





Central Oklahoma Master Conservancy District

Critical Need Water Supply Project

Environmental Assessment

Prepared for

Central Oklahoma Master Conservancy District

and

Bureau of Reclamation

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1.0 INTRODUCTION

In accordance with the Council on Environmental Quality Regulations (40 Code of Federal Regulations (CFR), Parts 1500-1508) for implementing the provisions of the National Environmental Policy Act (42 USC, Part 4321 et seq.), this Environmental Assessment (EA) has been prepared to evaluate potential environmental and socioeconomic effects of the proposed action and alternatives associated with conveying augmentation water to Lake Thunderbird from the Atoka Pipeline to help the Central Oklahoma Master Conservancy District (COMCD) facilitate meeting member city demands during drought periods.

Lake Thunderbird is a federally owned water storage facility, under the jurisdiction of the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), developed as part of the Norman Project in the early 1960s. The Norman Project includes Lake Thunderbird; Norman Dam, which creates the lake; and a water conveyance pumping and pipeline system that provides raw water to the cities of Norman, Del City, and Midwest City. Lake Thunderbird's primary intended use is to provide municipal and industrial water supply. Secondary intended uses include flood control, recreation, and fish and wildlife propagation.

COMCD operates and maintains the dam, lake, and raw water pumping and delivery system under contract with Reclamation. COMCD holds water rights for 21,600 acre-feet (7 billion gallons per year) that supplies raw water to the member cities of Norman, Midwest City, and Del City. Operation and maintenance of the Norman Project were transferred to COMCD in May 1966. The name of the reservoir was changed from Norman Reservoir to Lake Thunderbird in late 1965 at the request of the water users. Water deliveries to the City of Norman began February 1966, followed by deliveries to Midwest and Del Cities in March. Since its completion, Lake Thunderbird has continued to be a popular recreation area, and the recreation facilities have been expanded several times to address the regional demand.

1.1 Purpose and Need

The Lake Thunderbird watershed experienced a major drought between 2005 and 2006, which resulted in the lowest lake level since the dam was constructed. COMCD and Reclamation jointly determined that the stored water supply in the lake would require augmentation in the future to meet demands of the member cities during potential reoccurring drought periods. Although COMCD presently has 21,600 acre-feet of allocated water rights that are stored in Lake Thunderbird for delivery to the member cities, COMCD and Reclamation have determined that, during future critical droughts, the yield of the lake will be substantially less than 21,600 acre-feet. Based on a *Lake Operational Study* (Tetra Tech 2009), COMCD has estimated that up to 4,600 additional acre-feet of raw water per year would be needed in Lake Thunderbird to augment supply to the member cities during severe drought periods, based on historical data.

In the *2040 Strategic Water Supply Plan* (City of Norman 2001), the City of Norman examined more than 17 possible water supply alternatives for meeting the needs of the city through 2040. Through a rigorous evaluation process based on economics, cost-benefits, environmental impacts and public acceptance, the City determined that the best methods and sources for future water would be, one, expanding the use of well fields and, two, making use of additional raw water in Lake Thunderbird that could be obtained from Oklahoma City and delivered by COMCD through the existing supply system serving Norman, Del City, and Midwest City. The well fields are already under development. The proposed project has been developed to address the other water supply option.

Based on the need for COMCD to augment its water supply by up to 4,600 acre-feet per year during times of severe drought, COMCD developed the **Lake Thunderbird Critical Need Water Supply Project**, which is evaluated in this EA. The intent of this project is for COMCD to enter into an agreement with Oklahoma City to enable the purchase of augmentation water during severe drought periods. The water would be conveyed from the nearby Oklahoma City-owned Atoka Pipeline that presently conveys raw water from Lake Atoka to Stanley Draper Lake (See Figures 1 and 2). To achieve this, COMCD would connect to the Atoka Pipeline and convey raw augmentation water to Lake Thunderbird via either a buried pipeline or a combination of buried pipeline and natural surface drainage channel. The augmentation water is expected to naturally mix with Lake Thunderbird water, and the mixed water would then be conveyed through the existing raw water delivery system to the member cities.

Figure 1: Project Vicinity Map, Lake Thunderbird

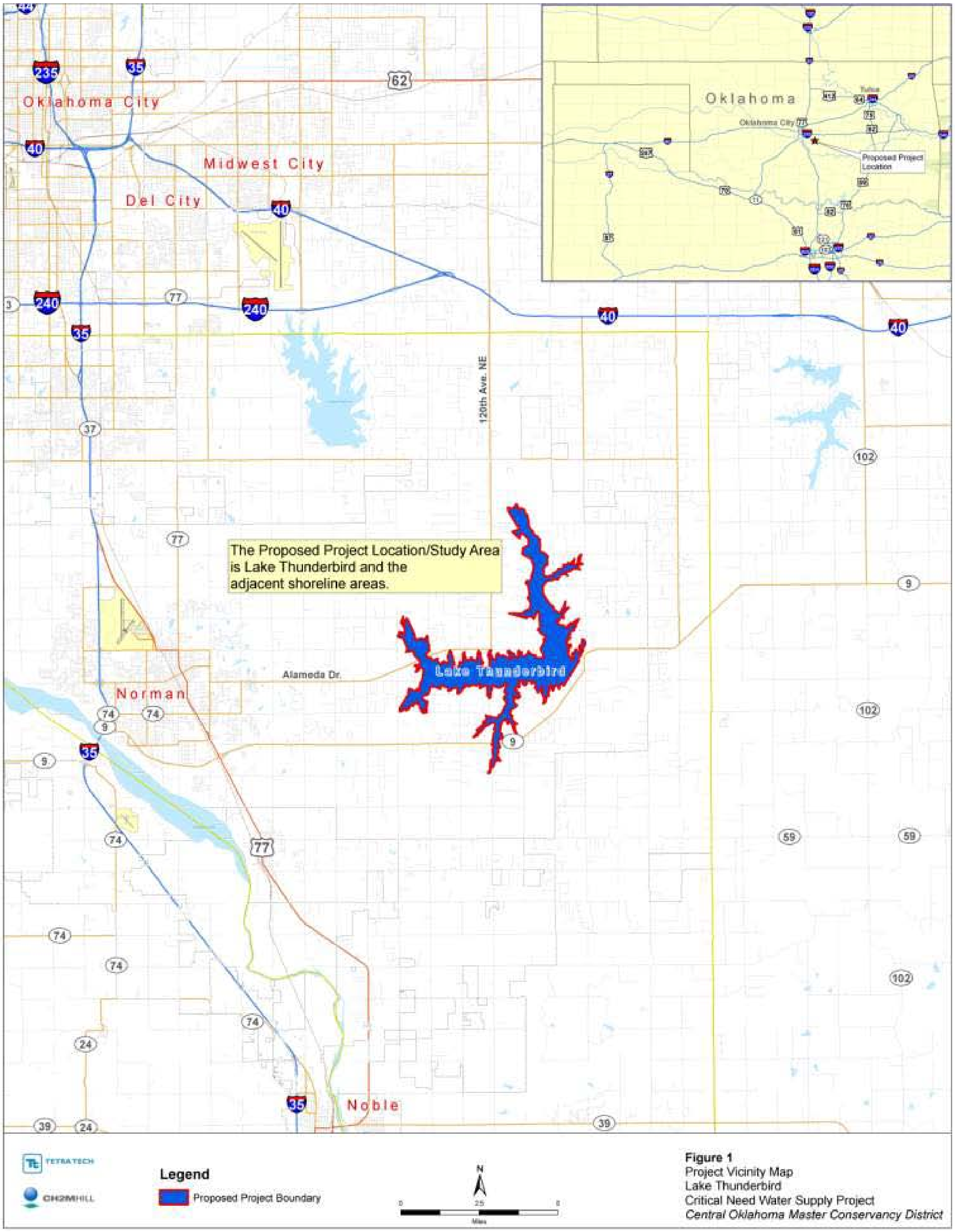

Figure 2: Lake Thunderbird, Nearby Roads, and Atoka Pipeline

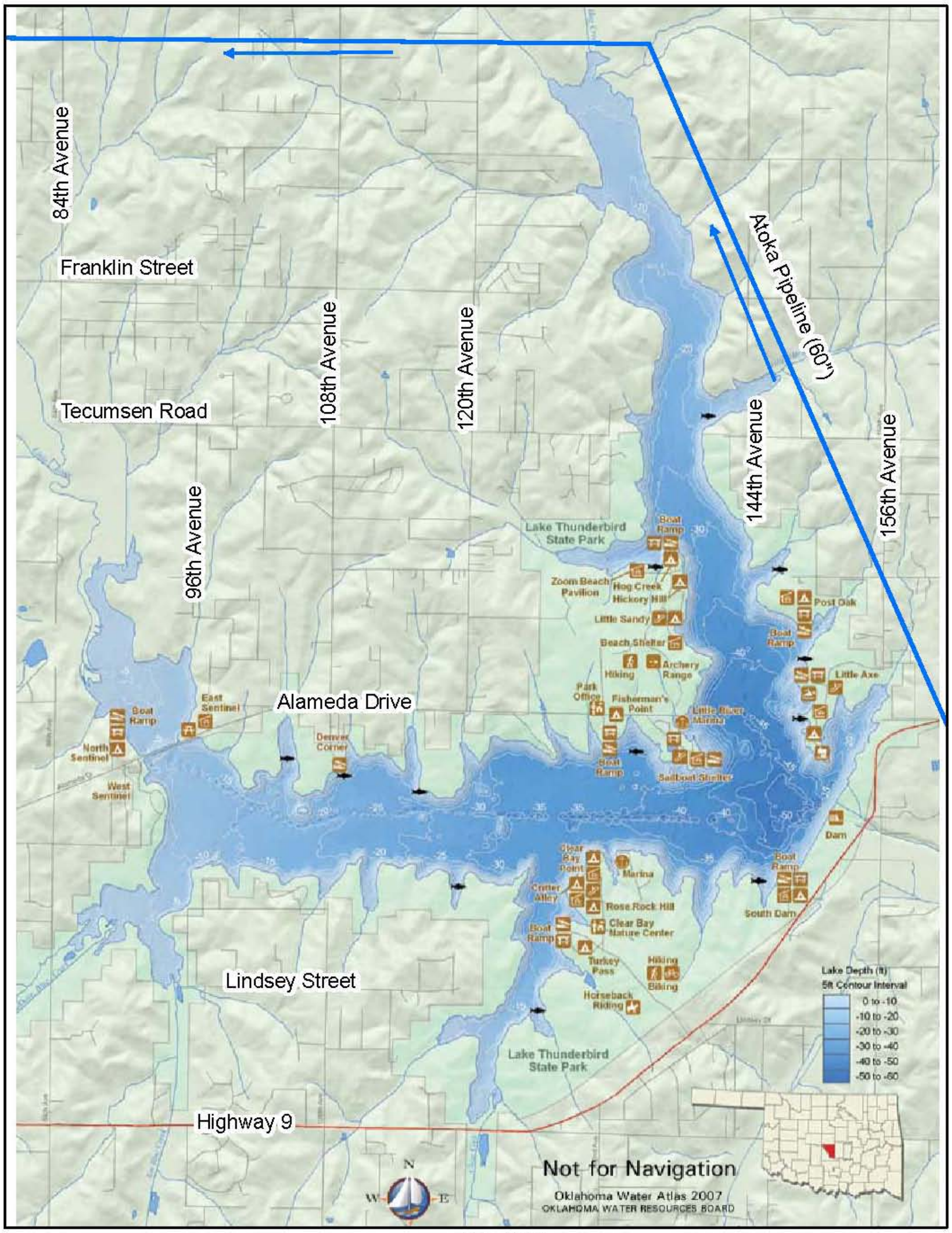

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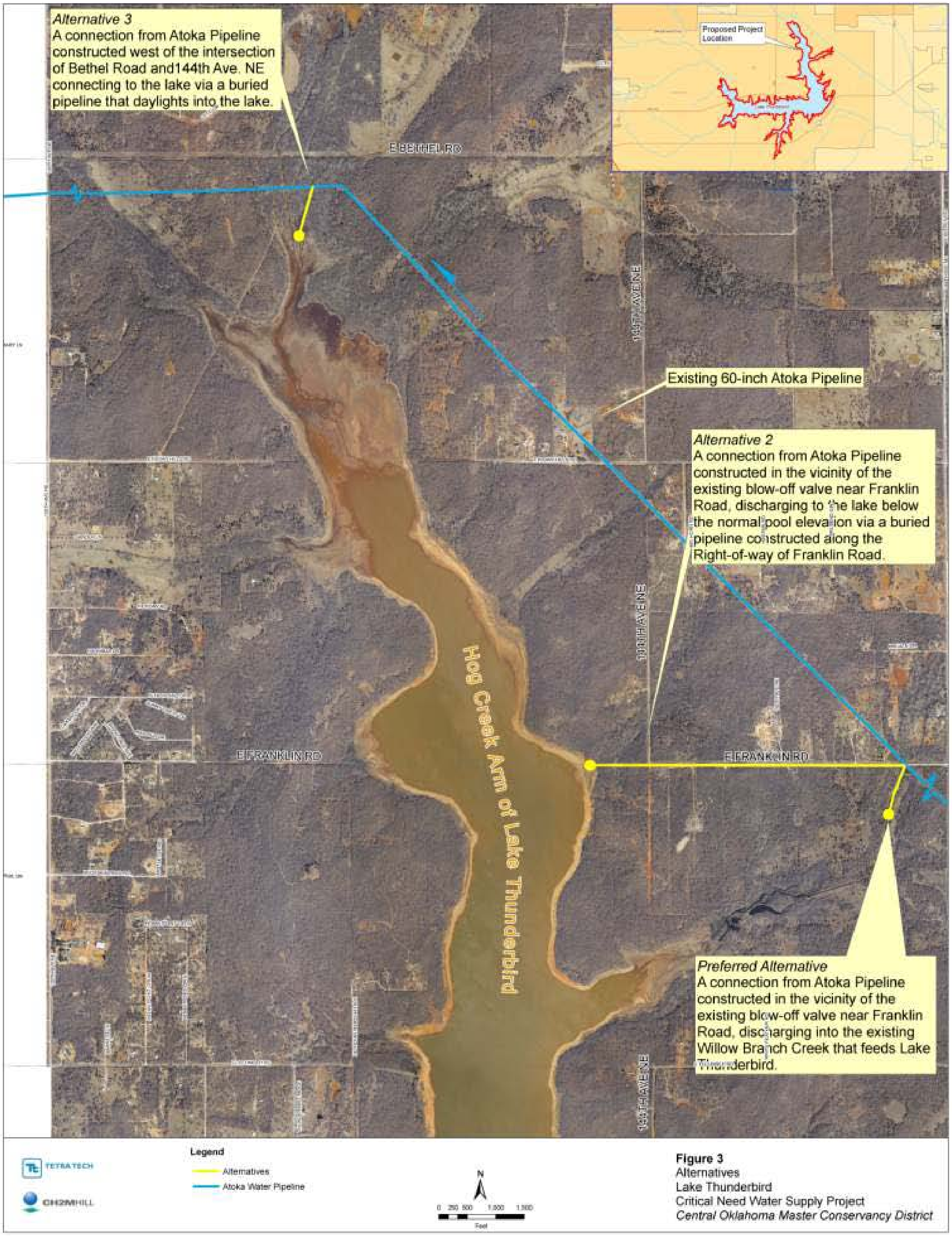
Figure 2
Lake Thunderbird, Nearby Roads, and Atoka Pipeline
Lake Thunderbird
Critical Need Water Supply Project
Central Oklahoma Master Conservancy District

1.2 Study Area for this Environmental Assessment

The study area investigated in this EA encompasses primarily the Lake Thunderbird reservoir and immediately adjacent lands. The study area also includes two possible connection points between the proposed augmentation pipeline and the Atoka Pipeline and three possible rights-of-way (ROW) between these connection points and Lake Thunderbird. The general locations of these two connection points and three ROWs are shown in Figure 3, and are described in Section 3.0 (Alternatives Evaluated in this EA).

In defining the study area, it was decided that Atoka Pipeline and the upstream sources of the water in the pipeline that are supplying the augmentation water for this project (Lake Atoka and McGee Creek) are outside the scope of this EA. This is because the amount of water being delivered through the Atoka Pipeline for this augmentation project is within the existing historical water rights already allocated to Oklahoma City from those sources. Therefore, any impacts on these upstream sources that might be associated with the use of these historical water rights would be within the purview of Oklahoma City, and would not be affected by this proposed augmentation project.

Figure 3: Proposed Alternatives



2.0 PROJECT DESCRIPTION

The proposed **Lake Thunderbird Critical Need Water Supply Project** consists of the following:

- An agreement between COMCD and Oklahoma City for COMCD to purchase and draw augmentation water from the nearby Oklahoma City-owned Atoka Pipeline that presently conveys raw water from Lake Atoka to Stanley Draper Lake (Figures 1 and 2).
- A connection between the Atoka Pipeline and Lake Thunderbird to be constructed, maintained, and operated by COMCD and used as needed under the agreement to convey raw augmentation water to Lake Thunderbird during critical drought periods.
- The existing storage capacity of Lake Thunderbird, as well as the existing pumping stations and pipelines presently conveying raw water from the lake to the cities of Norman, Del City, and Midwest City. No changes or modifications to these facilities would be required.

The existing and new elements that together comprise the proposed project are described in the following paragraphs.

2.1 Existing Elements of the Proposed Project

The existing elements of the proposed project are the original components of the Norman Project, which include: (a) Norman Dam on Little River approximately 13 miles east of the City of Norman; (b) two pump stations; (c) buried water pipelines to the cities of Norman, Midwest City, and Del City; and (d) numerous public recreation facilities and access areas around the lake (See Figure 2). One pipeline provides water directly from the lake to the City of Norman. A second line delivers water to a re-lift pump station, which then pumps water in separate pipelines to Del City and Midwest City.

The four existing elements are further described as follows:

- ***Norman Dam.*** The dam is an earthfill structure 7,260 feet long and 144 feet high. The spillway is uncontrolled with a capacity of 2,840 cubic feet per second (cfs). The outlet works consists of an approach channel, trash-rack structure, intake conduit, gate chamber, discharge conduit, stilling basin, and outlet channel. Maximum flow through the outlet works is 6,950 cfs. Lake Thunderbird has a maximum capacity of 196,200 acre-feet (not including temporary storage available for very large storms) and a surface area of 8,788 acres when at capacity.

- ***Reservoir Pump Station.*** This primary station is located on the north shore of Lake Thunderbird and houses eight vertical turbine pumping units. Four of the units supply water to the City of Norman Pipeline, with a total capacity just over 22 cfs. The other four units supply water to the Midwest City/Del City Pipeline system, with a total capacity of just over 29 cfs.

- ***Delivery Pipelines and Re-lift Pump Station.*** The City of Norman pipeline is a reinforced concrete pressure pipe, which begins at the Reservoir Pump Station and travels in a buried corridor approximately 8½ miles to the City of Norman. The pipeline has a capacity of approximately 22 cfs. A combined Midwest-Del City pipeline also begins at the Reservoir Pump Station and travels underground about 12 miles to the Re-lift Pump Station. For this initial 12 miles, the pipeline is a precast concrete pressure pipe with a capacity of 28 cfs. From the Re-lift Pump Station, two separate pipelines serve Midwest City and Del City. From the Re-lift Pump Station to its delivery point in Midwest City, the buried supply pipeline is a precast concrete pressure pipe with a capacity of just over 21 cfs. The buried Del City pipeline travels about 6½ miles from the Re-lift Pumping Station to the delivery point in Del City. It is a precast concrete pressure pipe with a capacity just under 8 cfs.

- ***Recreation Facilities and Access Points.*** Reclamation originally entered into a management agreement with the Oklahoma Tourism and Recreation Department (OTRD) to manage the lower reservoir area as a state park. Reclamation also entered into a management agreement with the Oklahoma Department of Wildlife Conservation (ODWC) to manage the upper reservoir area as a wildlife management area. In the late 1970s, ODWC transferred management of the wildlife area to OTRD. The two areas are now considered Lake Thunderbird State Park. In addition to traditional state park facilities that are operated and maintained by OTRD, there are additional recreation opportunities provided by concessionaires, including horseback riding, marina-based boating services, and lakeside dining. The state park is separated into two management areas: (a) Clear Bay on the south side of the lake, and (b) Indian Point on the north side of the lake. There are numerous public recreation access areas around the lake with different combinations of recreation resources at each. Some of these resources are accessible to those with disabilities. Figure 2 (previous) depicts the amenities of Lake Thunderbird State Park.

2.2 New Elements of the Proposed Project

The new elements of the proposed project would include those physical components required to connect the Oklahoma City-owned Atoka Pipeline (on the east side of the lake) to Lake Thunderbird to convey raw augmentation water for storage and use by COMCD during critical drought periods. The four main elements required for the proposed project are described as follows:

- ***Connection Point at the Atoka Pipeline.*** The connection to the Atoka Pipeline would include a positive shut-off valve to open and close the flow, as well as a flow meter to monitor the amount and rate of raw water withdrawal.

- ***Raw Water Conveyance Pipeline.*** The raw water drawn from the Atoka Pipeline would be conveyed via a buried ductile steel pipe to a designated discharge point.

- ***Raw Water Aeration System.*** This would be comprised of a non-mechanical means of aerating the raw water drawn from the Atoka Pipeline at or near the point of connection. The non-mechanical means of aeration would utilize cascade aeration, which allows oxygen in the surrounding air to mix with the water flow and enhance the dissolved oxygen in the augmentation water.

- ***Discharge Structure.*** The point of discharge of raw water from the conveyance pipeline would include a concrete structure with velocity baffles and smooth hydraulic transitions to minimize turbulence and the potential for erosion at the point of discharge.

2.3 Operation of the Proposed Project

The operation of the proposed project would be manually controlled by COMCD. The proposed valve at the Atoka Pipeline connection would be opened and closed manually to either initiate or terminate the augmentation flow based on needs during future critical drought periods. Tetra Tech, in consultation with COMCD and Reclamation, utilized the Lake Thunderbird Yield Model devised by Reclamation as part of a *Lake Operational Study* (Tetra Tech 2009) to develop an optimum operations plan for the proposed project that meets the primary objective of providing water to the member cities during critical droughts.

Under the proposed operations plan, COMCD would initiate the flow of augmentation water from the Atoka Pipeline during future critical droughts when the lake level drops to approximately 1,020 feet and terminate the flow of augmentation water when the lake level reaches an elevation of 1,036 feet. An agreement would be developed with Oklahoma City to supply COMCD with up to 4,600 acre-feet per year of augmentation water during critical drought periods. The actual volume and duration of augmentation water to be drawn by COMCD from the 4,600 acre-feet available in the proposed agreement would be determined at the time of a critical drought.

The proposed operations plan takes into account the Conservation Storage Pool in Lake Thunderbird that COMCD maintains, which is the storage volume in the lake reserved for COMCD to meet contractual obligations to provide municipal and industrial water supply to the member cities. The Conservation Storage Pool storage volume is maintained between lake levels 1,010 feet and 1,039 feet. The proposed operations plan also takes into account the influence that the cost of purchasing augmentation water from the Atoka Pipeline would have on the volume and duration of augmentation water. The lake levels in the proposed operations plan for initiation and termination of augmentation water (1,020 feet and 1,036 feet, respectively) were derived through the analysis and evaluation process summarized here:

- Numerous sets of initiation-termination lake levels (approximately 79) were simulated by Tetra Tech using Reclamation's Lake Thunderbird Yield Model, which is based on 82 years of historical data. For each set, the duration, total volume, and rate of augmentation water importation were calculated.

- The cost of the raw water (based on a forecast purchase price from Oklahoma City) was incorporated into the analysis to determine the cost of augmentation water for each set of lake levels, as well as projected cash-flow needs for COMCD to be in a position to supply augmentation water during future critical drought periods.

- COMCD held preliminary discussions with Oklahoma City regarding the proposed project and the long-term quantity of water available for augmentation. Taking into account all of the parameters discussed, COMCD then selected the initiation lake level of 1,020 feet and termination lake level of 1,036 feet for importing augmentation water as the optimum operations plan for the proposed project.

3.0 ALTERNATIVES EVALUATED IN THIS EA

As part of this proposed project, COMCD and Reclamation identified three alternative means of conveying the raw water from the Atoka Pipeline to Lake Thunderbird. These three action alternatives were evaluated as part of this EA, along with a No Action Alternative. Based on the evaluation of alternatives, a preferred alternative was selected among the action alternatives. The four alternatives evaluated and basis for selection of the preferred alternative (and rejection of the other alternatives, including no-action) are summarized as follows:

- **Preferred Alternative: Pipeline-Natural Creek Channel.** This alternative would involve constructing a short buried pipeline connection from the Atoka Pipeline at the existing blow-off valve near Franklin Road, to a discharge point in the existing Willow Branch Creek as shown in Figure 3, previously. This alternative was selected as the preferred alternative because it potentially disturbs less area than the other two action alternatives, involves no impacts to wetlands that could potentially require mitigation, has the shortest construction period, and is the least costly of the action alternatives.

- **Alternative 2: Pipeline along Franklin Road.** This alternative would involve constructing a buried pipeline along the right-of-way of Franklin Road, from the same point of connection to the Atoka Pipeline as Alternative 1, to a discharge point in Lake Thunderbird as shown previously in Figure 3. This alternative was rejected because, when compared to the preferred alternative, it potentially disturbs more area (including wetlands), would likely require wetland mitigation, has a longer construction period, and has a higher construction cost.

- **Alternative 3: Pipeline at North end of Lake.** This alternative would involve constructing a buried pipeline connection from a new connection point on the Atoka Pipeline west of the intersection of Bethel Road and 144th Avenue NE to a discharge point in Lake Thunderbird as shown in Figure 3, previously. This alternative was also rejected because it would require a new connection point on the Atoka pipeline; this connection could be complicated due to the age of the pipeline and the need to take the pipeline out of service during construction. Furthermore, when compared to the preferred alternative, it is similar to Alternative 2 in that it potentially disturbs more area (including wetlands), would likely require wetland mitigation, and has a longer construction period and higher construction cost.

- **No Action Alternative.** This alternative would involve not developing a raw water connection between the Atoka Pipeline and Lake Thunderbird. With this alternative, raw water would continue to be provided by COMCD to the member cities as it currently is with the existing infrastructure and existing system, and without augmentation water being available during critical drought periods. This alternative was rejected because, with this alternative, COMCD would not have augmentation water available to extend the period of supplying adequate quantities of raw water to the member cities during critical drought conditions, and substantial water conservation measures or other restrictions would likely need to be put in place sooner than they would if augmentation water were available.

4.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

4.1 Introduction

Baseline information in the study area on the physical, biological, and man-made resources potentially affected by the proposed project was assembled, and potential adverse and beneficial impacts of implementing the proposed project were identified and evaluated. This process included evaluation of potential impacts on the following resources:

- Water Resources
- Biological Resources
- Cultural Resources
- Land Use
- Native American Trust Assets
- Recreation Resources
- Socioeconomics
- Transportation
- Utilities
- Hazardous and Toxic Substances
- Public Safety and Noise
- Air Resources
- Climate, Geology, Soils
- Prime and Unique Farmlands
- Climate Change
- Aesthetic Resources

The evaluation of potential impacts on the above resource areas included *Direct Impacts*, those potentially occurring during project construction (short-term), and *Indirect Impacts*, those potentially occurring during project operations (longer-term). Cumulative impacts of the proposed action, when added to other past, present, and reasonably foreseeable future actions, were also addressed.

Based on the evaluation of potential impacts, it has become evident that implementation of the proposed project is not anticipated to have any impacts on Land Use, Hazardous and Toxic Substances, Noise, Air Resources, Geology and Soils, Prime and Unique Farmlands, and Utilities or contribute to cumulative impacts. Therefore, these resources are not further discussed in this EA.

Similarly, based on the evaluation, it is evident that implementation of the proposed project would have potential direct and/or indirect impacts on Water Resources, Biological Resources, Recreational Resources, Transportation, Socioeconomics, Public Safety, and Aesthetics. In the following sections, the baseline conditions for these resources within the proposed project study area (Affected Environment) and the potential direct and/or indirect impacts on these resources from implementing the preferred alternative are discussed.

Although there are no anticipated impacts to Cultural Resources, Native American Trust Assets, and Global Climate Change, discussions of these resources are included in the following sections in accordance with current Reclamation policy and because informal consultation with the Oklahoma State Historic Preservation Office (SHPO) is required when assessing potential impacts to Cultural Resources.

4.2 Water Resources

4.2.1 Affected Environment

Hydrology

Lake Thunderbird is a 6,070-acre reservoir (at full conservation pool) with 86 miles of shoreline. At conservation pool elevation, the elevation associated with the storage volume in the lake reserved for COMCD to meet its contractual obligations, the reservoir capacity is 119,565 acre-feet. Flood control, for seasonal flood storage, adds another 76,648 acre-feet of capacity, and surcharge capacity, necessary for flash flooding and very large storms, is 171,213 acre-feet (Table 1) (Bureau of Reclamation 2009).

Table 1: Hydrologic and Morphometric Lake Characteristics

Pool	Capacity (acre-feet)	Total Storage at Pool (acre-feet)	Elevation (mean sea level)	Area (surface acres)
Conservation	**119,565**	**119,565**	**1,039.0**	**6,070**
Flood Control	**76,648**	**196,213**	**1,049.4**	**8,788**
Surcharge	**171,213**	**367,426**	**1,064.7**	**13,829**

Source: Bureau of Reclamation 2009

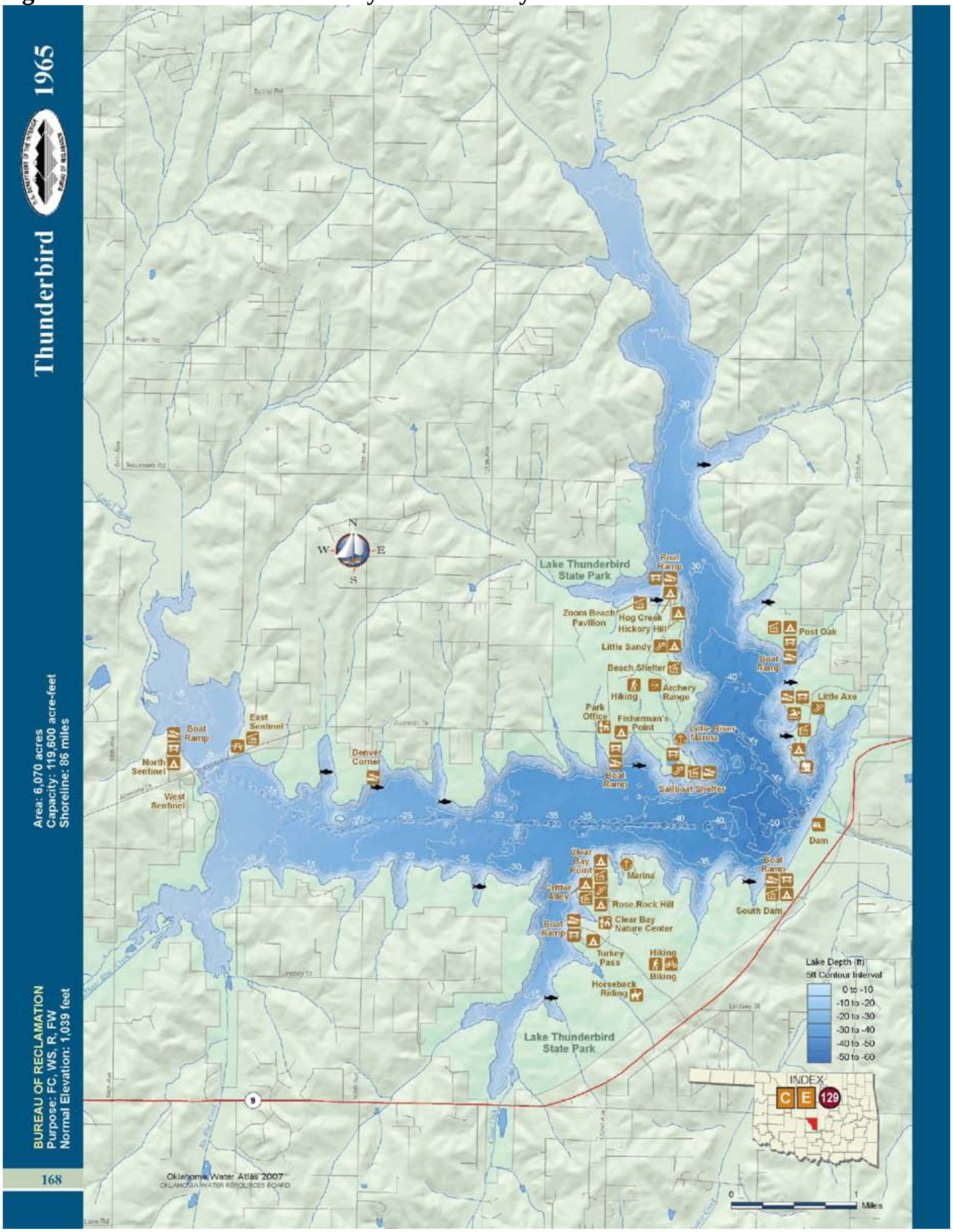
The lake is in the Little River watershed and impounds the Little River and Hog Creek at their juncture in Northeast Cleveland County. The watershed occupies 256 square miles of residential, commercial, and agricultural lands. The watershed includes Stanley Draper Lake, which encompasses approximately 5% of the watershed (13.07 square miles) (USGS 2008). Average annual precipitation is 35.98 inches. Maximum depth near the Norman Dam is 57.6 feet and the average depth of the lake is 19.70 feet (Bureau of Reclamation 2009). Water quality is discussed further in a subsequent section. Figure 4 provides the result of a bathymetric survey performed for Reclamation; bathymetric surveys provide depths throughout a lake.

Among the COMCD member cities, the City of Norman was allocated an annual-average of 8.4 million gallons per day (mgd) under its current contract (43.8% of the supply). Midwest City's allocation is approximately 7.8 mgd (40.4% of the available annual yield), and Del City's allocation is approximately 3.1 mgd (15.8% of the available annual yield). The maximum-annual yield of Lake Thunderbird is 21,600 acre-feet per year (or 19.4 mgd), as defined in its enabling legislation.

Additional water may be purchased by the member cities on an as-negotiated basis, provided surplus water is available in the reservoir at that time. Neither Midwest City nor Del City has ever utilized their full allotments to date. The City of Norman has exceeded its allotment in the lake 5 times since the lake was filled (City of Norman 2001).

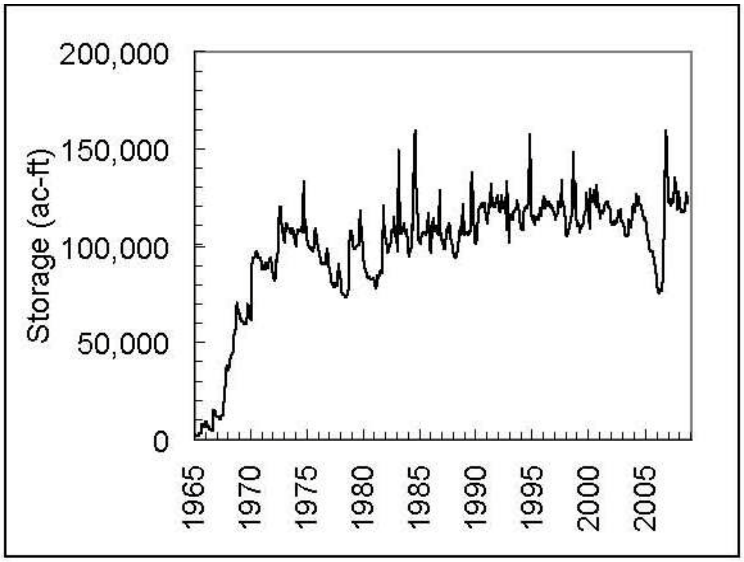
Inflows to Lake Thunderbird are primarily precipitation and tributary inflows; the outflows are primarily evaporation, gated releases, and raw water supply (OWRB 2006). Average discharge from the lake measured by the U.S. Geological Survey (USGS) gauge located downstream of the Dam, between 1982 and 2008, is an annual volume of 58,613.6 acre-feet or 52.33 mgd. Water levels are expected to vary from year to year but have been relatively consistent since the lake was filled in the early 1970s (Vieux, Inc. 2009). The exception is the drought in 2005 and 2006, followed by a record high water level in 2007. In 2006, the lake experienced one of its lowest levels, with a surface area of 4,967 acres in November. The record high level in 2007 was associated with a surface area of 7,270 acres in June 2007 (Vieux, Inc. 2009). Figure 5 provides an illustration of the varying lake levels at the end of each month from 1965 through mid-2009.

Figure 4: Lake Thunderbird Bathymetric Survey



Source: OWRB 2007b

Figure 5: Lake Levels at Month End, 1965 to mid-2009



Source: Vieux, Inc. 2009

Table 2 presents the monthly inflow and outflow rates for Lake Thunderbird during 2005 and 2006 based on U.S. Army Corps of Engineers (USACE) data. Both years are considered drought years, with the lake experiencing one of its lowest levels in 2006. In the table, the total inflow each month is the sum of stream and rainfall volumes, and the total outflow is the sum of evaporation, water supply, and spill release volumes. The difference between the total inflow and the total outflow for each month is also shown, as is the change in lake volume. The data in the table highlights the reduced volume of water in the lake that occurred during the 2005-2006 drought, as evidenced by a considerably greater total outflow than total inflow.

Table 2: Monthly Inflows and Outflows to/from Lake Thunderbird

Month	Total Inflows (acre-feet)	Total Outflows (acre-feet)	Difference (acre-feet)	Change in Lake Volume (acre-feet)
January 2005	**7745**	**2516**	**5229**	**3807**
February 2005	**6972**	**9737**	**-2765**	**-2470**
March 2005	**3490**	**3997**	**-507**	**-669**
April 2005	**2307**	**4948**	**-2641**	**-1646**
May 2005	**3191**	**5309**	**-2118**	**-1852**
June 2005	**6871**	**6390**	**481**	**-360**
July 2005	**5496**	**7442**	**-1946**	**-2212**
August 2005	**6675**	**6110**	**565**	**0**
September 2005	**1921**	**5730**	**-3809**	**-3499**
October 2005	**2014**	**4418**	**-2404**	**-2521**
November 2005	**2**	**3572**	**-3570**	**-3447**
December 2005	**159**	**2384**	**-2225**	**-1955**
Total 2005	**46,843**	**62,552**	**-15,709**	**-16,824**
January 2006	**933**	**3368**	**-2435**	**-2200**
February 2006	**458**	**2475**	**-2017**	**-1925**
March 2006	**3846**	**3741**	**105**	**-330**
April 2006	**5893**	**5121**	**772**	**165**
May 2006	**3827**	**5446**	**-1619**	**-2047**
June 2006	**3973**	**6030**	**-2057**	**-2930**
July 2006	**1302**	**6808**	**-5506**	**-5103**
August 2006	**2773**	**6289**	**-3516**	**-3758**
September 2006	**661**	**4687**	**-4026**	**-3973**
October 2006	**2744**	**3809**	**-1065**	**-2004**
November 2006	**2087**	**2557**	**-470**	**-1167**
December 2006	**4903**	**2221**	**2682**	**1436**
Total 2006	**33,400**	**52,552**	**-19,152**	**-23,656**

Source: OWRB 2006 and 2007a

Water Quality

General. The state of Oklahoma has identified Lake Thunderbird itself as Waterbody OK520810000020_00. Hog Creek and the west branch of Hog Creek (officially called Hog Creek, West Branch) are OK520810000030_00 and 520810000040_00, respectively. There are 18 total classified waterbody segments within the Lake Thunderbird watershed, not including Stanley Draper Lake, which is analyzed separately from the tributaries feeding Lake Thunderbird. Willow Branch Creek is not a classified segment within the state (i.e., it has not been assigned a specific water body identification number, thus is not assessed as part of the bi-annual Surface Water Quality Inventory required by Section 305(b) of the Clean Water Act) (ODEQ 2008).

Lake Thunderbird is eutrophic during most summer months, showing a high level of phosphorus and other nutrient loading with reduced dissolved oxygen. The elevated phosphorus and nitrogen levels have been attributed to upstream activity (Bureau of Reclamation 2009). As part of the continuing efforts to improve water quality in Lake Thunderbird, the Oklahoma Water Resources Board (OWRB) and COMCD continue to monitor chlorophyll-*a*, and nutrient concentrations in the lake. A watershed assessment was conducted and provided recommendations for Best Management Practices (BMPs) to be implemented within the watershed. Additionally, COMCD is currently in the process of developing a 2-year pilot study to perform a cost-benefit analysis on injecting oxygen into the lake to improve dissolved oxygen levels. If the effort proves successful, the project will continue for the foreseeable future (Worden 2010). Further, shoreline erosion control projects at Lake Thunderbird have been implemented through EPA's §319 nonpoint source pollution grants program (Bureau of Reclamation 2009).

To satisfy the requirements of Section 305(b) of the Clean Water Act, the state of Oklahoma must monitor all classified waterbodies in the state and provide a summary of these activities every other year. In Oklahoma, this summary is called the *Integrated Report* (ODEQ 2008). As part of the water quality standards, each classified waterbody in the state is assigned a beneficial use, which is associated with specific standards that must be met by that water body. Lake Thunderbird and the other waterbodies in its watershed have been assigned the following beneficial uses (OWRB 2008a):

- Public and Private Water Supply
- Warm Water Aquatic Community
- Agriculture

- Primary Body Contact Recreation
- Aesthetics

In the latest Oklahoma Department of Environmental Quality (ODEQ) *Integrated Report* (ODEQ 2008), Lake Thunderbird is classified as not supporting its beneficial use designations of warm water aquatic community and Public & Private Water Supply. Also within the Lake Thunderbird watershed, 6 tributaries, including Hog Creek and the west branch of Hog Creek, are all considered impaired because they are not supporting one or more of their designated beneficial uses. The cause of impairments include elevated chlorophyll-*a*, low dissolved oxygen, *E. coli* bacteria, total dissolved solids, and elevated turbidity (ODEQ 2008).

When a water body is classified as not supporting one or more of its designated beneficial uses, to satisfy Section 303(d) of the CWA, that water body is then placed on a list of impaired waters to be addressed, often called the 303(d) list. Because there are no significant point discharges in the Lake Thunderbird watershed, ODEQ may develop a watershed management plan rather than conducting a Total Maximum Daily Load analysis, as is typically required when a waterbody is considered impaired. An intensive one-year watershed and lake monitoring study was completed at the end of April 2009. ODEQ is currently developing the HSPF (Hydrologic Simulation Program Fortran) model for the watershed to perform further analyses, and activities to initiate a 3-dimensional lake model are being finalized. ODEQ intends to have a draft report resulting from both modeling efforts in June of 2010 (Fang 2009).

The Beneficial Use Monitoring Program (BUMP), administered by OWRB, is the program ODEQ uses to satisfy the monitoring requirements of Section 305(b) of the Clean Water Act. This program provides summaries of the information needed for the water quality standards evaluations and facilitates the prioritization of pollution control activities. The specific objectives of the BUMP are to detect and quantify water quality trends, document and quantify impairments of assigned beneficial uses, and identify pollution problems before they become a significant challenge (OWRB 2008b). BUMP data used in the analysis performed for this EA is presented in a later section.

Raw Water Characterization. Table 3 summarizes the raw water quality for Lake Thunderbird as sampled by Norman water treatment plant staff and supplemented with BUMP data (OWRB 2007c) and data from the *2003 Lake Thunderbird Algae Report* (OWRB 2004). The samples for the Monthly Operating Reports (MORs) are collected at the influent to the clarifiers, which is after chlorine and ammonia have been added. The samples for the total organic carbon are collected at a siphon on the raw water tank prior to any chemical addition. Minima, maxima, and averages for the years 2004 to 2008 are included, along with the five-year assessments.

Table 4 summarizes the raw water quality for the water in the Lake Atoka pipeline, which is assumed to be equivalent to the water quality in Lake Atoka itself. Minima, maxima, and averages for years 2004 to 2008 are included, along with the five-year assessment. The two main sources of data for this exhibit are *Oklahoma City Monthly Water Quality Monitoring Reports* provided by Oklahoma City staff and the 2006 to 2007 BUMP data for Lake Atoka (OWRB 2007c). The Oklahoma City data is based on a sample collection point located at the outfall of the Atoka Pipeline.

Table 3: Raw Water Characterization for Lake Thunderbird by Year and 5-year Overall

Constituent	2004			2005			2006			2007			2008			Overall		
	min	max	avg	min	max	avg	min	max	avg	min	max	avg	min	max	avg	min	max	avg
Temperature (Celsius)[1]	**6.0**	**27.0**	**17.6**	**6.0**	**28.0**	**17.6**	**6.0**	**29.0**	**18.0**	**6.0**	**29.0**	**18.2**	**6.0**	**29.0**	**17.8**	**6.0**	**29.0**	**17.8**
Chloride (mg/L)[1]	**12.0**	**35.0**	**26.9**	**25.0**	**35.0**	**28.5**	**28.0**	**39.0**	**32.2**	**20.0**	**38.0**	**27.3**	**21.0**	**32.0**	**25.1**	**12.0**	**39.0**	**28.0**
M alkalinity[1]	**138.0**	**180.0**	**163.0**	**146.0**	**192.0**	**173.3**	**88.0**	**198.0**	**180.5**	**56.0**	**194.0**	**159.1**	**106.0**	**182.0**	**157.6**	**56.0**	**198.0**	**166.7**
Total Hardness (mg/L as $CaCO_3$)[1]	**146.0**	**196.0**	**168.9**	**146.0**	**198.0**	**177.1**	**160.0**	**218.0**	**181.9**	**90.0**	**188.0**	**145.2**	**110.0**	**176.0**	**145.2**	**90.0**	**218.0**	**163.7**
Calcium Hardness (mg/L as $CaCO_3$)[1]	**70.0**	**158.0**	**100.2**	**76.0**	**160.0**	**105.0**	**72.0**	**134.0**	**101.8**	**50.0**	**128.0**	**93.8**	**26.0**	**188.0**	**104.5**	**26.0**	**188.0**	**101.1**
Magnesium Hardness (mg/L as $CaCO_3$)[1]	**20.0**	**112.0**	**68.8**	**18.0**	**101.0**	**72.1**	**46.0**	**114.0**	**80.0**	**2.0**	**106.0**	**51.3**	**1.0**	**106.0**	**40.9**	**1.0**	**114.0**	**62.6**
Turbidity (NTU)[1]	**3.0**	**29.0**	**10.7**	**2.0**	**34.0**	**7.6**	**5.0**	**33.0**	**12.6**	**4.0**	**56.0**	**15.5**	**3.0**	**46.0**	**12.5**	**2.0**	**56.0**	**11.8**
TOC (mg/L)[2]	**4.2**	**5.2**	**4.7**	**4.7**	**5.6**	**5.2**	**4.5**	**6.2**	**5.4**	**5.5**	**6.6**	**6.1**	**5.0**	**7.0**	**5.5**	**4.2**	**7.0**	**5.4**
pH[3]	**7.3**	**8.8**	**8.0**	**7.0**	**9.1**	**8.0**	**7.5**	**9.2**	**8.2**	**7.0**	**9.1**	**7.9**	**-**	**-**	**-**	**7.0**	**9.2**	**8.0**
TDS (mg/L)[4]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**180**	**230**	**210**
Color (PCU)[4]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**<70**
Total Nitrogen[4]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.59**	**1.18**	**0.78**
Total Phosphorous[4]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.023**	**0.429**	**0.059**

1. **Obtained from Lake Thunderbird Monthly Operation Report Summaries provided by Norman Utility.**
2. **Obtained from Lake Thunderbird Total Organic Carbon monthly report summary provided by Norman Utility.**
3. **Obtained from Lake Thunderbird daily pH readings summary provided by Norman Utility.**
4. **Obtained from 2006-2007 Local Monitoring (BUMP) Program report for Lake Thunderbird (OWRB 2007c).**
5. **Obtained from the 2003 Lake Thunderbird Algae Report (OWRB 2004).**

Table 4: Raw Water Characterization for the Lake Atoka Pipeline by Year and 5-year Overall

Constituent	2004			2005			2006			2007			2008			Overall		
	min	max	avg	min	max	avg	min	max	avg	min	max	avg	min	max	avg	min	max	avg
Carbonate Alkalinity (mg/L as $CaCO_3$)[1]	<0.4	<0.4	<0.4	0.00	0.40	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.01
Bicarbonate Alkalinity (mg/L as $CaCO_3$)[1]	25.0	30.0	27.0	25.6	39.5	36.3	21.0	56.0	35.6	0.0	36.0	26.4	24.0	36.0	28.8	0.0	56.0	30.8
Noncarbonate Hardness (mg/L as $CaCO_3$)[1]	2.00	14.00	6.50	0.45	28.00	7.76	2.73	11.20	5.97	0.00	48.60	10.88	1.00	25.40	8.47	0.00	48.60	7.91
Hardness (grains/gallons)[1]	1.64	2.57	1.96	2.34	3.16	2.56	1.52	2.82	2.29	1.68	4.71	2.27	1.75	3.12	2.14	1.52	4.71	2.24
Temperature (Celsius)	No historical regularly monitored data available.																	
Chloride (mg/L)[1]	4.50	5.72	5.02	5.20	5.96	5.69	4.65	6.20	5.63	2.78	5.57	3.89	2.95	4.97	3.56	2.78	6.20	4.76
Phenolphthalein Alkalinity (mg/L as $CaCO_3$)[1]	<0.4	<0.4	<0.4	0.00	0.20	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.01
Total Alkalinity (mg/L as $CaCO_3$)[1]	25.0	30.0	27.0	26.0	39.5	36.4	21.0	56.0	35.6	25.0	36.0	28.8	24.0	36.0	28.8	21.0	56.0	31.3
Total Hardness (mg/L as $CaCO_3$)[1]	28.0	44.0	33.5	40.0	54.0	43.8	26.0	48.2	39.1	28.8	80.6	38.8	30.0	53.4	36.6	26.0	80.6	38.3
Calcium (mg/L as Ca^{2+})[1]	5.60	9.60	7.73	8.80	9.60	9.33	4.80	11.04	9.16	2.72	15.52	8.43	7.44	11.84	9.47	2.72	15.52	8.82
Magnesium (mg/L as Mg^{2+})[1]	2.50	6.00	3.54	4.00	8.00	5.11	3.05	5.50	4.06	2.10	10.45	4.42	1.40	5.95	3.22	1.40	10.45	4.07
Turbidity (NTU)[2]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	95	53
Total Organic Carbon (mg/L)[1]	3.83	5.33	4.45	1.37	5.94	3.93	4.45	5.77	4.90	4.76	7.05	5.80	4.61	6.99	5.59	1.37	7.05	4.93
pH (Std. Units)[1]	7.42	8.40	7.75	7.53	8.36	7.71	7.29	7.80	7.59	7.00	8.60	7.35	7.20	8.05	7.48	7.00	8.60	7.58
Total Dissolved Solids (mg/L)[1]	102.0	136.0	117.2	81.0	102.0	91.9	51.0	103.0	86.3	54.0	102.0	73.7	40.0	97.0	73.5	40.0	136.0	88.5
Color (PCU)[2]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	160
Iron (mg/L)[1]	0.49	2.30	1.28	0.22	0.93	0.66	0.38	2.46	1.28	0.48	3.56	2.09	0.33	2.48	1.21	0.22	3.56	1.42
Total Nitrogen[2]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.46	1.06	0.71
Total Phosphorous[2]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.039	0.198	0.105
Taste and Odor (Biovolume um^3/mL)	No historical regularly monitored data available.																	
Nitrate (mg/L as NO_3-N)[1]	0.12	0.50	0.19	<0.003	0.11	0.03	0.01	0.12	0.05	<0.008	0.20	0.10	<0.001	0.20	<0.01	<0.001	0.50	0.10
Nitrite (mg/L as NO_2-N)[1]	<0.025	<0.025	<0.025	<0.025	0.015413	<0.025	<0.001	<0.025	<0.04	<0.001	0.011	<0.002	<0.001	0.0105	<0.001	<0.001	0.015413	0.01
Sulfate (mg/L)[1]	11.9	14.9	12.9	12.4	13.4	13.1	7.5	14.2	12.6	6.7	13.2	9.2	7.4	11.2	9.3	6.7	14.9	11.30
Bromide (mg/L)[1]	0.04	0.11	0.08	0.02	0.03	0.03	0.02	0.05	0.04	0.02	0.05	0.03	0.03	0.31	0.05	0.02	0.31	0.04
Fluoride (mg/L)[1]	0.07	0.16	0.10	0.08	0.09	0.09	0.06	0.15	0.11	0.09	0.15	0.10	0.09	0.13	0.11	0.06	0.16	0.10
Silica (mg/L as SiO_2)[1]	3.98	15.40	8.39	4.63	10.25	7.45	3.90	12.68	6.58	3.80	19.51	12.10	0.55	23.79	9.98	0.55	23.79	10.05
Sodium[1]	4.00	8.30	5.70	5.63	7.48	6.71	5.03	8.18	7.38	4.24	7.04	5.37	1.80	6.26	4.46	1.80	8.30	5.81
Potassium[1]	2.24	3.30	2.79	3.15	3.50	3.25	1.74	3.52	3.06	1.67	3.20	2.71	1.45	4.12	2.75	1.45	4.12	2.91
Specific Conductance (uSiemens/Cm)[1]	75.0	113.0	99.9	102.0	124.0	120.5	70.0	128.0	116.7	88.0	106.0	93.9	0.0	112.0	74.8	0.0	128.0	105.44
Ortho Phosphate (mg/L as as PO_4)[1]	0.02	0.02	0.02	<0.06	<0.2	<0.2	<0.2	<0.2	<0.2	<0.057	<0.2	<0.07	<0.057	<0.057	<0.057	<0.057	0.02	2.35

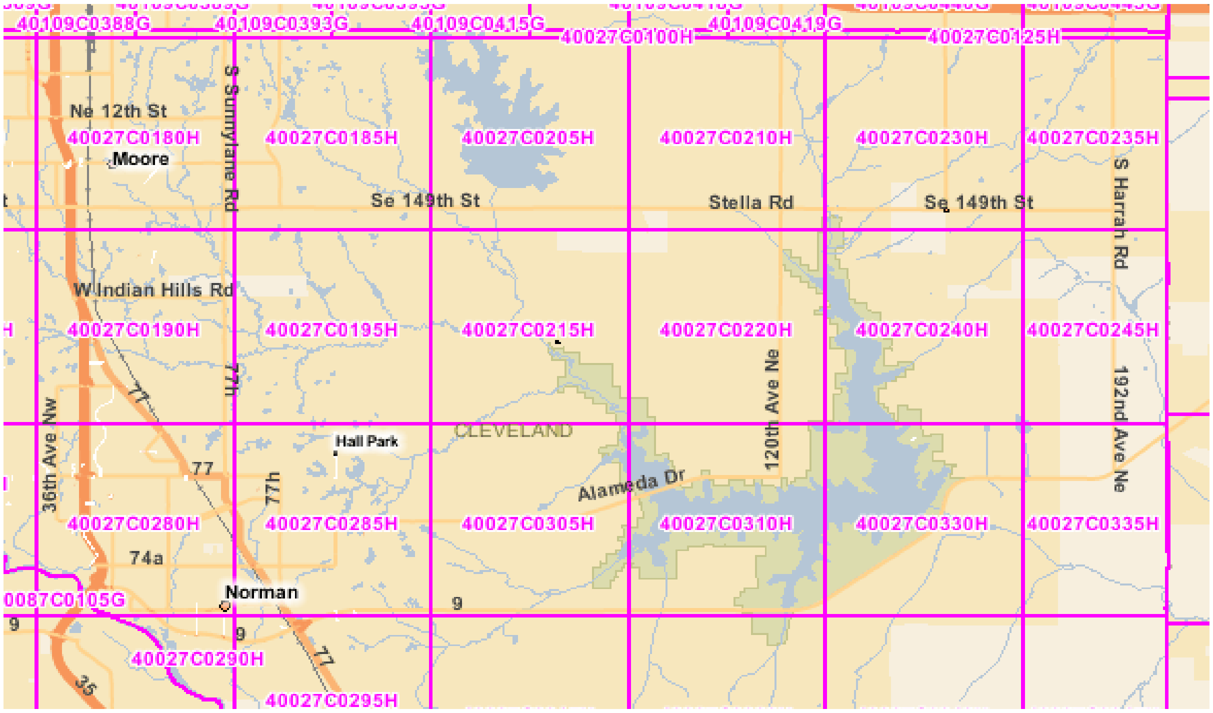
1. Obtained from Oklahoma City's Monthly Water Quality Reports for January 2004 through December 2008.
2. Obtained from the 2006-2007 BUMP Sampling Report for Lake Atoka (OWRB 2007c).

TETRA TECH

Floodplains. Floodplains are low, typically flat areas adjoining surface waters. A 100-year floodplain is the area subject to a 1 percent or greater chance of flooding in any given year (base flood). Regulations pertaining to floodplains are typically enacted at the local government level when a community enters the National Flood Insurance Program (NFIP). The NFIP, administered by the Federal Emergency Management Agency (FEMA), is a program that provides federally backed flood insurance to property owners. In the State of Oklahoma, OWRB is the coordinating state agency for the NFIP (OWRB 2009a).

The FEMA Flood Insurance Rate Maps (FIRMs) for Cleveland County were reviewed for the proposed project. The maps are grouped by community (e.g., a specific city, town, village, unincorporated area, etc.); the proposed project site is listed on numerous community panels within Cleveland County (Figure 6). As the study area mostly consists of a waterbody, the majority of the site lies in Zone AE, "areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage" (FEMA 2009). Detailed analyses are performed for such areas, thus base flood elevations (100-year flood) derived are shown at selected intervals within these zones. The preferred alternative would be at least partially within a 100-year floodplain.

Figure 6: Floodplain Panels Covering the Study Area*



Source: FEMA 2009

*****The numbers in pink are Map Panel Identification Numbers assigned by FEMA. Each number is associated with a FEMA-Issued Flood Map.

Groundwater. The study area overlies the Central Oklahoma aquifer, also known as the Garber-Wellington aquifer. The Oklahoma Water Science Center estimates groundwater withdrawals from the Central Oklahoma aquifer were 41.82 mgd in 2000 (Tortorelli 2000). Of this usage, 25.65 mgd (~61%) was for public water supply. Other uses included domestic/commercial, irrigation, industrial/mining, livestock/aquaculture, and thermoelectric power generation.

The hydrologic unit consists mainly of the Garber Sandstone and the Wellington Formation, which are part of the Sumner Group of Permian age (Ryder 1996). Also included in the aquifer are the older Chase, the Council Grove, and the Admire Groups of Permian age. Lithology consists of massive to cross-bedded, fine-grained sandstone that is interbedded with shale and siltstone (Ryder 1996). The Central Oklahoma aquifer has a maximum thickness of about 1,000 feet and a saturated thickness that ranges from 150 to 650 feet. Water in the Central Oklahoma aquifer is generally unconfined in approximately the upper 200 feet of the aquifer and partly confined or confined at greater depths (Ryder 1996).

4.2.2 Potential Environmental Impacts

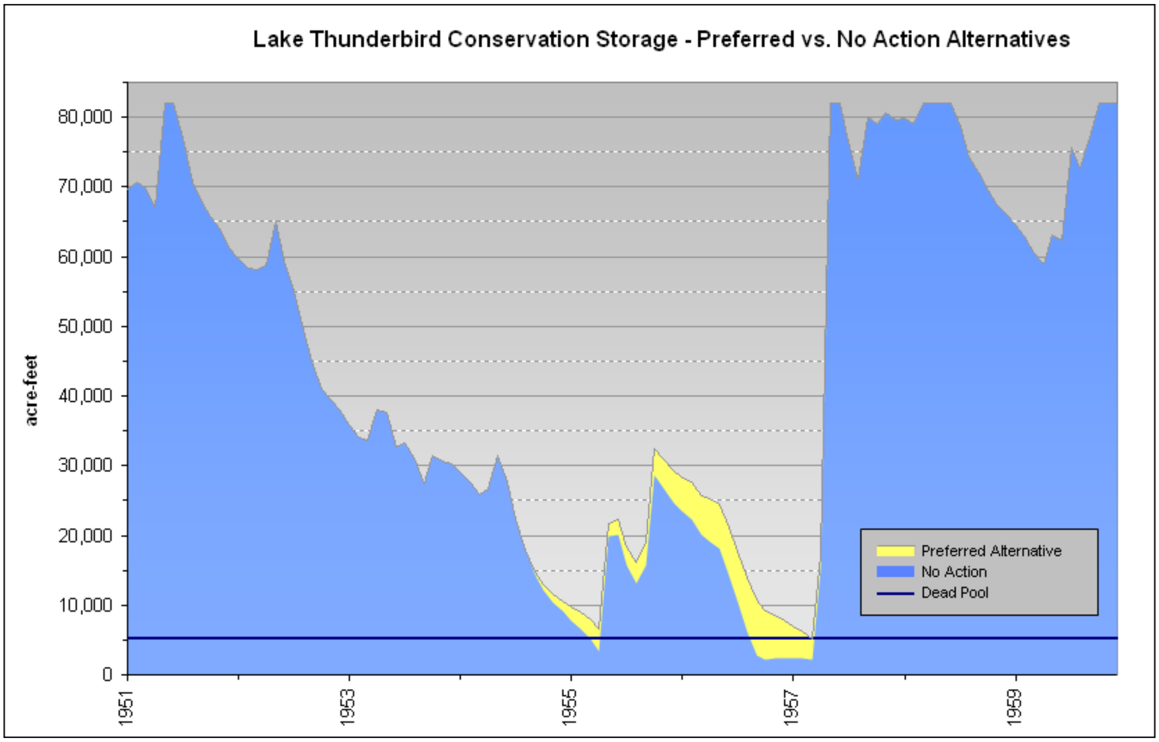
With respect to Water Resources, potential impacts on the hydrology, water quality, floodplains, and groundwater in the study area have been evaluated. The following paragraphs discuss the potential impacts to these four aspects of water resources resulting from the preferred alternative.

Hydrology

Direct Impacts. Construction of the pipeline trenches would result in the removal of vegetation along the approximately 15-foot wide, 1,000-foot long pipeline trench and associated work areas. This disturbance would increase the potential for accelerated runoff and scour in Willow Branch Creek, which could alter hydrology in the stream. The use of best management practices to manage potential runoff and erosion during construction and revegetation following construction would minimize the impact. Because construction would not disturb more than 1 acre, neither a construction stormwater permit nor a formal stormwater pollution prevention plan would be required.

Indirect Impacts. Regarding indirect hydrologic impacts on Lake Thunderbird, the preferred alternative would increase the volume of water in the lake during periods of drought. Figure 7 provides a graphical illustration of what Lake Thunderbird would look like during periods of drought (i.e., from 1955 to 1957) after implementation of the preferred alternative as compared to doing nothing. Under the no action alternative, storage volume would fall below 5,107 acre-feet, which would result in lake levels dropping below the dead pool elevation of 1,010 feet. This would result in COMCD not being able to deliver water to its member cities. Under the preferred alternative, augmentation water would be pumped into Lake Thunderbird to maintain the storage volume above the dead pool elevation such that municipal water could still be delivered to COMCD's member cities. Similar results would be expected during a repeat of the drought of record, should one occur.

Figure 7: Comparison of Storage Volume in Lake Thunderbird during the Drought of Record between the Preferred Alternative and the No Action Alternative



Water Quality

Direct Impacts. During construction, stormwater runoff would have the potential to transport sediment and other pollutants to receiving waters (Willow Branch Creek and Lake Thunderbird). However, implementation of standard construction best management practices (e.g., silt fences) during construction and revegetation following construction would minimize the risk.

Indirect Impacts. During operation, the potential for shoreline erosion would be minimized through the incorporation of appropriate protection and energy dissipation in the outfall design. The conceptual design would include a concrete outfall structure with energy dissipation baffles and reinforcement to ensure erosion is controlled. In addition to the erosion control components of the outfall itself, the design would also incorporate rip rap (or similar) below the water line to reduce the possibility of increased erosion due to augmentation initiation during extended periods of drought, which are associated with lower lake levels. A minimal increase in turbidity would occur at the onset of augmentation due to sediment on the rip rap material.

Within Lake Thunderbird, mixing of water from the Atoka pipeline with Lake Thunderbird water would have the potential to impact water quality in Lake Thunderbird. Table 3 previously summarized the raw water quality for Lake Thunderbird, and Table 4 summarized the raw water quality of water from the Atoka Pipeline. Minima, maxima, and averages for years 2004 to 2008 were shown, along with results for the combined five years.

A blending analysis was conducted for this EA using the average raw water quality of both the Atoka Pipeline water and Lake Thunderbird. The analysis assumed that the water is fully mixed prior to reaching the Lake Thunderbird Reservoir Pump Station that conveys water to the member cities, and that the blend consists of approximately 10 percent Lake Atoka water and 90 percent Lake Thunderbird water, based on the anticipated operation of the augmentation system. The assumption of fully mixed water by the time it is conveyed to the member cities is supported by the considerable distance in Lake Thunderbird between where the augmentation water would enter the lake and where lake water enters the Reservoir Pump Station intake. The results of this blending analysis were provided to the member cities. The City of Norman reviewed the results and concluded that the net impact on their treatment system would be negligible. However, the City of Norman suggested jar tests be conducted for confirmation. Each member city can and may elect to conduct jar tests at the time augmentation is occurring to determine if any modifications to their respective water treatment processes are necessary.

Table 6 shows the overall average water quality for Atoka Pipeline water and Lake Thunderbird water and the predicted average water quality for the blended water based on the assumptions described. For turbidity, a mass balance analysis was performed to evaluate the impact on total suspended solids (TSS) due to the proposed augmentation (Vieux, Inc. 2009). The mass balance analysis indicated that the proposed augmentation would result in a less than 2.1 milligram per liter (mg/l) increase in TSS concentrations. For comparison, historical TSS concentrations in Lake Thunderbird varied from less than 10 mg/l to 171 mg/l, with an average concentration near the dam of 21 mg/l.

Table 5: Blended Water Quality Versus Raw Water Quality Averages in Lakes Atoka and Thunderbird and the Estimated Resulting Blend

Water Quality Parameter	Lake Atoka	Lake Thunderbird	Blended Water Quality
Total Dissolved Solids, mg/L	**89**	**210**	**201**
Total Alkalinity, mg/L as $CaCO_3$	**31.1**	**166.0**	**156.2**
pH	**7.58**	**8.00**	**7.87**
Calcium (Total), mg/L as Ca^{2+}	**8.9**	**41.0**	**38.7**
Calcium (Total), as $CaCO_3$	**22.2**	**102.4**	**96.5**
Water Temperature, °C (temperature at which pH was analyzed)	**5.0**	**5.0**	**N/A**
Field Water Temperature, °C	**17.8**	**17.8**	**17.8**
Chloride (Cl^-), mg/L	**4.8**	**28.0**	**26.3**
Chloride (Cl^-), as $CaCO_3$	**6.8**	**39.5**	**37.1**
Magnesium (Mg^{2+}), mg/L	**4.1**	**15.0**	**14.2**
Magnesium (Mg^{2+}), as $CaCO_3$	**16.9**	**61.8**	**58.5**
Sulfate (SO_4^{2-}), mg/L	**11.3**	**132.0**	**123.2**
Sulfate (SO_4^{2-}), as $CaCO_3$	**11.8**	**137.5**	**128.4**
Total Nitrogen, mg/L	**0.71**	**0.78**	**0.77**
Total Phosphorus, mg/L	**0.105**	**0.059**	**0.061**
Total Organic Carbon, mg/L	**4.93**	**5.4**	**5.3**
Total Suspended Solids, mg/L[1]	**36.2**	**35.6**	**<1 mg/L increase**
Chlorophyll-*a*, µg/L[1]	**23**	**21**	**23.1**

The augmentation of Lake Thunderbird would likely improve the net settling of phosphorus by maintaining higher water levels and increasing the surface area of the lake during critical need periods, thus providing an indirect improvement in water quality. Also, pollutant loading from the watershed during drought periods is not anticipated to impact the water quality due to the lack of stormwater runoff. The net effect would be to minimize the overall impact on the phosphorus loading into Lake Thunderbird.

[1] These calculations were performed as part of Vieux, Inc., 2009.

A full discussion of the impact of implementing the preferred alternative is presented in the *Thunderbird Water Quality Assessment, Impact Assessment of Augmentation*, developed by Vieux, Inc. (Vieux, Inc. 2009) and provided in Appendix A.

Operating the preferred alternative is not expected to decrease dissolved oxygen (DO) levels. Although DO in the water exiting the Atoka pipeline is not known, it is anticipated to have a lower DO concentration than the water entering the pipeline from Lake Atoka. Cascade aeration would be included with the preferred alternative. Cascade aeration would impart DO into the water withdrawn from the Atoka Pipeline before the water is discharged into Lake Thunderbird. The temperature of the Atoka pipeline water and its density relative to the lake water would affect how and where mixing occurs within the lake. The augmentation water is expected to be cooler than the water in Lake Thunderbird due to cooling during transport. Thus, based on the modeling efforts, the augmentation water would sink to lower depths of the lake, mixing with relatively poor quality water (with respect to DO), and improving the water quality in these lower depths (Vieux, Inc. 2009).

Based on the analyses performed, while Lake Thunderbird is currently experiencing water quality challenges related to nutrients, chlorophyll-a, and dissolved oxygen that have initiated actions related to Section 303(d) of the Clean Water Act, implementing the preferred alternative is not expected to induce further degradation of the lake's water quality related to these water quality parameters.

Floodplains

Direct Impacts. The construction of the conveyance facilities may modify the localized floodplain temporarily due to the use of stormwater control BMPs.

Indirect Impacts. None anticipated.

Groundwater

Direct Impacts. It is assumed that the conveyance pipeline and other facilities associated with the preferred alternative would be installed using an open cut method. This method involves excavation of soil and rock to depths assumed to be between 4 and 6 feet below ground surface. To install the pipe and other structures, it may be necessary to dewater the trench during construction. This would likely lower the groundwater levels in the vicinity of the trench while the pumps are operating. This type of activity would be temporary and confined to an area near the construction activities.

During construction, the work area would be cleared and the trench or pit area would be temporarily open to the surface. The footprint would be open only long enough to install the pipe or structure, and then backfilled. Also, best management practices for stormwater control would minimize the chance for surface water to comingle with groundwater.

It is assumed that contaminated soils are not likely to be encountered in the study area due to the rural, undeveloped nature of the lands surrounding the lake. If pre-construction clearing activities indicate the presence of suspected contamination, suitable investigatory and remedial measures would be employed.

Indirect Impacts. The addition of augmentation water into Lake Thunderbird during times of drought could potentially increase groundwater levels in the unconfined area of the Garber-Wellington Aquifer.

4.3 Biological Resources

4.3.1 Affected Environment

Site Reconnaissance and Investigation

The project team conducted a site reconnaissance visit (site visit) of the study area on September 23, 2009. The purpose of the site visit was to document existing conditions and provide additional information to better characterize the proposed alternatives and identify potentially significant impacts associated with the alternatives. The following paragraphs summarize the site visit and the findings relative to potential biological and environmental constraints associated with the preferred alternative.

In addition to the actual site visit, site reconnaissance activities included the collection and review of available maps and other existing site information prior to the site visit. For example, the project team compiled USGS topographic maps depicting the key features of the study area. Features of interest were hydrologic in nature, including floodplains, geology, soils, vegetation and potential habitat of protected species, as well as wetlands compiled by the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI).

In general, the lake shoreline area has very flat slopes. The deepest portion of the lake is near the dam, which is approximately 50 feet. There is little to no agricultural use in the watershed. There are approximately 5 boat ramps and a couple of parking lots that provide access to the lake. The bed material in the area is sandstone, and the groundwater is shallow. Construction of a pipeline would require a "Care of Water" plan that considers this (Engleman 2009).

The terrestrial habitat at the preferred alternative site consists of a narrow, densely vegetated riparian corridor of Willow Branch Creek. Dominant tree species include black willow (*Salix nigra*), pecan (*Carya illinoinensis*), Eastern redbud (*Cercis canadensis*), and eastern redcedar (*Juniperus virginiana*). Shrub and herbaceous species include winged sumac (*Rhus copallinum*) and Atlantic poison oak (*Toxicodendron pubescens*). Bottomland forest near this site does not appear to be a forested wetland. However, a proper delineation would be required to verify this.

The preferred alternative would likely be located within the 100-year floodplain of Willow Branch Creek. At the time of the site visit, the creek had a low flow velocity. While the area had received more precipitation than is typical for the late summer, there had not been any rain events in the past few days. The creek slopes are steep and show severe bank erosion and cutting. No threatened or endangered species or critical habitats were observed during the site visit.

<u>Vegetation</u>

The Lake Thunderbird area is located in the northern cross timbers ecoregion, an area characterized by gently rolling hills and ridges. The typical vegetation types within the study area include Post Oak-Blackjack Oak Forest and Tallgrass Prairies (Hoagland 2008). Recent fire suppression in the cross timbers ecoregion has led to the rapid expansion of eastern red cedar (*Juniperus virginianus*) into tallgrass prairie communities.

Upland vegetation in the study area consists of post oak/blackjack oak forests found along hills and ridges throughout the study area. The dominant tree species in this habitat include post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), black hickory (*Carya texana*), and eastern red cedar. Prominent understory species include Eastern redbud (*Cercis canadensis*), Mexican plum (*Prunus mexicana*), and winged sumac (*Rhus copallinum*). Herbaceous and vine species include poison oak (*Toxicodendron pubescens*) and saw greenbriar (*Smilax bona-nox*).

Bottomland hardwood forest is the most common habitat type within the floodplains and riparian corridors of Lake Thunderbird. Dominant tree species include pecan (*Carya illinoiensis*), black hickory, and green ash (*Fraxinus pennsylvanica*). Black willow (*Salix nigra*) is also common along the forest edge. The understory is dominated by red mulberry (*Morus rubra*), roughleaf dogwood (*Cornus drummondii*), and poison ivy (*Toxicodendron radicans*).

Wetlands

USACE is directed by Congress under Section 404 of the Clean Water Act (33 USC 1344) and Section 10 of the Rivers and Harbor Act (33 USC 403) to regulate the discharge of dredged and fill material into all waters of the U.S., defined in 33 CFR Part 328 of the Clean Water Act (CWA), including "intrastate lakes, rivers, streams (including intermittent streams), mudflats, sand flats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds" (USACE 1971).

The *USACE Wetland Delineation Manual* (USACE 1987) defines wetlands as areas that have positive indicators for hydrophytic vegetation, wetland hydrology, and hydric soils or as "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions," with special exceptions. Wetlands that are waters of the U.S. or that have a significant nexus to waters of the U.S. are regulated under the CWA as jurisdictional wetlands. USACE further defines jurisdictional waters to include ephemeral (water flowing during and, for a short duration, after a rainfall event) tributaries of navigable waters, as well as adjacent wetlands and even man-made impoundments when those impoundments occur within drainages that meet the definition of jurisdictional waters.

Emergent wetlands border the entire shoreline of Lake Thunderbird. Dominant perennial vegetation in these emergent wetlands may include water willow (*Justicia americana*), hardstem bulrush (*Schoenoplectus acutus*), smartweeds (*Polygonum spp.*), and various sedges (*Cyperus spp.*). Black willow and buttonbush (*Cephalanthus occidentalis*) are also commonly found scattered throughout wetland areas where inundation is less frequent.

Figure 8 shows the NWI map of the study area with the locations of various wetland types. The NWI map does not likely show all wetlands since NWI maps typically are derived from aerial photo-interpretation with varying limitations due to scale, photo quality, inventory techniques, and other factors; therefore, wetlands may exist within the study area that are not identified on the NWI map. A proper field delineation and jurisdictional determination would be required prior to construction to confirm NWI mapping.

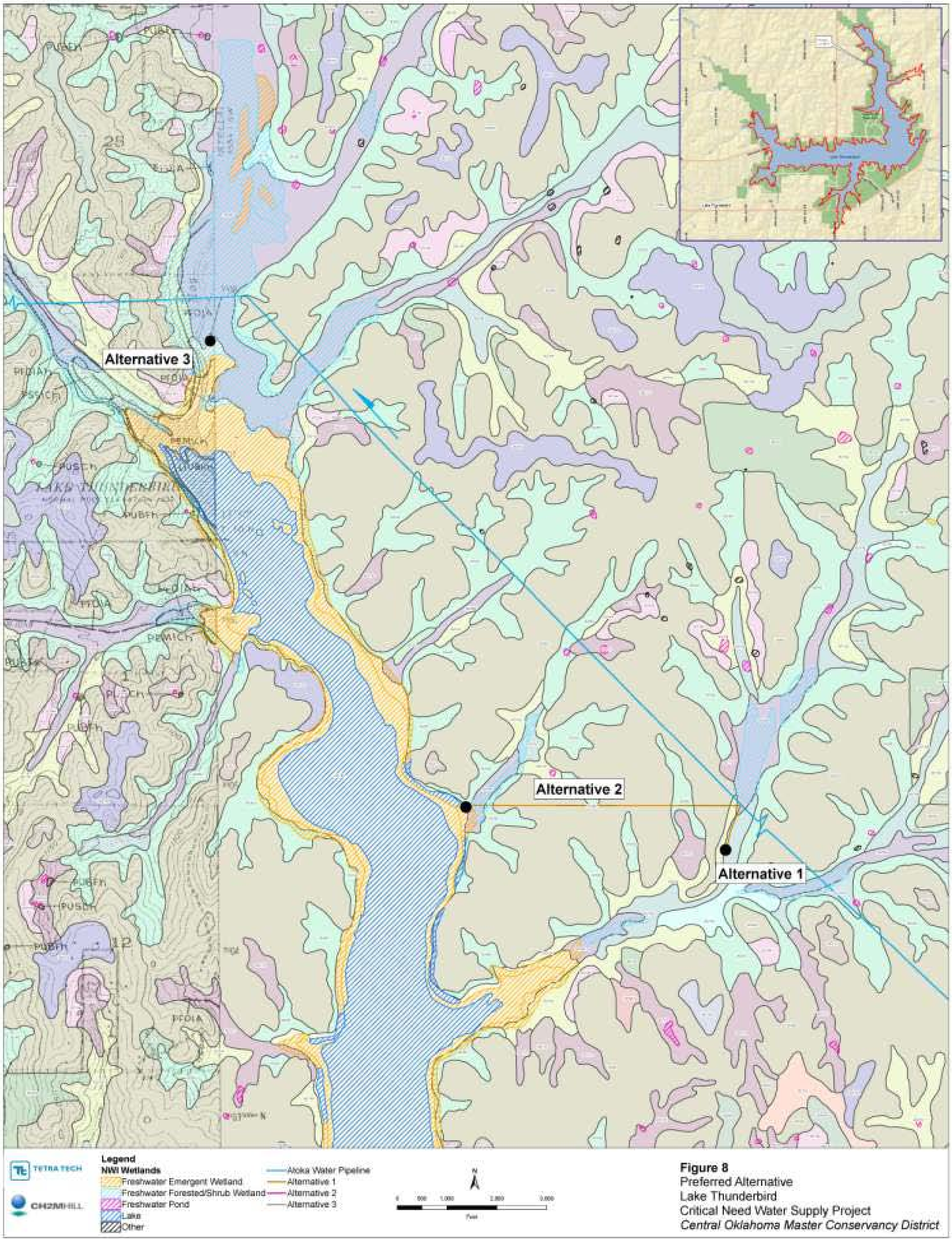
Wildlife and Aquatic Resources

The diversity of vegetation, soils, and available water resources in the study area provides habitat for a large number of wildlife species. Open grasslands, bottomland hardwood forests, emergent wetlands (lake shoreline only), creeks and streams are present within and adjacent to the study area. The Oklahoma Gap Analysis Program (GAP) prepared by the USGS (2001) reports records of observed species in specific areas. The Lake Thunderbird area is reported to have more than 300 vertebrate species, including approximately 50 mammalian species, approximately 50 reptilian species, fewer than 20 species of amphibians, and more than 175 bird species.

Mammals. Mammals most likely to occur within the study area include species that are tolerant of urban activity. These include squirrels (*Sciurus spp.*), Virginia opossum (*Didelphis virginiana*), nine-banded armadillo (*Dasypus novemcinctus*), Eastern cottontail (*Sylvilagus lovidanus*), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), coyote (*Canis latrans*), and several species of rodents.

Reptiles and Amphibians. Common reptile and amphibian species within the study area include ornate box turtle (*Terrapene carolina*), snapping turtle (*Chelydra serpentina*), common garter snake (*Thamnophis sirtalis*), Western massasauga (*Sistrurus catenatus*), Eastern yellow-bellied racer (*Coluber constrictor*), diamondback water snake (*Nerodia rhombifer*), coachwhip (*Masticophis flagellum*), fence lizard (*Sceloporus undulatus*), ground skink (*Scincella lateralis*), Western slender glass lizard (*Ophisaurus attenuatus*), Northern cricket frog (*Acris crepitans crepitans*), striped chorus frog (*Pseudacris triseriata*), gray treefrog (*Hyla versicolor*), bullfrog (*Rana catesbeiana*), American toad (*Bufo americanus*), and smallmouth salamander (*Ambystoma texanum*).

Figure 8: National Wetlands Inventory in the Study Area



Migratory Birds. The Migratory Bird Treaty Act prohibits, or, if necessary, regulates the taking, killing, possession of, or harm to migratory bird species listed in 50 CFR 10.13 (USFWS 2009c). Oklahoma is located within the central migratory bird flyway, and the study area may be used by birds during migratory breeding season (March 1 through August 31) and migratory season (the fall). Waterfowl, both migratory and perennial, can be found along stream corridors and the lake shoreline. Various duck species, such as the common teal (*Anas crecca*), ruddy ducks (*Oxyura jamaicensis*), and mallards (*Anas platyrhynchos*) are commonly observed throughout the area. Canada geese (*Branta Canadensis*), cormorants (*Phalacrocorax spp*.), and various egret and heron species, such as the great egret (*Ardea alba*), great blue heron (*Ardea herodias*), and green heron (*Butorides virescens*), are other types of waterfowl common to the region, as are turkey vultures (*Cathartes aura*), American coots (*Fulica americana*), red-shouldered hawks (*Buteo lineatus*), killdeer (*Charadrius vociferous*), and a variety of song birds.

The bald eagle (*Haliaeetus leucocephalus*) is a regular migrant and winter resident of Lake Thunderbird. Recently, the bald eagle was delisted under the Endangered Species Act (ESA) (50 CFR 17; USFWS 2007) and will be monitored for at least 5 years to determine whether relisting is warranted. The bald eagle remains protected under the Migratory Bird Treaty Act, which is administered by USFWS. Eagles can be found within the area from December through February (Bureau of Reclamation 2009).

Fish. Fish species common to Lake Thunderbird and associated streams include common carp (*Cyprinus carpio*), small mouth buffalo (*Ictiobus bubalus*), big mouth buffalo (*Ictiobus cyprinellus*), river carp sucker (*Carpiodes carpio*), fresh water drum (*Aplodinotus grunniens*), spotted gar (*Lepisosteus oculatus*), gizzard shad (*Dorosoma cepedianum*), inland silverside (*Menidia beryllina*), warmouth and longear sunfish (*Lepomis spp.*), yellow bullhead (*Ameiurus natalis*), red shiner (*Cyprinella lutrensis*), blunt nose minnow (*Pimephales notatus*) and mosquito fish (*Gambusia affinis*). Fish species targeted for recreational fishing include largemouth bass (*Micropterus salmoides*), white bass (*Morone crysops*), white crappie (*Pomoxis annularis*), channel catfish (*Ictalurus punctata*), and saugeye (*Stizostedion canadense x S. vitreum)* (ODWC 2005a). Recent fish stocking in the lake has included saugeye, walleye (*Stizostedion vitreum)*, Florida-strain largemouth bass, and channel catfish (Bureau of Reclamation 2009).

Lake Thunderbird is classified for Fish and Wildlife Propagation (FWP) under the Warm Water Aquatic Community subcategory as one of its designated uses set by the OWRB. Lake

Thunderbird is currently listed as not supporting its FWP beneficial use based on turbidity (ODEQ 2008).

<u>Threatened and Endangered Species</u>

Federally-Listed Species. The ESA prohibits the unauthorized taking, possession, sale, and transport of species listed as endangered, threatened, or candidates for listing as endangered or threatened. The USFWS Threatened and Endangered Species System internet database and the Oklahoma Natural Heritage Inventory (ONHI) database were reviewed prior to the site visit to determine if any federally listed endangered, threatened, or candidate species (species of concern) have the potential to occur in the study area. The database search identified seven listed animal species and no listed plant species with the potential to occur in Cleveland County.

Of the seven listed species, the American peregrine falcon (*Falco peregrinus anatum*) and bald eagle (Haliaeetus leucocephalus) have been delisted, but are still monitored to ensure that their populations remain stable. The remaining five species include the Arkansas river shiner (*Notropis gerardi*), black-capped vireo (*Vireo atricapilla*), least tern (*Sterna antillarum*), piping plover (*Charadrius melodus*), and whooping crane (*Grus americana*) (USFWS 2009a; ONHI 2003).

The land in and adjacent to the study area provides marginally suitable habitat for the black-capped vireo. The lake shoreline may also provide potential stopover habitat for migrating piping plovers and whooping cranes. No potentially suitable habitat for the other two federally listed species occurs in the study area and no federally listed species were observed during the September 23, 2009 site visit.

Protection of critical habitat for endangered and threatened species is a regulatory requirement. Critical habitat is defined within Section (3)(5)(A) of the ESA as "areas within a listed species' current (at time of listing) range that contain the physical or biological features that are essential to that species' conservation or that for some reason require special management; and areas outside the species' current range that the secretary determines to be essential to its conservation." A review of the existing data determined that the study area does not contain any designated critical habitat area, as defined under the ESA, as amended.

State Listed Species. Oklahoma does not have an endangered species act, although the state has several scattered provisions. Under these provisions, threatened and endangered wildlife can be listed based on scientific criteria (ODWC 2005b). There are no provisions for recovery plans, critical habitat designation or agency consultation. Penalties for takings and trafficking include fines of up to $1,000 and/or imprisonment of up to 30 days. Plant species are not protected under this provision. Nine animal species listed by the state as threatened, endangered, or rare have the potential to occur in Cleveland County (OHNI 2003). The listed species include the prairie mole cricket (*Gryllotalpa major*), Arkansas river shiner (*Notropis girardi*), Texas horned lizard (*Phrynosoma cornutum*), bald eagle (*Haliaeetus leucocephalus*), long-billed curlew (*Numenius americanus*), snowy plover (*Charadrius alexandrinus*), piping plover (*Charadrius melodus*), least tern (*Sternum antillarum*), and black-capped vireo (*Vireo atricapilla*). As mentioned previously, the habitat in and adjacent to the study area provides marginally suitable habitat for the black-capped vireo, migrating bald eagles, and snowy and piping plovers. No suitable habitat for other state-listed species occurs in the study area and no state-listed species were observed during the site visit.

<u>Non-Native and Invasive Species.</u>

Due to the nature of the preferred alternative considered in this analysis, the primary non-native and invasive species of concern for this project are aquatic nuisance species (ANS). The state of Oklahoma currently has a limited number of statutory and regulatory authorities related to the prevention and control of ANS, but the Oklahoma State Wildlife Action Plan, prepared by ODWC, identifies invasive species, in particular ANS, as a priority issue that threatens Oklahoma wildlife resources. To help control the spread of ANS, the ODWC, in collaboration with various partners, has developed an ANS Management Plan. The overall objective of the ANS Management Plan is to minimize the harmful ecological, economic, and social impact of ANS through preventing the introduction and managing the population growth and dispersal of ANS into, within, and from Oklahoma. As part of the plan, a priority ranking from 1 to 4 was assigned to ANS based on the species threat, known presence, and management potential.

Priority Class 1 species are considered the greatest threat to Oklahoma. These species are present and established in Oklahoma, have the potential to spread in Oklahoma, and there are limited or no known management strategies to control these species. However, they can be managed through actions that involve mitigation of impact, control of population size, and prevention of dispersal to other water bodies. These include:

- Bighead Carp (*Hypophthalmichthys nobilis*)
- Golden Alga (*Prymnesium parvum*)

- Grass Carp (*Ctenopharyngodon idella*)
- Hydrilla (*Hydrilla verticillata*)
- Silver Carp (*Hypophthalmichthys molitrix*)
- White Perch (*Morone americana*)
- Zebra Mussel (*Dreissena polymorpha*)

Priority Class 2 species are currently not known to be present in Oklahoma, but have a high potential to invade and there are limited or no known management strategies for these species. Appropriate management for this class includes prevention of introductions and/or eradication of pioneering populations. These include:

- Black Carp (*Mylopharyngodon piceus*)
- Northern Snakehead (*Channa argus*)
- Quagga Mussels (*Dreisena bugensis*)
- Viral Hemorrhagic Septicemia
- New Zealand Mudsnail (*Potamopyrgus antipodarum*)
- Rusty Crayfish (*Orconectes rusticus*)
- Spring Viremia of Carp
- Whirling Disease (*Myxobolus cerebralis*)

Priority Class 3 species are not known to be present in Oklahoma and have a high potential for invasion and appropriate management techniques are available. Appropriate management for this class includes prevention of introductions and/or eradication of pioneering populations. These include:

- Giant Salvinia (*Salvinia molesta*)
- Didymo (*Didymosphenia geminate*)

Priority Class 4 species have the potential to spread in Oklahoma, but there are management strategies available for these species. These species can be managed through actions that involve mitigation of impact, control of population size, and/or prevention of dispersal to other water bodies. These include:

- Purple Loosestrife (*Lythrum salicaria*)
- Alligatorweed (*Alternanthera philoxeroides*)
- Exotic Water Flea (*Daphnia lumholtzi*)
- Eurasian Watermilfoil (*Myriophyllum spicatum*)

- Nutria (*Myocastor coypus*)
- Largemouth Bass Virus
- Rudd (*Scardinius erythrophthalmus*)
- Brook Stickleback (*Culaea inconstans*)
- Water Hyacinth (*Eichornia crassipes*)

Initially, the ANS Management Plan is focusing only on the Priority Class 1 species listed. As the ANS Management program evolves, the focus will shift to the development and implementation of new programs designed to address the lower priority species and/or species yet to be determined as threats.

4.3.2 Potential Environmental Impacts

Regarding the Biological Resources in the study area, potential impacts on the vegetation, wetlands, wildlife and aquatic resources, threatened and endangered species, and non-native and invasive species have been evaluated and are discussed in the following paragraphs.

Vegetation

Direct Impacts. Based on an approximately 15-foot wide, 1,000-foot long pipeline trench and associated work areas, clearing and other construction activities anticipated if the preferred alternative were implemented would potentially impact 0.43 acres of bottomland hardwood forest. Possible measures to reduce, minimize, and compensate for impacts to vegetation from the construction of the pipeline and associated structures that could be employed include the following:

- Restrict the removal of vegetation required for roadways, laydown areas, intake sites, and pipeline installation and ROW.

- Following construction, revegetation of disturbed and cleared areas should occur. After revegetation, allow natural successional changes to proceed whenever possible.

All of the vegetation that would be impacted by the proposed project is commonly found in the project vicinity.

Indirect Impacts. None anticipated if the measures recommended in the previous section are followed.

Wetlands

Direct Impacts. A formal wetland delineation was not performed for this EA; wetland impacts were estimated by reviewing maps compiled by the USFWS NWI (See Figure 8). The NWI map does not likely show all wetlands since NWI maps typically are derived from aerial photo-interpretation with varying limitations due to scale, photo quality, inventory techniques, and other factors; therefore, wetlands may exist within the study area that are not identified on the NWI map. A proper field delineation and jurisdictional determination would be required prior to construction to confirm NWI mapping.

Should someone determine that there are, in fact, wetland impacts associated with the preferred alternative, the project team must contact USACE Tulsa District to identify compensatory mitigation needs due to unavoidable wetland losses as a condition of any permit issued for construction.

Indirect Impacts. None anticipated.

Wildlife and Aquatic Resources

Direct Impacts. Species normally found in forested upland and bottomland habitats, such as birds and small mammals, as well as aquatic resources, would most likely be subject to temporary or permanent displacement from construction zones and adjacent areas during construction, and animals could return to nearby areas after construction is complete. Displacement of animal species during construction could result in increased competition among species in the areas where displaced animals relocate. This could result in temporary decreases in reproductive success and incidental mortality. However, displacement effects would be temporary because the animals would assimilate to the new habitats or move back to familiar areas after construction completion.

Habitat suitable for various migratory bird species, such as bottomland hardwood forests and forested and emergent wetlands (lake shoreline only) are common throughout the study area. Construction activities occurring during the nesting/fledgling period could cause short-term impacts on migratory bird species such as nest abandonment and juvenile mortality. Whenever possible, construction activities would occur outside the migratory bird breeding season in areas where potential migratory bird habitat exists. If construction does occur within the migratory bird breeding season (March 1 to August 31) and potential migratory bird habitat exists, surveys for nests would be required. If nests are found, the area would remain undisturbed until after the breeding season.

There would be potential for temporary impacts to aquatic resources from increased sediment and turbidity as a result of construction activities. Best management practices to minimize sediment and turbidity-related impacts on aquatic resources are anticipated to be employed.

Indirect Impacts. Any habitat developed into facilities would be permanently lost. For the preferred alternative, this would only include the below ground soil volume replaced with the new pipeline. Limited incidental mortality of less mobile animal species could occur, but no populations would be at risk. Further, in the long-term, augmentation is expected to have beneficial impacts on water quality in Lake Thunderbird, thus aquatic wildlife.

Threatened and Endangered Species

Federally Listed Species. No federally listed species were observed in the location of the preferred alternative during the site visit on September 23, 2009. Of the seven threatened and endangered species identified by the USFWS as occurring in Cleveland County, four may have the potential to occur in the proposed project area. Based on information provided below, the proposed project would have no effect on all four species.

Piping plover. The piping plover prefers open, sparsely vegetated sand or gravel beaches. At Lake Thunderbird, the overgrowth of large trees around the reservoir is undesirable, and the shoreline is mostly clayey, eroded, and usually steep. Therefore, the shoreline and adjacent habitat are not suitable for piping plovers. There have also been no confirmed sightings of piping plovers in central Oklahoma. Based on this information, the proposed project would not affect the piping plover.

Whooping crane. Whooping cranes primarily use shallow, seasonally and semi-permanently flooded palustrine wetlands for roosting, and various cropland and emergent wetlands for feeding. Areas characterized by wetland mosaics appear to be the most suitable stopover habitat. Lake

Thunderbird does not have large areas of palustrine wetland, nor does it have a substantial amount of cropland on which whooping cranes could feed. Therefore, the shoreline and adjacent habitat are not suitable for whooping crane stopovers. Furthermore, there have been no known sightings of whooping cranes in the area. As a result, the proposed project would not affect the whooping crane.

Least tern: Interior least terns select sparsely vegetated sand and gravel bars in wide unobstructed river channels on which to nest and rear their young. They rarely nest on the edges of reservoirs, and there have been no documented occurrences of least terns, nesting or otherwise, at Lake Thunderbird (USFWS 1990). Based on this information, the proposed project would have no effect on the least tern.

Black-capped vireo. The black-capped vireo prefers shrubby oaks of varying heights with vegetative cover extending to ground level. A small breeding population of black-capped vireos has been documented near Lake Stanley Draper, approximately 6 miles north of Lake Thunderbird, as recently as 2006 (Wilkins et. al. 2006). However, no recent sightings of black-capped vireos have been reported at Lake Thunderbird (USFWS 2009). Due to the small amount of black-capped vireo habitat within the study area, the proposed project would not affect the black-capped vireo.

No designated critical habitat for listed species, as defined by the ESA, is located in or near the study area.

State-listed Species. Of the nine state-listed threatened or endangered species identified by the OHNI, the piping plover and black-capped vireo may potentially be impacted by implementation of the preferred alternative. These species and anticipated potential impacts are described in the previous section.

<u>Non-Native and Invasive Species</u>

The potential impacts of the preferred alternative on the spread of ANS into Lake Thunderbird were evaluated by assessing the presence of ANS in Lake Atoka (but not Lake Thunderbird) that have been assigned priority classes 1 through 4 (according to ODWC's ANS Management Plan), as well as by assessing the likelihood that certain ANS species could inhabit Lake Atoka in the reasonably foreseeable future. Lake Atoka was selected as the surrogate for this analysis because

Lake Atoka is the source of augmentation water that would be imported into Lake Thunderbird under the preferred alternative.

First, an assessment was made of ANS species that are known to exist in Lake Atoka but that do not currently exist in Lake Thunderbird. According to the ODWC's ANS Management Plan, the only ANS that meet these criteria is the exotic water flea (*D. lumholtzi*). *D. lumholtzi* is a zooplankton species that recently invaded North America from its native range of Africa, Asia, and Australia. It is believed that it was imported to North America through shipments of Nile perch from Lake Victoria in Africa. The earliest record of its occurrence in the U.S. is in Texas in 1990, and it has since been detected in 56 reservoirs in the southern and midwestern U.S. The most distinguishing characteristics of this species compared to native *Daphnia* spp. are its long helmet and tail spines.

Overall, the impacts of *D. lumholzi* on reservoir systems are not well studied. Some studies that have been conducted have evaluated the impacts of *D. lumholzi* on native *Daphnia* spp, which in-turn is used to assess impacts on fish populations. Researchers have predicted that, if *D. lumholzi* has a negative impact on other native zooplankton *Daphnia* populations in late summer, this could negatively affect fish that depend on zooplankton at that time period but are not able ingest *D. lumholzi* because of its long spines. However, studies comparing native *Daphnia* to *D. lumholtzi* have found that competition between these species is lower than expected. This is because *D. lumholtzi* is a tropical species that is adapted to warmer temperatures relative to native *Daphnia* spp. Therefore, during the summers when it is warmer, *D. lumholtzi* populations tend to increase when native *Daphnia* spp. are declining, so it appears that *D. lumholtzi* is filling a vacant "temporal niche" in the warmer summer months (Work and Gophen 1999; Goulden et al. 1995; East et al. 1999; Dzialowski et al. 2000; Johnson and Havel 2001) rather than outcompeting native *Daphnia* spp. Therefore, if *D. lumholtzi* is imported into Lake Thunderbird from Lake Atoka, it is unlikely that *D. lumholtzi* would have an adverse impact on native *Daphnia* spp. within Lake Thunderbird because they would occupy the lake during different time periods. This subsequently would have little impact on Lake Thunderbird's fish populations.

Next, the potential impacts of the preferred alternative on the spread of ANS into Lake Thunderbird were assessed by evaluating the reasonable likelihood that other ANS (that currently do not occupy Lake Thunderbird) could invade Lake Atoka, which in-turn could be imported into Lake Thunderbird. The term "reasonable likelihood" was assessed based on the current known distribution of the ANS species of concern, as well any notable trends in its expansion. Also, evidence must exist that supports the ANS' likelihood of colonizing Lake Atoka such that it is not based on pure speculation. Based on these criteria, only ANS that are currently known to occur in Oklahoma were considered for this analysis. Out of the 16 ANS species of concern listed above that are known to occur in Oklahoma, only the zebra mussel met the above criteria and was considered reasonably foreseeable as occurring in Lake Atoka in the future. Considered a high priority species, zebra mussels represent a serious threat to Oklahoma's aquatic resources and, according to ODWC's ANS Management Plan, deserve immediate management action.

According to ODWC's ANS Management Plan, the zebra mussel is one of the best known invaders of the Great Lakes region and other areas of the country where it has spread. Zebra mussels were introduced from Eastern Europe via ballast water discharge from European freighters. In the late-1980s, the zebra mussel was discovered in Lake St. Clair, between Lake Huron and Lake Erie. This species spread rapidly to 20 states in the Mississippi River drainage. Zebra mussels can easily survive overland transport while attached to boat hulls or in live wells, engine cooling systems, or bait buckets. The zebra mussel is a prolific fouling organism with great potential to disrupt fish passage facilities and cause ecological and economic damage. It is highly opportunistic, reproduces rapidly, and consumes large quantities of plankton from the water column. The potential and profound impacts to fisheries include changes in food availability and spawning areas. Reductions in density and biomass of the zooplankton community may result in reduced growth or abundance of newborn fish. The economic impacts of zebra mussels are primarily caused by their fouling characteristics. They build-up on water intake/discharge structures and can cause utilities and industries to incur significant costs associated with monitoring, cleaning, and controlling infestations.

According to ODWC's ANS Management Plan, within Oklahoma, zebra mussels have been found in the McClellan-Kerr Navigation System from Kerr Reservoir up through the Port of Catoosa. Populations have become established in Kaw, Sooner, Keystone, Oologah, Claremore, and Lynn Lane Lake in Tulsa and in the Arkansas River downstream from Zink Dam in Tulsa. Zebra mussels also have been reported from Grand Lake and Skiatook but populations have not become established. Based on the trend of zebra mussel infestation across Oklahoma, it seems reasonably foreseeable that the zebra mussel could invade either Lake Atoka or Lake Thunderbird in the future, but it is unknown as to which lake they would colonize first.

If the zebra mussel colonizes Lake Thunderbird first, then the preferred alternative would have no impact on the spread of zebra mussels because they would already exist at Lake Thunderbird. According some biologists, this seems like the more likely scenario (Chris Holdren, personal communications 2010). This is because Lake Thunderbird is a highly recreated lake with close to one million visitors per year, and a substantial amount of boat traffic exists between Lake Thunderbird and Lake Texoma, which already contains zebra mussels. It seems plausible therefore that the zebra mussel would invade Lake Thunderbird through its indirect connectivity with Lake Texoma rather than under the preferred alternative, which proposes to import water into Lake Thunderbird only during times of drought.

On the other hand, if the zebra mussel invades Lake Atoka prior to invading Lake Thunderbird, the importation of water from Lake Atoka to Lake Thunderbird under the preferred alternative could provide an avenue for zebra mussels to colonize Lake Thunderbird. However, if this occurs, the COMCD, in collaboration with Reclamation, is proposing to monitor the occurrence of zebra mussels in Lake Thunderbird and Lake Atoka and to discontinue project operations if zebra mussels are found at Lake Atoka before Lake Thunderbird. Currently, Reclamation is sampling zebra mussels on a monthly basis from late spring (April) to early fall (October) at three sampling locations within Lake Thunderbird. The sampling methodology consists of substrate sampling for adult zebra mussels and cross-polarized light microscopy sampling for larvae. If samples potentially contain zebra mussel larvae, then scanning electron microscopy and polymerase chain reaction methods would be employed to confirm zebra mussel presence/absence. The COMCD is proposing to continue this protocol and to expand zebra mussel sampling into Lake Atoka once the proposed project is ready for implementation[2] and it seems as though drought conditions could trigger importation. If zebra mussels are found to occur in Lake Atoka but not in Lake Thunderbird during a time of drought when importation would be occurring, the preferred alternative would *not* be initiated and/or importation would be *discontinued* until such time zebra mussels colonize Lake Thunderbird by other means, which likely would be the case based on arguments provided above. With this mitigation measure in place, the preferred alternative would not be expected to facilitate the invasion of zebra mussels into Lake Thunderbird.

[2] The proposed project would be ready for implementation after (1) Reclamation receives project-specific authorization from Congress that would allow water to be imported from Lake Atoka to Lake Thunderbird; (2) all applicable and necessary contracts are in place; and (3) infrastructure has been built to convey imported water.

4.4 Cultural Resources

4.4.1 Affected Environment

Existing Information

Archeological research at Lake Thunderbird Reservoir began in 1955 with a survey of the proposed Reservoir area by staff and students of the Department of Anthropology at the University of Oklahoma (Steinacher and Brooks 1985). The survey recorded 12 archaeological sites within the proposed reservoir area. In 1985, Steinacher and Brooks compiled a general review of archeological resources at the reservoir, which described 38 archeological sites. Since that time, six additional sites have been recorded, bringing the total to 44 archeological sites recorded at the reservoir.

Of the 44 total recorded sites, 38 are listed as unknown prehistoric. Two sites are reported to contain Late Paleo-Indian lithics of the Dalton variety. One site is reported to contain Archaic material only, and two sites were listed as having components from both the Archaic and Woodland periods. One other site was reported to have artifacts from the Plains Village and Woodland periods.

As property once assigned to the former Indian Territory, the lands in the Lake Thunderbird area were designated as properties of the Citizen Pottawatomie and Absentee Shawnee Nations. During pre-European periods, this area was frequented by the Wichita Nation (National Geographic Society 2007). Once the Indian Territory was opened as public land, white settlement occurred rapidly. Crop-based agriculture replaced earlier cattle ranches and cities developed in the area. By 1890, the University of Oklahoma was designated as having its home in Norman. Three sites are listed as historic homestead sites, one of which is known as the Little Doctor Homestead. It is an Absentee Shawnee homestead that probably includes two burials, and is found in the Post Oak Campground. This site also contains building foundations and some wood fences.

The presence of Native American tribes remains evident, particularly to the north, south, and west of Lake Thunderbird. The dominant presence includes the Citizen Potawatomi Nation which exercises governmental jurisdiction in an area bounded by the North Canadian River, the South

Canadian River, the Pottawatomie-Seminole County boundary (on the east), and the Indian Meridian (on the west). The governmental headquarters for the Citizen Potawatomi Nation are located in Shawnee, and the Citizen Potawatomi Nation casino, Firelake Entertainment, is located east of the study area on Highway 177 and Hardesty Road (Bureau of Reclamation 2009).

Field Survey of Alternative Corridors

A pre-field survey review of Oklahoma SHPO archival information was undertaken on September 17, 2009. The review found no archaeological sites or historic properties on record within or near the three alternative routes for the proposed augmentation water lines. A pedestrian field survey of the three alternative augmentation routes was conducted on September 19, 2009, by a two-person team. The survey revealed no significant cultural resources within the areas of the proposed augmentation routes. The only cultural resource findings during the survey were two concrete culvert abutments located near the western end of Alternative Route #2. The culvert and abutments were associated with the abandoned elevated roadbed of E Franklin Road at an unnamed stream crossing. The deck is gone and the abutments are undecorated. No inscription or date was observed on either of the abutments. The age of the culvert most likely predates the abandonment of E Franklin Road at the time of construction or filling of Lake Thunderbird (1961 to 1965). A copy of the cultural resources survey report is included in this EA as Appendix B.

4.4.2 Potential Environmental Impacts

Direct Impacts

The field survey of the three alternative corridors evaluated as part of this EA, conducted on September 19, 2009, identified a single cultural resource in the study area. This was a set of concrete abutments forming a culvert under the now abandoned roadbed of E. Franklin Road along the proposed ROW for Alternative 2 (see Figure 3). The date of construction of the abutments is uncertain, but they likely predate 1961-1965, the period of construction for Lake Thunderbird.

The concrete culvert is unremarkable in design and the type is redundant in the region, being commonly employed to channel minor drainages through roadbeds. For these reasons, it is considered to be ineligible for consideration to the National Register of Historic Places. No other cultural resources were observed in the field survey and none are on file with the Oklahoma SHPO.

Based on (a) the pre-field review on September 17, 2009, indicating no archaeological site or historic property on record within or near the route for the preferred augmentation water line alternative; and (b) the field survey of the preferred alternative route on September 19, 2009, verifying that there are no significant cultural resources within the proposed ROW, there is no indication of potential impacts to cultural resources with the implementation of the preferred alternative. Informal consultation was made with Oklahoma SHPO to seek concurrence with the findings of the archaeological study conducted for this EA. A copy of the concurrence letter from SHPO to Reclamation dated February 9, 2010, is included in Appendix B of this EA.

During the construction phase, should there be inadvertent discovery of cultural resources in the study area, work would be halted and the Oklahoma SHPO would be contacted for consultation regarding compliance with the relevant regulations.

Indirect Impacts

None anticipated if the measures recommended in the previous paragraphs are followed.

4.5 Native American Trust Assets

Native American trust assets are legal interests in property that are held in trust by the United States for Native American individuals or tribes. Reclamation is required to avoid impacts to such trust assets. There are no known Native American trust assets in the study area. Therefore, there would be no impact on any Native American Trust Assets.

4.6 Recreation Resources

4.6.1 Affected Environment

There are a wide variety of recreational facilities and opportunities at Lake Thunderbird State Park. In addition to traditional state park facilities that are operated and maintained by OTRD, recreation opportunities are provided by concessionaires, including horseback riding, marina-based boating services, and lakeside dining. As previously indicated, the state park is separated into two management areas—Clear Bay on the south side of the lake and Indian Point on the north side of the lake. There are numerous public recreation access areas around the lake with different combinations of recreation resources at each area. Some of the resources are accessible to those with disabilities.

The State Park Division of the OTRD has the primary recreation management responsibility for Lake Thunderbird State Park under a management agreement with Reclamation. Several other entities such as the ODWC, Bicycle League of Norman, and the Thunderbird Sailing Club partner with OTRD to provide additional public recreation opportunities at the park.

Figure 2 (previous) indicates the general location of the types of recreation amenities around the lake. Lake Thunderbird State Park offers 11 campground areas with over 500 total campsites. Some campgrounds have only tent camping sites, while others offer additional sites for recreational vehicles, and one area has small lake huts. The park offers a total of 261 RV pads for public use, all with electric and water hookups, concrete pad, picnic table, outdoor grill, and fire ring. All RV camps include comfort stations with showers and sanitary dump stations. There are 11 group pavilions scattered throughout the state park. Each pavilion has electricity, water, and a cookout grill, and can accommodate up to 100 people. Some pavilions are accessible to those with disabilities. More than 500 total picnic tables, six playgrounds, two primary trails, and green space is available throughout the park. There are self-guided interpretive nature trails, as well as multi-use trails serving hikers and mountain bikers in the park. The park hosts over a million visitors each year.

The lake is the primary draw for most visitors to the park, with several types of water-based activities available. In addition to the informal access points for fishing, the park has nine boat ramps, and two fishing piers, each with swimmable beaches. Most water sports are allowed on Lake Thunderbird (e.g., jet skiing, motor boating, water skiing, tubing, sail boating, canoeing, and wind surfing). However, motorized boating is the primary water sport. To facilitate this activity, two full-service marinas are located in the park, both offering fuel, groceries, a snack bar, a bait shop, fishing tackle, slip rentals, and boat storage. The Lake Thunderbird Aquatic Training Center was developed in partnership with the Thunderbird Sailing Club to provide a facility for lake-related educational and safety programs and sailing classes. A fully-accessible nature center was opened in 2008. In support of hunters, the ODWC partners with the OTRD to allow hunting in designated areas within project boundaries. During the appropriate seasons, deer (archery only) and waterfowl hunting are allowed.

There are five existing concession operations in the park that provide additional services and recreation opportunities for park visitors. Concession contracts between the State and concessionaires are authorized under the provisions of Article 5 of the OTRD contract with Reclamation, subject to the review and approval of Reclamation.

The majority of park use occurs during the summer months. The estimated average annual visitation for Lake Thunderbird State Park for the period Fiscal Years 2003 to 2007 is shown in Table 7 (Bureau of Reclamation 2009). There has been a general downward trend in visitation at Lake Thunderbird State Park over the past five years. A contributing factor to the declining visitation levels was the extended drought from 2005 through early 2007, followed by excessive rains during May and June of 2007.

Table 6: Lake Thunderbird State Park Attendance, Fiscal Years 2003-2007

	2003	2004	2005	2006	2007
July	130,403	133,070	117,469	109,081	102,627
August	102,489	81,292	74,850	77,449	61,036
September	67,773	54,573	82,491	52,175	46,554
October	50,128	53,136	51,954	51,572	32,012
November	47,719	36,710	36,653	37,190	21,206
December	28,400	33,047	25,354	34,802	19,763
January	31,018	33,252	24,158	29,841	17,493
February	30,197	40,031	29,986	25,474	28,358
March	52,987	55,019	51,233	40,946	56,485
April	80,733	71,984	63,878	65,882	62,946
May	208,616	253,297	180,864	122,648	119,592
June	185,782	187,439	203,319	144,930	115,729
Annual Total	1,016,245	1,032,850	942,209	791,990	683,801
Source: Bureau of Reclamation 2009					

Based upon surveys conducted during past studies of state park visitors (e.g., Caneday & Jordan 2003), the majority of overnight campers at Lake Thunderbird State Park are likely to be caucasian, middle-aged, and family groups. These visitors typically travel less than 40 miles to reach the park and make an average of eight visits to Lake Thunderbird each year. Day visitors to

Lake Thunderbird State Park are likely to be a much more diverse group that typically includes minorities.

The day visitors come to the park in small groups of about four individuals, commonly linked as members of the same household or family. Day visitors are expected to average 24 visits each year to the park and travel up to 18 miles on each visit. It can be concluded based on the foregoing numbers that both day visitors and campers at Lake Thunderbird are likely to be residents of the Oklahoma City metropolitan area. Also, day visitors are likely to be residents of suburbs on the south side of Oklahoma City, including Moore and Norman.

4.6.2 Potential Environmental Impacts

Direct Impacts

None Anticipated.

Indirect Impacts

The addition of augmentation water to Lake Thunderbird by COMCD during critical drought periods (preferred alternative) would bring boat launching ramps around the shoreline of the lake back into operation sooner than would occur with the no-action alternative.

4.7 Socioeconomics

4.7.1 Affected Environment

Demographics

Lake Thunderbird is located within the greater Oklahoma City metropolitan area, which includes Oklahoma County, Cleveland County, and Canadian County, three of the most highly populated counties in the state. The State of Oklahoma was estimated to have a population of over 3.5 million people in 2006. Although the current population of Cleveland County is estimated at approximately 200,000 people, much of the county remains quite rural, particularly the area south and east of the lake.

The 2000 census indicates that more than 95,000 people were residing in the City of Norman, the largest city near the lake (about 12 miles west of the lake). This population was comprised of

38,834 households and 22,562 families. The population density was estimated at approximately 540 people per square mile, and the housing density at about 235 units per square mile.

As reported in the Census, about 28% of the 38,834 households in Norman reported having children under the age of 18. Also, approximately 45% were comprised of married couples living together, about 9% reported a female head of household, and nearly 42% were identified as non-families. The average household size was 2.31 persons and the average family size was 2.93 persons. Approximately 30% of all households were reported as single individuals, and more than 6% of the households had someone living alone 65 years of age or older.

The approximate age distribution of population in Norman in 2000 was comprised of 21% under the age of 18 years, 21% between the ages of 18 and 24 years, 29% between 25 and 44 years, 19% between 45 and 64 years, and 9% were 65 years of age or older. The median age was 29 years. The gender distribution of male to female was very nearly 50/50. The overall age distribution was influenced by the presence of students at the University of Oklahoma.

The median income for a household in Norman was $36,713, and the median income for a family was $51,189. Norman was reportedly slightly below the statewide average for household income. Males reported a median income of $35,896, while females reported $26,394. The per capita income for the city was $20,630, slightly above the statewide average of $17,646 per person.

Environmental Justice

On February 11, 1994, President Clinton issued Executive Order 12898, Federal Actions to address Environmental Justice in Minority and Low-Income Populations. Environmental justice is analyzed to identify potential disproportionately high and adverse impacts on minority and low-income populations from proposed actions and to identify measures that can mitigate impacts. According to the 2000 census, the racial makeup of the City of Norman was 82.4% Caucasian, 4.3% African American, 4.5% Native American, 3.5% Asian, 0.05% Pacific Islander, 1.4% from other races, and 4.0% from two or more races. The Hispanic or Latino portion of the population comprised 3.9% of the total. Approximately 7.8% of families and 15.0% of the total population were reported below poverty level, including 11.4% of those under age 18 and 5.7% of those ages 65 and older.

Protection of Children

Executive Order 13045 seeks to protect children from disproportionately incurring environmental health or safety risks that might arise as a result of Federal policies, programs, and actions. In 2000, 20,287 children under the age of eighteen (21.2% of total population) were reported to be living in the City of Norman.

4.7.2 Potential Environmental Impacts

Direct Impacts

None Anticipated.

Indirect Impacts

With implementation of the preferred alternative, during periods of drought, the potential for longer-duration use of boat launching and other water-based recreation amenities around the lake through the introduction of augmentation water could have beneficial socioeconomic impacts. These would be in the form of quality of life for residents and visitors, and sales and tax revenues to local businesses and governments in the study area and surrounding region. These beneficial impacts would come about through an extension of the period when recreation, day use, camping, and tourism amenities would be available to those living within or visiting the study area.

With regard to environmental justice and protection of children, there would be no disproportionately high and adverse impacts on minority and low-income populations, and there would be no disproportionate health or safety risks to children from implementing the preferred alternative.

4.8 Transportation

4.8.1 Affected Environment

The Lake Thunderbird area is served by a network of local, county, state, and interstate roadways. The nearest railroad line is located in the nearby City of Norman, which is a passenger service (Amtrak Heartland Flyer) providing daily round trip service between the City of Norman, Oklahoma City, and Fort Worth, Texas. The nearest airport is the Max Westheimer Airport, a general aviation airport in the City of Norman. The nearest major regional commercial air transportation airport serving the Lake Thunderbird area is the Will Rogers World Airport in Oklahoma City, some 20 miles north of the lake.

Interstate Highway 35, running north and south through Cleveland County approximately 15 miles west of the lake, and Interstate Highway 40, a major east-west freeway through the county approximately 10 miles north of the lake, provide the primary regional transportation access to Lake Thunderbird. As shown previously in Figure 2, the lake is bounded on the south and southeast by State Highway 9, on the east by 156th Street, on the north by 149th Street, on the northwest by 108th Street and Alameda Drive, and on the west by 84th Avenue. Also, numerous county and municipal roads provide more local access and egress to Lake Thunderbird from a variety of directions.

4.8.2 Potential Environmental Impacts

Direct Impacts

Implementation of the preferred alternative would involve the construction and operation of a conveyance pipeline, outfall structure, and associated facilities. The mobilization of construction equipment on site and the use of various construction-related vehicles during the short construction period would result in short-term increases in local traffic on rural roads and intersections in the study area.

Indirect Impacts

None Anticipated.

4.9 Public Safety

4.9.1 Affected Environment

State Park Rangers at Lake Thunderbird State Park maintain and enforce compliance with all state of Oklahoma laws, including the management of hazardous materials (such as fuels) and the control of noise. These Rangers have the same powers with respect to criminal matters and enforcement of laws as sheriffs, highway patrol officers, and police officers. Park Rangers enforce all traffic laws and conduct on-scene investigations of vehicle collisions. They also can provide emergency medical attention when required.

4.9.2 Potential Environmental Impacts

Direct Impacts

Implementation of the preferred alternative would involve the construction and operation of a conveyance pipeline, outfall structure, and associated facilities. The short construction phase of the project would involve various activities that could pose risks to public safety. These include: (a) creation of temporary construction trenches and work pits; (b) accidental release of hazardous and toxic substances such as fuels, lubricants, and solvents; and (c) increased construction-related traffic on local rural roads in the study area. It is anticipated that with the use of industry-accepted practices for projects involving open excavations such as fencing, signage, and frequent backfill; the use of practices involving safe handling, storage, and disposal of hazardous and toxic materials at work sites; and the use of proper signage and safe-driving practices in construction zones, the risks to public safety would be minimized.

Indirect Impacts

None Anticipated.

4.10 Climate Change

Climate is defined simply as the average of various weather components over a period of many years. Temperature, precipitation, humidity, soil moisture, and other variables are all analyzed to determine climate. The climate may change due to several factors, including human interaction with the earth, and there is concern that the atmospheric buildup of greenhouse gases, including carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons (IPCC 2007), will cause global climate change. The World Meteorological Organization and the United Nations Environmental Program jointly established the Intergovernmental Panel on Climate Change (IPCC) in 1988 to predict how the earth's climate will respond to increased greenhouse gases. Their observations indicate that detectable climate changes will occur, and they predict increases in overall temperature and changes in rainfall, evaporation, groundwater recharge rates, soil moisture, and runoff patterns.

Reclamation has been directed to consider and analyze potential climate change impacts when developing NEPA and other decisional documents. The Council on Environmental Quality (CEQ) has also issued draft guidance on climate change that requires federal agencies to determine whether and to what extent (1) their actions may affect climate change, and (2) climate change may affect their actions.

The CEQ asserts that the first question may be better answered at the federal program level, as local, project-level emissions are largely insignificant, and predicting climatological impacts may be impossible. Indeed, the proposed project may temporarily increase greenhouse gas emissions locally due to construction of the pipeline to Lake Thunderbird. However, these emissions would be relatively small when compared with emissions emitted by the state, county, and other construction projects in the area.

It is more difficult to determine how climate change may affect the proposed project. Current climate modeling focuses on a global scale, and, to assess how climate change may affect the proposed project, it must be downscaled to model state climate change impacts. At this time, there is no widely-accepted method of downscaling global climate change data with local data, but the IPCC (Christensen et al. 2007) evaluated the effectiveness of 21 downscaled models for North America. There were varying results, and the IPCC found the models had some difficulty replicating historic climate, likely due to the resolution of global models being unable to replicate the impacts the Rocky Mountains have on weather patterns.

Overall, the mean of the different models predicts a warming trend for North America. Models predict a 3-5 degree Celsius temperature increase over the central United States (including Oklahoma). They also predict an increase in precipitation in the winter time and a decrease of precipitation in the summer time, resulting in an overall increase throughout the year. The precipitation increase is offset, however, by an increase in evaporation, so much so that an overall drying of the region could occur.

Others researchers have tried to further downscale climate models to the state, local, or drainage basin level. Very few downscaling attempts have been made for Oklahoma, but Zhang (2005) projects an overall decrease in precipitation and an increase in temperature by downscaling a global climate model to Kingfisher, Oklahoma, about 80 miles northwest of Lake Thunderbird. He also predicts precipitation will occur with greater intensity (e.g., torrential downpours rather than gentle rain), which will increase soil loss due to erosion.

While accurate evaluations of climate change for the study area are not available at this time, conclusions drawn by the models studied by the IPCC and Zhang are united in identifying a general trend. Augmenting the water supply for the member cities via the proposed project could help provide a reliable supply of water that would not be available otherwise due to climate change. As a best management practice, environmentally-friendly and energy efficient methods and equipment would be used to the extent practicable to avoid excessive greenhouse gas emissions.

4.11 Aesthetic Resources

4.11.1 Affected Environment

As illustrated in the following photos, the expanses of open water, the interface of the tree-lined shore and beach areas, and open space that comprise Lake Thunderbird afford a pleasing visual environment for park visitors. Numerous viewpoints around the lake and the open space amenities are available year-round to park users and travelers on Highway 9 and other roadways passing in proximity to Lake Thunderbird.

Photos 1-5. Aesthetic Resources of Study Area

4.11.2 Potential Environmental Impacts

Direct Impacts

Implementation of the preferred alternative would involve the construction and operation of a conveyance pipeline, outfall structure, and associated facilities. The ROW for the preferred alternative traverses rural land to the east and north of the Hog Creek Arm of Lake Thunderbird (see Figure 3). The visual amenities in this location are common to the majority of the areas surrounding Lake Thunderbird and are characterized by riparian and upland mixed deciduous forest with woody underbrush and scrub/shrub zones, the presence of rural roadways and utility rights-of way, and dispersed dwellings and outbuildings with associated clearings.

During and following construction, the aesthetic qualities of the local area in and adjacent to the construction site would be affected. The aesthetic quality of the project site would be temporarily degraded during the short construction period, since the ROW would be cleared and construction activities would be locally noticeable.

Indirect Impacts

Long-term impacts on aesthetic quality of the construction site would likely result from the establishment of a maintained ROW through a previously more homogeneous forested and scrub/shrub area.

5.0 CONSULTATION AND COORDINATION

5.1 Agency Meetings and Consultations

5.1.1 Oklahoma Water Resources Board (OWRB)

Representatives from COMCD, Reclamation, Tetra Tech, and Vieux, Inc met with the Oklahoma Water Resources Board (OWRB) in April 2009 to review the proposed project scope and objectives and discuss the approach being taken to assess potential water quality impacts associated with the proposed raw water augmentation concept. OWRB staff provided a positive response and requested that the impact analysis be submitted to OWRB when completed. Subsequently, the report titled *Thunderbird Water Quality Assessment, Impact Assessment of Augmentation* was completed by Tetra Tech sub-consultant Vieux, Inc. (Vieux 2009). The report concluded that potential impacts from the proposed periodic addition of augmentation water on the critical water quality parameters in Lake Thunderbird would be minimal. The report was submitted to OWRB on May 21, 2009. OWRB reviewed the report and provided positive feed back to COMCD and Reclamation regarding the proposed augmentation concept. A copy of the Vieux report is included in this EA as Appendix A.

5.1.2 Oklahoma Department of Environmental Quality (ODEQ)

In early June 2009, representatives from COMCD, Reclamation, Tetra Tech, and Vieux, Inc met with the Oklahoma Department of Environmental Quality (ODEQ) to review the proposed augmentation project scope and objectives and discuss the approach being taken to assess potential water quality impacts associated with the proposed raw water augmentation concept. It was concluded by ODEQ at the meeting that they did not foresee a need for a specific permit for the water transfer, since similar water transfers are already in place in Oklahoma. Following the meeting, the report titled *Thunderbird Water Quality Assessment, Impact Assessment of Augmentation* (Vieux 2009) was submitted to ODEQ for review. There were no adverse review comments received from ODEC.

5.1.3 Oklahoma State Historic Preservation Office (SHPO)

Informal consultation between Reclamation and the Oklahoma SHPO has been completed regarding the proposed project. The SHPO has provided written concurrence with the findings of the pedestrian archaeological and cultural resource field survey of the three alternative augmentation routes that was conducted on September 19, 2009. The letter of concurrence from SHPO to Reclamation, dated February 9, 2010, is included in Appendix B of this EA.

5.2 Public Involvement

5.2.1 Public Scoping Meeting

General

As part of the preparation of this EA, a public scoping meeting was held on September 1, 2009, at the Boat House facility on Lake Thunderbird to provide an opportunity for the public to suggest items to be included in the scope of the EA. During the month prior to the meeting, letters of invitation were mailed to numerous individuals, organizations, agencies, and groups that might have an interest in the project. Also, advertisements were placed in the local papers announcing the upcoming meeting.

At the scoping meeting, a number of handouts were provided, including an agenda, fact sheet, speaker sign-up sheets, and scoping comment forms. The public scoping meeting initiated a 30-day comment period to allow interested parties to submit comments, suggestions, and questions to the project team via mail, email, and phone call. The scoping meeting was attended by approximately 40 people. Ample time was provided during the meeting for participants to raise issues, comments, questions, and suggestions regarding the scoping of the EA. The comments provided at the meeting were recorded on flip chart and comment sheets and by note-taking.

Scoping Input Summary

Highlights of the scoping input from participants during the scoping meeting are as follows:

1. Please consider the water quality impacts from each of the alternative conveyance methods. Include impacts associated with: (a) different elevations of outfalls; (b) methods for conveying the water (pipeline alone with outfall into lake vs pipeline plus outfall into creek channel): (c) locations in the lake where discharge would occur.

2. Consider the effects that low dissolved oxygen levels and elevated levels of arsenic in water from the Atoka pipeline would have on Lake Thunderbird water quality.

3. Look at potential water quality impacts that long periods of import during severe droughts might have on Lake Thunderbird water.

4. Consider the water quality effects from mixing water from Lake Atoka with Lake Thunderbird water. Also, McGee Creek water is sometimes pumped into Lake Atoka, so consider the influence of its water quality as well.

5. Please consider an alternative that includes a direct connection from Atoka pipeline to the existing Midwest City and Del City pipeline (in the vicinity of Alternative #3).

6. Regarding the operation of the project, please explain the rationale and basis for the "trigger elevations" chosen for importing augmentation water during drought periods.

7. Consider the potential for invasive species to be introduced into Lake Thunderbird (e.g., zebra mussels) from the augmentation water.

8. Please consider the possibility of introducing toxic algae from Lake Atoka.

Consideration of Scoping Input

The input from the public scoping meeting highlighted in the above list was considered by the project team in the development of this EA. A summary of the consideration given is as follows:

1. The potential water quality impacts associated with the three action alternatives were evaluated, including 1a, b, and c, mentioned in the above summary list. It was determined that all three action alternatives would have the same level and types of water quality impact on Lake Thunderbird, as discussed in Section 4.2.2 of this EA. Alternative 1 was selected as the preferred alternative because it potentially disturbs less area than the other two alternatives, involves no impact to wetlands that could potentially require mitigation, has the shortest construction period, and is the least costly of the action alternatives. The preferred alternative discharge elevation is limited by the existing ground contour at the Willow Branch Creek. The outfall design would include energy dissipation baffles slow velocity from the connection pipeline to prevent erosion in the creek.

2. As discussed in Section 4.2.2 of this EA, operation of the preferred alternative is not expected to decrease dissolved oxygen (DO) levels in the lake. Although DO in the water drawn from the Atoka pipeline is not known, it is anticipated to undergo a reduction in DO concentration as it travels in the pipeline from Lake Atoka. It is therefore anticipated that cascade aeration would be included in the design of the preferred alternative to raise DO levels in the augmentation water prior to discharge into Lake Thunderbird.

   Also, the temperature of the Atoka pipeline augmentation water is expected to be cooler than the receiving water in Lake Thunderbird due to cooling during transport. Therefore, it is anticipated that the augmentation water would sink to lower depths of the lake, mixing with relatively poorer quality water (with respect to DO), and potentially improving the water quality in these lower depths (Vieux, Inc. 2009).

   Further, regarding whether or not arsenic was included in this analysis, arsenic was not included, mainly because it rarely is a contaminant of concern in Oklahoma surface water and is a much greater concern for groundwater. The influence of arsenic has been studied in other water supply planning efforts. For example, Oklahoma City draws water from Stanley Draper Lake, which is in the Lake Thunderbird watershed and is also augmented with raw water from Lake Atoka; Oklahoma City has not identified any arsenic concerns associated with this water. Also, the Oklahoma water quality inventory has not identified arsenic as a contaminant of concern related to Lake Atoka, Lake Stanley Draper, or Lake Thunderbird. The only surface waterbody in the state for which arsenic is a contaminant of concern is Tributary 8 of the Canadian River (ODEQ 2008).

3. Another concern expressed related to the need for evaluation of the affects of augmenting Lake Thunderbird for long periods of time. A *Lake Operational Study* (Tetra Tech 2009), conducted as part of developing the **Critical Need Water Supply Project**, incorporated the drought of record, or the worst drought experienced by the area. Therefore, the study modeled the longest length of time that augmentation would ever be likely to occur based on history. Even under these extreme conditions, the model results indicated a beneficial impact on water quality.

4. The water quality effects of mixing water from the Lake Atoka Pipeline (hence, Lake Atoka) with Lake Thunderbird water are described in detail in Section 4.2.2 of this EA. A concern was expressed regarding water quality in McGee Creek Reservoir, which flows into Lake Atoka, and its affect on Lake Thunderbird. The influence of McGee Creek Reservoir water quality on Lake Atoka water quality was addressed in the Lake Atoka BUMP report (OWRB 2008). Thus, the raw water quality data collected for Lake Atoka and used in the analyses described previously in Section 4.2.2 incorporates the water quality of McGee Creek Reservoir as it affects Lake Atoka.

5. It was suggested that an alternative be considered that involves constructing a raw water connection from the Atoka Pipeline directly to the combined Midwest City and Del City pipeline upstream of the Re-lift Pump Station, in the vicinity of the Alternative 3 connection (see Figure 3). This alternative was discussed and given consideration by COMCD and Reclamation, but was eliminated from evaluation in this EA because it does not meet the Purpose and Need for the proposed project, which is to provide raw augmentation water to the lake.

6. As discussed in Section 2.3 of this EA, a *Lake Operational Study* (Tetra Tech 2009) undertaken as part of the development of this project utilized Reclamation's Lake Thunderbird Yield Model to evaluate multiple augmentation water import scenarios that included various "trigger elevations" in lake levels and various quantities of augmentation water from the Atoka Pipeline. The trigger elevations selected were chosen by COMCD based on the evaluation process described in Section 2.3, taking into account the availability of water from the Atoka Pipeline, the frequency of anticipated need for augmentation, as well as the cost and cash flow needs to provide the augmentation during future critical droughts.

7. If zebra mussels are encountered at Lake Atoka and are still not known to occur at Lake Thunderbird, then pumping operations would not be initiated until such time that zebra mussels are encountered at Lake Thunderbird by means other than the proposed project.

8. A concern regarding augmentation water conveying toxic algae from Lake Atoka was also raised. Cyanobacteria, known as blue-green algae, are ecologically important for their ability to fix nitrogen gas and are naturally present in reservoirs, lakes and streams.

In nutrient-rich waters, blue-green algae are known to produce nuisance blooms during the summer and some species produce toxins or taste and odor issues, thus its nickname "toxic algae". A 2003 study (OWRB 2003) concluded that Lake Thunderbird contains potential toxin, taste, and odor producing species of algae. Some of these algae species are capable of becoming nuisance blooms. Most of the potential bloom-forming species have been identified in small quantities at Lake Thunderbird and do not raise great concern. No evidence of bloom-forming species in Lake Atoka was discovered by the project team in the preparation of this EA. Thus, the addition of Lake Atoka water is not expected to increase the potential for blue-green algae blooms.

Further, mechanisms are in place to reduce the chance (and/or severity) of blue-green algae blooms occurring within Lake Thunderbird. Annual toxicity testing of raw water tracks yearly toxin production in the lake (OWRB 2003). Additionally, the maintenance of lower nutrient levels through the use of best management practices in the lake (e.g., vegetated swales and minimum widths for riparian buffers) continues to minimize risk from nuisance algae. Moreover, the Oklahoma Aquatic Nuisance Species Management Plan (2008) provides background information and response roles for state agencies should a blue-green algae bloom occur, reducing impacts. ODEQ is the identified first responder.

5.3 Environmental Commitments

Measures that would be taken to avoid and/or minimize impacts include, but are not limited to:

a. All state and federal permit conditions necessary for construction and/or operation of the project would be followed.
b. Existing trees and woody vegetation should remain undisturbed to the extent possible. If unavoidable, stands of woody vegetation would be surveyed for nesting migratory birds during the nesting period of March 1st through August 31st, and then not disturbed if any were found.
c. All construction equipment would be thoroughly washed to remove dirt, seeds, and plant materials prior to entry into the project area. Any equipment that has been located in or near another water body within the past 30 days would be thoroughly cleaned with 140 degree water and dried for a minimum of five days before usage on the project site.

d. Erosion control techniques would be followed during construction with native grasses being used to reseed disturbed areas following construction.
e. If zebra mussels are encountered at Lake Atoka and are still not known to occur at Lake Thunderbird, then pumping operations would not be initiated until such time that zebra mussels are encountered at Lake Thunderbird by means other than the proposed project.
f. Prior to construction, a proper wetland field delineation and jurisdictional determination would be conducted to confirm NWI mapping.

6.0 REFERENCES

Bureau of Reclamation. 2009. *Lake Thunderbird/Norman Project Resource Management Plan*. Prepared in cooperation with Oklahoma Tourism and Recreation Department. January.

Engleman, Neal/Central Oklahoma Master Conservancy District. 2009. Personal communication with Heather Harris/CH2M HILL. September.

Canadian Wildlife Service and U.S. Fish and Wildlife Service. 2007. International Recovery Plan for the whooping crane. http://ecos.fws.gov/docs/recovery_plan/070604_v4.pdf. Accessed on January 19, 2010.

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menéndez, J. Räisänen, A. Rinke, A. Sarr and P. Whetton, 2007: Regional Climate Projections. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Accessed at <http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_Ch11.pdf> 21 January 2010.

City of Norman. 2001. *2040 Strategic Water Supply Plan for the Norman Utilities Authority*. Norman, Oklahoma. February.

Dzialowski, A. R., W. J. O'Brien and S. M. Swaffar. 2000. Range expansion and potential dispersal mechanisms of the exotic cladoceran *Daphnia lumholtzi*. Journal of Plankton Research 22(12):2205-2223.

East, T. L., K. E. Havens, A. J. Rodusky, and M. A. Brady. 1999. *Daphnia lumholtzi* and Daphnia ambigua: population comparisons of an exotic and a native cladoceran in Lake Okeechobee, Florida. Journal of Plankton Research 21(8):1537-1551.

Fang, Andrew/Oklahoma Department of Environmental Quality. 2009. Personal communication with Heather Harris/CH2M HILL. October.

Federal Emergency Management Agency. 2009. *MSC Product Map Search*. October. https://www.fema.gov. Accessed on October 15, 2009.

Goulden, C.L., D. Tomljanovich, D. Kreeger, and E. Corney. The invasion of Daphnia lumholtzi Sars (Cladocera, Daphniidae) into a North American reservoir. Pages 9-38 In: Hamilton, S.W., D.S. White, E.W. Chester, and A.F. Scott (eds.). 1995. Proceedings of the sixth symposium on the natural history of the lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Hoagland, B.W. 2008. “Earth Sciences and Mineral Resources of Oklahoma.” *Oklahoma Geological Survey Educational Publication #9*. Norman, Oklahoma.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate change 2007: Synthesis Report. Accessed at <http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf> 21 January 2010.

Johnson, J. L., and J. E. Havel. 2001. Competition between native and exotic Daphnia: in situ experiments. Journal of Plankton Research 23(4):373-387.

National Geographic Society. 2007. *Web Atlas of Oklahoma*. http://www.okatlas.org/okatlas. Accessed on September 17, 2009.

NatureServe. 2009. Piping Plover. http://www.natureserve.org/explorer/servlet/NatureServe?sourceTemplate=tabular_report.wmt&loadTemplate=species_RptComprehensive.wmt&selectedReport=RptComprehensive.wmt&summaryView=tabular_report.wmt&elKey=106046&paging=home&save=true&startIndex=1&nextStartIndex=1&reset=false&offPageSelectedElKey=106046&offPageSelectedElType=species&offPageYesNo=true&post_processes=&radiobutton=radiobutton&selectedIndexes=106046&selectedIndexes=741188&selectedIndexes=741174. Accessed on January 19, 2010.

Oklahoma Department of Environmental Quality. 2008. *Water Quality in Oklahoma, Integrated Report*.

Oklahoma Department of Wildlife Conservation. 2005a. Lake Thunderbird 5-Year Management Plan.

Oklahoma Department of Wildlife Conservation. 2005b. “Game and Fish.” *Oklahoma Administrative Code*. Title 29. Chapters 5 and 7. November.

Oklahoma Department of Wildlife Conservation. 2008. *Oklahoma Aquatic Nuisance Species Management Plan*.

Oklahoma Department of Wildlife Conservation. 2009. *Golden Alga*. http://www.wildlifedepartment.com/golden_alga.htm 10/16/. Accessed on October 3, 2009.

Oklahoma Natural Heritage Inventory. 2003. *Federal and State Endangered, Threatened, and Candidate Species in Oklahoma by County*. Distributed by Oklahoma Biological Survey. Norman, OK.

Oklahoma Natural Heritage Inventory. 2009. *Historical Records: Black-capped Vireo*. Distributed by Oklahoma Biological Survey. Norman, OK.

Oklahoma Water Resources Board. 2004. *Lake Thunderbird Algae 2003.* May.

Oklahoma Water Resources Board. 2006. *Lake Thunderbird Hydraulic and Nutrient Budget 2005*. July.

Oklahoma Water Resources Board. 2007a. *Lake Thunderbird Water Quality 2006*. September.

Oklahoma Water Resources Board. 2007b. *Oklahoma Water Atlas*.

Oklahoma Water Resources Board. 2007c. *2006-2007 Lakes Report, Beneficial Use Monitoring Program.*

Oklahoma Water Resources Board. 2008a. “Oklahoma’s Water Quality Standards.” *Oklahoma Administrative Code*. Title 785, Chapter 45. May.

Oklahoma Water Resources Board. 2008b. *2007-2008 Lakes Report, Beneficial Use Monitoring Program*.

Oklahoma Water Resources Board. September 2009a. Oklahoma Water Resources Board Beneficial Use Monitoring Program. http://www.owrb.ok.gov/hazard/fp/floodplain.php. Accessed on October 15, 2009.

Oklahoma Water Resources Board. 2009b. *Reported Well Locations of Oklahoma*. Vector Digital Data. http://www.owrb.ok.gov/maps/data/layers/Reported_Well_Logs.zip. Accessed on October 5, 2009.

Ryder, Paul D. 1996. *The Groundwater Atlas of the United States: Oklahoma, Texas*. U.S. Geological Survey. Publication HA 730-E.

Stubbs, Kevin/U.S. Fish and Wildlife Service (USFWS). 2009. Personal communication. December 2.

Tetra Tech. 2009. *Lake Thunderbird Critical Need Water Supply Project–Lake Operational Study*.

Tortorelli, Robert L. 2000. *Estimated Freshwater Withdrawals in Oklahoma, 2000*. Oklahoma Water Science Center Online Publication (Table 3). http://ok.water.usgs.gov/wateruse/wateruse00.html. Accessed on October 15, 2009.

USACE. 1971. "Definition of Waters of the Unites States." *Code of Federal Regulations.* Title 33, Part 328. http://www.usace.army.mil/cw/cecwo/reg/33cfr328.htm. Accessed on October 13, 2009.

USACE. 1987. *Corps of Engineers Wetlands Delineation Manual*. Environmental Laboratory, Department of the Army. January.

USGS. 2001. *A GAP analysis of Oklahoma (OK-GAP).*

USGS. 2008. *Water-Data Report 2008, 07229445 Stanley Draper Lake Near Oklahoma City, OK.*

USFWS. 1990. Recovery Plan for the Interior Population of the Least Tern. http://ecos.fws.gov/docs/recovery_plan/900919a.pdf. Accessed on January 19, 2010.

USFWS. 1991. Black-capped vireo recover plan. http://ecos.fws.gov/docs/recovery_plan/910930h.pdf. Accessed on January 21, 2010.

USFWS. 2007. "Endangered and Threatened Wildlife and Plants." *Code of Federal Regulations*. Title 50, Part 17. July.

USFWS. 2009a. Species list for Cleveland County. http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm. Accessed on September 29, 2009.

USFWS. 2009b. *American Peregrine Falcon*. http://www.fws.gov/southwest/es/oklahoma/peregrn1.htm. Accessed on October 19, 2009.

USFWS. 2009c. "General Provisions." *Code of Federal Regulations*. Title 50, Part 10. October.

USFWS. 2009c. Bald Eagle. http://www.fws.gov/Midwest/eagle/. Accessed on January 19, 2010.

Vieux, Inc. 2009. *Thunderbird Water Quality Assessment, Impact Assessment of Augmentation*. June.

Wilkins, Neal, Robert A. Powell, April A.T. Conkey, and Amy G. Snelgrove. 2006. *Population Status and Threat Analysis for the Black-capped Vireo*. May 2006.

Worden, Randy/ Central Oklahoma Master Conservancy District. 2010. Conference Call Discussion with Heather Harris/CH2M HILL. January 15.

Work, K. A., and M. Gophen. 1999. Factors which affect the abundance of an invasive cladoceran, *Daphnia lumholtzi,* in U.S. reservoirs. Freshwater Biology 42:1-10.

Zhang, X.C. 2005. Spatial downscaling of global climate model output for site-specific assessment of crop production and soil erosion. Agricultural and Forest Meteorology 135 (2005). pp. 215-229. Accessed at <http://search.nal.usda.gov/bitstream/10113/13822/1/IND43791497.pdf> 21 January 2010.

APPENDICES

APPENDIX A

Lake Thunderbird Water Quality Assessment

Impact Assessment of Augmentation

Introduction

Assessing the impact on Lake Thunderbird water quality due to water from the Atoka pipeline relies on the characterization of the existing water quality in both lakes. A macro-analysis of Lake Thunderbird using a completely mixed model compares the anticipated effects of Lake Atoka water on total phosphorus (TP), suspended solids, chlorophyll-a, temperature and dissolved oxygen. The limiting nutrient in this lake is phosphorus, and therefore, effects of augmentation on nitrogen are not considered. The analysis of augmentation impacts is performed using a simplified model developed by Vieux & Associates for Lake Thunderbird and used in previous studies for the Oklahoma Conservation Commission pertaining to the Lake Thunderbird watershed. This model assumes complete mixing and thus represents average conditions expected to occur over multiple years.

Lake Thunderbird turns over each spring and fall, so the assumption of complete mixing is consistent with long-term performance. Local impacts and seasonal variation in current water quality are expected, but are not considered in the macro analysis performed except in qualitative assessments of the effects of augmentation on DO and temperature.

Water quality in Lake Thunderbird is characterized for each parameter examined as follows. Total Nitrogen (TN) averages 0.78 mg/L with a range of 0.59-1.18 mg/L. Total Phosphorus (TP) averages 59 µg/L with a range of 30-100 µg/L. Total Suspended Solids (TSS) averages 18 mg/L lakewide and 21 mg/L near the dam (Site 1). Total suspended solids range from <10 mg/L to 171 mg/L according to 2007 water quality sampling in Lake Thunderbird. Chlorophyll-a averages 18.00 µg/L at Site 1, but ranges from 2.16-71.5 µg/L across the Lake. In the epilimnion (above 5 meters), Dissolved Oxygen (DO) is generally good where concentrations are above 6 mg/L. Temperature varies throughout the year and with depth. During stratification in the warm season from May to September, temperatures often exceed 28°C in the epilimnion with cooler temperatures in the lower de-oxygenated hypolimnion zone below 5-10 meters.

The following hydrologic and morphometric lake characteristics used in the water quality assessment are summarized as follows. The volume of the lake at the conservation pool elevation, 1039 ft-msl, is assumed to be 105,838 ac-ft, with an area of 5,439 ac or approximately 22 km^2 (OWRB, 2001). Average discharge from the lake measured by the USGS gauge located downstream of the dam, from 1982 to 2008, amounts to an annual volume of 58,613.6 ac-ft or 7.230E+07 m^3/yr. Spillage from the lake estimated from the Bureau of Reclamation Yield Model (BRYM) used by Tetra Tech in this study depends on the reservoir operational strategies, which result in approximately 30,398 to 30,704 ac-ft (Runs #24 and #48) per year during the 82-yr study period. Reasons for the difference between the BRYM spillage and the amount recorded by the USGS from 1982-2008 could be due to drought or lower runoff periods considered in the BRYM model that are not present in the record measured by USGS, which is known to contain a wetter than normal period, generally in the 1990's.

Water levels are expected to vary from year to year but have been relatively consistent since filling in the early 1970's, except for the recent drought in 2005-2006 followed by a record high water level in 2007, as seen Figure 1. In 2006, the lake experienced one of its lowest levels, with a surface area of 4967 ac in November, due to prolonged drought. A record high water level followed with a surface area of 7270 ac in June 2007.

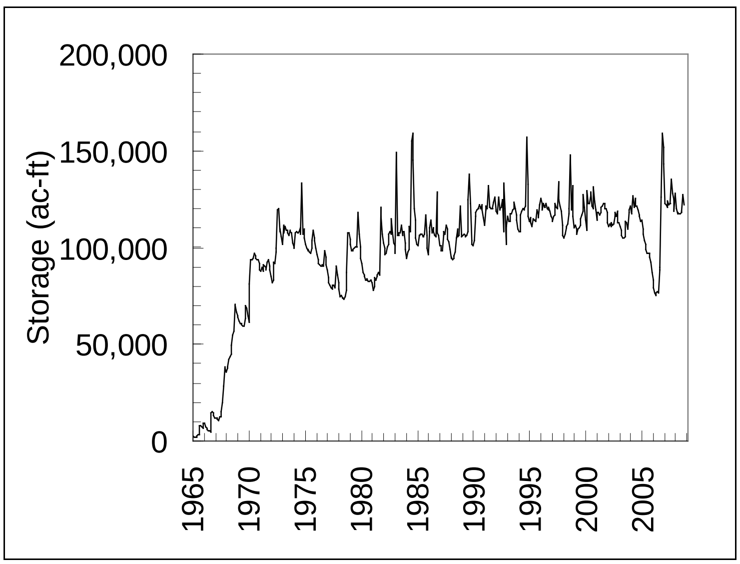


Figure 1 End-of-month storage in Lake Thunderbird

The projected impact of augmentation for each of the water quality parameters considered is described in the following sections.

Phosphorus

The mass balance for phosphorus assuming a well-mixed lake provides a relationship between the phosphorus loads from watershed runoff to the lake and the concentration of phosphorus in the lake. The total phosphorus concentration is computed as,

$$V\frac{dp}{dt} = W - Qp - vA_s \tag{1}$$

where V is the volume of the lake (m^3); t is time (yr); W is the mass phosphorus load to the lake (mg/yr): Q is the outflow rate (spillage) for the lake (m^3/yr); v is the apparent settling velocity within the lake (m/yr); A_s is the bottom area over which settling occurs (m^2); and p is in-lake phosphorus concentration (mg/m^3).

The mass load of total phosphorus from external sources is the input of total phosphorus to the lake from the watershed plus any phosphorus added with the augmentation water. This model is applicable to long-term averages but does not account for seasonal variations, inter-annual variations, or stratification. The vertical distribution of phosphorus within the water column is assumed uniform in a completely mixed system.

A previous study by Vieux & Associates, Inc. conducted for the Oklahoma Conservation Commission identified the annual loading of phosphorus to the lake from existing conditions (2001) in the watershed as 18,241 kg/yr. The apparent settling velocity for total phosphorus in the lake was estimated as 11.14 m/yr for a phosphorus concentration of TP=0.057 mg/L, and Chl-a=30.8 µg/L (Vieux, 2008).

TP for the body of the lake is calculated as a function of loading, outflow (spillage), settling velocity, and the surface area of the lake.

$$TP = \frac{W + W_{Aug}}{Q + vA} \tag{2}$$

where W is the phosphorus loading to the lake from the watershed; W_{Aug}, is the phosphorus loading from augmentation, Q is the discharge (spillage) for the lake, v is the apparent settling velocity for the lake, and A is the surface area.

Computing the effect of augmentation with Eq. 2 assumes that the Atoka Pipeline will discharge water to the lake at the rate of 3,048 to 9348 ac-ft per year depending on the operation strategy adopted. In actuality, the augmentation will be during critical need periods that may not extend for a full year depending on the extent of drought conditions. The net settling velocity during augmentation is assumed to be consistent with previous studies, or v=11.15 m/yr, and the volume discharged from the lake is taken as the spillage under the BYRM operational scenarios of 30,398 to 30,704 ac-ft per year. The concentration of TP in the augmentation water is assumed to be 105 µg/L as reported in the 2006-2007 Atoka BUMP Monitoring report.

The expected average concentration of TP resulting from watershed loading plus augmentation is TP=65 µg/L at 3048 ac-ft, which increases to 66 µg/L when augmentation is increased to 9348 ac-ft per year. The additional load of phosphorus associated with augmentation from Atoka at the higher augmentation rate tested, i.e. 9348 ac-ft, is only 1211 kg/yr compared to nonpoint source runoff loading expected from the watershed of 18,241 kg/yr.

If we consider that the SWS lake Chl-a criterion is for a three-year moving average, we can evaluate the effects of augmentation during a recent low-runoff period that persisted from 2005 through 2006, followed by a record high-water level in 2007. Considering augmentation during a low-water level period, November 2006 when the surface area declined to A = 4967 ac, the projected average phosphorus concentration could increase to TP=80 µg/L assuming the same input loading and outflow as under normal conditions. In June 2007, the lake storage was at a record high with and area of A=7270 ac. During this high-water level the phosphorus concentration would decrease to TP=51 µg/L. Considering the three-year period, 2005, 2006, and 2007, the concentrations would be TP=61 µg/L, 80 µg/L, and 51 µg/L, or TP_{avg}=64 µg/L. However, during drought conditions, loading from the watershed and outflow from the lake could be assumed to be zero. With no inflow or outflow during drought, the effect of augmentation each year would be to increase TP by 5 µg/L, estimated by Eq. 2, above existing levels if there is no inflow from the watershed or spillage from the lake.

While the reduction in phosphorus concentrations in the lake due to oxygenation of the hypoliminion through augmentation is unknown, it should be beneficial. To understand how the lake performed during record low and high water level periods, it is useful to look at the 2006-2007 monitoring data. BUMP data from October 2006 through June 2007, encompassing the low and high water levels, had an average surface TP concentration of 59 µg/L, and a range of measured TP from 23 µg/L in the winter 2006, to 429 µg/L in spring 2007.

The increase in TP concentration from augmentation is expected to be 1 µg/L or less under average conditions, which is well within the range of TP concentrations, 30-100 µg/L, found in the lake (BUMP surface concentrations). The increase in concentration and loading of TP due to augmentation is negligible considering the variation in the lake concentrations monitored with depth, spatially among the sampling sites, or seasonally at any location.

Chlorophyll-a

A relationship between Chl-a and TP was developed by the OWRB using 2001-2003 BUMP data for surface waters in Lake Thunderbird (OWRB, 2004). The relationship between Chl-a (µg/L) and TP, (mg/L) for Lake Thunderbird is expressed as,

$$\text{Chl-a} = 632 * \text{Total P} - 5.49 \qquad (3)$$

This regression equation is used to estimate the Chl-*a* from TP where phosphorus is a limiting condition. The estimated impact on Chl-*a* is computed using Eq. 3 as,

Existing: $Chl\text{-}a = 632*0.065 - 5.49 = 35.6\ \mu g/L$

Augmentation: $Chl\text{-}a = 632 \cdot 0.066 - 5.49 = 36.2\ \mu g/L$

The increase in Chl-a due to augmentation is expected to be less than 1 µg/L. Considering that Chl-a varies from 2 to 71 µg/L in Lake Thunderbird, the projected effect of augmentation is less than this variation, and not statistically signficant.

Total Suspended Solids (TSS)

Suspended solids (TSS) in the lake depends on inflow from the watershed, settling from the water column, turbulent resuspension due to wind and waves in shallow areas, dead or dying algae, and seasonal turn over. A net settling velocity for TSS is not known, so a conservative estimate is calculated using simplifying assumptions that consider the annual loading of TSS due to augmentation, but without overflow or net settling. Neglecting the effect of overflow during spillage would only serve to reduce the projected TSS concentration.

The TSS concentration under existing conditions is 21 mg/L, whereas in Atoka, the concentration is 23 mg/L. Assuming the augmentation rate is 9348 ac-ft per year, the load from Atoka consists of 265,417 kg added to the existing TSS load in the lake of 2,679,521 kg. The resulting concentration is TSS=23.1 mg/L, which is an increase of 2.1 mg/L. The concentration of TSS in Lake Thunderbird ranges from <10 mg/L to 171 mg/L. The projected increase in TSS is less than the range of variation across the lake, and is likely less because reduction in TSS concentration due to spillage was not included.

Temperature and Dissolved Oxygen

Dissolved oxygen (DO) in the water exiting the Atoka Pipeline is not known but is likely to be less than DO concentrations entering the pipeline from Lake Atoka. The temperature of the Atoka Pipeline water, and its density, relative to the lake water will affect how and where mixing occurs. The augmentation water is expected to be cooler than Lake Thunderbird due to cooling while in the Atoka Pipeline during its transport over approximately 100 miles. The cooler augmentation water is expected to plunge to lower depths of the lake when added during the summer and warmer surface water exists in the lake. In the hypolimnion, the plunging water is expected to mix with poor quality water that is anoxic and containing high TP concentrations.

Lake Thunderbird Watershed Study

Oklahoma Department of Environmental Quality (ODEQ) is currently studying this watershed to determine total daily maximum loads, or TMDLs for nutrients in runoff to the lake. The goal of the TMDL study is to determine acceptable loading rates for nutrients and suspended solids that will help the intended beneficial use of Lake Thunderbird to be achieved. In light of the unique challenges associated with reducing nonpoint source contributions, ODEQ intends to use a watershed-based plan in lieu of a TMDL for the lake. The reduction in TP and Chl-a in the lake can be related to reduction in phosphorus loading achieved through watershed management activities implemented. Less than a 1% reduction in TP load from the nonpoint sources in the watershed would restore the lakewide total phosphorus to the assumed baseline concentration of 65 µg/L. Variation in TP loading from the watershed would be larger than the projected increase in phosphorus concentration due to augmentation, and would be mitigated by management practices implemented in the Lake Thunderbird watershed. If the watershed management goals are met and Chl-a concentrations reduced to 10 µg/L, the increase due to augmentation would still amount to less than or equal to 1 µg/L assuming net settling velocities for TP and outflow remain the same.

Lake Benefits from Augmentation

Benefits are expected to result from introducing oxygenated water through augmentation during periods of critical need. Augmentation is expected to add oxygenated water to the hypoliminion where anoxic waters exist in Lake Thunderbird. Efforts to mechanically aerate this layer have been attempted in the past by COMCD to mediate anoxic conditions, as recommended by OWRB. The addition of augmentation water should have beneficial impacts in the lake's hypoliminion because oxidizing conditions would result. Similarly, Lake Stanley Draper, which receives most of its water from the Atoka Pipeline, has benefited because of its water quality. This lake is classified by the OWRB as oligotrophic due to low concentration of Chl-a and TP in the lake even though its water is derived from the same source proposed for augmentation, i.e. Atoka. Augmentation of Lake Thunderbird will help maintain higher water levels and increase the surface area of the lake during critical need periods, which will improve the net settling of phosphorus. Loading from the watershed during drought periods will be minimal, and augmentation will improve lake levels during critical need periods. From this analysis, impacts of augmentation water on TSS, TN, and TP are expected to be beneficial or have minimal impacts considering the range of concentrations of Chl-a and nutrients found in the lake.

APPENDIX B

Cultural Resources Survey and SHPO Concurrence Letter

CULTURAL RESOURCE SURVEY OF PROPOSED AUGMENTATION WATER LINES, LAKE THUNDERBIRD CRITICAL NEED WATER SUPPLY PROJECT

CLEVELAND COUNTY, OKLAHOMA

Conducted for:

Srini Sundaramoorthy, P.E.,
Project Manager, Tetra Tech
7645 E. 63rd Street, Suite 301, Tulsa. Oklahoma 74133

By:

Donald O. Henry, PhD, Consulting Archaeologist
2102 East 25th Street., Tulsa, Oklahoma 74114
(918) 794 7332, (918) 631 2889, Cell (918) 688 4466
donald-henry@utulsa.edu

23 September 2009

***NATURE AND DESCRIPTION OF PROJECT*:**

An archaeological and cultural resource survey of approximately 1.5 miles of proposed augmentation water lines along three alternative routes was conducted at the request of Srini Sundaramoorthy, P.E., Project Manager, Tetra Tech, Inc., 7645 E. 63rd Street, Suite 301, Tulsa, Oklahoma, 74133.

The proposed construction activity associated with development of the water lines will significantly disturb the surface and subsurface deposits along with any cultural resources contained therein. The survey was conducted in order to inventory and evaluate archaeological, historic, and cultural resources found along or near the proposed water lines.

ARCHAEOLOGIST and ASSISTANTS: ***DATE(S) OF SURVEY:***

Donald O. Henry, PhD
Nancy A. Henry, MLS

19 September 2009

***PREFIELD INVESTIGATION*:**

No archaeological site or historic property is on record within or near the routes of the proposed water lines with the Oklahoma Archaeological Survey (Phone requested records search, 9-17-09) or the State Historic Preservation Office (http://www.ocgi.okstate.edu/shpo/natreg.htm; accessed 9-17-09).

LEGAL & MAP DESCRIPTIONS:

PLSS / Legal:

Alternative Route #1
NE ¼ , NE ¼, Section 8, T9N \ R1E, Cleveland County, Oklahoma

Alternative Route #2
N ½ , N ½, Section 8 & NE ¼ , NE ¼, Section 7, T9N \ R1E, Cleveland County, Oklahoma

Alternative Route #3
NE ¼ , NE ¼, Section 36, T10N \ R1W, Cleveland County, Oklahoma

Maps:
USGS Quad Sheets: Stella 1956, Photorevised 1969, 1975, Photoinspected 1981; Franklin 1956, Photorevised 1969, 1975; see Figures 1 & 2.

***ENVIRONMENTAL DESCRIPTION*:**

The study area is located within the North Cross Timbers Major Land Resource Area of the Osage Plains Section of the Central Lowland Province of the Interior Plains.

It is an area of rolling to hilly uplands with narrow stream valleys that display steep gradients. Specifically, the study area is located in rolling uplands drained by Hog Creek to the south to the Little River.

The geologic substrate of the area is composed of Permian sandstones and shales. Surface sediments are largely represented by clayey and sandy loams. The uplands largely consist of fine sandy loams of the Stephen-Darsil-Newalla Complex, sandy savannah soils that have developed from the weathered residuum of sandstone. On lower slopes and ridge-toes, Harrah sandy loam has developed on colluvium, against which alluvial terraces have formed along Hog Creek and its drainages. Pulaski and Tribbey fine sandy loams are present on these terraces.

Relative to the proposed water line routes: Route #1 and #3 and the western end of Route #2 are principally situated in lowland, alluvial terrace settings associated with Pulaski and Tribbey fine sandy loams, whereas most of Route #2 crosses uplands and slopes that display extensive bedrock exposures and fine sandy loams of the Stephen-Darsil-Newalla Complex.

Chert is not locally available, but Ogallala quartzite gravels appear as isolated clasts and seams in the uplands.

***FIELD METHODOLOGY*:**

The survey was conducted over a one- day period by a two-person team under warm, mostly sunny conditions. The routes of the three alternate water lines were identified in the field on the basis of GPS coordinates (Garmin GPSmap60CSx), structures, roads, fence-lines, and prominent natural features. The 1927 NAD map datum was used to generate GPS coordinates and allow for correlation with the USGS quad sheets. Beginning, mid-point, and end-point UTM (NAD 83) coordinates were provided by Tetra Tech, Inc. and these were converted to NAD 27 coordinates using NOAA's NADCON program. *Google Earth* and NRCS soil survey imagery were also used to help guide the field survey.

A 30m wide swath was walked along the proposed routes. Alternate routes #1 and #3 and the western end of route #2 were double walked, once outbound and again on a return walk. The remainder of Alternate Route #2 was walked once. Shovel probes were dug in areas of poor surface visibility and in areas deemed likely to hold archaeological materials. In the wooded areas, leaf litter was removed with shovel scrapes.

Surface visibility varied greatly along the proposed routes. In general, Alternative Route #1, Alternative Route #3, and the western terminus of Alternative Route #2 displayed poor (0-25%) to moderate (>25-50%) visibility. Most of Alternative Route #2 displayed moderate to excellent (>75-100%) surface visibility and extensive portions of Alternative Route #1 exhibited excellent visibility due to recent trail clearance and scraping.

CULTURAL RESOURCES:

The cultural resource finding in the survey was limited to concrete culvert abutments located near the western end of Alternative Route #2 (Figure 1). The culvert is associated with the abandoned elevated roadbed of E Franklin Road at an unnamed stream crossing. The culvert is constructed of concrete with full height abutments and wingwalls. It is about 9m (30') in length with a 5-6m (16-19') span. The deck is gone and the abutments are undecorated. No inscription or date was observed on either of the abutments.

The age of the culvert most likely predates the abandonment of E Franklin Road at the time of construction or filling of Lake Thunderbird. The lake was constructed by the Bureau of Reclamation from 1961 to 1965.

RECOMMENDATIONS:

I recommend that clearance be given for construction of the proposed augmentation water lines without additional study of the cultural resources.

The field survey resulted in the identification of a single cultural resource: concrete abutments forming a culvert under the now abandoned roadbed of E. Franklin Road (Figure 1). The date of construction of the abutments is uncertain, but likely predates 1961-1965, the period of construction for Lake Thunderbird.

The concrete culvert is unremarkable in design and the type is redundant in the region, being commonly employed to channel minor drainages through roadbeds. For these reasons it is considered to be not eligible for consideration to the National Registrar of Historic Places. No other cultural resource was observed in the field survey and none is on file with the Oklahoma Archaeological Survey or Oklahoma Office of Historic Preservation.

Donald O. Henry
23 September 2009

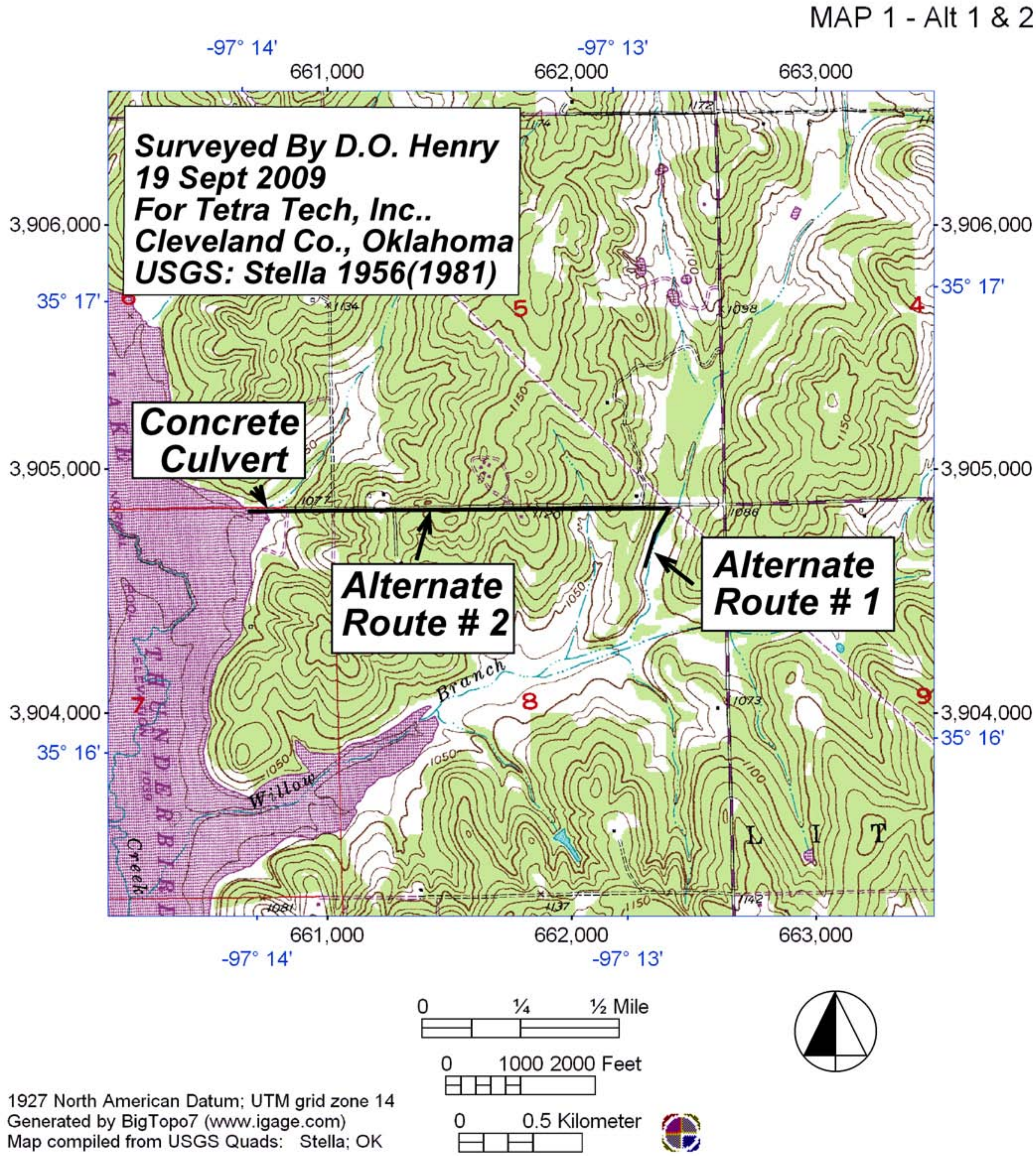


Figure 1: Map showing the locations of the study area, proposed alternative routes #1 and #2, the concrete culvert and prominent natural features.

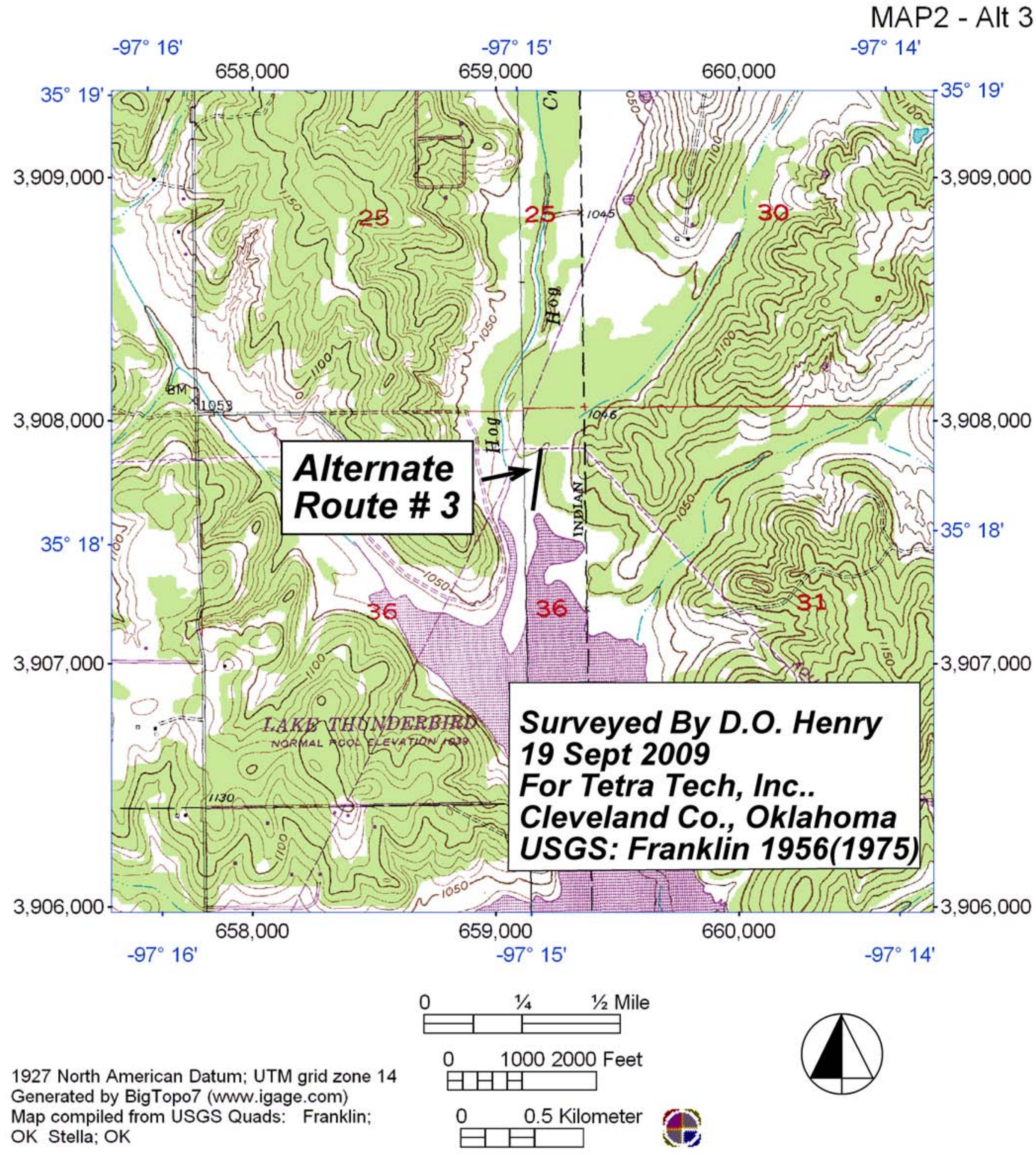


Figure 2: Map showing the locations of the study area, proposed alternative route #3 and prominent natural features.

Oklahoma Archeological Survey

THE UNIVERSITY OF OKLAHOMA

February 9, 2010

Bob Blasing
Bureau of Reclamation
5924 NW 2nd Street, Ste. 200
Oklahoma City, Oklahoma 73127-6514

Re: Three proposed alternate routes for an augmentation waterline at Lake Thunderbird.
Legal Description: NE ¼ NE ¼ Section 8, N ½ W ½ Section 8, and NE ¼ NE ¼ Section 7 T9N R1E, Cleveland County, Oklahoma.

Dear Mr. Blasing:

A cultural resources report of investigations has been received by this agency on the above referenced project. This agency confirms the recommendations contained in the report. The review was conducted in cooperation with the State Historic Preservation Office, Oklahoma Historical Society.

Please contact this office at (405) 325-7211 if buried archaeological materials such as chipped stone tools, pottery, bone, historic crockery, glass, metal items, or building materials are exposed during construction activities.

In addition to our comment on the cultural resource inventory conducted for this project, under 36CFR Part 800.3 you are reminded of your responsibility to consult with the appropriate Native American tribe/groups for any concerns they may have pertaining to this report.

Sincerely,

Robert L. Brooks
State Archaeologist

:ls

Cc: SHPO

111 E. Chesapeake, Room 102, Norman, Oklahoma 73019-5111 PHONE: (405) 325-7211 FAX: (405) 325-7604
A UNIT OF ARTS AND SCIENCES SERVING THE PEOPLE OF OKLAHOMA