A	N/A	N/A	N/A	60	47.5	15 PCU
Biological Parameters							
Fecal coliforms (#/100mL)	12	260	100 - 400	390	280	91.3	N/A
Total coliforms (#/100mL)	220	1500	5200 - 8000	560	400	272.5	N/A

Notes:

Units expressed as mg-N/L represent the mass of the consituent as nitrogen per liter of water.

Units expressed as mg-P/L represent the mass of the consituent as phosphorus per liter of water.

Based on the information presented in Tables 2 and 3, the constituent of concern for the Yellow River is color. The mean values at both the SR 2 and SR 87 sites were both well above the 15 PTU guideline listed in the NSDWSRs. All other constituents are within reasonable limits; TDS levels are below 500 mg/L and turbidity levels are below 100 NTUs. Water quality data for pesticides was not provided for the Yellow River and thus could not be quantified for this study.

Tables 2 and 3 also indicate the presence of total and fecal coliforms in the Yellow River. As stated for the Shoal River, NPDWRs do not allow the presence of total and fecal coliforms, but these constituents can be removed using chemical disinfection and conventional treatment, which are included in the process proposed for the treatment of raw water from the Yellow River.

Taking into consideration the location of the area proposed for in-bank filtration, the data from the Milligan and SR 87 sites better represents the water quality of the Yellow River section that may influence the groundwater proposed for use. Again, it should be noted that using the surface water quality of the Yellow River to approximate water quality conditions of the in-bank filtered groundwater affected by the river could prove to be an inaccurate assumption with further testing of the in-bank filtered groundwater necessary to determine the final treatment method. In general, groundwater contains higher levels of TDS than surface water, thus causing increased hardness and pH, which could have a significant impact on the treatment techniques used for the water. Also, limited knowledge is available on the effects of in-bank filtration on the groundwater in the proposed area. Depending on the characteristics of the groundwater and the bank, the effects could be positive, in the case of solids removal, or negative, in the case of mineral removal from the bank.

The surface water quality of the Yellow River could be treated and brought to drinking water standards using conventional water treatment.

PRIVATE WELL GROUNDWATER QUALITY DATA EVALUATION

Presented in Table 4 is the groundwater data provided for this study from the four private wells located along the Sand and Gravel Aquifer. The quality of the water drawn from the wells had similar pH levels, but lower color, turbidity, and TDS values compared to the surface water quality data of the Yellow and Shoal Rivers. Although the values of color and turbidity are lower for the groundwater, the UDI is not conclusive; thus, it is assumed that a full production well with a continuous draw down gradient will cause an increase in these constituents. With elevated levels of color and turbidity, the treatment train for the groundwater would require a treatment process such as coagulation to remove these constituents before distribution for consumption. The presence of fecal coliforms evaluated in the groundwater samples indicates that disinfection will be required as part of the treatment process proposed for the groundwater.

Due to the limited amount of groundwater data provided, it cannot be determined if these groundwater quality characteristics are representative of the area proposed for the in-bank well field. Furthermore, the influence of the Yellow River on the ground water of the Sand and Gravel Aquifer and the effects of in-bank filtration on groundwater drawn from wells along the Sand and Gravel Aquifer could not be determined due to this limited review of water quality data.

Based on the limited groundwater quality data provided and reviewed, it is assumed for this study that the overall groundwater quality exhibits similar water quality characteristics to the surface water quality; therefore, the in-bank filtered groundwater is assumed to be treated with conventional treatment means.

To properly evaluate groundwater classified by Florida State regulation "under the direct influence of surface water" (UDI), additional testing must be made. The specific alternative locations of possible well fields should be identified. In each alternative well location within the confined aquifer region, a 70% to 100% production well should be established and operated to ensure UDI conditions are reached by establishing proper gradient pressures through draw-down. Constituents should be analyzed to establish proper UDI conditions. EPA has developed a process to determine if groundwater is UDI using microscopic particulate analysis (MPA). MPA identifies organisms that occur in surface water whose presence in groundwater would clearly indicate the mixing of the two. Particular interest would be the presence of insects, macroorganisms, algae, *Giardia Lamblia* or Cryptosporidium, changes in turbidity, temperature, conductivity and pH. Groundwater with UDI has been determined by the EPA to pose significant risk, always requiring additional treatment. Jar tests from the test wells should be made checking all NPDWRs and NSDWRs, and THMs.

WATER TREATMENT FACILITIES

A) Alternatives 1–4, Shoal River Surface Water Facilities

Selection of the water treatment process considered the results of water quality analysis for Shoal River. Consideration was given for those constituents in the raw water data that would require specific process needs beyond conventional treatment, while specifically responding to EPA's current Long-Term 2 Enhanced Surface Water Rule (LT2ESWR), particularly with respect to TOCs.

The results of the water quality analysis show that for the four alternative water treatment facilities located on the Shoal River, only a single sampling point (Shoal River at US 90) and historical data at Shoal River at SR 85 provided the water quality data baseline, and therefore, the treatment process will be identical for the three reservoir sites, alternative sites 1–3 and alternative 4, Shoal River Direct Diversion. The water quality data specifically shows minimal compliance issues during low flow and also storm flows with the greatest treatment challenges being to eliminate color and to balance pH, as well as removal of fecal coliform and total coliform. For alternatives 2 and 3, the reservoir sites are not anticipated to provide reliable annual storage. For Alternative 1, Pond Reservoir, although an annual reservoir will be expected, there is not likely to be any treatment benefits (such as reduced turbidity and color) from the reservoir. Therefore, river water quality was used to determine water treatment methods on raw water quality expectations. Specific attention was also given to salinity (chloride) concentrations which are present in other surface water sources, particularly in eastern Florida. However, the maximum observed chloride concentration is 3.6 milligrams per liter (mg/L) well below the EPA's drinking water standard of 250 mg/L.

Therefore, the anticipated treatment components for all four alternative water treatment sites located on the Shoal River shall be identical to meet a 25 MGD average production (no plant peaking is expected, or costed).

Anticipated treatment components shall include:

- **Primary disinfection** – Chlorination and ammonia addition to produce chloramines for initial biological pathogen kill;
- **Primary Treatment Clarifier** – Rapid mix coagulation, flocculation, use of slaker lime feed, alum for color removal, and turbidity reduction, addition of liquid polymer for clarification aid;
- **Filtration** – Gravity multimedia filters to reduce biological pathogen and turbidity, air scour backwash, and the addition of polymer for polishing aid;
- **Chlorine Contact Basin/Clearwell** – Provide a baffled clearwell to introduce chloramines (chlorine and ammonia) to finished water if necessary for secondary disinfection.
- **Chemical Systems**
  - Lime feed – Dry system for slaker feed
  - pH control – Carbon dioxide package system
  - Chlorine and ammonia (liquid ammonia sulfate) for primary and secondary disinfection.
  - Liquid alum system and/or polymer for coagulate aid and filtration aid for color.
- **Backwash facilities** – Blower system for air scour; backwash storage pond and decant pump station and return piping
- **Sludge handling** – Dewatering thickener, pump station, belt press, and offsite disposal.
- **Process control and instrumentation system –** Including Intelligent Instrumentation and Supervisory Control and Data Acquisition System (SCADA).

Specific state-of-the-art technologies, including reverse osmosis, ozone, peroxide and ultraviolet radiation, were not considered necessary based on the water quality data. Additional analysis for TOC production, brackish water, salinity (chloride), pH excursions and turbidity (TSS) should all be given the greatest consideration in preliminary design to ensure that membrane technology and other treatment alternatives are not necessary.

B) Alternative 5, In-bank filtration

In-bank well facilities that may be used to develop the water supply were considered along the Yellow River, southwest of Crestview, Florida. The scope of this study had insufficient well data to provide quantitative conclusions relevant to reduction in treatment methods, and it was assumed that there was no change in water quality of the Yellow River in the wells. In-bank production wells can be constructed along banks of rivers at relatively shallow depths to help with water quality and to assist with potential water supply and water quality during seasonal reduced river flows. UDI groundwater is created by gradient differential created by the well draw-down. Water quality may be found to be of better quality compared to surface water, but only following a rigorous test well, water quality analysis can quantitative determination be made. UDI groundwater can potentially reduce chemical cost as turbidity and color may be reduced. If turbidity and color can be established for the UDI wells under varying stormwater conditions, it may prove that coagulation and flocculation could be eliminated in light of nano-filtration. Sludge treatment and disposal costs could likely be reduced compared to surface water. Proper jar tests and treatability studies from the test wells will help with the evaluation of final treatment methods.

The four individual wells identified in Table 4 were not considered ground wells at full production as UDI wells, and therefore, are not good representations for treatment type and methods. However, even these wells show turbidity, TSS, pH and alkalinity outside EPA limits. It will become important in preliminary design to obtain specific test well samples from in-bank sites anticipated for the source in order to consider possible treatment effects from the wells. Treatment could be as minimal as disinfectant treatment, and it could also be anticipated that certain minerals and certain soluble constituents could influence water treatment from in-bank. All in all, it would be expected to significantly reduce overall water treatment costs, compared to surface water treatment costs.

In light of insufficient well data, our scope could not quantitatively identify the benefits of the in-bank ground wells on treatment type and costs, and therefore, we considered treatment requirements and cost based on the surface water quality of the Yellow River. Overall, the Yellow River water quality provided from the sampling point of the Yellow River at SR 2, and from the Yellow River at Milligan, was very similar to that found in the Shoal River (see Tables 1, 2, and 3).

Surface Water Treatment Facility Cost Estimates

Alternatives 1–5 all utilized identical conventional surface water treatment plant criteria, since this planning study had no distinctions in water quality data for each withdrawal location and the reservoirs themselves provided no treatment advantage. Therefore, for Alternatives 1–5, treatment plant costs are identical.

During preliminary design, water treatment requirements must be evaluated on a site-by-site basis to determine specific treatment parameters for each possible alternative. Water quality sampling should occur over multiple seasonal conditions to determine specific treatment parameters and treatment requirements. NPDWRs and NSDWRs, THMs and pesticides should be among the test standards to evaluate treatment methods.

Planning level cost estimates for a conventional water treatment plant facility were derived from interpreting St. Johns River Water Management District Special Publication SJ97-SP15 based on the Lake Griffin Basin, which used conventional treatment, and from other studies that PBS&J has conducted, along with construction costs for specific projects. The St. Johns treatment costs included raw water diversion structures (RWI), and Aquifer Storage and Recovery Wells (ASR). Therefore, we have adjusted costs to exclude the RWI and ASR facilities, while applying Engineering News Record Construction Cost Index (CCI) to update costs. The construction cost estimate for a 25 MGD surface water treatment plant using conventional treatment was estimated to be $28,400,000 excluding land, and land acquisition. At 25 MGD, the anticipated land requirements are assumed to be 20 acres, which provides sufficient land for erosion protection water quality facilities and buffer areas. The final clearwell is anticipated to be 5 MG and is included in the treatment costs. The costs also include an administration building with laboratory.

Operation and Maintenance costs (annual) were estimated at 8% of construction costs or $2,272,000 for a 25 MGD facility, which excludes any booster pump costs from the water treatment plant. These costs are based on imperical data sources for Texas treatment plants' O&M and engineering experience of treatment O&M costs.

Attachment C

Riverbank Filtration Analysis

DRAFT TECHNICAL MEMORANDUM

To: Ron Bartel (NWFWMD)

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Date: May 11, 2006

Subject: Surface Water Supply Facilities Planning and Feasibility Analyses
Riverbank Filtration Analysis

Introduction

The objective of this study is to provide the Northwest Florida Water Management District (NWFWMD) with an initial evaluation of the engineering and conceptual planning level cost estimates to determine the feasibility of alternative water supplies in Okaloosa County, Florida. The alternative projects identified in this study are intended to provide water supplies to communities in Okaloosa County to satisfy demands beyond 2020. Alternative water supplies evaluated in this study are limited to surface water and Riverbank filtration facilities at selected sites in Okaloosa County, Florida. For additional information related to this conceptual alternative and ancillary facilities, e.g. pipelines, water treatment, high service pumping stations, wetlands mitigation, associated with Riverbank Filtration supplies, please reference the "Draft **Conceptual Alternative Water Supply Development Projects and Planning Level Cost Estimates"** Technical Memorandum. This Riverbank Filtration Technical Memorandum is focused only on the following infrastructure elements:

Riverbank Filtration Alternative Well Designs

- Conventional Vertical Wells
- Horizontal Wells
- Collector wells (Ranney Wells)

The purpose of this Technical Memorandum (TM) is to document the range of planning level cost estimates for the three alternative well designs listed above. A separate Technical Memorandum – "Conceptual Alternative Projects and Planning Level Cost Estimates" will document and provide planning level cost estimates for a conceptual alternative which includes Riverbank Filtration as an alternative water supply to surface water supplies.

Background on Riverbank Filtration

RBF production wells are constructed near the banks of rivers at relatively shallow depths to pump and supply large amounts of potable water. The pumping action of these wells creates a pressure head difference between the river and the shallow aquifer with the higher head at the river. ("Riverbank Filtration", 2003) The higher head of the river water and lower head in the aquifer induces the river water to flow downward through the porous sands into the pumping wells. The water from these wells is a combination of groundwater originally present in the shallow aquifer and filtered surface water from the river. Ideally, RFB wells will pull >50% of water from the river. During movement of this water through the river bed sediments, dissolved and suspended contaminants plus various pathogens are removed due to the combination of physical, chemical, and biological processes. The use of RBF filtration wells began in Germany with the construction of the Flehe Waterworks' RBF system in the 1870's, and this system is still in operation today. In the United States, Riverbank filtration systems have been operating for about 50 years, and often provide the only treatment other than chlorination and fluoridation prior to consumption.

RBF Water Treatment

RBF systems are increasingly being used for relatively inexpensive means of providing potable water. RBF systems provide various treatment processes such as adsorption, reduction, physiochemical filtration, and biodegradation which produces water that is relatively consistent in quality. RBF systems have long been recognized in Europe to provide potable water at relatively lower costs than typical water supply systems. Many utilities in North America are interested in RBF technology because it has the potential to remove pathogenic microbes such as viruses, *Giardia or Cryptosporidium* from surface water, thus improving raw water quality and reducing costs of in-plant conventional treatment. Some European countries use this technology to augment the removal of natural organic matter (NOM), organic contaminants, and pathogenic microbes from as much as 80% of their drinking water (Netherlands, 7%, Germany, 16%, Hungary, 40%, Finland, 48%, France 50%, Switzerland, 80%). Outside of Europe RBF systems are not widespread because surface water and groundwater of adequate quality are readily available (Environmental Science and Technology, 2002).

Limited information is available on the effects of the proposed RBF system on the groundwater in the proposed study area. The scope of study for the RBF filtration treatment assumes that there was no change in water quality of the Yellow River from the wells, due to insufficient test well data available at this point in the investigation. One could calculate the cost assuming .5 log credit and 1 log credit. *The TM Water Quality Analysis and Surface Water Treatment Requirements* further discusses this aspect. EPA requires sampling to determine *Cryptosporidium* levels in the surface water and treatment requirements.

Environmental Protection Agency (EPA) RBF Filtration Regulations

EPA defines Ground Water Under the Direct Influence of Surface Water (GWUDI) as well water containing substantial proportions of recent surface water and is regulated as a surface water supply system. EPA also defines Bank Filtration as a subset of GWUDI sites stating that natural filtration is determined to be an effective alternative/supplement to conventional treatment (coagulation, sedimentation and rapid sand filtration or direct filtration). Under proposed regulations, Bank Filtration is a pre-treatment alternative for systems that filter but have high *Cryptosporidium* concentrations in the raw water. Under existing regulations, any State or Primacy Agent can grant Bank Filtration credit for *Giardia or Cryptosporidium* removal so that a system may avoid constructing a filtration plant (based on site specific data).

Under EPA proposed regulations for vertical wells:

- 25 foot separation distance between river and wellhead receives 0.5 log credit (construction and operation requirements must also be met). Only vertical or horizontal wells are eligible for credit. Only wells located in unconsolidated, granular aquifers are eligible for bank filtration treatment credit. A core must be extracted from the aquifer to demonstrate that in at least 90% of the core length, grains less than 1 mm in diameter constitute at least 10% of the core material. The supply wells must be monitored continuously for turbidity (every 4 hours) and the monthly average must be below 1.0 NTU. A cost savings of 50% could be achieved if the treatment requirements for *Cryptosporidium* are reduced from 2 log to 1 log.
- 50 foot separation distance between river and wellhead receives 1 log credit (construction and operation requirements must also be met as above).
- Separation distance is defined as the map distance between the 100 year return period elevation or floodway boundary (as defined on a FEMA flood hazard map) and the well head of a vertical well.

For horizontal wells:

- Horizontal well laterals must be separated from the normal-flow river-bottom by either 25 or 50 feet (for 0.5 or 1.0 log credit)
- Construction and operation requirements must also be met as above.
  Bank filtration facilities can receive greater than 1.0 log credit for *Cryptosporidium* treatment if the reduction is demonstrated through a study. *Cryptosporidium* samples must be collected from the production well and a monitoring well screened along the shortest flow path between the surface water body and the production well.

RBF Facilities

Aspects important to the design of RBF systems include well location, well capacity, aquifer characteristics, and water quality. Well types utilized for RBF systems include conventional vertical wells, horizontal wells, or collector (Ranney) wells. For one conventional vertical well, the site footprint will be small compared to one horizontal well and one collector well, however, since the yield of horizontal wells and collector wells can be 3 to 5 times greater, the site footprint is not a significant factor. Drilling costs are easier to define for vertical wells, which are commonly drilled in the area. However, individual well yields for vertical wells may be significantly less than horizontal wells or collector wells. The design of well casing and screen materials will depend on the aquifer lithology, yield, and water quality. All three types of well designs will provide some treatment of surface water by natural filtration through the river bed sediments.

One horizontal well will require a larger site footprint than one vertical well because it extends laterally 200 feet, but they can produce 2 to 3 times as much water. The feasibility of horizontal wells may be limited by the site geology and potential borehole collapse. However, the potential well yield is significantly greater for a horizontal well than a conventional screened vertical well.

One collector (Ranney) well will require a larger site footprint than one vertical well because the laterals extend out 200 to 400 feet, but have the potential to produce very large quantities of water (from 2 to 80 mgd). The lateral length is limited to 200 feet because of the jacking pressures and frictional forces required to pull the pipe back. Cost estimates for collector wells may be more difficult to quantify for northwest Florida, because this technology is not commonly used. Overall, the land area required for the three systems to produce 25 mgd would be similar.

Initial conceptual design criteria for Riverbank filtration facilities are shown in Table 1 for this conceptual planning study as follows:

Table 1 –Riverbank Filtration Facility Design Criteria

Facility Type	***Component/Aspect***	***Design Consideration***	***Approach to Finalize***	***Remarks***
Vertical Wells	Well Location, Well Capacity, Aquifer characteristics, Water quality	Small property footprint, depth to water, thickness of aquifer, aquifer lithology, geochemistry, distance from river, aquifer safe yield, well screen and casing material, PVC, steel	Review data provided by NWFWMD, determine site locations, aquifer characteristics, water quality	Data gaps will be defined, well yields estimated, drilling costs estimates from similar wells more accurate
Horizontal Wells	Well location, Well capacity, Aquifer Characteristics, Water Quality	Larger property footprint required, horizontal drilling feasibility, greater potential yield, depth to water, thickness of aquifer, aquifer lithology, geochemistry, well materials, distance from river, river component of flow	Review data provided by NWFWMD, determine site locations, aquifer characteristics, water quality	Data gaps will be defined, drilling costs more difficult to estimate than for conventional wells
Collector (Ranney) Wells	Well location, Well capacity, Aquifer characteristics, Water quality	Larger property footprint required, greater potential yield, depth to water, thickness of aquifer, aquifer lithology, geochemistry, well materials, travel time in aquifer (treatment), filtration capacity of the surface water/aquifer interface, rate of infiltration	Review data provided by NWFWMD, determine site locations, aquifer characteristics, water quality	Data gaps will be defined, more assumptions for drilling/construction costs of collector wells

<u>Sand-and-Gravel Aquifer</u>

Locally, the Sand-and-Gravel Aquifer is composed of sands, gravel, silt and clays. Sand and occasional gravel-sized particles comprise the principal lithology with discontinuous layers of inter-bedded clay and silt. The water table of the Sand-and-Gravel Aquifer is subject to atmospheric pressure under unconfined conditions. Where present, intermittent clay deposits may cause semi-confined conditions in the lower portion of the aquifer. The Sand-and-Gravel Aquifer thickens generally from north-east to south-west with distinct local differences due to variations in relief. Thickness of the aquifer varies from <30 feet in parts of Walton County to more than 400 feet in Santa Rosa County.

In the study area along the northern banks of the Yellow River, the Sand-and-Gravel aquifer is estimated to be <30 feet thick and thickens to over 70 feet at the Santa Rosa/Okaloosa County border. Estimates are based on interpretations of existing FGS well logs made by NWFWMD staff.

Assumptions/Uncertainties

For the purpose of conceptual preliminary engineering design, the RBF wells were situated along the north shore of the Yellow River in western Okaloosa County downstream from the confluence of the Shoal and Yellow River (Figure 1). Aquifer parameters including saturated thickness, hydraulic conductivity, and well yield were used from the existing groundwater flow model developed by the NWFWMD for Riverbank filtration. Aquifer parameters from the model area follow:

Aquifer Saturated Thickness – 35 to 40 feet, assume 40 feet for cost analysis

Hydraulic Conductivity – 80 ft/day

Transmissivity – 2,800 ft^2/day to 3,200 ft^2/day

Vertical Well Yield – 1 mgd

The model parameters are based on data from three existing FGS wells. The well logs were used to estimate the thickness of the sand and gravel aquifer at the proposed site for the Riverbank filtration study. It is assumed that the water levels in the flood plain are near land surface and that the aquifer will yield 1 mgd per well from vertical wells.

The actual yield from wells installed in the flood plain along the Yellow River will be determined after site specific groundwater investigation studies are performed by the NWFWMD. These cost estimates are based on the above assumptions from the groundwater flow model. There are no existing water supply wells or aquifer test data in the study area.

Conventional Vertical Wells

Assumptions:

Well Depth 40 feet

Screen Diameter 12 inches

Screened Interval	5 to 40 feet
Pumping Rate	700 gpm (1 mgd)
Number of Wells	12 wells to yield 12 mgd
Well Spacing	1,000 feet to minimize overlapping drawdown effects
Distance from River	300 feet
Well House	Built in flood plain, tower 10 feet above ground, water tight

<u>Horizontal Wells</u>

Assumptions:

Well Depth	20 to 40 feet
Screen Diameter	12 inches
Screened Interval	200 to 500 feet of horizontal screen
Pumping Rate	1,388 gpm (2 mgd)
Number of Wells	6 wells to yield 12 mgd (from Directed Technologies Drilling)
Well Spacing	1,000 feet to minimize overlapping drawdown effects
Distance from River	300 feet
Well House	Built in flood plain, tower 10 feet above ground, watertight

<u>Collector Wells (Ranney Wells)</u>

Assumptions:

Well Depth	40 feet (13-foot diameter caisson driven to 45 feet)
Screen Diameter	6 inches
Screened Interval	Four horizontal laterals between depths of 5 to 40 feet, 200 feet long

Pumping Rate	5,000 gpm (7.2 mgd)
Number of Wells	2 wells to yield 14.4 mgd
Well Spacing	1,000 feet to minimize overlapping drawdown effects
Distance from River	300 feet
Well House	Built in flood plain, water tight caisson 10 feet above ground

<u>Planning Level Cost Estimates</u>

Conventional Vertical Wells

The cost for a 12-inch screened well producing 1 mgd including well installation, a permanent pump capable of 700 gpm, controls, well development, and disinfection is in the range of $200,000 to $250,000 from an estimate by Layne-Central, Pensacola (telephone call with Doyle Goodman on 4/19/06). For planning purposes, assume a cost of $225,000 for 1 mgd, plus an annual O&M cost of $35,453, for a total of $260,453. For 12 mgd, the cost would be $3,125,436 and for 25 mgd would be $6,511,325. However, the associated piping costs and O&M costs would be more with 12 or 25 wells and pumps, versus fewer wells and pumps required for horizontal or collector wells. The above costs do not include power to the site or piping and conveyance to a collection point.

Horizontal Wells

Drilling costs for a similar project in Iowa City, Iowa (telephone call with Jim Doesburg from Directed Drilling Technologies, Inc.) were $200 per foot for drilling 700 total feet and installing 500 feet of 12-inch diameter well screen beneath the Cedar River. The well produces 500 gpm. Estimated drilling costs to produce 1 mgd are $200,000. Adding the costs for a permanent pump, controls, development, and disinfection, and O&M of $35,453 per year, assume a total of $335,453. For 12 mgd, the cost would be on the order of $4,025,436. For 25 mgd, the cost would be on the order of $8,386,325. The above costs do not include power to the site or piping and conveyance to a collection point.

Collector (Ranney) Wells

Drilling costs are estimated from Ranney, Ohio as $1,950,000 for a 7.2 mgd well. The estimated drilling cost to produce 1 mgd is $270,833. For 2 Ranney collector well systems capable of 14.4 mgd, the cost is estimated as $3,900,000. For 4 Ranney collector well systems capable of 28.8 mgd, the cost is estimated as $7,800,000. The above costs do not include power to the site or piping and conveyance to a collection point. The well screens are more difficult to maintain because of access, but because of lower entrance velocities, maintenance is required less often than vertical wells and typically the first maintenance is not until 10 years of operation.

Advantages/Disadvantages of Well Designs

Conventional Vertical Wells

Advantages

1. Common method, large number of drilling contractors.
2. Least expensive of three methods per well
3. Easy to construct
4. Potentially easier to permit than groundwater/surface water source because vertical wells are commonly permitted through the water management district.

Disadvantages

1. Typically lower well yield than horizontal/collector wells
2. Greater drawdown near well, potential impacts on other users or wetlands in close proximity to the well.
3. More wells required for desired yield, therefore potentially higher total cost for 12 to 25 mgd
4. Higher O&M costs, more wells and pumps to maintain

Horizontal Wells

Advantages

1. Can construct well along river or below river to get better surface water withdrawal.
2. Greater yield per well than vertical wells, fewer wells required.
3. Drawdown is spread out laterally, less impact on other wells or wetlands.
   The horizontal well could be installed approximately 100 feet away from the river and extend 200 feet in length, parallel to the river to flatten the drawdown impacts. Could model as a drain for a preliminary estimate of drawdown impacts.

Disadvantages

1. Uncommon drilling method, small number of drilling contractors to choose from.
2. Potential construction difficulties, well development difficulties If cobbles or boulders are encountered, the well screen cannot be advanced. If drilling mud is used in the construction, the mud can be very difficult to develop out of long horizontal wells.
3. Greater cost per foot to drill compared to vertical wells.
4. Have a history of high maintenance due to fouling. It can be more difficult to maintain the screen by swabbing, acidulation, and jetting as compared to a vertical well.

Collector Wells (Ranney Wells)

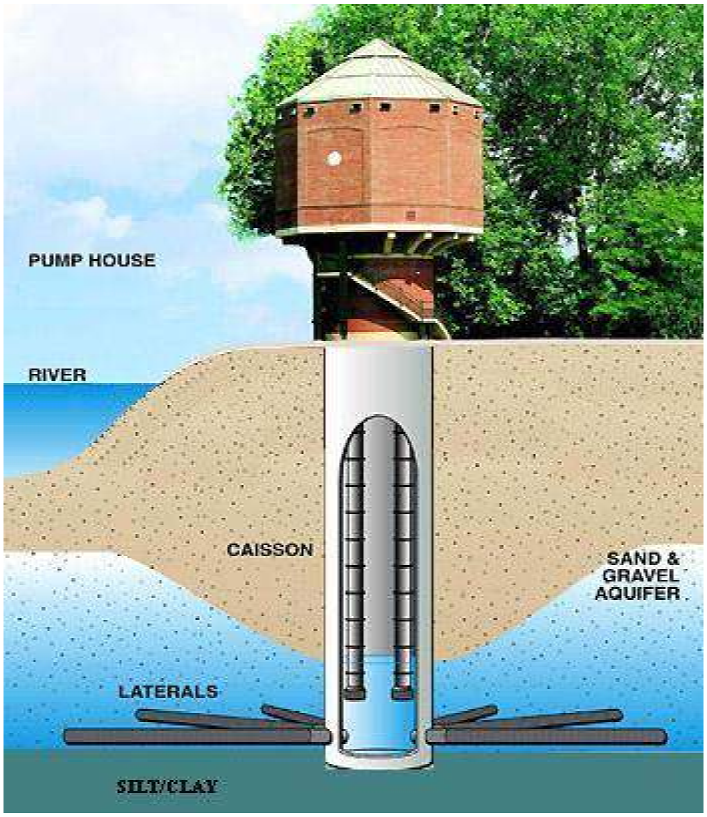
Advantages

1. Well suited for Riverbank filtration sites, commonly used along large rivers, see Figure 1.
2. Greater yield/well than vertical or horizontal, can produce very large pumping rates.
3. Can construct well along river or below river to get better surface water influence.
4. Drawdown is spread out laterally, less impact on other wells or wetlands, similar to horizontal wells.

Disadvantages

1. Uncommon drilling method, fewer qualified drilling contractors.
2. Potential construction difficulties, well development difficulties.
3. Greater cost per foot to drill compared to vertical wells.

Figure 1 - Schematic of Radial Collector Well



Summary and Recommendations

In summary, the individual well cost for vertical wells is the least expensive option. However, collector wells may be the most cost effective selection when considering long-term costs of O&M because of fewer number of pumps and less piping and valves to tie into water systems. Recommendations for the next step in bank filtration analysis include:

1. Conduct groundwater modeling using MODFLOW and the drain package to determine drawdown impacts from collector wells.
2. Develop a reconnaissance program to explore the entire bank filtration site along the north side of the river. Drill approximately 5 borings at 5 sites to determine site geology, grain size, and permeability. Select the best of the five sites for a detailed data acquisition program.
3. Develop a detailed data acquisition program at the site selected from the reconnaissance program above. Continuous cores should be collected to a depth of 40 feet to determine aquifer characteristics including grain size, permeability, and aquifer thickness. Soil borings should be conducted every 20 feet along proposed 200 foot screen lengths, approximately 100 feet from the river bank. A direct-push coring technique would have minimal impacts to the environment and provide continuous geologic samples. Conduct an aquifer performance test using vertical wells to determine the aquifer yield and firm capacity for the collector system.
4. Design the collector well system.

Summary of Cost Comparison

Well Type	Construction Cost	Equipment and Appurtenances	O&M Cost per year	Total Cost for 1 MGD	Total Cost for 12 MGD	Total Cost for 25 MGD
Vertical Well	$125,000	$100,000	$35,453	$260,453	$3,125,436	$6,511,325
Horizontal Well	$200,000	$100,000	$35,453	$335,453	$4,025,436	$8,386,325
Collector Well	$170,833	$100,000	$35,453	$306,286	$3,675,432	$7,657,150

Note: Collector well cost estimate was from contractor for one caisson system producing 7.2 mgd for a cost of $1,950,000. Two collector wells would produce 14.4 mgd for $3,900,000 and four collector wells would produce 28.8 mgd for $7,800,000. The above table compares the costs per 1 mgd.

Attachment D

Detailed Cost Estimates

Pond Creek Reservoir

Item Code	Item Description	Unit	Quantity	Unit Cost	Item Total
	Mobilization (% of Construction)	10%	1	$1,314,150.00	$ 1,314,150.00
	Diversion and Care of Water	LS	1	$500,000.00	$ 500,000.00
	Clear and Grub embankment and spillway areas	AC	36	$1,500.00	$ 53,891.18
	Cut	CY	430,000	$4.00	$ 1,720,000.00
	Fill	CY	372,000	$6.00	$ 2,232,000.00
	Seepage Cut-off Trench	CY	58,000	$6.00	$ 348,000.00
	Seepage Control Drainage System	CY	46,950	$25.00	$ 1,173,750.00
	Reinforced Concrete (9-inch): Spillway & Outlet Works	CY	11,000	$350.00	$ 3,850,000.00
	8-inch Gravel Base for Slab	CY	11,000	$30.00	$ 330,000.00
	Spillway Subsurface Drainage	CY	1,826	$150.00	$ 273,866.56
	Rock Riprap Slope Protection (U/S Slope)	CY	34,000	$60.00	$ 2,040,000.00
	Soil Retention Blanket (Temporary)	SY	9,000	$2.00	$ 18,000.00
	Topsoil, Native Grass Seeding and Irrigation (D/S Slope)	SY	183,000	$4.00	$ 732,000.00
	20-Ft Access Road (8-inch Flex Base)	SY	7,000	$10.00	$ 70,000.00
	Instrumentation	LS	1	$ 300,000	$ 300,000.00
				Construction Subtotal	$ 15,000,000.00

Bear Creek Reservoir

Item Code	Item Description	Unit	Quantity	Unit Cost	Item Total
	Mobilization (% of Construction)	10%	1	$456,340.00	$ 456,340.00
	Diversion and Care of Water	LS	1	$38,461.54	$ 38,461.54
	Clear and Grub embankment and spillway areas	AC	20	$1,500.00	$ 29,269.97
	Cut	CY	180,000	$4.00	$ 720,000.00
	Fill	CY	149,000	$6.00	$ 894,000.00
	Seepage Cut-off Trench	CY	31,000	$6.00	$ 186,000.00
	Seepage Control Drainage System	CY	25,500	$25.00	$ 637,500.00
	Reinforced Concrete (9-inch): Spillway & Outlet Works	CY	1,000	$350.00	$ 350,000.00
	8-inch Gravel Base for Slab	CY	1,000	$30.00	$ 30,000.00
	Spillway Subsurface Drainage	CY	111	$150.00	$ 16,670.14
	Rock Riprap Slope Protection (U/S Slope)	CY	15,000	$60.00	$ 900,000.00
	Soil Retention Blanket (Temporary)	SY	14,000	$2.00	$ 28,000.00
	Topsoil, Native Grass Seeding and Irrigation (D/S Slope)	SY	108,000	$4.00	$ 432,000.00
	20-Ft Access Road (8-inch Flex Base)	SY	4,000	$10.00	$ 40,000.00
	Instrumentation	LS	1	$ 300,000	$ 300,000.00
				Construction Subtotal	$ 5,100,000.00

West Dog Creek Reservoir

Item Code	Item Description	Unit	Quantity	Unit Cost	Item Total
	Mobilization (% of Construction)	10%	1	$343,510.00	$ 343,510.00
	Diversion and Care of Water	LS	1	$27,327.94	$ 27,327.94
	Clear and Grub embankment and spillway areas	AC	17	$1,500.00	$ 25,309.92
	Cut	CY	122,000	$4.00	$ 488,000.00
	Fill	CY	91,000	$6.00	$ 546,000.00
	Seepage Cut-off Trench	CY	31,000	$6.00	$ 186,000.00
	Seepage Control Drainage System	CY	22,050	$25.00	$ 551,250.00
	Reinforced Concrete (9-inch): Spillway & Outlet Works	CY	1,000	$350.00	$ 350,000.00
	8-inch Gravel Base for Slab	CY	1,000	$30.00	$ 30,000.00
	Spillway Subsurface Drainage	CY	84	$150.00	$ 12,587.66
	Rock Riprap Slope Protection (U/S Slope)	CY	9,000	$60.00	$ 540,000.00
	Soil Retention Blanket (Temporary)	SY	8,000	$2.00	$ 16,000.00
	Topsoil, Native Grass Seeding and Irrigation (D/S Slope)	SY	90,000	$4.00	$ 360,000.00
	20-Ft Access Road (8-inch Flex Base)	SY	3,000	$10.00	$ 30,000.00
	Instrumentation	LS	1	$ 300,000	$ 300,000.00
				Construction Subtotal	$ 3,800,000.00

Alternative # 1 Pond Creek Reservoir										
Item	***Dia (in)***	***miles***	***ft***	***acres***	***mgd***	***Horsepower***		***Unit costs***		***Total***
River Intake & Pumping Station					10	836				2,943,968
land for intake				5			$	10,000		50,000
Pipelines	36	10.6	55968				$	155		8,675,040
	24	1.7	8976				$	100		897,600
Easement for pipeline				45			$	10,000		447,273
Dam & Spillway							$	15,000,000		15,000,000
Land for Reservoir				3,006			Varies			24,019,000
Reservoir Intake, PS and Pipeline					25	958				3,238,365
Water Treatment Plant										28,400,000
Land for WTP				20			$	10,000		200,000
High Service Pumping Station					25	1253				2,661,347
	Construction costs total								$	61,816,320
	Contingency 25%								$	15,454,080
	Engineering/Addt'l Services, Legal, Administration & Permiting 25%								$	15,454,080
	Conflict Resolution 10%								$	6,181,632
	Land Costs and Easements								$	24,716,273
	Environmental Mitigation			866			$	95,955	$	83,049,150
							Total Capitol		**$**	**206,671,536**
							O&M		**$**	**2,813,818**
							Power Costs		**$**	**1,592,962**

Alternative # 2 Bear Creek Reservoir

Item	Dia (in)	miles	ft	acres	mgd	Horsepower		Unit costs		Total
River Intake & Pumping Station					25	444				1,766,381
land for intake				5			$	10,000		50,000
Pipelines	36	4.9	25872				$	155		4,010,160
	24	0					$	100		-
Easement for pipeline				18			$	10,000		178,182
Dam & Spillway							$	5,100,000		5,100,000
Land for Reservoir				264			Varies			1,758,000
Reservoir Intake, PS and Pipeline					25	864				2,943,968
Water Treatment Plant										28,400,000
Land for WTP				20			$	10,000		200,000
High Service Pumping Station					25	756	$	3,000,000		1,766,381
	Construction costs total								$	43,986,890
	Contingency 25%								$	10,996,722
	Engineering/Addt'l Services, Legal, Administration & Permiting 25%								$	10,996,722
	Conflict Resolution 10%								$	4,398,689
	Land Costs and Easements								$	2,186,182
	Environmental Mitigation			129			$	95,955	$	12,330,232
							Total Capitol		**$**	**84,895,438**
							O&M		**$**	**2,550,520**
							Power Costs		**$**	**1,079,053**

Alternative # 3 West Dog Creek Reservoir									
Item	***Dia (in)***	***miles***	***ft***	***acres***	***mgd***	***Horsepower***		***Unit costs***	***Total***
River Intake & Pumping Station					25	808			2,943,968
land for intake				5			$	10,000	50,000
Pipelines	36	11.7	61776				$	155	9,575,280
	24	0					$	100	-
Easement for pipeline				43			$	10,000	425,455
Dam & Spillway							$	3,800,000	3,800,000
Land for Reservoir				106			Varies		696,000
Reservoir Intake, PS and Pipeline					25	776			2,649,571
Water Treatment Plant									28,400,000
Land for WTP				20			$	10,000	200,000
High Service Pumping Station					25	1024	$	3,000,000	2,355,175
	Construction costs total								$ 49,723,994
	Contingency 25%								$ 12,430,999
	Engineering/Addt'l Services, Legal, Administration & Permiting 25%								$ 12,430,999
	Conflict Resolution 10%								$ 4,972,399
	Land Costs and Easements								$ 1,371,455
	Environmental Mitigation			55			$	95,955	$ 5,229,554
							Total Capitol		**$ 86,159,399**
							O&M		**$ 2,623,471**
							Power Costs		**$ 1,363,454**

Alternative # 4 Shoal River Direct Diversion									
Item	***Dia (in)***	***miles***	***ft***	***acres***	***mgd***	***Horsepower***		***Unit costs***	***Total***
River Intake & Pumping Station					25	652			2,355,175
land for intake				5			$	10,000	50,000
Pipelines	36	2.5	13200				$	155	2,046,000
	24	0					$	100	-
Easement for pipeline				9			$	10,000	90,909
Dam & Spillway									-
Land for Reservoir				0			Varies		-
Reservoir Intake, PS and Pipeline									-
Water Treatment Plant									28,400,000
Land for WTP				20			$	10,000	200,000
High Service Pumping Station					25	650			1,570,116
	Construction costs total								$ 34,371,291
	Contingency 25%								$ 8,592,823
	Engineering/Addt'l Services, Legal, Administration & Permiting 25%								$ 8,592,823
	Conflict Resolution 10%								$ 3,437,129
	Land Costs and Easements								$ 340,909
	Environmental Mitigation			5			$	95,955	$ 479,776
							Total Capitol		**$ 55,814,750**
							O&M		**$ 2,390,592**
							Power Costs		**$ 680,681**

Alternative # 5 In-Bank Filtration										
Item	***Dia (in)***	***miles***	***ft***	***acres***	***mgd***	***Horsepower***		***Unit costs***		***Total***
Collector Wells					25	840				7,657,150
Land for Well fields				50			$	10,000		500,000
Pipelines	36	2.97	15681.6				$	155		2,430,648
Pipelines (Urban)	36	6.93	36590.4				$	205		7,501,032
	20	2	10560				$	85		897,600
Easement for pipeline				18.072727			$	10,000		180,727
Dam & Spillway										-
Land for Reservoir				0			Varies			-
Reservoir Intake, PS and Pipeline					25	0				
Ground Storage Tank										3,179,486
Water Treatment Plant										28,400,000
Land for WTP				20			$	10,000		200,000
High Service Pumping Station					25	1201				2,661,347
	Construction costs total								$	52,727,263
	Contingency 25%								$	13,181,816
	Engineering/Addt'l Services, Legal, Administration & Permiting 25%								$	13,181,816
	Conflict Resolution 10%								$	5,272,726
	Land Costs and Easements								$	880,727
	Environmental Mitigation			35			$	95,955	$	3,358,429
							Total Capitol		**$**	**88,602,777**
							O&M		**$**	**2,482,279**
							Power Costs		**$**	**1,067,028**

Alternative 1 Pond Creek Reservoir

Life Cycle Cost Analysis

Year 2006	Project Cost = **$206,671,536**	Annual O&M Cost = **$2,813,818**
Year 2012	Project Cost = **$281,251,000**	Annual O&M Cost = **$3,461,000**

(Estimated Costs originated in 2006 inflated @ 4.5% to 2012)

YEAR	*YIELD (ac-ft / yr)*	*BOND PAYMENTS ($1,000)*	*O & M COSTS ($1,000)*	*POWER CONSUMPTION COSTS ($1,000)*	*TOTAL COST ($1,000)*	*ANNUAL UNIT COST ($/1,000 gal)*	*PRESENT VALUE of UNIT COST (2006$ / 1,000 gal)*
2012	28,006	$0	$0	$0	$0	$0.00	**$0.00**
2013	28,006	$19,566	$0	$0	$19,566	$2.14	**$1.68**
2014	28,006	$19,566	$0	$0	$19,566	$2.14	**$1.63**
2015	28,006	$19,566	$3,950	$1,818	$25,333	$2.78	**$2.04**
2016	28,006	$19,566	$4,127	$1,900	$25,593	$2.80	**$1.99**
2017	28,006	$19,566	$4,313	$1,985	$25,864	$2.83	**$1.94**
2018	28,006	$19,566	$4,507	$2,074	$26,147	$2.86	**$1.90**
2019	28,006	$19,566	$4,710	$2,168	$26,444	$2.90	**$1.85**
2020	28,006	$19,566	$4,922	$2,265	$26,753	$2.93	**$1.81**
2021	28,006	$19,566	$5,143	$2,367	$27,076	$2.97	**$1.77**
2022	28,006	$19,566	$5,375	$2,474	$27,414	$3.00	**$1.73**
2023	28,006	$19,566	$5,617	$2,585	$27,768	$3.04	**$1.70**
2024	28,006	$19,566	$5,869	$2,701	$28,137	$3.08	**$1.66**
2025	28,006	$19,566	$6,134	$2,823	$28,522	$3.13	**$1.63**
2026	28,006	$19,566	$6,410	$2,950	$28,925	$3.17	**$1.59**
2027	28,006	$19,566	$6,698	$3,083	$29,347	$3.22	**$1.56**
2028	28,006	$19,566	$6,999	$3,222	$29,787	$3.26	**$1.53**
2029	28,006	$19,566	$7,314	$3,367	$30,247	$3.31	**$1.50**
2030	28,006	$19,566	$7,644	$3,518	$30,727	$3.37	**$1.47**
2031	28,006	$19,566	$7,988	$3,676	$31,230	$3.42	**$1.45**
2032	28,006	$19,566	$8,347	$3,842	$31,755	$3.48	**$1.42**
2033	28,006	$19,566	$8,723	$4,015	$32,303	$3.54	**$1.40**
2034	28,006	$19,566	$9,115	$4,195	$32,876	$3.60	**$1.37**
2035	28,006	$19,566	$9,525	$4,384	$33,475	$3.67	**$1.35**
2036	28,006	$19,566	$9,954	$4,581	$34,101	$3.74	**$1.33**
2037	28,006	$19,566	$10,402	$4,788	$34,755	$3.81	**$1.31**
2038	28,006	$19,566	$10,870	$5,003	$35,439	$3.88	**$1.29**
2039	28,006	$19,566	$11,359	$5,228	$36,153	$3.96	**$1.27**
2040	28,006	$19,566	$11,870	$5,463	$36,899	$4.04	**$1.26**
2041	28,006	$19,566	$12,404	$5,709	$37,679	$4.13	**$1.24**
2042	28,006	$19,566	$12,963	$5,966	$38,495	$4.22	**$1.22**
TOTAL	***868,186***	***$586,974***	***$213,251***	***$98,151***	***$898,376***	***$3.18***	*$1.51*

NOTES:

1. Inflation Rate (% / year) = 4.5%
   - -- Total Project Cost (mid 2012) : $281,251,000
   - -- Total O&M Cost (mid 2012): $3,461,000

2. Term for Bonds (years) = 30

2. Interest Rate based on 2006 US Treasury rate (% / year) = 5.6%
   (on capital cost over financing period)
   - -- Annuity calculation for Bond Payments:
     $ 19,565,809

3. Inflation Rate based on CPI used for Present Value Unit Cost (% / year)** = 3.5%

4. Power Consumption (2012) = **$1,592,962**

Alternative 2 Bear Creek Reservoir

Life Cycle Cost Analysis

Year 2006 Project Cost = **$84,895,438** Annual O&M Cost = **$2,550,520**

Year 2012 Project Cost = **$115,531,000** Annual O&M Cost = **$3,137,000**

(Estimated Costs originated in 2006 inflated @ 4.5% to 2012)

YEAR	YIELD (ac-ft / yr)	BOND PAYMENTS ($1,000)	O & M COSTS ($1,000)	POWER CONSUMPTION COSTS ($1,000)	TOTAL COST ($1,000)	UNIT COST ($/1,000 gal)	PRESENT VALUE of UNIT COST (2006$ / 1,000 gal)
2012	28,006	$0	$0	$0	$0	$0.00	**$0.00**
2013	28,006	$8,037	$0	$0	$8,037	$0.88	**$0.69**
2014	28,006	$8,037	$0	$0	$8,037	$0.88	**$0.67**
2015	28,006	$8,037	$3,580	$1,231	$12,848	$1.41	**$1.03**
2016	28,006	$8,037	$3,741	$1,287	$13,065	$1.43	**$1.01**
2017	28,006	$8,037	$3,909	$1,345	$13,291	$1.46	**$1.00**
2018	28,006	$8,037	$4,085	$1,405	$13,528	$1.48	**$0.98**
2019	28,006	$8,037	$4,269	$1,468	$13,775	$1.51	**$0.96**
2020	28,006	$8,037	$4,461	$1,535	$14,033	$1.54	**$0.95**
2021	28,006	$8,037	$4,662	$1,604	$14,303	$1.57	**$0.94**
2022	28,006	$8,037	$4,872	$1,676	$14,585	$1.60	**$0.92**
2023	28,006	$8,037	$5,091	$1,751	$14,879	$1.63	**$0.91**
2024	28,006	$8,037	$5,320	$1,830	$15,187	$1.66	**$0.90**
2025	28,006	$8,037	$5,559	$1,912	$15,509	$1.70	**$0.88**
2026	28,006	$8,037	$5,810	$1,998	$15,845	$1.74	**$0.87**
2027	28,006	$8,037	$6,071	$2,088	$16,196	$1.77	**$0.86**
2028	28,006	$8,037	$6,344	$2,182	$16,564	$1.81	**$0.85**
2029	28,006	$8,037	$6,630	$2,280	$16,947	$1.86	**$0.84**
2030	28,006	$8,037	$6,928	$2,383	$17,348	$1.90	**$0.83**
2031	28,006	$8,037	$7,240	$2,490	$17,767	$1.95	**$0.82**
2032	28,006	$8,037	$7,566	$2,602	$18,205	$1.99	**$0.82**
2033	28,006	$8,037	$7,906	$2,719	$18,663	$2.04	**$0.81**
2034	28,006	$8,037	$8,262	$2,842	$19,141	$2.10	**$0.80**
2035	28,006	$8,037	$8,634	$2,970	$19,640	$2.15	**$0.79**
2036	28,006	$8,037	$9,022	$3,103	$20,163	$2.21	**$0.79**
2037	28,006	$8,037	$9,428	$3,243	$20,708	$2.27	**$0.78**
2038	28,006	$8,037	$9,852	$3,389	$21,278	$2.33	**$0.78**
2039	28,006	$8,037	$10,296	$3,541	$21,874	$2.40	**$0.77**
2040	28,006	$8,037	$10,759	$3,701	$22,497	$2.46	**$0.77**
2041	28,006	$8,037	$11,243	$3,867	$23,148	$2.54	**$0.76**
2042	28,006	$8,037	$11,749	$4,041	$23,828	$2.61	**$0.76**
TOTAL	***868,186***	***$241,115***	***$193,287***	***$66,486***	***$500,888***	***$1.77***	*$0.82*

NOTES:

1. Inflation Rate (% / year) = 4.5%
   - -- Total Project Cost (mid 2012) : $115,531,000
   - -- Total O&M Cost (mid 2012): $3,137,000

2. Term for Bonds (years) = 30

2. Interest Rate based on 2006 US Treasury rate (% / year) = 5.6%
   (on capital cost over financing period)
   - -- Annuity calculation for Bond Payments:
   $ 8,037,154

3. Inflation Rate based on CPI used for Present Value Unit Cost (% / year)** = 3.5%

4. Power Consumption (2012) = **$1,079,053**

Alternative 3 West Dog Creek Reservoir

Life Cycle Cost Analysis

Year 2006	Project Cost = **$86,159,399**	Annual O&M Cost = **$2,623,471**
Year 2012	Project Cost = **$117,251,000**	Annual O&M Cost = **$3,227,000**

(Estimated Costs originated in 2006 inflated @ 4.5% to 2012)

YEAR	***YIELD (ac-ft / yr)***	***BOND PAYMENTS ($1,000)***	***O & M COSTS ($1,000)***	***POWER CONSUMPTION COSTS ($1,000)***	***TOTAL COST ($1,000)***	***UNIT COST ($/1,000 gal)***	***PRESENT VALUE of UNIT COST (2006$ / 1,000 gal)***
2012	28,006	$0	$0	$0	$0	$0.00	**$0.00**
2013	28,006	$8,157	$0	$0	$8,157	$0.89	**$0.70**
2014	28,006	$8,157	$0	$0	$8,157	$0.89	**$0.68**
2015	28,006	$8,157	$3,683	$1,556	$13,395	$1.47	**$1.08**
2016	28,006	$8,157	$3,848	$1,626	$13,631	$1.49	**$1.06**
2017	28,006	$8,157	$4,021	$1,699	$13,877	$1.52	**$1.04**
2018	28,006	$8,157	$4,202	$1,776	$14,135	$1.55	**$1.02**
2019	28,006	$8,157	$4,392	$1,855	$14,404	$1.58	**$1.01**
2020	28,006	$8,157	$4,589	$1,939	$14,685	$1.61	**$0.99**
2021	28,006	$8,157	$4,796	$2,026	$14,979	$1.64	**$0.98**
2022	28,006	$8,157	$5,011	$2,117	$15,286	$1.67	**$0.97**
2023	28,006	$8,157	$5,237	$2,213	$15,606	$1.71	**$0.95**
2024	28,006	$8,157	$5,473	$2,312	$15,942	$1.75	**$0.94**
2025	28,006	$8,157	$5,719	$2,416	$16,292	$1.79	**$0.93**
2026	28,006	$8,157	$5,976	$2,525	$16,658	$1.83	**$0.92**
2027	28,006	$8,157	$6,245	$2,639	$17,041	$1.87	**$0.91**
2028	28,006	$8,157	$6,526	$2,757	$17,440	$1.91	**$0.90**
2029	28,006	$8,157	$6,820	$2,881	$17,858	$1.96	**$0.89**
2030	28,006	$8,157	$7,127	$3,011	$18,295	$2.00	**$0.88**
2031	28,006	$8,157	$7,447	$3,147	$18,751	$2.05	**$0.87**
2032	28,006	$8,157	$7,783	$3,288	$19,228	$2.11	**$0.86**
2033	28,006	$8,157	$8,133	$3,436	$19,726	$2.16	**$0.85**
2034	28,006	$8,157	$8,499	$3,591	$20,246	$2.22	**$0.85**
2035	28,006	$8,157	$8,881	$3,752	$20,791	$2.28	**$0.84**
2036	28,006	$8,157	$9,281	$3,921	$21,359	$2.34	**$0.83**
2037	28,006	$8,157	$9,699	$4,098	$21,953	$2.41	**$0.83**
2038	28,006	$8,157	$10,135	$4,282	$22,574	$2.47	**$0.82**
2039	28,006	$8,157	$10,591	$4,475	$23,223	$2.54	**$0.82**
2040	28,006	$8,157	$11,068	$4,676	$23,901	$2.62	**$0.81**
2041	28,006	$8,157	$11,566	$4,887	$24,609	$2.70	**$0.81**
2042	28,006	$8,157	$12,086	$5,107	$25,350	$2.78	**$0.80**
TOTAL	***868,186***	***$244,704***	***$198,833***	***$84,010***	***$527,547***	***$1.86***	*$0.87*

NOTES:

1. Inflation Rate (% / year) = 4.5%
   - -- Total Project Cost (mid 2012) : $117,251,000
   - -- Total O&M Cost (mid 2012): $3,227,000

2. Term for Bonds (years) = 30

2. Interest Rate based on 2006 US Treasury rate (% / year) = 5.6%
   (on capital cost over financing period)
   - -- Annuity calculation for Bond Payments:
   $ 8,156,809

3. Inflation Rate based on CPI used for Present Value Unit Cost (% / year)** = 3.5%

4. Power Consumption (2012) = **$1,363,454**

Alternative 4 Direct Diversion

Life Cycle Cost Analysis

Year 2006 Project Cost = **$55,814,750** Annual O&M Cost = **$2,390,592**

Year 2012 Project Cost = **$75,956,000** Annual O&M Cost = **$2,940,000**

(Estimated Costs originated in 2006 inflated @ 4.5% to 2012)

YEAR	YIELD (ac-ft / yr)	BOND PAYMENTS ($1,000)	O & M COSTS ($1,000)	POWER CONSUMPTION COSTS ($1,000)	TOTAL COST ($1,000)	UNIT COST ($/1,000 gal)	PRESENT VALUE of UNIT COST (2006$ / 1,000 gal)
2012	28,006	$0	$0	$0	$0	$0.00	**$0.00**
2013	28,006	$5,284	$0	$0	$5,284	$0.58	**$0.46**
2014	28,006	$5,284	$0	$0	$5,284	$0.58	**$0.44**
2015	28,006	$5,284	$3,355	$777	$9,416	$1.03	**$0.76**
2016	28,006	$5,284	$3,506	$812	$9,602	$1.05	**$0.75**
2017	28,006	$5,284	$3,664	$848	$9,796	$1.07	**$0.74**
2018	28,006	$5,284	$3,829	$886	$9,999	$1.10	**$0.73**
2019	28,006	$5,284	$4,001	$926	$10,211	$1.12	**$0.72**
2020	28,006	$5,284	$4,181	$968	$10,433	$1.14	**$0.71**
2021	28,006	$5,284	$4,369	$1,012	$10,665	$1.17	**$0.70**
2022	28,006	$5,284	$4,566	$1,057	$10,907	$1.19	**$0.69**
2023	28,006	$5,284	$4,771	$1,105	$11,160	$1.22	**$0.68**
2024	28,006	$5,284	$4,986	$1,154	$11,424	$1.25	**$0.67**
2025	28,006	$5,284	$5,210	$1,206	$11,701	$1.28	**$0.67**
2026	28,006	$5,284	$5,445	$1,261	$11,989	$1.31	**$0.66**
2027	28,006	$5,284	$5,690	$1,317	$12,291	$1.35	**$0.65**
2028	28,006	$5,284	$5,946	$1,377	$12,606	$1.38	**$0.65**
2029	28,006	$5,284	$6,213	$1,439	$12,936	$1.42	**$0.64**
2030	28,006	$5,284	$6,493	$1,503	$13,280	$1.46	**$0.64**
2031	28,006	$5,284	$6,785	$1,571	$13,640	$1.49	**$0.63**
2032	28,006	$5,284	$7,090	$1,642	$14,016	$1.54	**$0.63**
2033	28,006	$5,284	$7,410	$1,715	$14,409	$1.58	**$0.62**
2034	28,006	$5,284	$7,743	$1,793	$14,820	$1.62	**$0.62**
2035	28,006	$5,284	$8,091	$1,873	$15,249	$1.67	**$0.62**
2036	28,006	$5,284	$8,455	$1,958	$15,697	$1.72	**$0.61**
2037	28,006	$5,284	$8,836	$2,046	$16,166	$1.77	**$0.61**
2038	28,006	$5,284	$9,234	$2,138	$16,655	$1.82	**$0.61**
2039	28,006	$5,284	$9,649	$2,234	$17,167	$1.88	**$0.60**
2040	28,006	$5,284	$10,083	$2,335	$17,702	$1.94	**$0.60**
2041	28,006	$5,284	$10,537	$2,440	$18,261	$2.00	**$0.60**
2042	28,006	$5,284	$11,011	$2,549	$18,845	$2.06	**$0.60**
TOTAL	***868,186***	***$158,521***	***$181,149***	***$41,940***	***$381,611***	***$1.35***	*$0.62*

NOTES:

1. Inflation Rate (% / year) = 4.5%
   - -- Total Project Cost (mid 2012) : $75,956,000
   - -- Total O&M Cost (mid 2012): $2,940,000

2. Term for Bonds (years) = 30

2. Interest Rate based on 2006 US Treasury rate (% / year) = 5.6%
   (on capital cost over financing period)
   - -- Annuity calculation for Bond Payments:
     $ 5,284,037

3. Inflation Rate based on CPI used for Present Value Unit Cost (% / year)** = 3.5%

4. Power Consumption (2012) = **$680,681**

Alternative 5 In-Bank Filtration

Life Cycle Cost Analysis

Year 2006	Project Cost = **$88,602,777**	Annual O&M Cost = **$2,482,279**
Year 2012	Project Cost = **$120,576,000**	Annual O&M Cost = **$3,053,000**

(Estimated Costs originated in 2006 inflated @ 4.5% to 2012)

YEAR	*YIELD (ac-ft / yr)*	*BOND PAYMENTS ($1,000)*	*O & M COSTS ($1,000)*	*POWER CONSUMPTION COSTS ($1,000)*	*TOTAL COST ($1,000)*	*UNIT COST ($/1,000 gal)*	*PRESENT VALUE of UNIT COST (2006$ / 1,000 gal)*
2012	28,006	$0	$0	$0	$0	$0.00	**$0.00**
2013	28,006	$8,388	$0	$0	$8,388	$0.92	**$0.72**
2014	28,006	$8,388	$0	$0	$8,388	$0.92	**$0.70**
2015	28,006	$8,388	$3,484	$1,218	$13,090	$1.43	**$1.05**
2016	28,006	$8,388	$3,641	$1,272	$13,301	$1.46	**$1.03**
2017	28,006	$8,388	$3,805	$1,330	$13,522	$1.48	**$1.01**
2018	28,006	$8,388	$3,976	$1,390	$13,753	$1.51	**$1.00**
2019	28,006	$8,388	$4,155	$1,452	$13,995	$1.53	**$0.98**
2020	28,006	$8,388	$4,342	$1,517	$14,247	$1.56	**$0.96**
2021	28,006	$8,388	$4,537	$1,586	$14,511	$1.59	**$0.95**
2022	28,006	$8,388	$4,741	$1,657	$14,786	$1.62	**$0.93**
2023	28,006	$8,388	$4,955	$1,732	$15,074	$1.65	**$0.92**
2024	28,006	$8,388	$5,178	$1,810	$15,375	$1.68	**$0.91**
2025	28,006	$8,388	$5,411	$1,891	$15,690	$1.72	**$0.89**
2026	28,006	$8,388	$5,654	$1,976	$16,018	$1.76	**$0.88**
2027	28,006	$8,388	$5,908	$2,065	$16,362	$1.79	**$0.87**
2028	28,006	$8,388	$6,174	$2,158	$16,720	$1.83	**$0.86**
2029	28,006	$8,388	$6,452	$2,255	$17,095	$1.87	**$0.85**
2030	28,006	$8,388	$6,742	$2,357	$17,487	$1.92	**$0.84**
2031	28,006	$8,388	$7,046	$2,463	$17,897	$1.96	**$0.83**
2032	28,006	$8,388	$7,363	$2,573	$18,324	$2.01	**$0.82**
2033	28,006	$8,388	$7,694	$2,689	$18,772	$2.06	**$0.81**
2034	28,006	$8,388	$8,041	$2,810	$19,239	$2.11	**$0.80**
2035	28,006	$8,388	$8,402	$2,937	$19,727	$2.16	**$0.80**
2036	28,006	$8,388	$8,780	$3,069	$20,237	$2.22	**$0.79**
2037	28,006	$8,388	$9,176	$3,207	$20,771	$2.28	**$0.78**
2038	28,006	$8,388	$9,588	$3,351	$21,328	$2.34	**$0.78**
2039	28,006	$8,388	$10,020	$3,502	$21,910	$2.40	**$0.77**
2040	28,006	$8,388	$10,471	$3,660	$22,519	$2.47	**$0.77**
2041	28,006	$8,388	$10,942	$3,824	$23,154	$2.54	**$0.76**
2042	28,006	$8,388	$11,434	$3,996	$23,819	$2.61	**$0.76**
TOTAL	***868,186***	***$251,644***	***$188,112***	***$65,745***	***$505,501***	***$1.79***	*$0.83*

NOTES:

1. Inflation Rate (% / year) =	4.5%
-- Total Project Cost (mid 2012) :	$120,576,000
-- Total O&M Cost (mid 2012):	$3,053,000
2. Term for Bonds (years) =	30
2. Interest Rate based on 2006 US Treasury rate (% / year) = (on capital cost over financing period)	5.6%
-- Annuity calculation for Bond Payments: $ 8,388,120	
3. Inflation Rate based on CPI used for Present Value Unit Cost (% / year)** =	3.5%
4. Power Consumption (2012) =	**$1,067,028**