# *Coastal Bend Regional Water Planning Area*

## *2011 Regional Water Plan*

***Study 2***
***Optimization and Implementation Studies***
***for Off-Channel Reservoir***

***Prepared by:***

**Coastal Bend Regional Water Planning Group**

***With administration by:***

**Nueces River Authority**

***With technical assistance by:***

**HDR Engineering, Inc.**


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# *Study 2*
# *Optimization and Implementation Studies for Off-Channel Reservoir (Final)*


4/15/09

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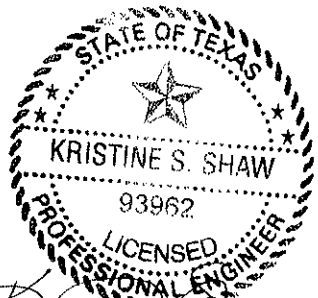


4/20/09

*Kristine S. Shaw, P.E.*

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| | |
|---|---|
| acft | Acre- Feet |
| B&E | Bay and Estuary |
| CCR | Choke Canyon Reservoir |
| CCR/LCC | Choke Canyon Reservoir/ Lake Corpus Christi System |
| CCWSM | Corpus Christi Water Supply Model |
| cfs | Cubic Feet per Second |
| FEMA | Federal Emergency Management Agency |
| ft-msl | Feet- Mean Sea Level |
| LCC | Lake Corpus Christi |
| MGD | million gallons per day |
| OCR | Off-Channel Reservoir |
| RWPG | Regional Water Planning Group |
| TCEQ | Texas Commission on Environmental Quality |
| TWDB | Texas Water Development Board |
| TPWD | Texas Parks and Wildlife Department |
| USACE | U.S. Army Corps of Engineers |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | United States Geological Survey |

# *Executive Summary*

The 2006 Coastal Bend Regional Water Plan (2006 Plan) and the 2007 State Water Plan included the Nueces Off-Channel Reservoir (OCR) near Lake Corpus Christi as a recommended future water management strategy for the Coastal Bend Region to meet needs by Year 2040. The U.S. Army Corps of Engineers (USACE) is currently studying the OCR as part of the Nueces River Feasibility Study to evaluate opportunities for flood damage reduction, ecosystem restoration, and/or water supply benefits in South Texas. During the 2007 Texas legislative session, the Nueces Off-Channel Reservoir site was designated as one of 19 unique reservoir sites in the State of Texas. The Texas Water Development Board (TWDB) Reservoir Site Protection Study[1] recommended the Nueces Off-Channel Reservoir as one of the top-ranked sites in Texas for protection or acquisition.

The OCR is a water management strategy that could be used to (1) enhance the system yield of Choke Canyon Reservoir (CCR) and Lake Corpus Christi (LCC), (2) capture water that would otherwise spill from LCC, and (3) reduce flood events downstream of LCC (to a lesser extent) while still maintaining desired freshwater inflows to the Nueces Bay and Estuary pursuant to the Texas Commission on Environmental Quality (TCEQ) 2001 Agreed Order.

The 2006 Plan analysis showed the optimal size for the OCR is between 200,000 and 300,000 acft, with a diversion pipeline delivery rate between 750 and 1,500 cfs.

This study includes further analysis of the OCR as a water management strategy for the Coastal Bend Region. The purposes of this study are to identify a preferred location for the OCR considering potential environmental impacts, optimize its capacity and diversion pipeline delivery rate, and evaluate alternative reservoir operating policies to assist with effective management of system storage and water supply yields.

The results of this study show that the optimal size for the OCR based on acceptable cost and project yield is 280,000 acft with a pipeline delivery rate of between 1,250 cfs and 1,500 cfs. The annual unit costs of raw water supply range between $469 per acft and $484 per acft, respectively, which is comparable to existing water supplies in the region. With Federal participation, as may be available through the USACE Nueces River Basin Feasibility Study, project costs could potentially be reduced.

[1] Texas Water Development Board, HDR Engineering, R.J. Brandes Company, et al "Reservoir Site Protection Study", TWDB Report 370, July 2008.

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## *1.0 Introduction*

The Coastal Bend Region relies predominantly upon surface water supplies from two reservoirs located in the Nueces River Basin: Choke Canyon Reservoir (CCR) and Lake Corpus Christi (LCC). These two reservoirs, when operated as a system, currently provide water supplies to meet about one half of the total regional water demands including municipal and non-municipal use, with the remaining supplies coming from Lake Texana and, to a lesser extent, groundwater and local supplies.

CCR has a storage capacity of 695,271 acft at a conservation pool elevation of 220.5 ft-msl and a contributing drainage area of 5,490 square miles.[1] According to a volumetric survey conducted by the Texas Water Development Board (TWDB) in 2002, LCC has a storage capacity of 257,260 acft at a conservation pool elevation of 94.0 ft-msl and a contributing drainage area of 16,656 square miles. This configuration creates a situation where the smallest reservoir has the largest potential for capturing storm events because of the larger contributing drainage area.

The yield of the system is affected by the storage capacity of LCC and its limited ability to capture a significant portion of large storm events that travel down the Nueces River. Since LCC has the smaller capacity, many times it fills and spills during times when the bay has adequate freshwater inflow. However, if water could be pumped into an off-channel reservoir (OCR), it would result in more water in storage and enhance the system yield. The OCR could be operated to capture water that would otherwise spill from LCC while still maintaining desired freshwater inflows to the Nueces Bay and Estuary (B&E) and could potentially be operated to reduce flood events downstream of LCC. The U.S. Army Corps of Engineers (USACE) is currently studying the OCR as part of the Nueces River Basin Feasibility Study to evaluate opportunities for flood damage reduction, ecosystem restoration, and/or water supply benefits in South Texas.

## *1.1 Background*

As part of the Senate Bill 1 statewide water planning process, the 2006 Coastal Bend Regional Water Plan (2006 Plan) included an evaluation of preliminary OCR reservoir capacities and diversion pipeline delivery rates located near LCC. The most favorable options included OCR capacities ranging between 200,000 and 300,000 acft and a diversion pump station with a pipeline delivery rate from 750 to 1,500 cfs. The 2006 Coastal Bend Regional Water Plan and the 2007 State Water Plan included the Nueces OCR near LCC as a recommended future water management

[1] United States Geological Survey Texas Water Science Center, http://tx.usgs.gov

strategy for the Coastal Bend Region to meet needs by Year 2040. Since the 2006 Plan, the Corpus Christi Water Supply Model (CCWSM) has been updated to simulate an OCR located near LCC with the current CCR/LCC/Lake Texana system. This update provided an essential tool which was used in this study to evaluate alternative reservoir operating parameters, as discussed in Section 4.

During the 2007 Texas legislative session, the Nueces OCR was designated as one of 19 unique reservoir sites in the State of Texas. The TWDB Reservoir Site Protection Study[2] recommended the Nueces OCR as one of the top-ranked sites in Texas for protection or acquisition. The report findings showed an increase in system firm yield of 39,935 for an OCR capacity of 250,000 acft and diversion pipeline delivery rate of 1,000 cfs.

### *1.2 Need for Study and Project Objectives*

In order to facilitate implementation of the OCR as a water management strategy, a more detailed study was necessary. The OCR study results from the 2006 Plan and TWDB Reservoir Site Protection Study were used as a baseline for further analysis. This study was conducted to determine the optimal size for the OCR and pump station facilities in addition to preferable reservoir operations to provide the greatest amount of additional water supply benefits to the CCR/LCC/Lake Texana system while minimizing environmental impacts and unit costs.

## *2.0 Description of Study*

Topographic maps, LCC volumetric survey, and other local studies were considered to identify preferred locations for the OCR, intake, pipeline, and pump station. The TWDB's LCC volumetric survey included cross-sectional contours and shaded water depth ranges, which was used to identify deep channel areas near the OCR and upstream of LCC to determine a suitable location for the intake and pump station. A desktop environmental analysis was conducted to identify area-specific environmental characteristics, which was considered as part of the preliminary OCR site selection. After preferred location and size of the OCR were determined, a detailed analysis of the OCR was performed to determine the optimal OCR capacity between 200,000 and 300,000 acft for pipeline delivery rates between 750 cfs and 1,500 cfs. Alternative reservoir operating policies, such as varying triggers for water supply releases from LCC and

[2] Texas Water Development Board, HDR Engineering, R.J. Brandes Company, et al "Reservoir Site Protection Study", TWDB Report 370, July 2008.

diversions to or releases from the OCR, were evaluated to best manage water supply, water quality, and ecosystem restoration benefits.

## *3.0 Methodology and Approach*

The CCR/LCC/Lake Texana system is currently operated to make water supply releases from CCR when water levels at LCC are at or below 74 ft-msl.[3] The CCWSM simulates current CCR/LCC/Lake Texana operations and has been updated to include simulation of an OCR located near LCC. The OCR is simulated in the model to receive water pumped from LCC based on LCC water level criteria and to release stored water from the OCR to LCC when LCC water levels drop below a user-selected level. This process of transferring water between LCC and the OCR is illustrated in Figure 3-1.

Preliminary OCR analyses were conducted using the CCWSM to determine the relative impact on water supply yields with different LCC water level triggers. Based on previous studies, the preferred operation of pumping water to the OCR is when LCC is at or above 93 ft-msl (or 1 ft below conservation pool elevation of 94 ft-msl). Preliminary analyses showed the highest water supply yields are achieved when water stored in the OCR is released back into LCC when water levels in LCC are between 75 ft-msl and 83 ft-msl.

### *3.1 Off-Channel Reservoir Site Selection*

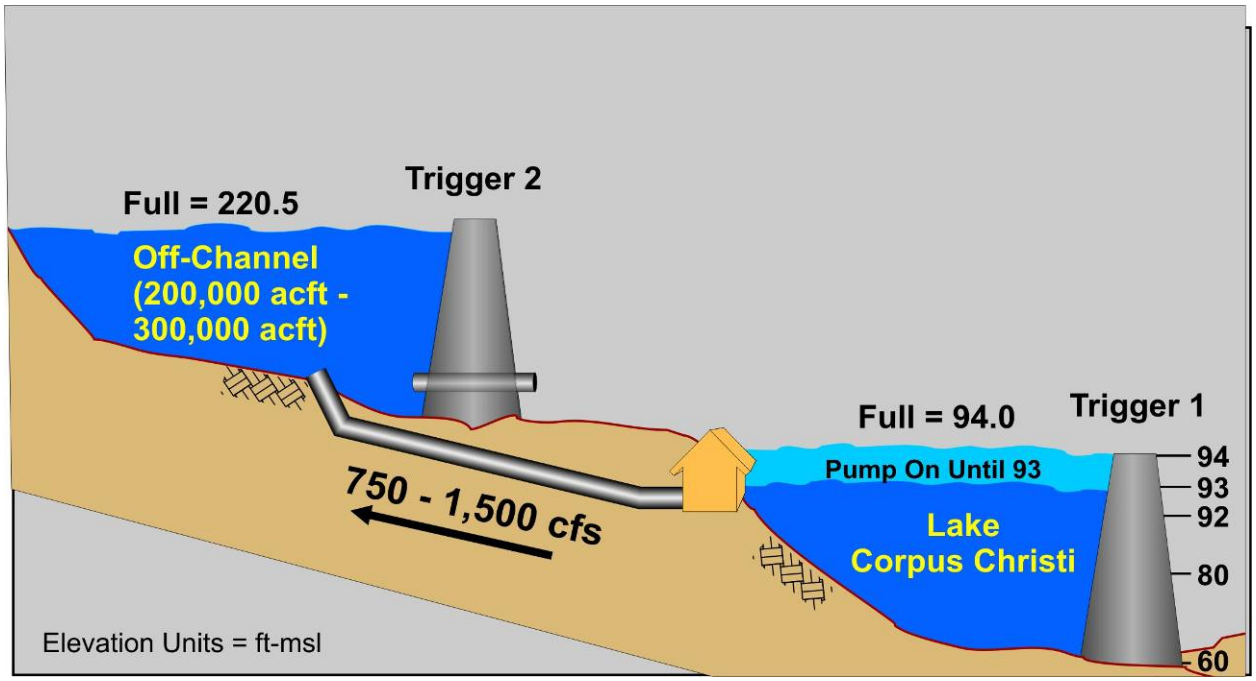
An alternative reservoir site analysis was conducted to determine the most desirable OCR location based on cost and environmental impacts. Elevation-area-capacity curves were developed using USGS 7 ½ minute topographic maps to estimate inundated surface area, average depth, and proposed elevation required for the optimal OCR size. Four potential OCR locations near LCC (Sites A through D) were identified that would be suitable for storing up to 300,000 acft as shown in Figure 3-2. The criteria used to evaluate potential sites for the OCR included consideration of embankment volumes, land needs, existing structures and roadways (to minimize disturbances), energy costs, and environmental issues.

A desktop environmental analysis of potential OCR sites included:

- Identifying dominant vegetation and wildlife habitats;
- Evaluating the suitability of wildlife habitats for endangered and threatened species listed in the region;

[3] Based on the modified Phase IV, or maximum yield, operation policy for the CCR/LCC System. Phase IV operating policy is the maximum yield policy intended to apply to the system when water user demand exceeds 200,000 acft annually.

***(a) Pipeline Operations from LCC to OCR***




***(b) Release of Stored Water from OCR to LCC***

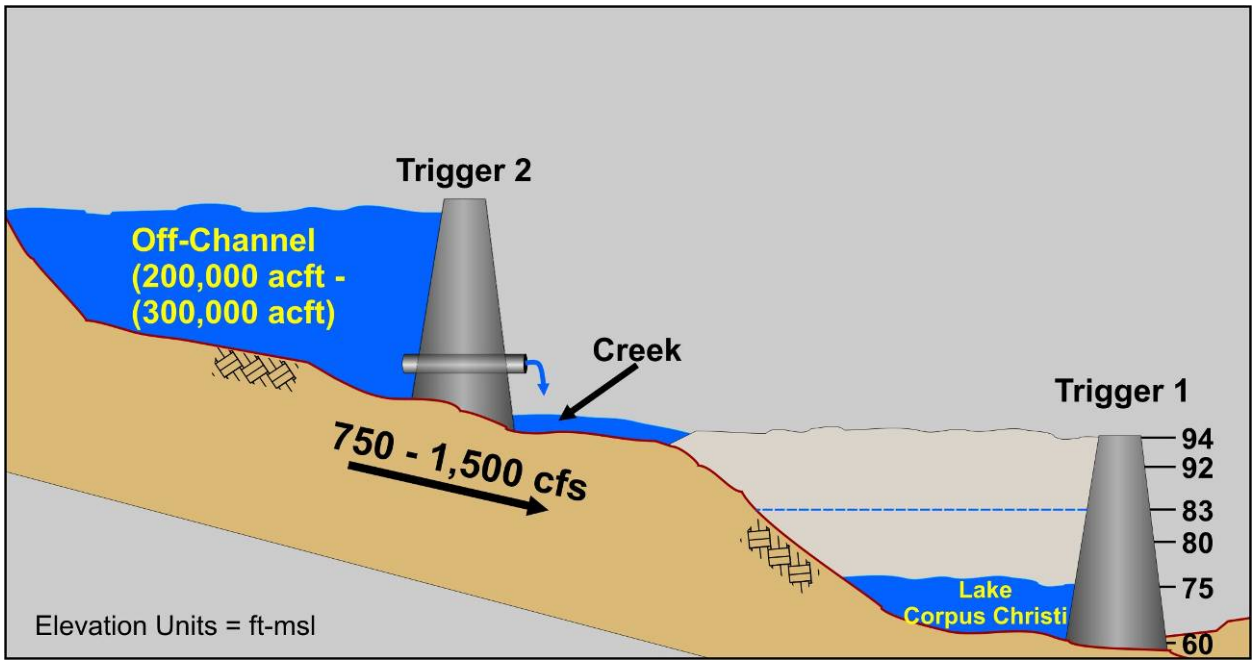



***Figure 3-1. Pipeline Operations between LCC and OCR***

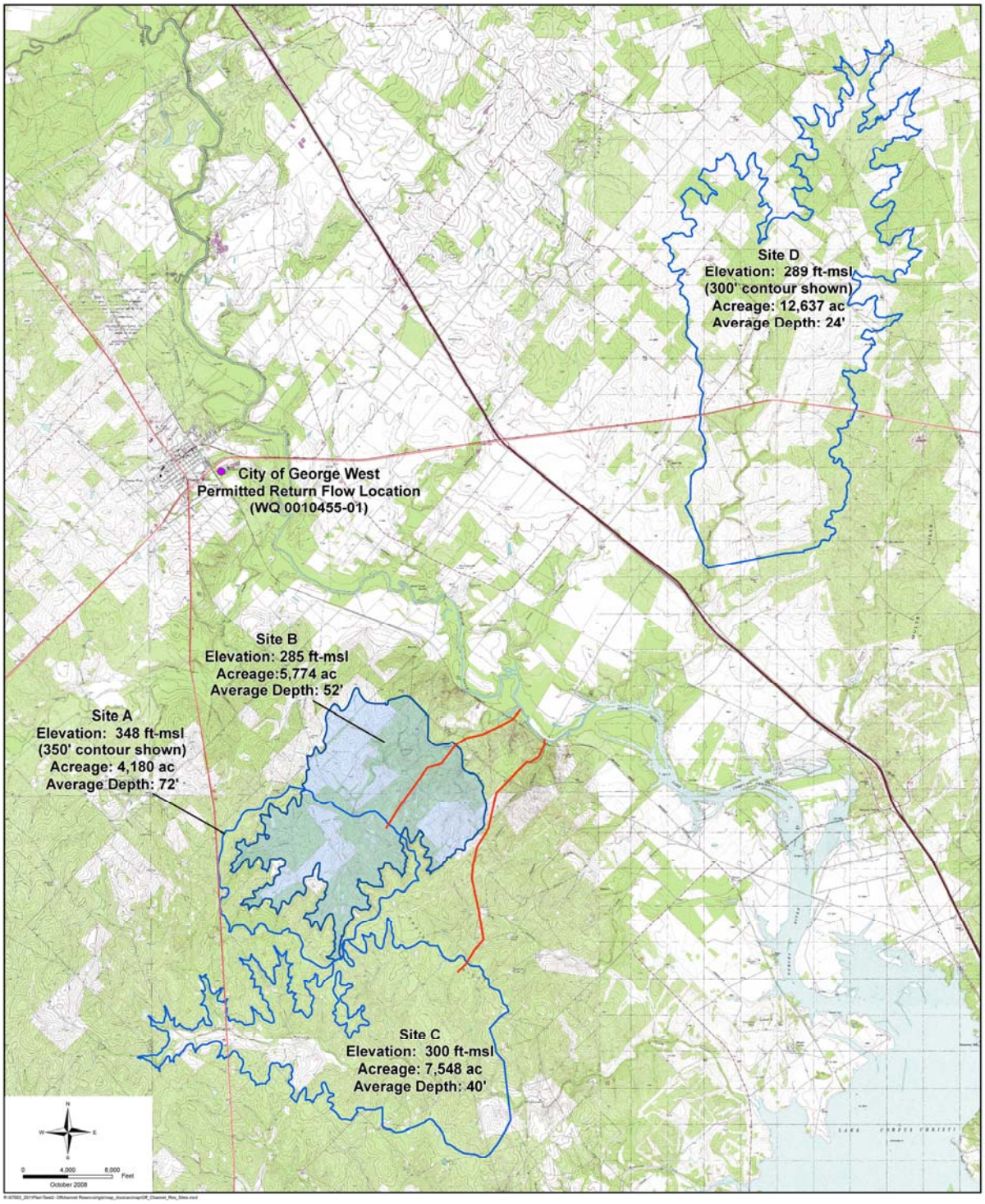



***Figure 3-2. Alternative Reservoir Sites Considered for OCR***
***(NOTE: Reservoir footprints based on 300,000 acft OCR)***

- Identifying water quality and aquatic habitats (including jurisdictional wetlands) potentially affected by the OCR site; and
- Evaluating known cultural resources and archeological sites.

Additional information considered for site selection included the TWDB volumetric survey for LCC, available groundwater data, Texas Parks and Wildlife Department (TPWD) Natural Diversity database,[4] Texas Historical Commission cultural resources data, and other area-specific studies.

### *3.2 Sizing the Off-Channel Reservoir*

Based on previous study results, a series of model runs was performed using the CCWSM to evaluate a range of OCR storage capacities between 200,000 and 300,000 acft (at 20,000 acft increments) with a range of pipeline delivery rates between 750 and 1,500 cfs (at 250 cfs increments). A total of twenty four combinations of OCR storage capacities and pipeline delivery rates were evaluated. The criteria for selecting optimal sizes included: (1) identifying the option with least unit cost of water, and (2) upsizing to increase yield up to maximum acceptable unit cost. The objective was to identify the OCR capacity and pipeline delivery rate that provided the largest water supply while minimizing capital costs and unit costs of raw water supplies and environmental impacts. Planning level cost estimates were calculated in accordance with the TWDB's "General Guidelines for Regional Water Plan Development (2007-2012)," Section 4.1.2. Costs are reported in second quarter 2007 dollars, and will be updated to September 2008 dollars during Phase II development of the 2011 Plan.

### *3.3 Evaluating Alternative OCR Operating Procedures*

The CCWSM was used to conduct a series of model runs to evaluate impacts of modifying OCR operating policies as part of the CCR/LCC/Lake Texana system. Storage and frequency plots were developed to determine a management approach of system storage to minimize evaporative loss and optimize additional water supply yield, while continuing to provide desired freshwater inflow to the Nueces B&E system.

[4] Texas Parks and Wildlife Department, Wildlife Division Diversity Program, Natural Diversity Database (5/20/08).

## *4.0 Study Results*

### *4.1 Off-Channel Reservoir Site Selection and Consideration of Environmental Issues*

Based on the potential reservoir sites shown in Figure 3-2, Site D was determined to be the least desirable OCR location and was removed from consideration since it required (1) the largest amounts of land up to 12,637 acres for the maximum reservoir size of 300,000 acft and (2) would impact portions of U.S. Hwy 59.

A preliminary environmental assessment was conducted of the three remaining potential OCR sites (Sites A, B, and C).

The TPWD lists 16 threatened or endangered species potentially occurring in Live Oak County. Of these 16, five (5) are listed by the U.S. Fish and Wildlife Service (USFWS) as endangered. According to the TPWD Texas Natural Diversity Database, there have been no sightings reported of any state or federal listed threatened or endangered species within five miles of the potential OCR sites (Sites A, B, and C). The local vegetation and wildlife habitats are primarily shrub and brush rangeland that may provide suitable habitat for some rare species.

A review was conducted of USGS, USFWS, and Federal Emergency Management Agency (FEMA) maps to evaluate water quality and aquatic habitats. There are no open water features, on-channel impoundments, or upland ponds found within the potential OCR Sites A, B, or C. However, the FEMA maps show a possibility that OCR pipeline alignments would be located in a 100 year floodplain area.

The Texas Historical Commission identified two recorded cultural resources sites in Live Oak County. These include Fort Merrill, a fort established as protection for settlers against Indians which is listed in the National Register of Historic Places. This fort is located on the George West quad approximately 3.5 miles northwest of Dinero off FM 534. The second cultural resource site is located south of both the Missouri Pacific railroad tracks and the Nueces River. Neither of these archeological sites is within proposed OCR areas or pipeline alignments.

More detailed results of the desktop environmental analysis are included in Appendix A to supplement the environmental discussion in Section 4C of the 2006 Plan. From a desktop analysis level, there are no significant differences in environmental impacts for OCR Sites A, B, or C, other than the extent of potential wildlife habitat impact with larger reservoir footprints. Prior to design and implementation of the project, a more detailed evaluation of the inundated area and habitats will be necessary.

After considering environmental issues, Site C was removed from further consideration since it had the largest footprint of 7,550 acres and would impound an area where a portion of US Hwy 281 is located.

Sites A and B were then evaluated to determine the preferable site, with cost being the primary criteria. Site B requires from 900 to 1,500 acres more land than Site A depending on reservoir size, as shown in Figure 4-1. Using previous studies on area land costs[5], Site B is expected to cost as much as $3,601,500 more for land than Site A for a 300,000 acft capacity OCR. However, Site A would require an additional 6,333,000 cubic yards of embankment fill (based on a 300,000 acft capacity) for the increase in reservoir depth as compared to Site B as shown in Figure 4-2. Using an average cost of $5 per cubic yard for embankment fill, the cost for Site A embankment fill could be $31,665,000 more than Site B, which is nearly 10 times the increased land cost for Site B. Also, the costs to pump water to Site A would be higher and require an additional two miles of pipeline as compared to Site B. Considering the higher costs for Site A, Site B was determined to be the most economical OCR site. Relocation costs for product transmission pipeline, powerlines, and active oil and gas wells will need to be considered for Site B during preliminary design.

The desktop environmental analysis did not indicate anticipated impacts to protected environmental and cultural resources requiring mitigation based on the proposed project location. However, if during a more detailed evaluation of the inundated area and surrounding habitats during the design and construction phase of the project it is determined that adverse impacts exist to environmental and cultural resources, then unavoidable impacts will likely require mitigation. The project cost estimates provided in Figure 4-4 and Section 5, include provisions for additional detailed environmental and archaeological studies and mitigation (if necessary). The cost for these additional studies and mitigation is estimated at about 5% of the total project cost.

## *4.2 Optimizing Off-Channel Reservoir Capacity and Delivery Rate*

Based on the 2006 Plan results, six OCR sizes from 200,000 acft to 300,000 acft (at 20,000 acft increments) were evaluated for five pipeline delivery rates of 750 cfs to 1,500 cfs (at 250 cfs increments). The CCWSM was used to simulate 24 combinations of OCR size and pipeline delivery rate to determine the firm yield water supply of

[5] Texas A&M University Rural Land Price estimates of $2,401 per acre for the Coastal Prairie-South (LMA 20) area from http://recenter.tamu.edu

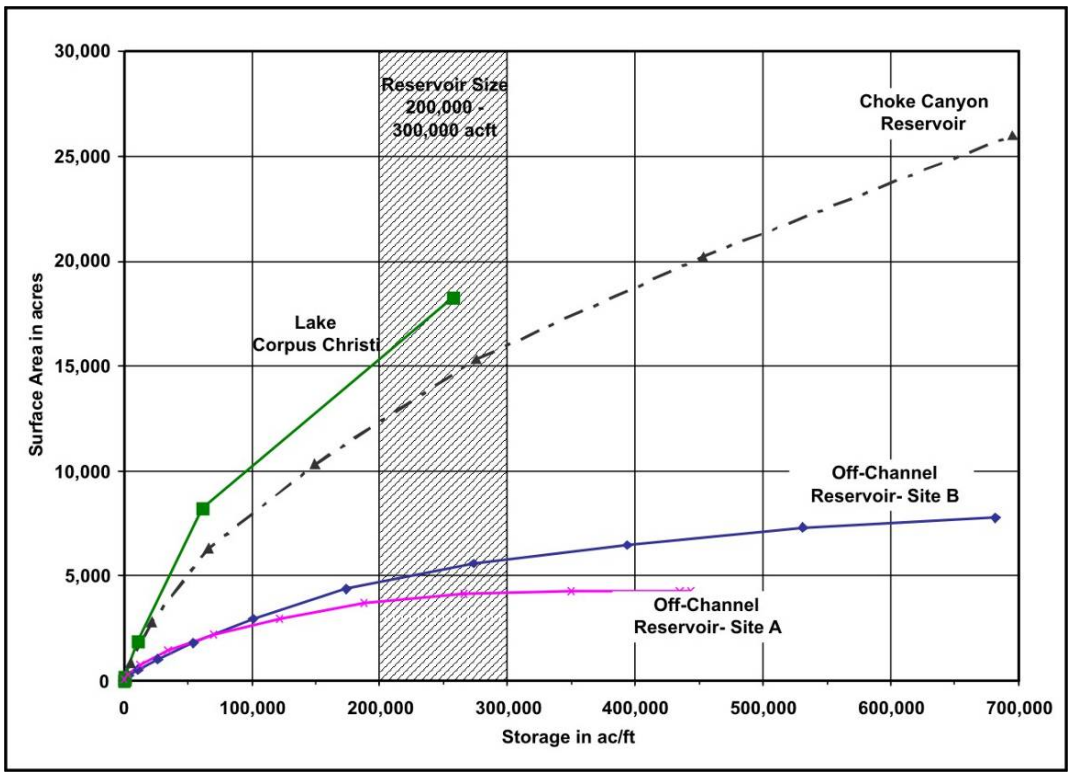



***Figure 4-1. Comparison of Surface Area Required for Reservoir Sites A and B (as Compared to Lake Corpus Christi and Choke Canyon Reservoir)***

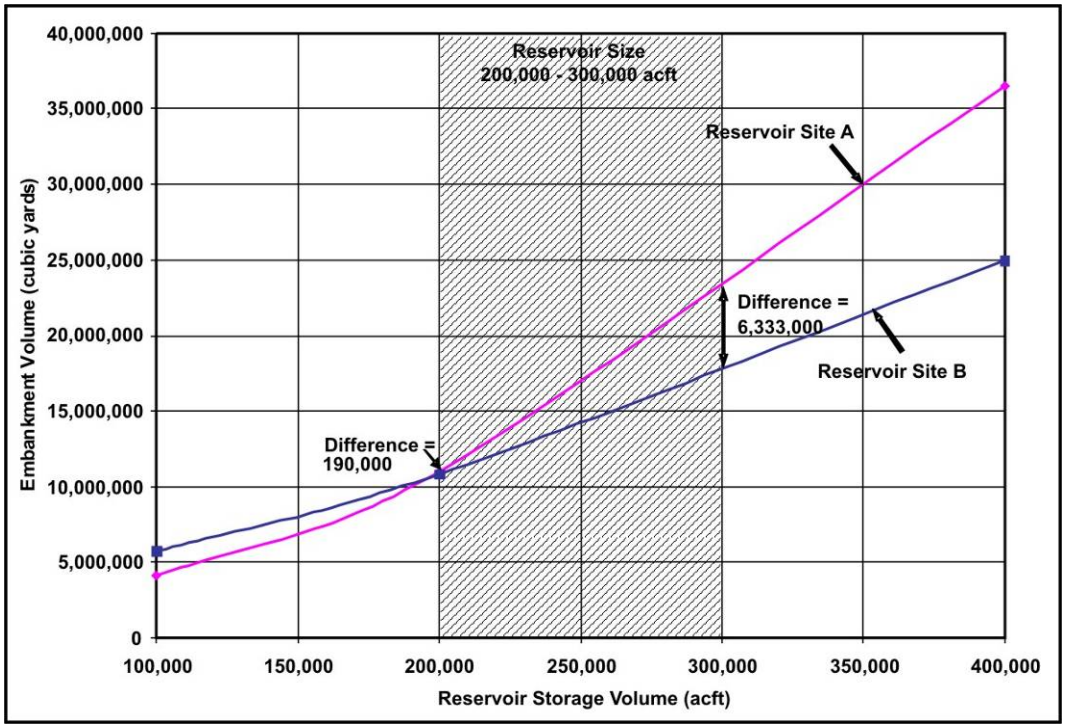



***Figure 4-2. Comparison of Embankment Volumes for Reservoir Site A and B***

each reservoir size and delivery rate combination. The amount of firm yield attributable to adding an OCR to the CCR/LCC/Lake Texana system is shown in Figure 4-3. As expected, the increase in system yield is generally correlated with reservoir size and delivery rate (i.e., as reservoir size and delivery rate increases, firm yield increases). However, as reservoir sizes increase above 280,000 acft, the increase in firm yield is minimal.

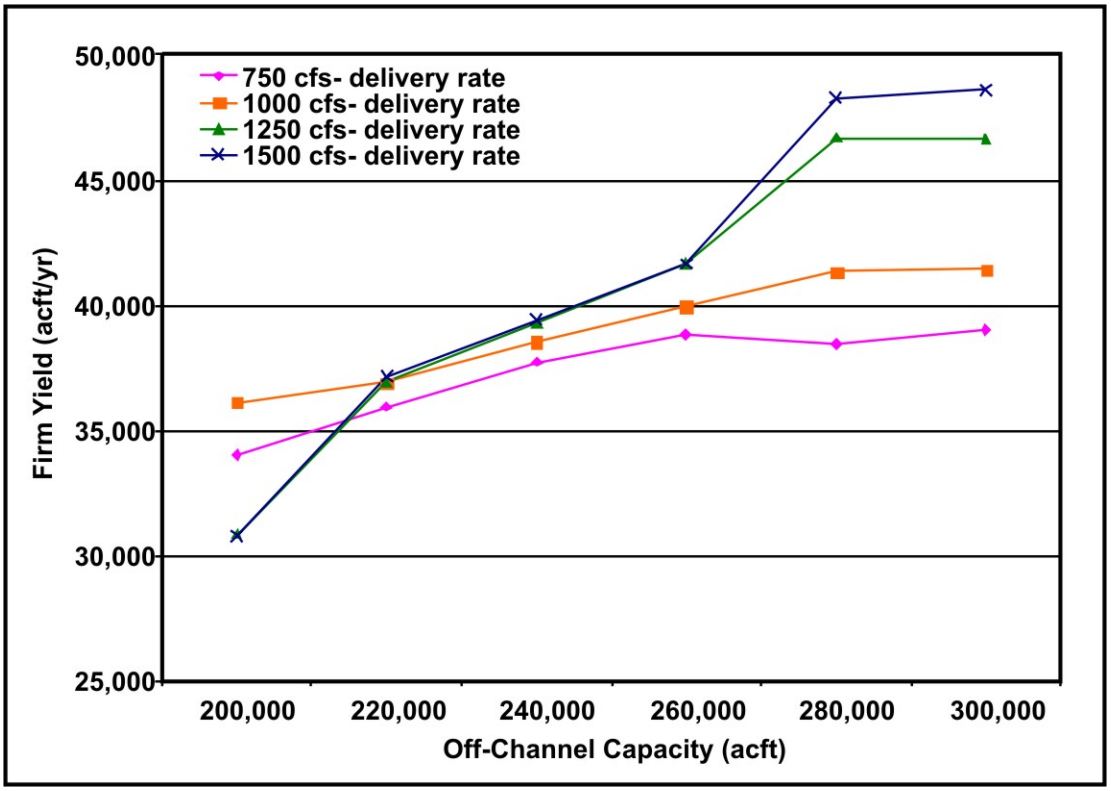



***Figure 4-3. Firm Yield Summary of Off-Channel Reservoir Sizes***

There are three primary factors which affect CCWSM calculation of firm yield: (1) timing of releases to the Nueces B&E pursuant to 2001 TCEQ Agreed Order, (2) pipeline delivery capacity, and (3) reservoir system storage. For the OCR sized at 200,000 acft with larger pipeline delivery rates of 1,250 cfs and 1,500 cfs, the firm yield is less than for the two smaller pipeline delivery rates of 750 cfs and 1,000 cfs. This is attributable to the first factor (timing of releases to the Nueces B&E pursuant to the 2001 TCEQ Agreed Order) which is based on total system storage. At the larger pipeline delivery rates for the 200,000 acft OCR capacity, there is more water stored in the LCC/CCR/OCR system just prior to the drought of record (1996-1997) resulting in a couple of additional months when combined system storage is in a higher Nueces B&E inflow release schedule as compared to 750 cfs and 1000 cfs delivery rates. For the OCR

sized at 280,000 acft, the second and third factors prevail. For larger pipeline delivery capacities, more water is able to be stored in the OCR as compared to the smaller pipeline delivery rates of 750 cfs and 1,000 cfs. This results in more firm yield with the OCR upsized to 280,000 acft for 1,250 cfs and 1,500 cfs pipeline delivery rates, as compared to the smaller pipeline delivery rates.

Total project costs[6] were calculated for each of the OCR size and delivery rate combination and are estimated to range from $168 million to $297 million as shown in Figure 4-4. Annual costs are shown in Figure 4-5, which range from $13.5 million to $24.2 million depending on OCR size and pipeline delivery rate. Detailed cost estimates for the twenty four OCR size and delivery rate combinations are included in Appendix B.

Unit costs of firm raw water supply were calculated for each OCR size and pipeline delivery rate combination by dividing the annual cost by the increase in system yield. The least unit cost of raw water is about $400 per acft for an OCR sized at 200,000 acft and pipeline delivery rate of 750 cfs. However as shown in Figure 4-6, the unit costs of additional water supply decrease substantially for OCR sized at 280,000 acft with pipeline delivery rates of 1,250 cfs and 1,500 cfs. To confirm the results of the unit cost evaluation, incremental costs were calculated for each reservoir size to determine the optimal pipeline delivery rate that would provide additional water supply at a reasonable cost. Incremental costs are calculated as the difference in annual cost ($ million) between each alternative divided by the difference in yield. As shown in Figure 4-7, the incremental costs of the 280,000 acft OCR are the lowest among other OCR sizes between 200,000 and 300,000 acft. The incremental costs for the twenty four combinations are based on increases in additional firm yield with different pipeline delivery rates as well as different reservoir sizes. With smaller increases in firm yield between reservoir size and pipeline delivery rate options, incremental unit costs are generally higher than with those resulting in larger increases in firm yield. This is most clearly illustrated for the OCR sized at 300,000 acft, which shows minimal increases in firm yield as compared to an OCR sized at 280,000 acft (Figure 4-3) with high incremental costs (Figure 4-7). With larger increases in firm yield, the annual cost increases are distributed over more yield and therefore have lower incremental unit costs per acft of water.

With Federal participation, the OCR sized at 280,000 acft is cost competitive with other regional water supply projects and provides additional firm yield than the OCR sized at 200,000

[6] Project costs include capital costs, engineering/legal costs and contingencies, environmental mitigation, land acquisition, interest during construction (4 years), and initial filling of reservoir. Engineering and legal costs and contingencies are 30% for pipeline and pump station, and 35% for reservoirs.

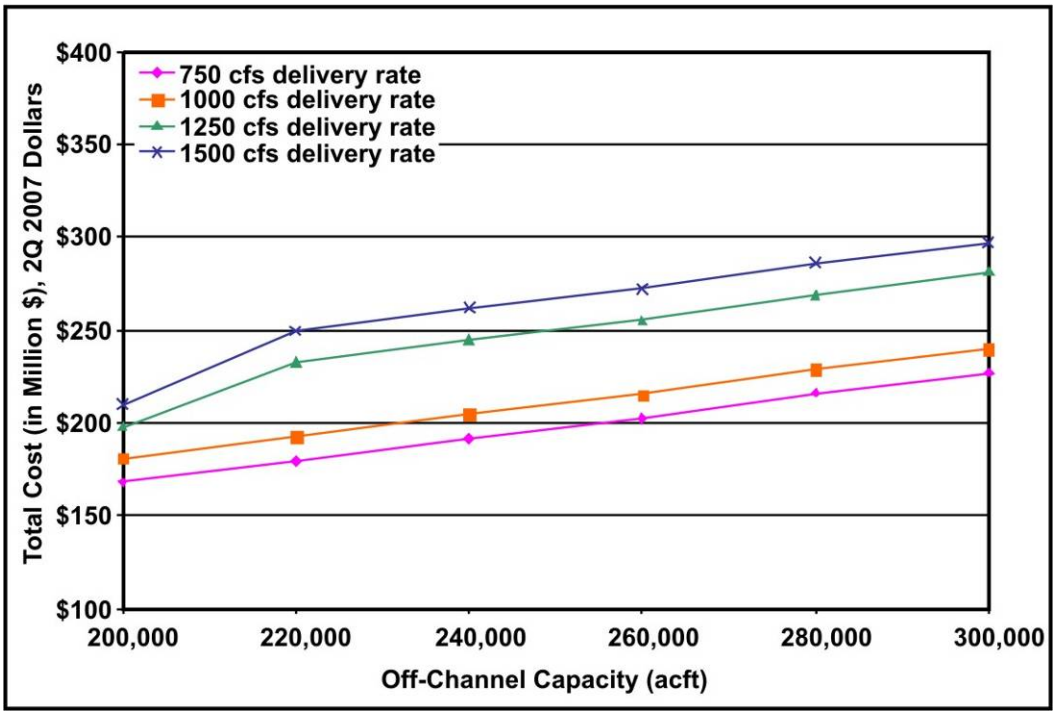



***Figure 4-4. Total Project Costs of Off-Channel Reservoir Sizes (in Second Quarter 2007 Dollars)***

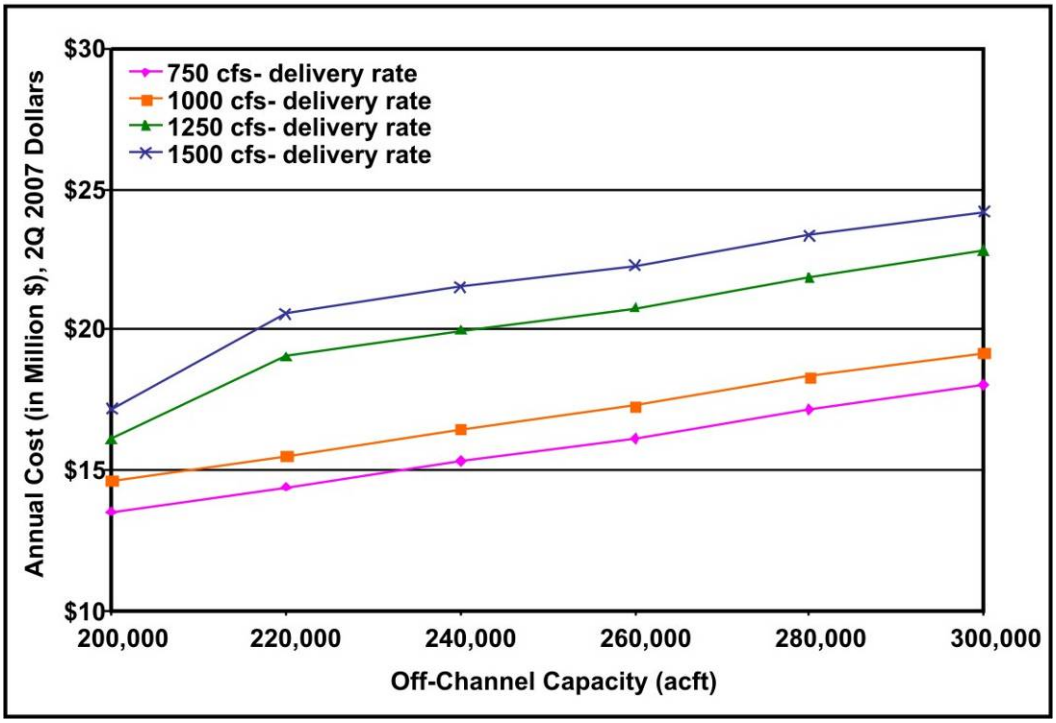



***Figure 4-5. Annual Costs of Off-Channel Reservoir Sizes (in Second Quarter 2007 Dollars)***

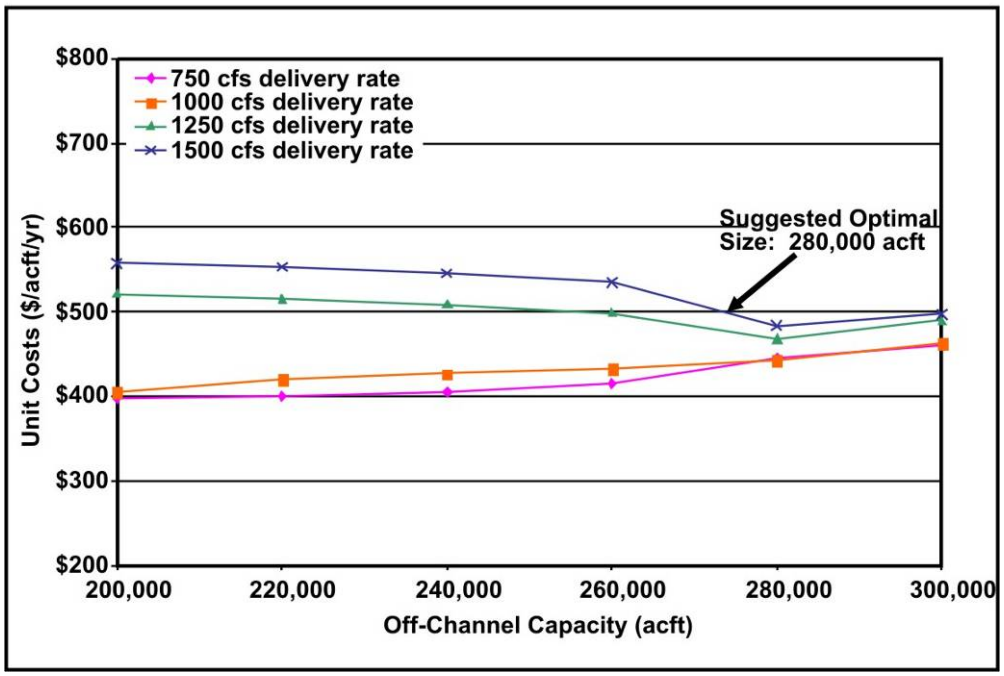



***Figure 4-6. Unit Costs of Raw Water for Off-Channel Sizes (in Second Quarter 2007 Dollars)***

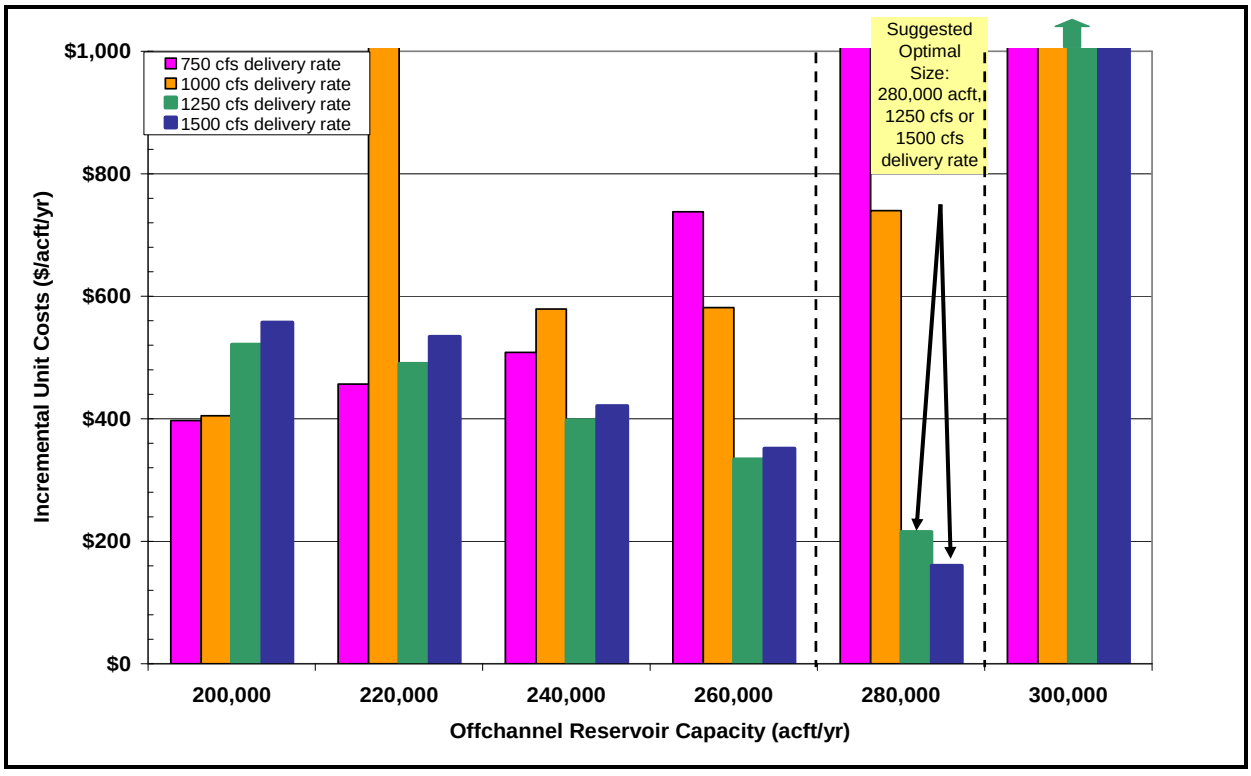



***Figure 4-7. Incremental Costs of Water for Off-Channel Sizes for Pipeline Delivery Rates of 1,250 cfs and 1,500 cfs (in Second Quarter 2007 Dollars)***

acft. Of the twenty four combinations of reservoir size and pipeline delivery rate, the preferred size for the OCR is 280,000 acft with a pipeline delivery rate between 1,250 cfs and 1,500 cfs. There was not an appreciable cost or firm yield difference (less than 5% difference) between pipeline delivery rates of 1,250 cfs and 1,500 cfs and therefore, both were included in the recommendation.

The 280,000 acft OCR located at Site B is shown in Figure 4-8, and includes locations for the intake, pump station, and pipeline to deliver water from LCC to the OCR. Based on local topography and OCR capacity of 280,000 acft, the proposed conservation pool elevation is 281.1 ft-msl with an average water depth of 50 feet and a surface area of 5,627 acres.

### *4.3 Alternative Reservoir Operations*

The CCWSM was used to simulate the OCR and determine the relative impact to water supply yields with different LCC water level triggers to send water from the OCR to LCC. Based on previous studies, the preferred operation of pumping water to the OCR is when LCC is at or above 93 ft-msl (or 1 ft below conservation pool elevation of 94 ft-msl). For this study, it was shown that benefits are achieved when water stored in the OCR is released into LCC when LCC water levels are at or below 75 ft-msl or 83 ft-msl, as shown in Figure 4-9. These benefits include water supply and recreational benefits associated with higher water levels in LCC.

Monthly OCR storage values simulated by the CCWSM were evaluated to determine how often the OCR will be utilized based on historical hydrologic conditions from 1934-2003 for LCC water level triggers of 75 ft-msl and 83 ft-msl at the two pipeline delivery rates of 1,250 cfs and 1,500 cfs. As shown in Figure 4-10, if the OCR were operated at a pipeline pumping capacity of 1,250 cfs with a 75 ft-msl LCC water level trigger then it would be empty about 16% of the time with median storage of about 168,026 acft (or 56% full). For the same pipeline pumping capacity with an 83 ft-msl LCC water level trigger, the OCR would be empty about 25% of the time with a median storage of about 91,897 acft (or 31% full). The OCR would have less stored water with the higher LCC trigger, because the OCR would be filling LCC more often.

Similar trends were observed for a pipeline pumping capacity of 1,500 cfs as shown in Figure 4-11. With the 75 ft-msl LCC trigger level, the OCR would be empty about 16% of the time with median storage of about 159,785 acft (or 53% full). With the 83 ft-msl trigger level for filling LCC, the OCR would be empty about 30% of the time with median storage of about 78,054 acft (or 26% full).

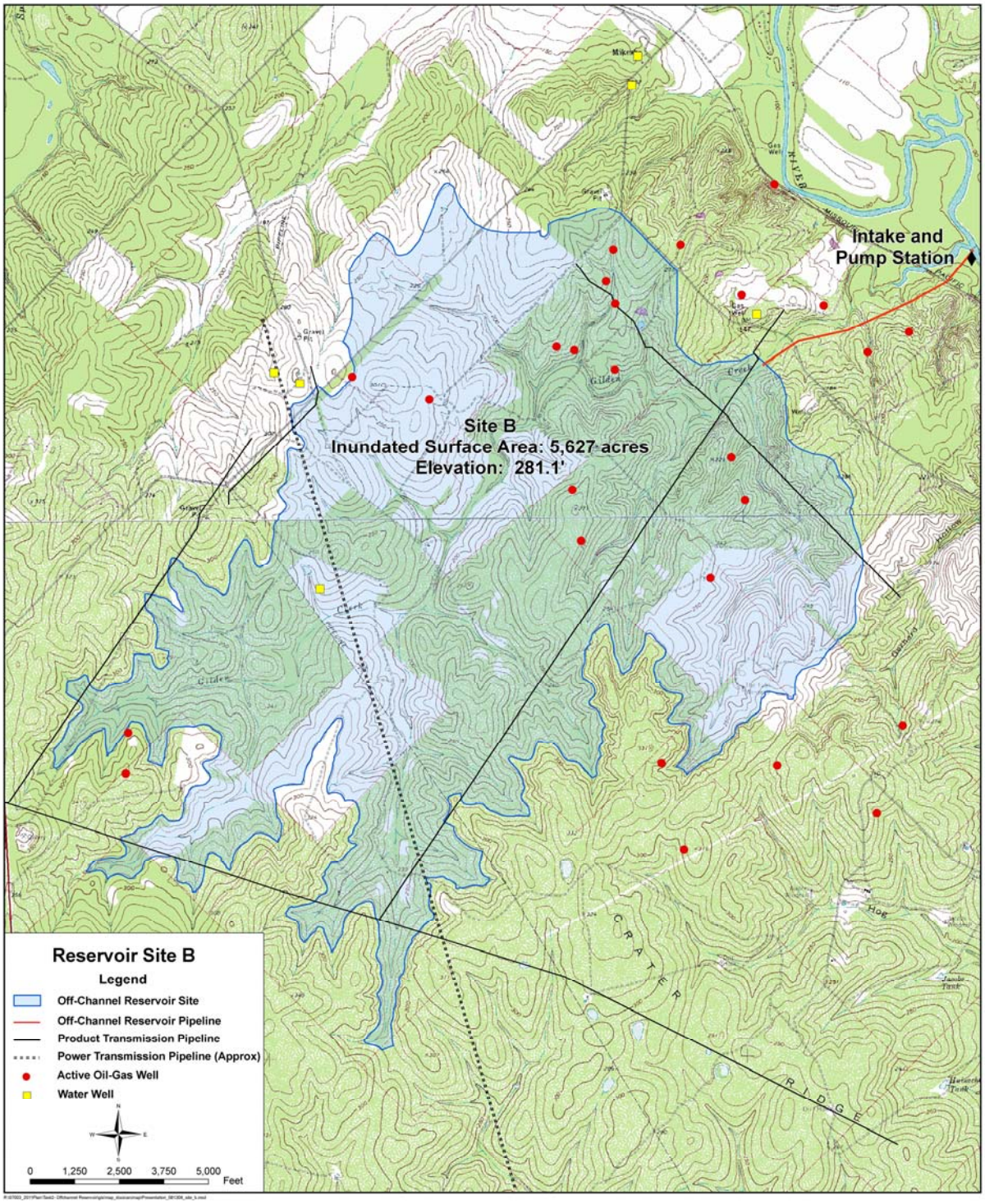



***Figure 4-8. Preferred Off-Channel Reservoir Site at 280,000 acft Storage Capacity***

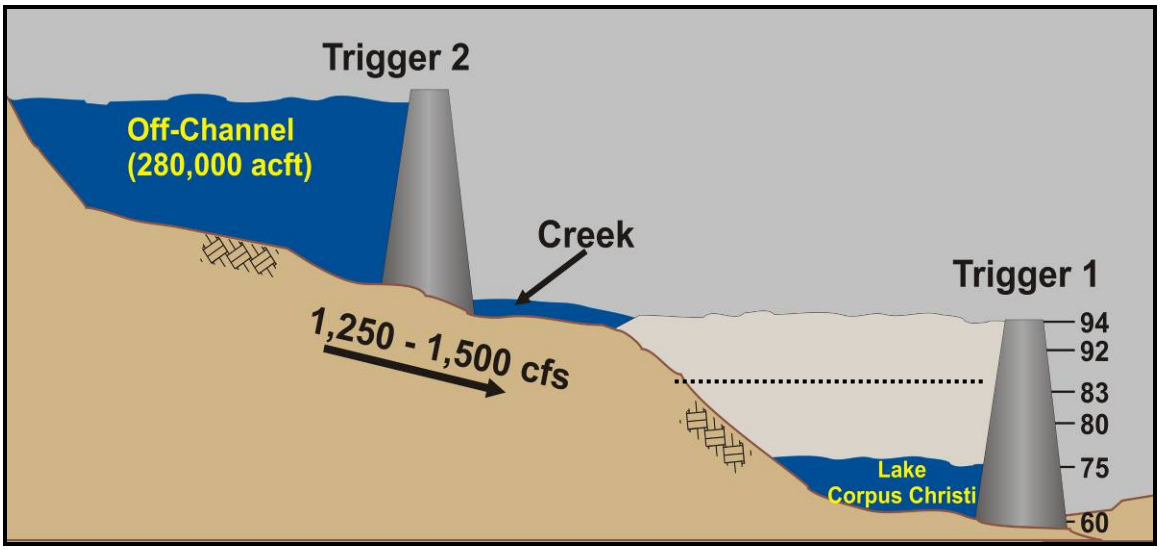



***Figure 4-9. Recommended Pipeline Operations from OCR Storage to LCC***

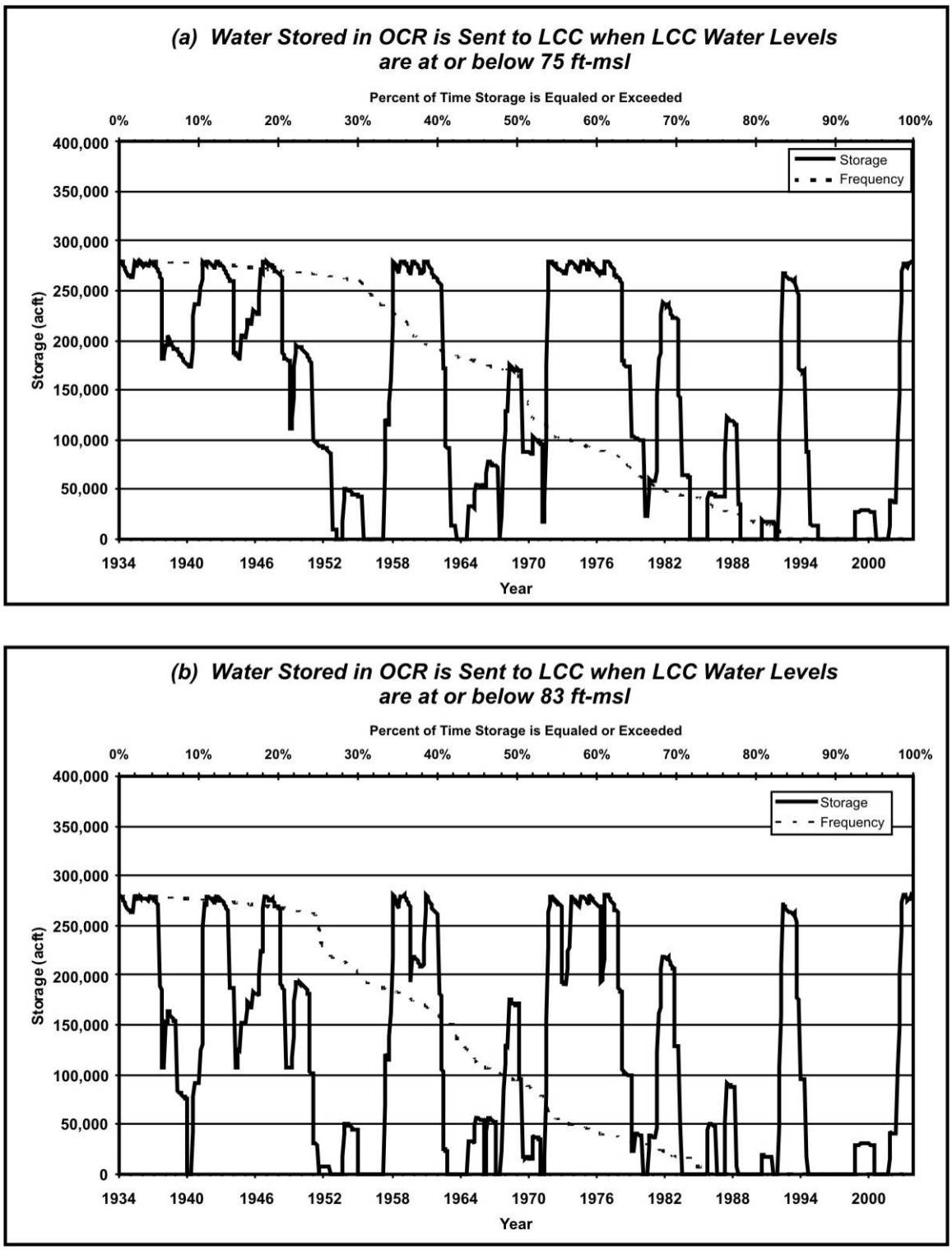



***Figure 4-10. Storage and Frequency Plot of Operating OCR (280,000 acft Capacity at 1,250 cfs Pipeline Rate)***

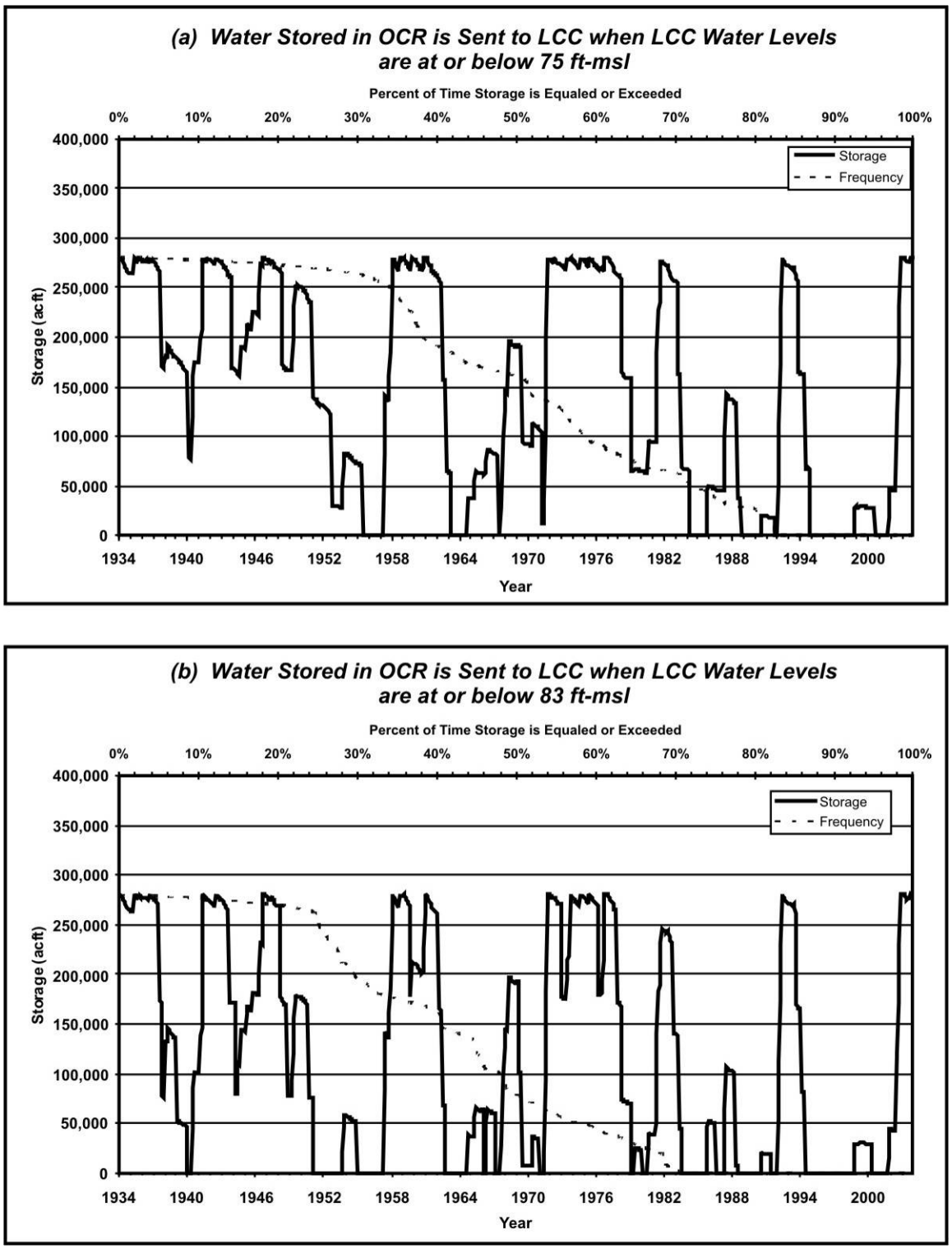



***Figure 4-11. Storage and Frequency Plot of Operating OCR (280,000 acft Capacity at 1,500 cfs Pipeline Rate)***

The maximum system storage with a 280,000 acft OCR added to the CCR/LCC system in the Nueces River Basin would be 1,232,531 acft, of which 56% would be stored in CCR, 21% in LCC, and 23% in the OCR. A comparison of system storage and desired Nueces B&E inflow criteria is shown in Figure 4-12. With the OCR added to the CCR/LCC system, stored water would be greater than 70% system storage less often than without an OCR project. Although reservoir system operations may impact OCR storage as discussed above, the overall impact of changing trigger levels to release OCR stored water to LCC does not significantly impact the overall total reservoir system storage in the Nueces River Basin.

The OCR impacts to the Nueces B&E are shown in Figures 4-13 and 4-14. The Nueces Bay includes the freshwater inflow to the Nueces B&E and fixed return flows pursuant to the 2001 Agreed Order provisions, whereas the Nueces Estuary also includes return flows based on a percentage of water demand (currently set to 52% of demand). With the OCR operated as part of the reservoir system, monthly inflows to the Nueces Bay would be slightly lower than without OCR as shown in Figure 4-13. However, with increased utilization of firm yield associated with the OCR and increased return flows, the flows to the Nueces Estuary are anticipated to be higher about 80% of the time as compared to without the OCR as shown in Figure 4-14. The annual inflows to the Nueces Estuary, which include return flows, are increased on average by 45,808 acft with the OCR for years with annual flows less than 190,000 acft/yr.[7] Alternative OCR operations for different pipeline delivery rates and LCC water level triggers do not show appreciable differences to freshwater inflows into the Nueces Estuary.

[7] Annual inflow to Nueces Estuary less than 190,000 acft/yr are assumed to be representative of drought conditions. In the 70 year hydrologic period from 1934-2003, there are 17 years when annual inflow (without off-channel reservoir project) was less than 190,000 acft/yr.

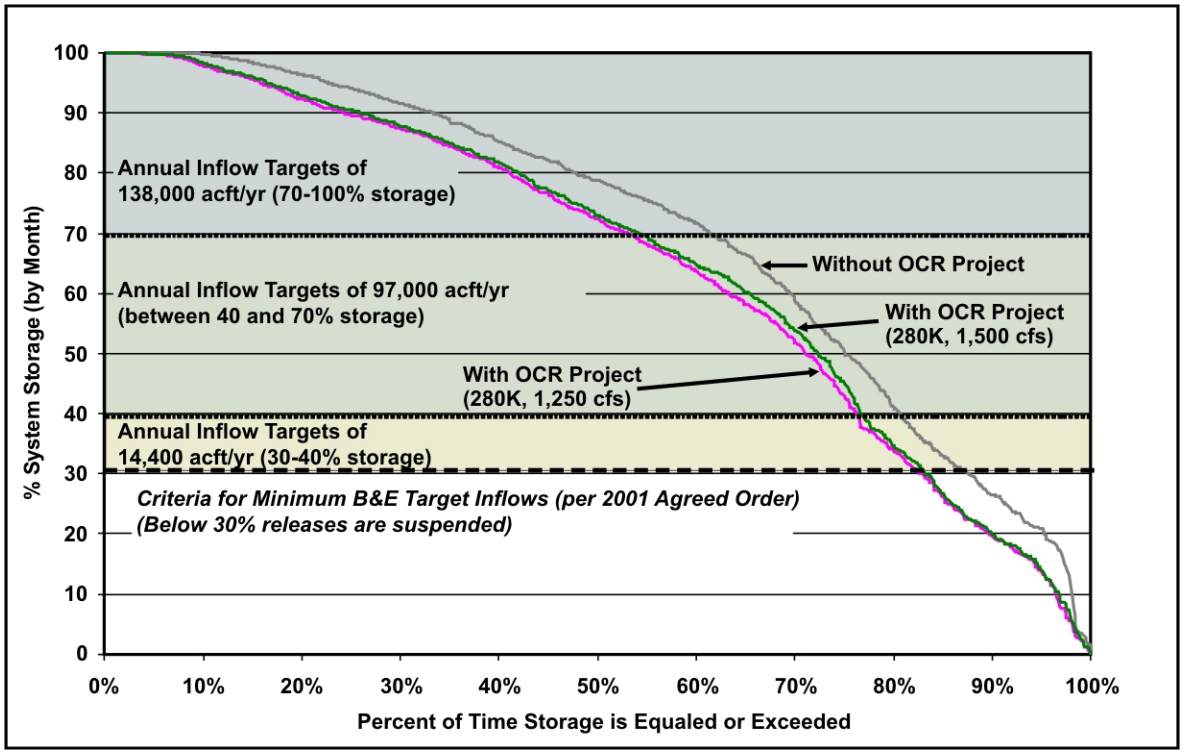



***Figure 4-12. Frequency Distribution of Combined Reservoir System (CCR/LCC/OCR) With and Without OCR Project***

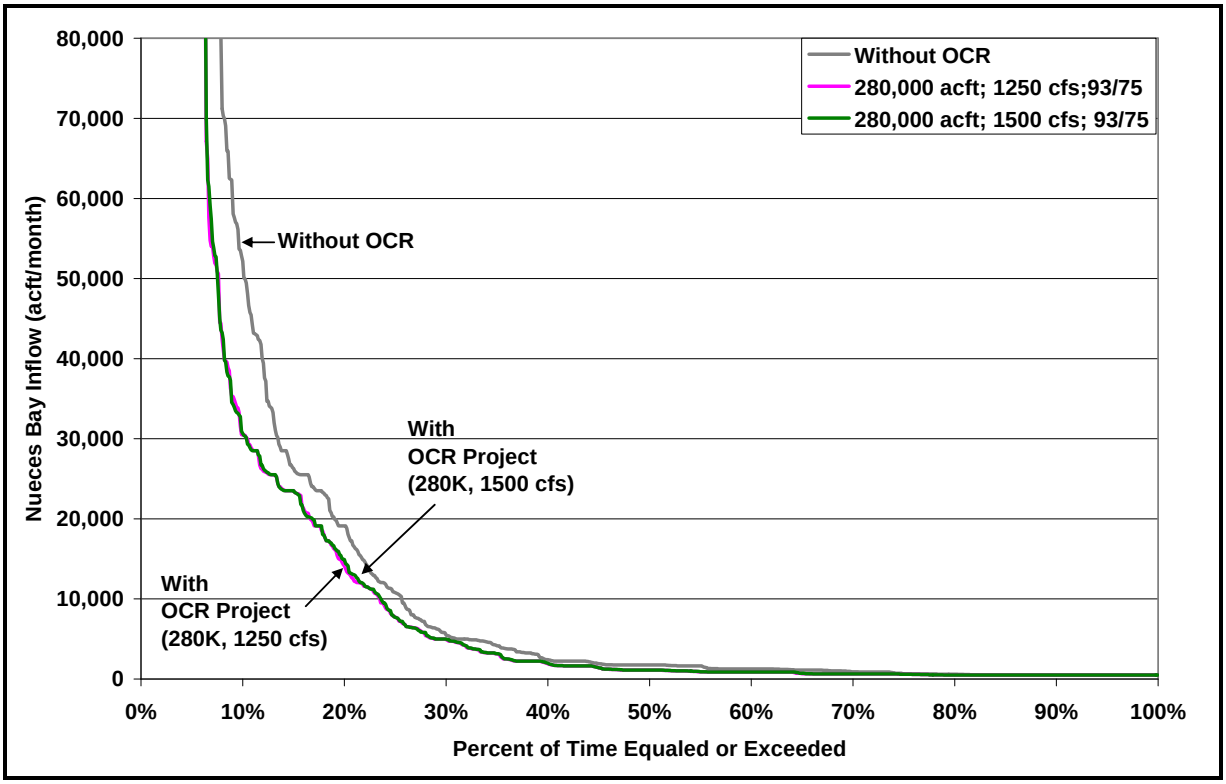



***Figure 4-13. Project Impacts on Freshwater Inflows into the Nueces Bay***

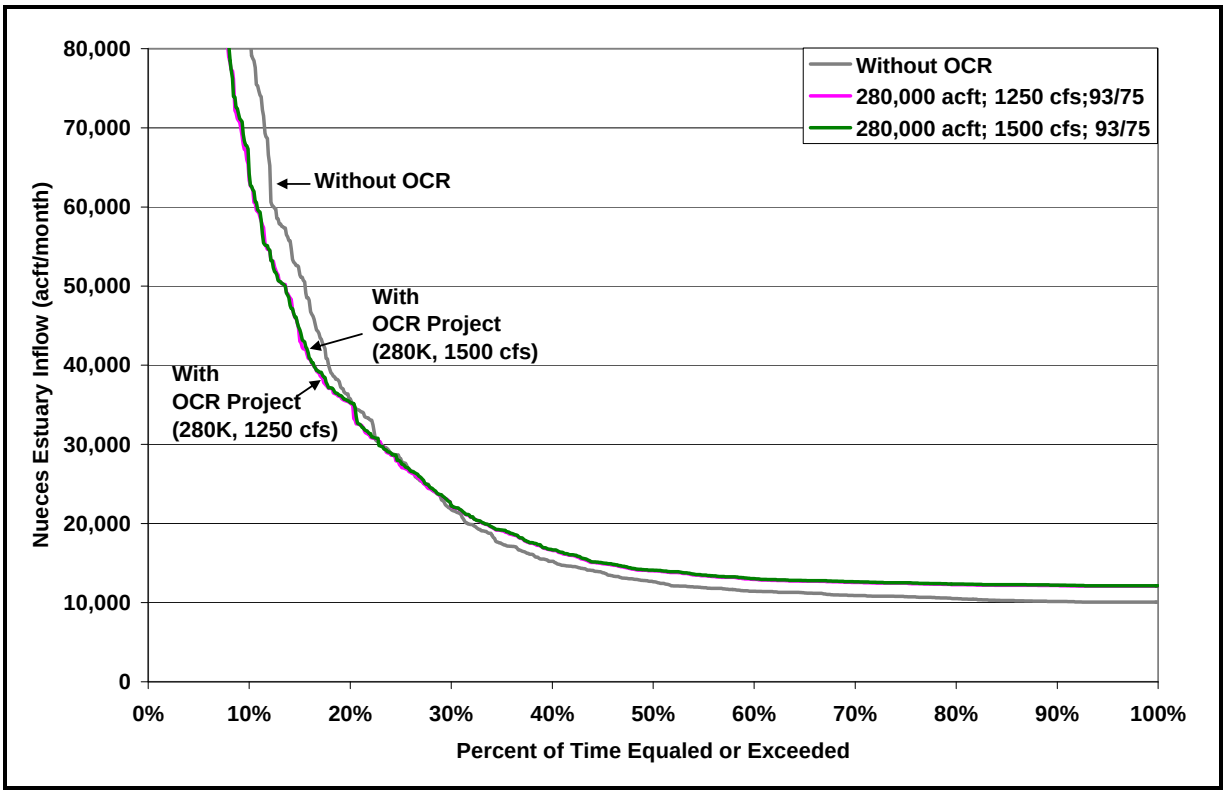



***Figure 4-14. Project Impacts on Freshwater Inflows into the Nueces Estuary***

## *5.0 Engineering and Costing*

Tables 5-1 and 5-2 provide detailed summaries of the estimated costs to implement a 280,000 acft OCR at pipeline delivery rates of 1,250 cfs and 1,500 cfs, respectively. The annual costs include pumping energy costs that would be required to initially fill the OCR. The project requires a four mile transmission pipeline to pump water from LCC to the OCR, an intake near LCC and in the OCR, and an outfall in the OCR.

A 280,000 acft OCR at pipeline delivery rate of 1,250 cfs is estimated to provide a firm yield of 46,677 acft at unit raw water cost of $469 per acft ($1.44 per 1000 gallons). A 280,000 acft OCR at a pipeline delivery rate of 1,500 cfs is estimated to provide a firm yield of 48,296 acft at unit raw water cost of $484 per acft ($1.48 per 1000 gallons). With treatment costs assumed at $268 per acft[8], treated water supplies from a 280,000 acft OCR range from $737 to $752 per acft ($2.26 to 2.31 per 1000 gallons). The project cost could potentially be reduced through Federal participation, as may be available through the USACE Nueces River Basin Feasibility Study.

[8] The water treatment cost assumed in the 2006 Plan of $225 per acft, was updated to 2007 2nd quarter costs.

***Table 5-1.***
***Cost Estimate Summary for Off-Channel Reservoir (280,000 acft)***
***and Pipeline (1,250 cfs) Second Quarter 2007 Prices***

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5627 acres, 265 ft. m | $84,628,000 |
| Intake and Pump Station (1212 MGD) | $50,614,000 |
| Transmission Pipeline (3 pipes, 114 in dia., 1.4 miles) | $19,084,000 |
| **Total Capital Cost** | **$154,326,000** |
| Engineering, Legal Costs and Contingencies | $53,060,000 |
| Environmental & Archaeology Studies and Mitigation | $13,550,000 |
| Land Acquisition and Surveying (5649 acres) | $13,992,000 |
| Interest During Construction (4 years) | $30,422,000 |
| Initial Filling of Reservoir | $3,568,000 |
| **Total Project Cost** | **$268,918,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $7,586,000 |
| Reservoir Debt Service (6 percent, 40 years) | $10,933,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,456,000 |
| Dam and Reservoir | $1,269,000 |
| Pumping Energy Costs (6944277.6028259 kW-hr @ 0.09 $/kW-hr) | $625,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$21,869,000** |
| **Available Project Yield (acft/yr)** | 46,677 |
| **Annual Cost of Water ($ per acft)** | $469 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.44 |

***Table 5-2.***
***Cost Estimate Summary for Off-Channel Reservoir (280,000 acft) and Pipeline (1,500 cfs) Second Quarter 2007 Prices***

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5627 acres, 265 ft. msl) | $85,384,000 |
| Intake and Pump Station (1455 MGD) | $59,829,000 |
| Transmission Pipeline (3 pipes, 120 in dia., 1.4 miles) | $20,902,000 |
| **Total Capital Cost** | **$166,115,000** |
| Engineering, Legal Costs and Contingencies | $57,095,000 |
| Environmental & Archaeology Studies and Mitigation | $13,550,000 |
| Land Acquisition and Surveying (5649 acres) | $13,992,000 |
| Interest During Construction (4 years) | $31,830,000 |
| Initial Filling of Reservoir | $3,537,000 |
| **Total Project Cost** | **$286,119,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $8,745,000 |
| Reservoir Debt Service (6 percent, 40 years) | $11,016,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,705,000 |
| Dam and Reservoir | $1,281,000 |
| Pumping Energy Costs (6944166.90719416 kW-hr @ 0.09 $/kW-hr) | $625,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$23,372,000** |
| **Available Project Yield (acft/yr)** | 48,296 |
| **Annual Cost of Water ($ per acft)** | $484 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.48 |

## *6.0 Evaluation Summary*

An evaluation summary of the OCR as a regional water management option is provided in Table 6-1.

***Table 6-1.***
***Evaluation Summary for Off-Channel Reservoir 280,000 acft***
***With Pipeline Delivery of 1,250 or 1,500 cfs***

| *Impact Category* | *Comment(s)* |
|---|---|
| a. Water supply: | |
| 1. Quantity | 1. Firm Yield: 46,677 to 48,296 acft/yr |
| 2. Reliability | 2. Firm Supply |
| 3. Cost of water | 3. Generally low cost between $469 to $484 per acft. With $268 added for treatment, cost of treated water is $737 to $752 acft |
| b. Environmental factors: | |
| 1. Instream flows | 1. Generally increases streamflows below LCC. |
| 2. Bay and estuary inflows | 2. Slight decrease in freshwater inflows to Nueces Bay. Increase freshwater inflows to Nueces Estuary, primarily attributable to increased return flows with increased water demands. |
| 3. Wildlife habitat | 3. Some impact to wildlife habitat. Inundated land area for off-channel reservoir. |
| 4. Wetlands | 4. Low impact to wetlands. |
| 5. Threatened and endangered species | 5. Low impact to threatened and endangered species. |
| 6. Cultural resources | 6. No cultural resources identified in project area based on Texas Historical Commission data. |
| 7. Water quality<br>a. dissolved solids<br>b. salinity<br>c. bacteria<br>d. chlorides<br>e. bromide<br>f. sulfate<br>g. uranium<br>h. arsenic<br>i. other water quality constituents | 7. Minimal impact to water quality. |
| c. State water resources | • No negative impacts on other water resources |
| d. Threats to agriculture and natural resources in region | • None |
| e. Recreational | • Benefits with higher LCC water level with 83 ft-msl trigger |
| f. Equitable comparison of strategies | • Standard analyses and methods used |
| g. Interbasin transfers | • Not applicable |
| h. Third party social and economic impacts from voluntary redistribution of water | • Not applicable |
| i. Efficient use of existing water supplies and regional opportunities | • Maximizes opportunities to capture water from a large drainage area. |
| j. Effect on navigation | • None |

## *7.0 Texas Water Development Board Report Formalities*

This report was prepared in accordance with the approved Scope of Work pursuant to TWDB Contract No. 0704830699. The preliminary draft report was posted in November 2008 on the Nueces River Authority website for Regional Water Planning Group and public comment. All draft report comments were addressed. The draft report was approved by the Coastal Bend RWPG on November 13, 2008 and submitted to the TWDB on December 23, 2008.

The TWDB provided comments on the draft report in March 2009. The Coastal Bend RWPG approved responses to the TWDB comments on March 12, 2009. A copy of TWDB comments on the draft study report and written summary of how the final report addresses these comments is provided in Appendix C.

# *Appendix A*
# *Desktop Environmental Analysis of Off-Channel Reservoir Site Alternatives*

## *A.1 Introduction*

The potential off-channel reservoir sites with associated pipeline for delivery of Nueces River supplies are located in Live Oak County approximately six miles southeast of the town of George West. Three off-channel site evaluations were considered (Site A, Site B, and Site C) for storage of 300,000 acre-ft per year as a conservative estimate of potential environmental impacts (Note: Optimal size of off-channel storage has since been determined to be 280,000 acre-ft). Site A contained the smallest footprint for 300,000 acre-ft of storage at about 4,180 acres; Site B at 5,775 acres; and Site C had the largest footprint at about 7,550 acres. This report includes general impacts expected as a result of the construction and maintenance of any of the three off-site reservoir areas and pipelines associated with each site.

The project area is located in the Interior Coastal Plains of the Gulf Coastal Plains Physiographic Province. This area is locally characterized as a prairie which contains parallel ridges and valleys. The geologic structure within this area is tilted toward the Gulf and contains bedrock types which include unconsolidated sands and muds. Elevation levels in this area range from 300 to 800 feet above mean sea level.

## *A.2 Vegetation and Wildlife Habitats*

Vegetation types found within the project area are primarily shrub and brush rangeland, with crops and pasture the second largest type, and the remaining portions containing herbaceous rangeland, mixed rangeland, and small amounts of mixed forest areas.

The study area occurs within the South Texas Plains Vegetational Area. This area merges with the Mexico Plains on the west and the Gulf Coastal Plains on the east. A slightly to moderately dissected plain, this area is nearly level to rolling. The original vegetation of this area was open grassland or savannah-type along the coastal areas and brushy chaparral-grassland in the uplands. At one time dense thickets found on ridges and along streams were formed by oaks, mesquite, pecan and ash.

Many woody species have recently increased in this area, including mesquite (*Prosopis glandulosa*), live oak (*Quercus virginiana*), acacia (*Acacia* sp.), brazil (*Condalia hookeri*), spiny hackberry (*Celtis pallida*), whitebrush (*Aloysia gratissima),* lime prickly ash (*Zanthoxylum fagara*) and lotebush (*Zizyphus obtusifolia*). Characteristic grasses of this area include coast bluestem (*Schizachyrium scoparium* var. *littorale*), bristlegrasses (*Setaria* sp.), windmillgrasses

(*Chlororis* sp.), and silver bluestem (*Bothriochloa saccharoides* var. *torreyana*). Common forbes include pricklypear (*Opuntia* sp.), orange zexmania (*Wedelia hispida*), bush sunflowers (*Simsia* sp.), Texas croton (*Croton texensis*) and velvet bundleflower (*Desmanthus velutinus*) among others.

The major land uses within this area vary. Irrigated and dryland cropping of cotton, sorghum, and forage is common. Livestock production and wildlife production for hunting and recreational use are becoming increasingly important within this area.

Wildlife habitat within this area was originally grassland, however, after the suppression of fire and the elimination of the buffalo, this region developed into the South Texas brush country of today. The climate within this area includes long, hot summers, mild winters and erratic precipitation distribution with an average annual rainfall rate of 20-25 inches. Mesquite and associated thorny shrubs account for much of the dense understory of low-growing cover which is interspersed with occasional larger trees species and grassland areas. Brush species are typically found upon the rocky gravelly ridges and uplands. The topography is gently sloping to level and the soils range from loamy sand to heavy clay. Caliche outcroppings and gravel ridges are common within the area.

Adequate cover, food, and water found within close proximity to the Nueces River have resulted in productive wildlife habitat. White-tailed deer, javelina, wild turkeys, mourning and white-winged dove, bobwhite and scaled quail, rabbits, coyotes, gray foxes, bobcats, mountain lions, feral hogs, and many other wildlife species inhabit the area. Endangered or threatened species found within Live Oak County which usually inhabit the South Texas brush county include the indigo snake (*Drymarchon corais*), jaguarundi (*Herpailurus yaguarondi*), ocelot (*Leopardus pardalis*), reticulate collared lizard (*Crotaphytus retuiculates*), and Texas horned lizard (*Phrynosoma cornutum*) (See Table 1).

## *A.3 Threatened and Endangered Species*

In Live Oak County there may occur sixteen state-listed endangered or threatened species and 5 federally-listed endangered or threatened wildlife species, according to the county lists of rare species published by Texas Parks and Wildlife Department (TPWD). There were no previous, site-specific studies readily identified for the study area. A list of these species is provided in Table A-1.

***Table A-1***
***Endangered, Threatened and Rare Species Listed for Live Oak County***

| ***Common Name*** | ***Scientific Name*** | ***Summary of Habitat Preference*** | ***Listing Entity*** | | ***Potential Occurrence In Counties*** |
|---|---|---|---|---|---|
| | | | ***USFWS[1]*** | ***TPWD[1]*** | |
| Audubon's Oriole | *Icterus graduacauda audubonii* | Scrub, mesquite, nests in dense trees or thickets, usually along water courses | | | Resident |
| Black-Spotted Newt | *Notophthalmus meridionalis* | Ponds and resacas in south Texas | | T | Resident |
| Coastal gay-feather | *Liatris bracteata* | Endemic: black clay soils of prairie remnants. | | | Resident |
| Golden orb | *Quadrula aurea* | Sand and gravel, Guadalupe, San Antonio, and Nueces river basins | | | Resident |
| Indigo Snake | *Drymarchon corais* | Thornbush-chaparral woodlands of south Texas in dense riparian corridors, moist microhabitats. | | T | Resident |
| Interior Least Tern | *Sterna antillarum athalassos* | Subspecies is listed only when inland more than 50 miles from coastline. Nests along braided waterways. | LE | E | Resident |
| Jaguarundi | *Herpailurus yaguarondi* | South Texas thick brushlands, favors areas near water | LE | E | Resident |
| Mountain Plover | *Charadrius montanus* | Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts | | | Nesting/ Migrant |
| Ocelot | *Leopardus pardalis* | Dense chaparral thickets; mesquite-thorn scrub and live oak mottes | LE | E | Resident |
| Peregrine falcon | *Falco peregrinus anatum (American)* | Open country; cliffs | DL | E | Nesting/ Migrant |
| | *Falco peregrinus tundrius (Arctic)* | | DL | T | |
| Plains Spotted Skunk | *Spilogale putorius interrupta* | Prefers wooded, brushy areas and tallgrass prairie. | | | Resident |
| Red Wolf | *Canis rufus* | Extirpated | LE | E | Historic Resident |

| *Common Name* | *Scientific Name* | *Summary of Habitat Preference* | *Listing Entity* | | *Potential Occurrence In Counties* |
|---|---|---|---|---|---|
| | | | *USFWS*[1] | *TPWD*[1] | |
| Reticulate collared lizard | *Crotaphytus reticulates* | Requires open brush-grasslands; thorn-scrub vegetation. | | T | Resident |
| Sheep Frog | *Hypopachus variolosus* | Predominately grassland and savanna; moist sites in arid areas | | T | Resident |
| South Texas Rushpea | *Caesalpinia phyllanthoides* | Shrublands or grasslands on very shallow soil over rock. | | | Resident |
| Spot-tailed earless lizard | *Holbrookia lacerata* | Moderately open prairie-brushland | | | Resident |
| Texas Horned Lizard | *Phrynosoma cornutum* | Varied, sparsely vegetated uplands, grass, cactus, brush | | T | Resident |
| Texas Tortoise | *Gopherus berlandieri* | Open brush w/ grass understory; open grass/bare ground avoided | | T | Resident |
| Western Burrowing Owl | *Athene cunicularia hypugaea* | Open grasslands, especially prairie, plains and savanna | | | Resident |
| White-faced Ibis | *Plegadis chihi* | Prefers freshwater marshes | | T | Resident |
| White-tailed Hawk | *Buteo albicaudatus* | Coastal prairies, savannahs and marshes in Gulf coastal plain | | T | Nesting/ Migrant |
| Whooping Crane | *Grus americana* | Potential migrant | LE | E | Migrant |
| Wood Stork | *Mycteria americana* | Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX | | T | Migrant |

Source: TPWD, Annotated County List of Rare Species, Live Oak County, October 30, 2007.

- LE/LT=Federally Listed Endangered/Threatened
- E/SA, T/SA=Federally Listed Endangered/Threatened by Similarity of Appearance
- DL, PDL=Federally Delisted/Proposed for Delisting
- E, T=State Listed Endangered/Threatened
- Blank = Rare, but no regulatory listing status

Inclusion in Table A-1 does not imply that a species will occur within the study area, but only acknowledges the potential for occurrence in Live Oak County. A more intensive field reconnaissance would be necessary to confirm and identify specific suitable habitat that may be present in the project area. In addition to county lists, HDR also reviewed Texas Natural Diversity Database (TXNDD) map data for known occurrences of listed species within or near the proposed study area. **Based on information provided by TPWD on the 1:24,000 quadrangle level for potential reservoir site areas, there were no reported sightings of any state or federal listed threatened species within five miles of the project area.** The presence or absence of potential habitat within an area does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the study area for this report.

The federal Endangered Species Act of 1973, as amended, prohibits the "take" of any threatened or endangered species. The term "take" under the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." The term "harm" was further defined to include "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering." Designation of critical habitat areas has been established for the public knowledge where the publishing of such information would not cause harm to the species. Additional federal protection is extended to migratory birds, and bald and golden eagles under the Migratory Bird Treaty Act (MBTA) as amended, and the Bald and Golden Eagle Protection Act. Protection is also afforded to Texas state-listed species. The Texas Parks and Wildlife Department enforces the state regulations.

The MBTA protects most bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the project area, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands, and woodland and forested areas. Construction activities could disturb migratory bird habitats and/or species' activities.

Reasonable and prudent measures should be taken to avoid and minimize the potential effects of the proposed project's activities on threatened and endangered species as well as bald eagles. Species' locations, activities, and habitat requirements should be considered based on FWS and TPWD recommendations.

In Live Oak County the jaguarundi (*Herpailurus yagouaroundi*) is listed as endangered by both the state and federal government. This species prefers to inhabit thick brushlands near water, conditions found within the project area. Sightings of this species are documented near George West and a study[1] focusing on this cat has occurred within the County. The ocelot (*Felis pardalis*) a species which prefers dense chaparral thickets, is also listed as endangered within Live Oak County. The red wolf (*Canis rufus*) was once found in this County, but is now considered extirpated.

The Texas Department of Transportation (TxDOT) district in South Texas is working with the U.S. Fish and Wildlife Services (USFWS) to create "wildlife corridors" to help protect ocelots and jaguarundis.[2] The TxDOT district has created four cat crossings in Live Oak County for U.S. 281 widening project. The South Texas wildlife corridors consist of a culvert beneath roadways, were dense brush is allowed to grow up from the edge of right of way up to the end of the culvert. Where culverts open to the median, chainlink fences are installed to keep wildlife within the crossing. There were no reports readily available documenting the success of the TxDOT wildlife corridor program in Live Oak County.

Many migratory birds are dependent on estuarine environments in order to complete their foraging and nesting requirements during migration. One of the most well known of these migratory birds is the Whooping Crane (*Grus americana*), which is listed as endangered by both the United States Fish and Wildlife Service (USFWS) and TPWD. A growing population of whooping cranes winter in and near the Aransas National Wildlife Refuge located adjacent to the Mesquite Bay and the southern and western portions of San Antonio Bay. This wintering population has grown from a low of only 16 birds in 1941 to a high of 257 birds in December 2007. Three other migratory birds are listed by TPWD for Live Oak County; two are threatened, the white-tailed hawk (*Buteo albicaudatus*) and the wood stork (*Mycteria americana*), and the peregrine falcon (*Falco peregrinus*) is listed as endangered. Resident bird species which are listed in this county include the interior least tern (*Sterna antillarum athalassos*) listed by the state and federal government as an endangered species, and a state listed threatened species, the white-faced ibis (*Plegadis chihi*).

[1] TPWD. 1988-1993. Endangered feline population and habitat enhancement. Performance Reports, Federal Aid Project No. W-103 and 125 and ESEC 6, Job No. 12. Texas Parks and Wildlife Department, Austin, Texas.

[2] **Env**ision newsletter, Summer 1995.

Several reptile and amphibian species listed as threatened by the state may possibly be affected by the project. These include the Texas horned lizard (*Phrynosoma cornutum*), Texas tortoise (*Gopherus berlandieri*), black-spotted newt (*Notophthalmus meridionalis*), indigo snake (*Drymarchon corais*), reticulate collared lizard (*Crotaphytus reticulates*), and sheep frog (*Hypopachus variolosus*). Many of these reptile species are dependent on shrubland or riparian habitat, while amphibians prefer moist sites in ponds, resacas and grassland areas.

One rare species, the golden orb (*Quadrula aurea*) has been the reason for the designation of the Nueces River from the headwaters of Lake Corpus Christi upstream to US 59 in Live Oak County (within TNRCC classified stream segment 2103) as a significant stream segment by TPWD. This species is restricted to five rivers in Texas. This segment of the Nueces River contains one of only four known remaining populations of this endemic mollusk.

## *A.4 Cultural Resources*

A request was made for archeological site records recorded within an area which included all potential reservoir areas and pipeline alternatives, from the Texas Historical Commission's (THC) restricted Texas Archeological Sites Atlas. Information received from the THC indicates that there are two recorded sites within the requested search area. These include Fort Merrill, a fort established as protection for settlers against Indians which is listed in the National Register of Historic Places. This fort is located on the George West quad approximately 3.5 miles northwest of Dinero off FM 534. This site contains both prehistoric and historic components, and is marked with a gray granite historical marker. At one time there may have been as many as twenty two buildings within this fort. The second cultural resource site is located south of both the Missouri Pacific railroad tracks and the Nueces River. It is approximately 1.1 miles west-northwest of the confluence of Gilden Creek and the Nueces River, and is about 0.7 miles slightly east of north of the permanent benchmark at elevation 147 feet. There is no additional information available on this site. **Neither of these sites is within proposed reservoir areas nor pipeline alignments although they are both within one half mile of the proposed pipelines**.

A review of the Texas Historical Commission Texas Historic Sites Atlas data base indicated that there are no other sites or cemeteries listed within the project area. Although no other sites have been recorded within this project area, this does not mean other sites are not present. The lack of recorded prehistoric or historic remains may indicate that this project is in

an area not yet explored for sites or that the sites may not be visible on the modern ground surface.

***Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291).***

## *A.5 Waters of the US and Jurisdictional Wetlands*

The determination of potential waters of the U.S., including wetlands, has been performed by interpretation of the study area utilizing the following data sources:

- USGS 7.5 minute quadrangle topographic maps,
- FWS National Wetland Inventory (NWI) maps,
- FEMA flood plain maps,
- Live Oak County soil survey,
- the hydric soil list, and
- 1-meter resolution 2004 aerial imagery (NAIP color infrared photography).

Potential waters of the U.S., including wetlands, are located in areas that are characteristically a mosaic of hydric and non-hydric vegetation communities which are not easily distinguished through photo interpretation alone. However, the locations subsequently mentioned have the greatest potential for supporting waters of the U.S. including wetland communities. Field investigations will be required to determine the full extent of any wetlands within the study area.

Potential waters of the U.S., including wetlands, within the study area occur primarily within the watershed of the Nueces River and two intermittent tributaries, Gilden Creek, and Gerard Hollow. Long Hollow, an intermittent stream found within evaluation site C, drains southeast to Lake Corpus Christi rather than to the Nueces River. Portions of these areas may include waters of the U.S. under Section 404 of the Clean Water Act; however, no jurisdictional determination has been made at this time. Wetland areas within the study area are primarily widely scattered small palustrine ponds with unknown bottoms. No open water features, on-channel impoundments, or upland ponds are found within the study area. There are no hydric soils listed in Live Oak County.

Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) illustrate floodplain areas within the study area. Zone A designates the area of the 1% annual chance flood, or "100-year" flood. Only the portion of the study area near the Nueces River is mapped on a FIRM. The Nueces River and small portions of Gilden Creek, Gerard Hollow and Long Hollow near their mouths have Zone A areas designated within the study area. These Zone A areas would occur only within areas of the pipeline alignments.

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# *Appendix B*
# *Cost Estimates for All Off-Channel Reservoir Sizing and Pipeline Delivery Rate Options Considered*

## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (200,000 acft; 750 cfs)*
## *N-10b - Off Channel Reservoir (200K, 750 cfs, 75-93*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 4688 acres, 265 ft. ms | $56,495,000 |
| Intake and Pump Station (484 MGD) | $23,407,000 |
| Transmission Pipeline (2 pipes, 108 in dia., 1.4 miles) | $11,565,000 |
| **Total Capital Cost** | **$91,467,000** |
| Engineering, Legal Costs and Contingencies | $31,435,000 |
| Environmental & Archaeology Studies and Mitigation | $11,296,000 |
| Land Acquisition and Surveying (4704 acres) | $11,626,000 |
| Interest During Construction (4 years) | $19,769,000 |
| Initial Filling of Reservoir | $2,615,000 |
| **Total Project Cost** | **$168,208,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $3,863,000 |
| Reservoir Debt Service (6 percent, 40 years) | $7,646,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $701,000 |
| Dam and Reservoir | $847,000 |
| Pumping Energy Costs (5028802.05492722 kW-hr @ 0.09 $/kW-hr) | $453,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$13,510,000** |
| **Available Project Yield (acft/yr)** | 34,012 |
| **Annual Cost of Water ($ per acft)** | $397 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.22 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (200,000 acft; 1000 cfs)*
## *N-10b - Off Channel Reservoir (200K, 1000 cfs, 75-93*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 4688 acres, 265 ft. ms | $57,251,000 |
| Intake and Pump Station (646 MGD) | $29,150,000 |
| Transmission Pipeline (2 pipes, 120 in dia., 1.4 miles) | $13,934,000 |
| **Total Capital Cost** | **$100,335,000** |
| Engineering, Legal Costs and Contingencies | $34,421,000 |
| Environmental & Archaeology Studies and Mitigation | $11,296,000 |
| Land Acquisition and Surveying (4704 acres) | $11,626,000 |
| Interest During Construction (4 years) | $20,860,000 |
| Initial Filling of Reservoir | $2,565,000 |
| **Total Project Cost** | **$181,103,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $4,709,000 |
| Reservoir Debt Service (6 percent, 40 years) | $7,728,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $868,000 |
| Dam and Reservoir | $859,000 |
| Pumping Energy Costs (5268068.59956385 kW-hr @ 0.09 $/kW-hr) | $474,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$14,638,000** |
| **Available Project Yield (acft/yr)** | 36,127 |
| **Annual Cost of Water ($ per acft)** | $405 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.24 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (200,000 acft; 1250 cfs)*
## *N-10b - Off Channel Reservoir (200K, 1250 cfs, 75-93*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 4688 acres, 265 ft. ms | $58,008,000 |
| Intake and Pump Station (810 MGD) | $34,871,000 |
| Transmission Pipeline (3 pipes, 114 in dia., 1.4 miles) | $19,084,000 |
| **Total Capital Cost** | **$111,963,000** |
| Engineering, Legal Costs and Contingencies | $38,233,000 |
| Environmental & Archaeology Studies and Mitigation | $11,296,000 |
| Land Acquisition and Surveying (4710 acres) | $11,691,000 |
| Interest During Construction (4 years) | $22,243,000 |
| Initial Filling of Reservoir | $2,543,000 |
| **Total Project Cost** | **$197,969,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $5,844,000 |
| Reservoir Debt Service (6 percent, 40 years) | $7,811,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,063,000 |
| Dam and Reservoir | $870,000 |
| Pumping Energy Costs (5507392.00416994 kW-hr @ 0.09 $/kW-hr) | $496,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$16,084,000** |
| **Available Project Yield (acft/yr)** | 30,849 |
| **Annual Cost of Water ($ per acft)** | $521 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.60 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (200,000 acft; 1500 cfs)*
## *N-10b - Off Channel Reservoir (200K, 1500 cfs, 75-93*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 4688 acres, 265 ft. ms | $58,764,000 |
| Intake and Pump Station (969 MGD) | $40,576,000 |
| Transmission Pipeline (3 pipes, 120 in dia., 1.4 miles) | $20,902,000 |
| **Total Capital Cost** | **$120,242,000** |
| Engineering, Legal Costs and Contingencies | $41,039,000 |
| Environmental & Archaeology Studies and Mitigation | $11,296,000 |
| Land Acquisition and Surveying (4710 acres) | $11,691,000 |
| Interest During Construction (4 years) | $23,272,000 |
| Initial Filling of Reservoir | $2,585,000 |
| **Total Project Cost** | **$210,125,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $6,637,000 |
| Reservoir Debt Service (6 percent, 40 years) | $7,894,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,223,000 |
| Dam and Reservoir | $881,000 |
| Pumping Energy Costs (5986270.03712666 kW-hr @ 0.09 $/kW-hr) | $539,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$17,174,000** |
| **Available Project Yield (acft/yr)** | 30,805 |
| **Annual Cost of Water ($ per acft)** | $558 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.71 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (220,000 acft; 750 cfs)*
## *N-10b - Off Channel Reservoir (220K, 750 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 4930 acres, 265 ft. ms | $62,775,000 |
| Intake and Pump Station (484 MGD) | $23,407,000 |
| Transmission Pipeline (2 pipes, 108 in dia., 1.4 miles) | $11,565,000 |
| **Total Capital Cost** | **$97,747,000** |
| Engineering, Legal Costs and Contingencies | $33,633,000 |
| Environmental & Archaeology Studies and Mitigation | $11,877,000 |
| Land Acquisition and Surveying (4946 acres) | $12,219,000 |
| Interest During Construction (4 years) | $21,314,000 |
| Initial Filling of Reservoir | $2,874,000 |
| **Total Project Cost** | **$179,664,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $3,882,000 |
| Reservoir Debt Service (6 percent, 40 years) | $8,390,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $701,000 |
| Dam and Reservoir | $942,000 |
| Pumping Energy Costs (5268320.59264243 kW-hr @ 0.09 $/kW-hr) | $474,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$14,389,000** |
| **Available Project Yield (acft/yr)** | 35,937 |
| **Annual Cost of Water ($ per acft)** | $400 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.23 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (220,000 acft; 1000 cfs)*
## *N-10b - Off Channel Reservoir (220K, 1000 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 4930 acres, 265 ft. ms | $63,532,000 |
| Intake and Pump Station (646 MGD) | $29,150,000 |
| Transmission Pipeline (2 pipes, 120 in dia., 1.4 miles) | $13,934,000 |
| **Total Capital Cost** | **$106,616,000** |
| Engineering, Legal Costs and Contingencies | $36,619,000 |
| Environmental & Archaeology Studies and Mitigation | $11,877,000 |
| Land Acquisition and Surveying (4946 acres) | $12,219,000 |
| Interest During Construction (4 years) | $22,405,000 |
| Initial Filling of Reservoir | $2,798,000 |
| **Total Project Cost** | **$192,534,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $4,726,000 |
| Reservoir Debt Service (6 percent, 40 years) | $8,473,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $868,000 |
| Dam and Reservoir | $953,000 |
| Pumping Energy Costs (5507559.94178002 kW-hr @ 0.09 $/kW-hr) | $496,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$15,516,000** |
| **Available Project Yield (acft/yr)** | 36,897 |
| **Annual Cost of Water ($ per acft)** | $421 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.29 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (220,000 acft; 1250 cfs)*
## *N-10b - Off Channel Reservoir (220K, 1250 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 4930 acres, 265 ft. ms | $64,288,000 |
| Intake and Pump Station (1212 MGD) | $50,614,000 |
| Transmission Pipeline (3 pipes, 114 in dia., 1.4 miles) | $19,084,000 |
| **Total Capital Cost** | **$133,986,000** |
| Engineering, Legal Costs and Contingencies | $45,941,000 |
| Environmental & Archaeology Studies and Mitigation | $11,877,000 |
| Land Acquisition and Surveying (4952 acres) | $12,284,000 |
| Interest During Construction (4 years) | $25,487,000 |
| Initial Filling of Reservoir | $2,866,000 |
| **Total Project Cost** | **$232,441,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $7,535,000 |
| Reservoir Debt Service (6 percent, 40 years) | $8,555,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,456,000 |
| Dam and Reservoir | $964,000 |
| Water Treatment Plant | $0 |
| Pumping Energy Costs (5986342.55168628 kW-hr @ 0.09 $/kW-hr) | $539,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$19,049,000** |
| **Available Project Yield (acft/yr)** | 36,896 |
| **Annual Cost of Water ($ per acft)** | $516 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.58 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (220,000 acft; 1500 cfs)*
## *N-10b - Off Channel Reservoir (220K, 1500 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 4930 acres, 265 ft. ms | $65,044,000 |
| Intake and Pump Station (1455 MGD) | $59,829,000 |
| Transmission Pipeline (3 pipes, 120 in dia., 1.4 miles) | $20,902,000 |
| **Total Capital Cost** | **$145,775,000** |
| Engineering, Legal Costs and Contingencies | $49,976,000 |
| Environmental & Archaeology Studies and Mitigation | $11,877,000 |
| Land Acquisition and Surveying (4952 acres) | $12,284,000 |
| Interest During Construction (4 years) | $26,895,000 |
| Initial Filling of Reservoir | $2,809,000 |
| **Total Project Cost** | **$249,616,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $8,692,000 |
| Reservoir Debt Service (6 percent, 40 years) | $8,638,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,705,000 |
| Dam and Reservoir | $976,000 |
| Pumping Energy Costs (6225740.83887582 kW-hr @ 0.09 $/kW-hr) | $560,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$20,571,000** |
| **Available Project Yield (acft/yr)** | 37,164 |
| **Annual Cost of Water ($ per acft)** | $554 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.70 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (240,000 acft; 750 cfs)*
## *N-10b - Off Channel Reservoir (240K, 750 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5173 acres, 265 ft. ms | $69,638,000 |
| Intake and Pump Station (484 MGD) | $23,407,000 |
| Transmission Pipeline (2 pipes, 108 in dia., 1.4 miles) | $11,565,000 |
| **Total Capital Cost** | **$104,610,000** |
| Engineering, Legal Costs and Contingencies | $36,035,000 |
| Environmental & Archaeology Studies and Mitigation | $12,460,000 |
| Land Acquisition and Surveying (5189 acres) | $12,814,000 |
| Interest During Construction (4 years) | $22,985,000 |
| Initial Filling of Reservoir | $3,022,000 |
| **Total Project Cost** | **$191,926,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $3,892,000 |
| Reservoir Debt Service (6 percent, 40 years) | $9,195,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $701,000 |
| Dam and Reservoir | $1,045,000 |
| Pumping Energy Costs (5268320.59264243 kW-hr @ 0.09 $/kW-hr) | $474,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$15,307,000** |
| **Available Project Yield (acft/yr)** | 37,742 |
| **Annual Cost of Water ($ per acft)** | $406 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.24 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (240,000 acft; 1000 cfs)*
## *N-10b - Off Channel Reservoir (240K, 1000 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5173 acres, 265 ft. ms | $70,395,000 |
| Intake and Pump Station (646 MGD) | $29,150,000 |
| Transmission Pipeline (2 pipes, 120 in dia., 1.4 miles) | $13,934,000 |
| **Total Capital Cost** | **$113,479,000** |
| Engineering, Legal Costs and Contingencies | $39,021,000 |
| Environmental & Archaeology Studies and Mitigation | $12,460,000 |
| Land Acquisition and Surveying (5189 acres) | $12,814,000 |
| Interest During Construction (4 years) | $24,076,000 |
| Initial Filling of Reservoir | $3,063,000 |
| **Total Project Cost** | **$204,913,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $4,745,000 |
| Reservoir Debt Service (6 percent, 40 years) | $9,278,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $868,000 |
| Dam and Reservoir | $1,056,000 |
| Pumping Energy Costs (5747055.53587036 kW-hr @ 0.09 $/kW-hr) | $517,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$16,464,000** |
| **Available Project Yield (acft/yr)** | 38,534 |
| **Annual Cost of Water ($ per acft)** | $427 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.31 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (240,000 acft; 1250 cfs)*
## *N-10b - Off Channel Reservoir (240K, 1250 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5173 acres, 265 ft. ms | $71,151,000 |
| Intake and Pump Station (1212 MGD) | $50,614,000 |
| Transmission Pipeline (3 pipes, 114 in dia., 1.4 miles) | $19,084,000 |
| **Total Capital Cost** | **$140,849,000** |
| Engineering, Legal Costs and Contingencies | $48,343,000 |
| Environmental & Archaeology Studies and Mitigation | $12,460,000 |
| Land Acquisition and Surveying (5195 acres) | $12,879,000 |
| Interest During Construction (4 years) | $27,158,000 |
| Initial Filling of Reservoir | $3,068,000 |
| **Total Project Cost** | **$244,757,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $7,549,000 |
| Reservoir Debt Service (6 percent, 40 years) | $9,360,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,456,000 |
| Dam and Reservoir | $1,067,000 |
| Pumping Energy Costs (6225821.92942298 kW-hr @ 0.09 $/kW-hr) | $560,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$19,992,000** |
| **Available Project Yield (acft/yr)** | 39,267 |
| **Annual Cost of Water ($ per acft)** | $509 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.56 |

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***Cost Estimate Summary***
***Water Supply Project Option***
***Second Quarter 2007 Prices (240,000 acft; 1500 cfs)***
***N-10b - Off Channel Reservoir (240K, 1500 cfs, 75-93)***

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5173 acres, 265 ft. ms | $71,907,000 |
| Intake and Pump Station (1455 MGD) | $59,829,000 |
| Transmission Pipeline (3 pipes, 120 in dia., 1.4 miles) | $20,902,000 |
| **Total Capital Cost** | **$152,638,000** |
| Engineering, Legal Costs and Contingencies | $52,378,000 |
| Environmental & Archaeology Studies and Mitigation | $12,460,000 |
| Land Acquisition and Surveying (5195 acres) | $12,879,000 |
| Interest During Construction (4 years) | $28,566,000 |
| Initial Filling of Reservoir | $3,029,000 |
| **Total Project Cost** | **$261,950,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $8,708,000 |
| Reservoir Debt Service (6 percent, 40 years) | $9,443,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,705,000 |
| Dam and Reservoir | $1,079,000 |
| Pumping Energy Costs (6465213.86943039 kW-hr @ 0.09 $/kW-hr) | $582,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$21,517,000** |
| **Available Project Yield (acft/yr)** | 39,411 |
| **Annual Cost of Water ($ per acft)** | $546 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.68 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (260,000 acft; 750 cfs)*
## *N-10b - Off Channel Reservoir (260K, 750 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5416 acres, 265 ft. ms | $75,184,000 |
| Intake and Pump Station (484 MGD) | $23,407,000 |
| Transmission Pipeline (2 pipes, 108 in dia., 1.4 miles) | $11,565,000 |
| **Total Capital Cost** | **$110,156,000** |
| Engineering, Legal Costs and Contingencies | $37,976,000 |
| Environmental & Archaeology Studies and Mitigation | $13,044,000 |
| Land Acquisition and Surveying (5432 acres) | $13,410,000 |
| Interest During Construction (4 years) | $24,371,000 |
| Initial Filling of Reservoir | $3,321,000 |
| **Total Project Cost** | **$202,278,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $3,914,000 |
| Reservoir Debt Service (6 percent, 40 years) | $9,863,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $701,000 |
| Dam and Reservoir | $1,128,000 |
| Water Treatment Plant | $0 |
| Pumping Energy Costs (5507845.96961881 kW-hr @ 0.09 $/kW-hr) | $496,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$16,102,000** |
| **Available Project Yield (acft/yr)** | 38,819 |
| **Annual Cost of Water ($ per acft)** | $415 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.27 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (260,000 acft; 1000 cfs)*
## *N-10b - Off Channel Reservoir (260K, 1000 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5416 acres, 265 ft. ms | $75,940,000 |
| Intake and Pump Station (646 MGD) | $29,150,000 |
| Transmission Pipeline (2 pipes, 120 in dia., 1.4 miles) | $13,934,000 |
| **Total Capital Cost** | **$119,024,000** |
| Engineering, Legal Costs and Contingencies | $40,962,000 |
| Environmental & Archaeology Studies and Mitigation | $13,044,000 |
| Land Acquisition and Surveying (5432 acres) | $13,410,000 |
| Interest During Construction (4 years) | $25,462,000 |
| Initial Filling of Reservoir | $3,359,000 |
| **Total Project Cost** | **$215,261,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $4,767,000 |
| Reservoir Debt Service (6 percent, 40 years) | $9,946,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $868,000 |
| Dam and Reservoir | $1,139,000 |
| Pumping Energy Costs (6226060.1052476 kW-hr @ 0.09 $/kW-hr) | $560,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$17,280,000** |
| **Available Project Yield (acft/yr)** | 39,937 |
| **Annual Cost of Water ($ per acft)** | $433 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.33 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (260,000 acft; 1250 cfs)*
## *N-10b - Off Channel Reservoir (260K, 1250 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5416 acres, 265 ft. ms | $76,696,000 |
| Intake and Pump Station (1212 MGD) | $50,614,000 |
| Transmission Pipeline (3 pipes, 114 in dia., 1.4 miles) | $19,084,000 |
| **Total Capital Cost** | **$146,394,000** |
| Engineering, Legal Costs and Contingencies | $50,284,000 |
| Environmental & Archaeology Studies and Mitigation | $13,044,000 |
| Land Acquisition and Surveying (5438 acres) | $13,475,000 |
| Interest During Construction (4 years) | $28,545,000 |
| Initial Filling of Reservoir | $3,312,000 |
| **Total Project Cost** | **$255,054,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $7,567,000 |
| Reservoir Debt Service (6 percent, 40 years) | $10,029,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,456,000 |
| Dam and Reservoir | $1,150,000 |
| Pumping Energy Costs (6465304.16842544 kW-hr @ 0.09 $/kW-hr) | $582,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$20,784,000** |
| **Available Project Yield (acft/yr)** | 41,637 |
| **Annual Cost of Water ($ per acft)** | $499 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.53 |

*KS* *11/10/2008*

## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (260,000 acft; 750 cfs)*
## *N-10b - Off Channel Reservoir (260K, 1500 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5416 acres, 265 ft. ms | $77,453,000 |
| Intake and Pump Station (1455 MGD) | $59,829,000 |
| Transmission Pipeline (3 pipes, 120 in dia., 1.4 miles) | $20,902,000 |
| **Total Capital Cost** | **$158,184,000** |
| Engineering, Legal Costs and Contingencies | $54,319,000 |
| Environmental & Archaeology Studies and Mitigation | $13,044,000 |
| Land Acquisition and Surveying (5438 acres) | $13,475,000 |
| Interest During Construction (4 years) | $29,953,000 |
| Initial Filling of Reservoir | $3,277,000 |
| **Total Project Cost** | **$272,252,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $8,726,000 |
| Reservoir Debt Service (6 percent, 40 years) | $10,111,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,705,000 |
| Dam and Reservoir | $1,162,000 |
| Pumping Energy Costs (6704689.20145067 kW-hr @ 0.09 $/kW-hr) | $603,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$22,307,000** |
| **Available Project Yield (acft/yr)** | 41,657 |
| **Annual Cost of Water ($ per acft)** | $535 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.64 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (280,000 acft; 750 cfs)*
## *N-10b - Off Channel Reservoir (280K, 750 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5627 acres, 265 ft. ms | $83,116,000 |
| Intake and Pump Station (484 MGD) | $23,407,000 |
| Transmission Pipeline (2 pipes, 108 in dia., 1.4 miles) | $11,565,000 |
| **Total Capital Cost** | **$118,088,000** |
| Engineering, Legal Costs and Contingencies | $40,753,000 |
| Environmental & Archaeology Studies and Mitigation | $13,550,000 |
| Land Acquisition and Surveying (5643 acres) | $13,927,000 |
| Interest During Construction (4 years) | $26,248,000 |
| Initial Filling of Reservoir | $3,560,000 |
| **Total Project Cost** | **$216,126,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $3,931,000 |
| Reservoir Debt Service (6 percent, 40 years) | $10,768,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $701,000 |
| Dam and Reservoir | $1,247,000 |
| Pumping Energy Costs (5747378.44922831 kW-hr @ 0.09 $/kW-hr) | $517,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$17,164,000** |
| **Available Project Yield (acft/yr)** | 38,476 |
| **Annual Cost of Water ($ per acft)** | $446 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.37 |

*KS* *11/10/2008*

## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (280,000 acft; 1000 cfs)*
## *N-10b - Off Channel Reservoir (280K, 1000 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5627 acres, 265 ft. ms | $83,872,000 |
| Intake and Pump Station (646 MGD) | $29,150,000 |
| Transmission Pipeline (2 pipes, 120 in dia., 1.4 miles) | $13,934,000 |
| **Total Capital Cost** | **$126,956,000** |
| Engineering, Legal Costs and Contingencies | $43,738,000 |
| Environmental & Archaeology Studies and Mitigation | $13,550,000 |
| Land Acquisition and Surveying (5643 acres) | $13,927,000 |
| Interest During Construction (4 years) | $27,339,000 |
| Initial Filling of Reservoir | $3,566,000 |
| **Total Project Cost** | **$229,076,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $4,782,000 |
| Reservoir Debt Service (6 percent, 40 years) | $10,850,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $868,000 |
| Dam and Reservoir | $1,258,000 |
| Pumping Energy Costs (6226060.1052476 kW-hr @ 0.09 $/kW-hr) | $560,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$18,318,000** |
| **Available Project Yield (acft/yr)** | 41,340 |
| **Annual Cost of Water ($ per acft)** | $443 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.36 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (280,000 acft; 1250 cfs)*
## *N-10b - Off Channel Reservoir (280K, 1250 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5627 acres, 265 ft. ms | $84,628,000 |
| Intake and Pump Station (1212 MGD) | $50,614,000 |
| Transmission Pipeline (3 pipes, 114 in dia., 1.4 miles) | $19,084,000 |
| **Total Capital Cost** | **$154,326,000** |
| Engineering, Legal Costs and Contingencies | $53,060,000 |
| Environmental & Archaeology Studies and Mitigation | $13,550,000 |
| Land Acquisition and Surveying (5649 acres) | $13,992,000 |
| Interest During Construction (4 years) | $30,422,000 |
| Initial Filling of Reservoir | $3,568,000 |
| **Total Project Cost** | **$268,918,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $7,586,000 |
| Reservoir Debt Service (6 percent, 40 years) | $10,933,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,456,000 |
| Dam and Reservoir | $1,269,000 |
| Pumping Energy Costs (6944277.6028259 kW-hr @ 0.09 $/kW-hr) | $625,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$21,869,000** |
| **Available Project Yield (acft/yr)** | 46,677 |
| **Annual Cost of Water ($ per acft)** | $469 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.44 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (280,000 acft; 1500 cfs)*
## *N-10b - Off Channel Reservoir (280K, 1500 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5627 acres, 265 ft. ms | $85,384,000 |
| Intake and Pump Station (1455 MGD) | $59,829,000 |
| Transmission Pipeline (3 pipes, 120 in dia., 1.4 miles) | $20,902,000 |
| **Total Capital Cost** | **$166,115,000** |
| Engineering, Legal Costs and Contingencies | $57,095,000 |
| Environmental & Archaeology Studies and Mitigation | $13,550,000 |
| Land Acquisition and Surveying (5649 acres) | $13,992,000 |
| Interest During Construction (4 years) | $31,830,000 |
| Initial Filling of Reservoir | $3,537,000 |
| **Total Project Cost** | **$286,119,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $8,745,000 |
| Reservoir Debt Service (6 percent, 40 years) | $11,016,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,705,000 |
| Dam and Reservoir | $1,281,000 |
| Pumping Energy Costs (6944166.90719416 kW-hr @ 0.09 $/kW-hr) | $625,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$23,372,000** |
| **Available Project Yield (acft/yr)** | 48,296 |
| **Annual Cost of Water ($ per acft)** | $484 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.48 |

*KS* *11/10/2008*

## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (300,000 acft; 750 cfs)*
## *N-10b - Off Channel Reservoir (300K, 750 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5774 acres, 265 ft. ms | $89,481,000 |
| Intake and Pump Station (484 MGD) | $23,407,000 |
| Transmission Pipeline (2 pipes, 108 in dia., 1.4 miles) | $11,565,000 |
| **Total Capital Cost** | **$124,453,000** |
| Engineering, Legal Costs and Contingencies | $42,980,000 |
| Environmental & Archaeology Studies and Mitigation | $13,903,000 |
| Land Acquisition and Surveying (5790 acres) | $14,287,000 |
| Interest During Construction (4 years) | $27,737,000 |
| Initial Filling of Reservoir | $3,859,000 |
| **Total Project Cost** | **$227,219,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $3,953,000 |
| Reservoir Debt Service (6 percent, 40 years) | $11,485,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $701,000 |
| Dam and Reservoir | $1,342,000 |
| Pumping Energy Costs (5986918.29312962 kW-hr @ 0.09 $/kW-hr) | $539,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$18,020,000** |
| **Available Project Yield (acft/yr)** | 39,040 |
| **Annual Cost of Water ($ per acft)** | $462 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.42 |

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## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (300,000 acft; 1000 cfs)*
## *N-10b - Off Channel Reservoir (300K, 1000 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5774 acres, 265 ft. ms | $90,237,000 |
| Intake and Pump Station (646 MGD) | $29,150,000 |
| Transmission Pipeline (2 pipes, 120 in dia., 1.4 miles) | $13,934,000 |
| **Total Capital Cost** | **$133,321,000** |
| Engineering, Legal Costs and Contingencies | $45,966,000 |
| Environmental & Archaeology Studies and Mitigation | $13,903,000 |
| Land Acquisition and Surveying (5790 acres) | $14,287,000 |
| Interest During Construction (4 years) | $28,828,000 |
| Initial Filling of Reservoir | $3,842,000 |
| **Total Project Cost** | **$240,147,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $4,802,000 |
| Reservoir Debt Service (6 percent, 40 years) | $11,568,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $868,000 |
| Dam and Reservoir | $1,354,000 |
| Pumping Energy Costs (6465569.39092497 kW-hr @ 0.09 $/kW-hr) | $582,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$19,174,000** |
| **Available Project Yield (acft/yr)** | 41,432 |
| **Annual Cost of Water ($ per acft)** | $463 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.42 |

*KS* *11/10/2008*

## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (300,000 acft; 1250 cfs)*
## *N-10b - Off Channel Reservoir (300K, 1250 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5774 acres, 265 ft. ms | $90,993,000 |
| Intake and Pump Station (1212 MGD) | $49,957,000 |
| Transmission Pipeline (3 pipes, 120 in dia., 1.4 miles) | $20,902,000 |
| **Total Capital Cost** | **$161,852,000** |
| Engineering, Legal Costs and Contingencies | $55,603,000 |
| Environmental & Archaeology Studies and Mitigation | $13,903,000 |
| Land Acquisition and Surveying (5796 acres) | $14,352,000 |
| Interest During Construction (4 years) | $32,029,000 |
| Initial Filling of Reservoir | $3,842,000 |
| **Total Project Cost** | **$281,581,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $7,721,000 |
| Reservoir Debt Service (6 percent, 40 years) | $11,650,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,458,000 |
| Dam and Reservoir | $1,365,000 |
| Pumping Energy Costs (7183647.05853215 kW-hr @ 0.09 $/kW-hr) | $647,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$22,841,000** |
| **Available Project Yield (acft/yr)** | 46,622 |
| **Annual Cost of Water ($ per acft)** | $490 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.50 |

*KS* *11/10/2008*

## *Cost Estimate Summary*
## *Water Supply Project Option*
## *Second Quarter 2007 Prices (300,000 acft; 1500 cfs)*
## *N-10b - Off Channel Reservoir (300K, 1500 cfs, 75-93)*

| *Item* | *Estimated Costs for Facilities* |
|---|---|
| **Capital Costs** | |
| Dam and Reservoir (Conservation Pool 200000 acft, 5774 acres, 265 ft. ms | $91,750,000 |
| Intake and Pump Station (1455 MGD) | $59,829,000 |
| Transmission Pipeline (3 pipes, 120 in dia., 1.4 miles) | $20,902,000 |
| **Total Capital Cost** | **$172,481,000** |
| Engineering, Legal Costs and Contingencies | $59,323,000 |
| Environmental & Archaeology Studies and Mitigation | $13,903,000 |
| Land Acquisition and Surveying (5796 acres) | $14,352,000 |
| Interest During Construction (4 years) | $33,319,000 |
| Initial Filling of Reservoir | $3,569,000 |
| **Total Project Cost** | **$296,947,000** |
| **Annual Costs** | |
| Debt Service (6 percent, 30 years) | $8,747,000 |
| Reservoir Debt Service (6 percent, 40 years) | $11,733,000 |
| Operation and Maintenance | |
| Intake, Pipeline, Pump Station | $1,705,000 |
| Dam and Reservoir | $1,376,000 |
| Pumping Energy Costs (7183647.05853215 kW-hr @ 0.09 $/kW-hr) | $647,000 |
| Purchase of Water ( acft/yr @ $/acft) | $0 |
| **Total Annual Cost** | **$24,208,000** |
| **Available Project Yield (acft/yr)** | 48,608 |
| **Annual Cost of Water ($ per acft)** | $498 |
| **Annual Cost of Water ($ per 1,000 gallons)** | $1.53 |

*KS* *11/10/2008*

# *Appendix C*
# *TWDB Comments and*
# *Summary of the Coastal Bend RWPG Responses*

**TWDB Contract No. 0704830699**

**Region N, Region-Specific Study 2:**

**TWDB Comments on Draft Final Region-Specific Study Reports:**
**2) Optimization and Implementation Studies for Off-Channel Reservoir**

## Region-Specific Study 2: Optimization and Implementation Studies for Off-Channel Reservoir

1. Pg. 6, Figure 3-2, Site C should be labeled as such. It currently is labeled as “alternate site".

   *Response:* Revised per comment.

2. Task B (first bullet) of the Contract Scope or Work states that the study will "identify a suitable location for the intake and pump station..." Report does not appear to indicate any suitable locations for an intake or pump station. Please identify a suitable location in the report.

   *Response:* A suitable location for the intake and pump station was identified as part of this study as described on page 3 (Section 2), “Topographic maps, LCC volumetric survey, and other local studies were considered to identify preferred locations for the OCR, intake, pipeline, and pump station.” A sentence has been added to state: “The TWDB’s LCC volumetric survey included cross-sectional contours and shaded water depth ranges, which was used to identify deep channel areas near the OCR and upstream of LCC to determine a suitable location for the intake and pump station.”

   The intake and pump station location have been added to Figure 4-8: Preferred Off-Channel Reservoir Site at 280,000 acft Storage Capacity.

3. Task B (second bullet) of the Contract Scope of Work states that the study will "identify and evaluate the potential for mitigating unavoidable impacts to environmental and cultural resources." There does not appear to be any discussion of mitigation in the report. Please identify and evaluate the potential for mitigating unavoidable impacts to environmental and cultural resources.

   *Response:* This study considered the potential for mitigating unavoidable impacts to environmental and cultural resources. The following text has been added to Section 4.1: “The desktop environmental analysis did not indicate anticipated impacts to protected environmental and cultural resources requiring mitigation based on the proposed project location. However, if during a more detailed evaluation of the inundated area and surrounding habitats during the design and construction phase of the project it is determined that adverse impacts exist to environmental and cultural resources, then unavoidable impacts will likely require mitigation. The project cost estimates provided in Figure 4-4 and Section 5, include provisions for additional detailed environmental and archaeological studies and mitigation (if necessary). The cost for these additional studies and mitigation is estimated at about 5% of the total project cost.”

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