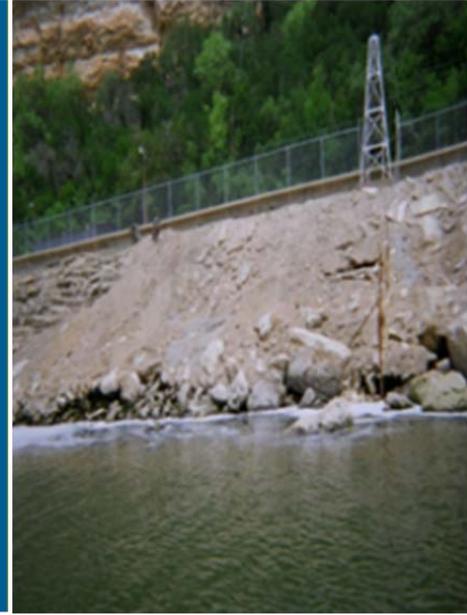


## **APPENDIX V: TRANSPORTATION PLAN**



# **Lower Bois d'Arc Creek Reservoir Transportation Plan**

Prepared for:

**North Texas Municipal Water District**

May 2011

Prepared by:

**FREESE AND NICHOLS, INC.**  
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NTD06128

North Texas Municipal Water District



*Kevin R. Johnson* 5/3/11

FREESE AND NICHOLS, INC.  
TEXAS REGISTERED  
ENGINEERING FIRM  
F-2144



*Vuibin Kau* 05.03.2011

FREESE AND NICHOLS, INC.  
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- Appendix A FM 1396 Bridge Cost Estimate
- Appendix B Meeting Minutes
- Appendix C Draft Design Summary Report (DSR)
- Appendix D Geotechnical Data for FM 1396 Bridge

## **EXECUTIVE SUMMARY**

NTMWD is planning to develop a water supply reservoir on Bois d'Arc Creek. The proposed reservoir, Lower Bois d'Arc Creek Reservoir, would be created by an earthen dam located in Fannin County about 15 miles northeast of Bonham, Texas. The proposed reservoir would have a surface area of about 16,500 acres and a storage capacity of about 367,600 acre-feet with a normal pool elevation of 534 feet msl.

This Lower Bois d'Arc Creek Reservoir Transportation Plan report summarizes the discussions, agreements and results of an effort by North Texas Municipal Water District (NTMWD), Texas Department of Transportation (TxDOT) and Fannin County to address the future transportation needs in the area of the proposed Lower Bois d'Arc Creek Reservoir.

The details of this report contain:

- (1) Coordination details with state and local agencies
- (2) Alternatives considered and the preferred alignment of FM 1396
- (3) Alternatives considered for addressing County Roads affected by the proposed reservoir

Information in this report includes geographic, geological and cost data prepared during the transportation planning process with respect to modifying the transportation network located in the proposed Lower Bois d'Arc Creek Reservoir limits. A detailed topographic survey, property survey, geotechnical investigation and design will be required to further define the impacts and better define the costs of the proposed improvements.

The primary TxDOT road that could be impacted by the proposed reservoir is FM 1396. The current alignment of FM 1396 spans one of the widest portions of the proposed reservoir and would impact recreational uses if relocated in the same location. Several different options were studied and are included in this report. The recommendation is Option 4, construct a new bridge over the reservoir by extending FM 897 North of Lannius. It is recommended to construct this bridge with a low chord elevation of 551 (approximately 17' clearance above normal pool). The estimated cost is \$32.14M not including engineering, surveying, permitting, etc.

In addition to FM 1396, there are 27 county roads that could be impacted by the proposed reservoir. A majority of the county roads located within the footprint of the proposed reservoir are shorter in length and therefore make up a smaller portion of the proposed transportation plan for this project. It is recommended to reconstruct nine crossings at a higher elevation, leave 13 crossings in place and close five crossings, all at an estimated cost of \$5.1M, not including engineering, surveying, permitting, etc.

## **1.0 INTRODUCTION**

The North Texas Municipal Water District submitted an application for a State of Texas water rights permit for the proposed Lower Bois d'Arc Creek Reservoir project in December 2006. An application for a Section 404 permit was submitted to the Tulsa District of the U.S. Army Corps of Engineers (USACE) in June 2008. In support of the permitting activities associated with this project, a transportation planning study was completed to evaluate alternative routes and costs associated with abandonment, relocation or reconstruction of the existing roadway infrastructure.

Various Fannin County and TxDOT roadways are located within the area proposed to be inundated by constructing the proposed Lower Bois d'Arc Creek Reservoir. TxDOT's major road in the area is FM 1396, a two-lane asphalt roadway. The existing roadway would be inundated by the proposed reservoir following construction and therefore alternatives were developed to provide transportation access across the lake. These alternatives were developed to obtain consensus from the parties involved of the preferred alignment of the roadway. With these alternatives, the impact to the landowners, recreational opportunities of the proposed reservoir, costs and impact to the transportation network were analyzed. Fannin County has 27 other roadways that could be affected by the proposed reservoir, most of which are unimproved surfaces.

The purpose of this report is to identify the roadways that could be impacted by the proposed reservoir project and propose solutions for maintaining the transportation connectivity throughout the county. Conceptual level cost estimates for the proposed solutions have been prepared for budgeting purposes.

## 2.0 FM 1396 RELOCATION

### 2.1 Options

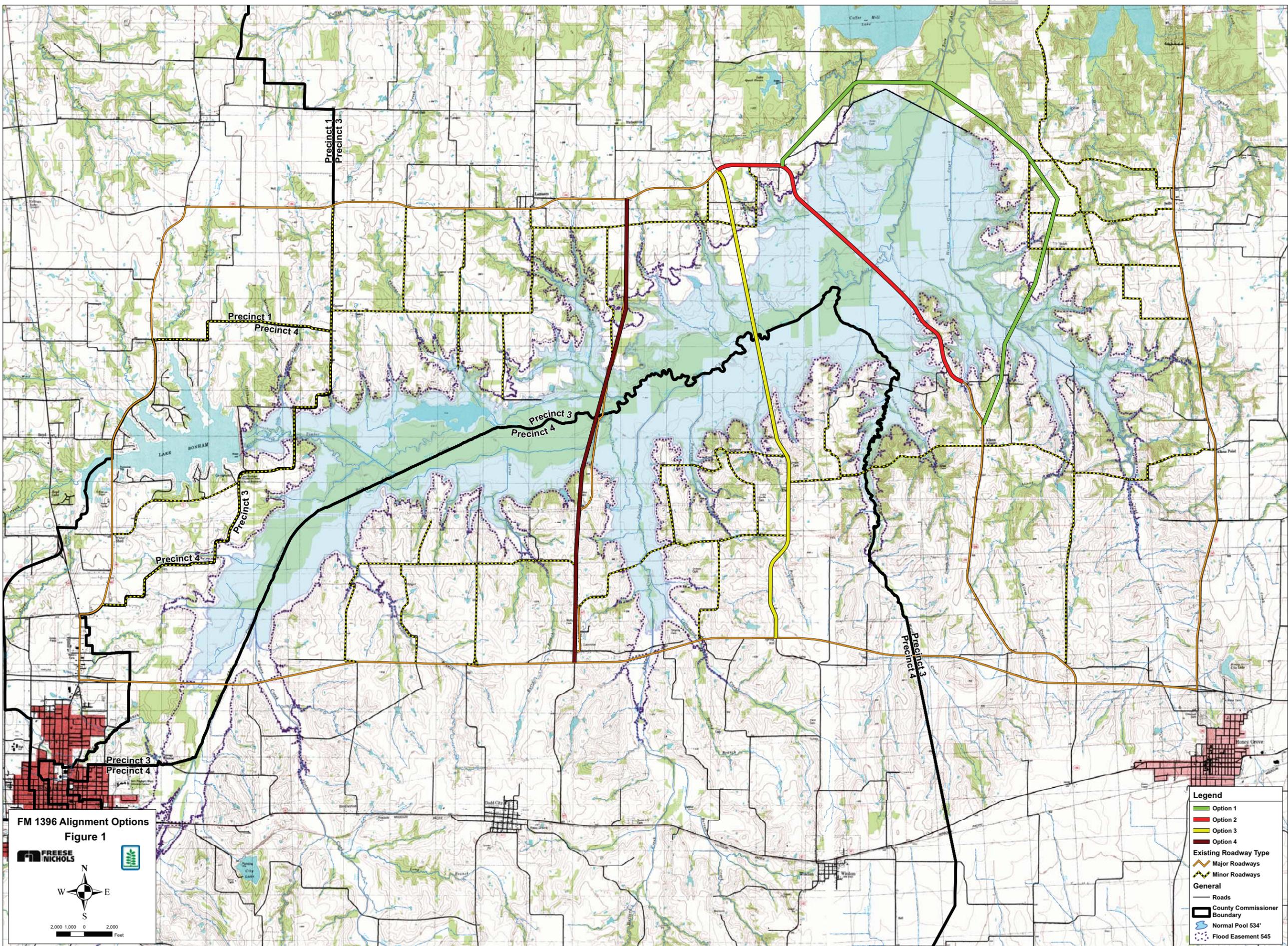
FM 1396 is an existing two-lane TxDOT asphalt road located within the proposed reservoir limits. The affected portion of roadway is located northwest of the community of Honey Grove. The existing roadway and bridge lie within the proposed reservoir boundary and therefore would need to be raised or relocated as part of the proposed reservoir construction. Various options were investigated with respect to landowner impacts, cost, schedule and travel time for the relocation of FM 1396. These are summarized below and shown in Figure 1.

1. Reroute FM 1396 around the proposed dam
2. Reconstruct FM 1396 along the existing alignment (raise road and new bridge)
3. Relocate FM 1396 approximately 10,000 feet to southwest with a new alignment and bridge
4. Replace FM 1396 by extending FM 897 North out of Lannius with a new bridge over the proposed reservoir
5. Terminate FM 1396 at the shoreline and provide no new route over or around the proposed reservoir

Table 2.1 summarizes some of the advantages and disadvantages for each proposed option.

**Table 2.1 Analysis of Different Alignment Options for FM 1396**

<b>Option</b>	<b>Advantages</b>	<b>Disadvantages</b>
1	<ul style="list-style-type: none"> <li>• No bridge would be needed over the proposed reservoir</li> </ul>	<ul style="list-style-type: none"> <li>• May impact the Caddo National Grasslands</li> <li>• Additional travel time vs. the existing route</li> </ul>
2	<ul style="list-style-type: none"> <li>• Existing FM 1396 roadway outside of proposed reservoir boundary could be utilized</li> <li>• No additional travel time</li> </ul>	<ul style="list-style-type: none"> <li>• Restricts water surface area for recreational purposes</li> <li>• Longest length of bridge required</li> </ul>
3	<ul style="list-style-type: none"> <li>• Similar travel time to existing alignment</li> </ul>	<ul style="list-style-type: none"> <li>• Restricts water surface area for recreational purposes</li> <li>• Longer length of bridge required than Option 4</li> <li>• Requires a new roadway to be constructed on the northern and southern sides of the reservoir (existing County Road ROW may be utilized)</li> </ul>
4	<ul style="list-style-type: none"> <li>• Preferred alignment of County, TxDOT, and NTMWD</li> <li>• Maximizes water surface area for recreational purposes</li> <li>• Similar travel time to existing alignment</li> <li>• Shortest bridge length required</li> </ul>	<ul style="list-style-type: none"> <li>• Requires a new roadway to be constructed on the northern and southern sides of the reservoir (existing County Road ROW may be utilized)</li> </ul>
5	<ul style="list-style-type: none"> <li>• Least expensive alternative</li> </ul>	<ul style="list-style-type: none"> <li>• Dramatically increases travel time in area</li> </ul>



**FM 1396 Alignment Options**  
**Figure 1**

**FREESE NICHOLS**

Scale: 2,000 1,000 0 2,000 Feet

**Legend**

- Option 1
- Option 2
- Option 3
- Option 4
- Existing Roadway Type
  - Major Roadways
  - Minor Roadways
- General
  - Roads
  - County Commissioner Boundary
  - Boundary
  - Normal Pool 534'
  - Flood Easement 545

## 2.2 Design Considerations

Various standards and guidelines were considered for the design assumptions made in this plan. TxDOT design guidelines were utilized for the roadway standards. TxDOT and regional requirements for proposed drainage improvements were considered for the county road improvements. The bridge height recommendation was developed based on maximizing the recreation potential and from discussions with City of Dallas staff regarding Lake Ray Hubbard. Dallas recently utilized a minimum 15' clearance above normal pool for a new bridge across the Lake and feels that it provides an adequate clearance for recreational purposes and for maintenance and operational activities.

## 2.3 Estimated Costs

Conceptual level construction costs were developed for the various options. These costs include Rights-of-Way (ROW), bridge and roadway costs for each alternative. Cost estimates for Option 1 and 5 were not developed due to these being considered impractical alternatives. Cost estimates for Options 2-4 were developed and are shown below in Table 2.2. These estimates are conceptual in nature due to the limited investigation, research and data available.

**Table 2.2 Estimated Costs for FM 1396 Options Based on Different Bridge Heights<sup>1</sup>**

Option	Bottom of Bridge = 546 (12' clearance) <sup>2</sup>	Bottom of Bridge = 551 (17' clearance) <sup>2</sup>	Bottom of Bridge = 556 (22' clearance) <sup>2</sup>	Bottom of Bridge = 561 (27' clearance) <sup>2</sup>
1	Not developed			
2	\$33.65 M	\$36.72 M	\$39.89 M	\$45.53 M
3	\$35.31 M	\$37.17 M	\$39.97 M	\$45.27 M
4	\$29.86 M	\$32.14 M	\$34.62 M	\$38.64 M
5	Not developed			

<sup>1</sup> Engineering, surveying, materials testing and construction management costs are not included.

<sup>2</sup> Clearances are referenced from the normal pool elevation of 534'.

- Detailed cost estimating data is included in Appendix A.
- Soil for embankment is from on-site source.
- Drilled shafts for bridge piers are approximately 50' deep.
- ROW costs are assumed at \$0.50 per sq. ft.
- The road costs are approximately \$500/LF.

Bridge heights referenced in Table 2.2 are based on clearance intervals above normal pool elevation of 534'. The normal pool elevation of 534' is approximately 7' below the emergency spillway elevation of 541'.

## ***2.4 Coordination with State and Local Agencies***

Extensive coordination occurred between North Texas Municipal Water District (NTMWD), Fannin County and Texas Department of Transportation (TxDOT) with regards to the transportation opportunities around the proposed Lower Bois d' Arc Creek Reservoir. These entities have been coordinating the proposed roadway improvements associated with proposed reservoir construction for several years.

Detailed discussions have taken place on the transportation plan regarding the County and TxDOT improvements within the proposed reservoir area. These meetings are summarized below:

- 5/18/07 - Meeting at TxDOT in Sherman – Discussed TxDOT & County Roads (TxDOT, NTMWD, FNI)
- 3/12/09 – Meeting at Fannin County Courthouse in Bonham – Discussed TxDOT & County Roads (Fannin County, TxDOT, NTMWD, FNI)
- 12/2/09 – Meeting at Fannin County Precinct 4 Office – Discussed County Roads (Fannin County, NTMWD, FNI)
- 12/29/09 – Meeting at Fannin County Office in Bonham - Discussed County Roads (Fannin County, TxDOT, NTMWD, FNI)
- 2/5/10 – Meeting at TxDOT Bonham Office – Discussed TxDOT & County Roads (Fannin County, TxDOT, NTMWD, FNI)
- 3/26/10 – Meeting at TxDOT Paris District Office to begin Design Summary Report (DSR) (Fannin County, TxDOT, NTMWD, FNI)

Meeting minutes were prepared for the meetings on 12/29/09 and 3/26/10 and are included in Appendix B. The draft DSR prepared on 2/5/10 is included in Appendix C.

## ***2.5 Geotechnical Data***

Freese and Nichols performed a geotechnical investigation in the approximate location of Option 4. The purpose of this investigation was to provide additional information for cost estimating. A summary of the findings in the geotechnical study, as well as the boring logs can be found in Appendix D.

The assumptions made with regards to soil types and depths of rock were confirmed with the investigation. The four borings performed showed a variety of clay material in the area of Option 4. The on-site material will be suitable for embankment of the roadway, although some soil reinforcement may be required.

An analysis was done to determine at what height it became more cost effective to utilize a bridge in lieu of embankment. Based on the soil condition and cost estimates developed, it was determined that the bridge cost equaled embankment cost when the fill height is 45'. Based on

this analysis the cost estimates assume embankment will be used along the roadway when the height of the road is less than 45'. When the height of the road exceeds 45' from the natural ground, a bridge will be utilized.

## ***2.6 Preferred Alignment for FM 1396***

Based on the alternatives analysis performed, multiple discussions with TxDOT and Fannin County, all entities have agreed the preferred alignment is Option 4. This option will replace FM 1396 by extending FM 897 North out of Lannius with a new bridge over the proposed reservoir. It is also our recommendation to construct the proposed FM 1396 Bridge at a proposed height of approximately 15' to 17' above the normal pool elevation. This elevation will allow adequate height for recreational purposes and any maintenance and operational activities that may need to occur on the reservoir and the bridge. The final elevations and clearances will be determined during design.

This option would provide similar travel times to the existing alignment and would likely maximize the recreational opportunity of the proposed reservoir. Some additional details and requests by the parties involved are outlined below:

- TxDOT has requested the new FM 897 be designed to TxDOT Farm to Market Road Standards with 120' ROW and a 70 mph design speed.
- TxDOT would assume maintenance of the new FM 897 extension and associated bridge after construction is complete.
- TxDOT would end maintenance on existing FM 1396 at the intersection with FM 2029 on the North side of the proposed reservoir. Fannin County would maintain from this point to the shoreline.
- TxDOT would end maintenance on existing FM 1396 at crossing #12 on the South side of the proposed reservoir. Fannin County would maintain from this point to the shoreline.
- TxDOT requested the pavement be reconstructed and widened (28') along the existing FM 897 through Lannius.
- TxDOT requested the pavement be reconstructed along FM 1396 from Allen's Chapel to crossing #12.
- NTMWD may consider rerouting the existing portion of FM 897 around Lannius (not included in cost estimates).
- Final bridge elevations or lengths have not been decided. Safety, recreational purposes, conveyance of water and many other items should be considered in the final design of the bridge.

### **3.0 COUNTY ROADS**

#### **3.1 Process – Objectives**

County roads make up a major component of the transportation network in the proposed Lower Bois d'Arc Creek Reservoir area. A summary of all county road conflicts is shown in Figure 2. An analysis was performed to minimize the impacts of the proposed reservoir to local residents and landowners. In this analysis various items were taken into account to finalize the recommended solutions. These items included:

1. Is the roadway needed?
2. Is there a significant increase in travel distance if a road does not exist?
3. Are there alternative means of ingress/egress?
4. Would the road crossing be inundated by the proposed reservoir?
5. If inundated, at what frequency?

Based on the above criteria the roadways were placed into three categories:

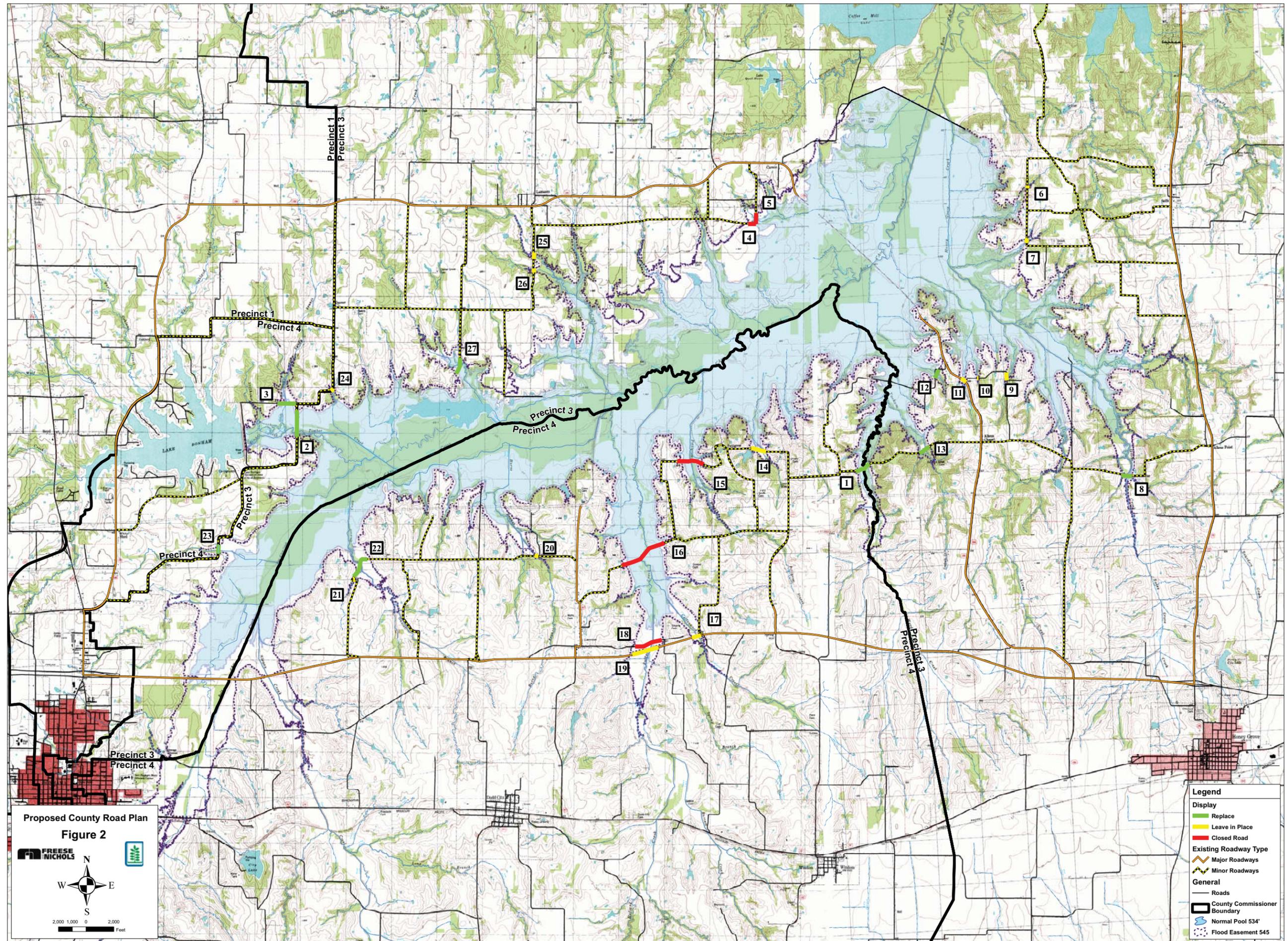
- Reconstruct - Road is needed to maintain access, therefore, it needs to be reconstructed. The road would be reconstructed with a culvert or bridge to maintain access up to the 100-yr storm event.
- Leave in place – The road is desirable to maintain access, but not critical. These roadways would not be inundated by the proposed reservoir's normal pool, and potentially may be inundated at a given storm event. With the proposed reservoir construction, gates would be installed on each side of the potential affected road section, for the county to maintain and close if the roadway is inundated.
- Close Road – The roadway is not required and would be inundated by the proposed reservoir. For these roadways, barricades would be constructed near the shoreline and appropriate "road closed" signage would be placed along the roadway with construction.

#### **3.2 Costs**

Conceptual cost estimates were developed for the proposed improvements to the County Roads. These costs are shown in Table 3.1. Depending on the crossing, the cost estimates may include culvert replacements, bridge construction, demolition costs, signage, and/or roadway reconstruction. A hydrologic & hydraulic analysis will need to be performed at each crossing location during final design to determine the proposed improvements.

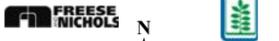
#### **3.3 Recommendations**

Twenty seven county road crossings were identified within the limits of the proposed Lower Bois d'Arc Creek Reservoir. Based on the criteria described above and the agreements with the County Commissioners in those precincts where the crossings are located, five county road crossings would be closed, thirteen county road crossings would be left in place and nine county road crossings would be reconstructed. A map showing these crossings is shown in Figure 2. A table showing the proposed improvements and associated costs of these improvements is shown in Table 3.1



Proposed County Road Plan

Figure 2



2,000 1,000 0 2,000 Feet

**Legend**

**Display**

- Replace (Green line)
- Leave in Place (Yellow line)
- Closed Road (Red line)

**Existing Roadway Type**

- Major Roadways (Thick orange line)
- Minor Roadways (Thin orange line)

**General**

- Roads (Thin black line)
- County Commissioner Boundary (Thick black line)
- Normal Pool 534' (Blue shaded area)
- Flood Easement 545 (Purple dashed line)

**TABLE 3.1: COUNTY ROAD PLAN COST ESTIMATE**

LEGEND	
Green=	Replace/Reconstruct
Yellow=	Leave in place
Red=	Close Road

Project #	Road Name	Crossing Name	Needed?	Crossing Type	Project length (ft)	Add'l Detour Distance (ft)	Road/Bridge Elevation (ft msl)	Event WSE (ft msl)	Storm event of possible inundation	Recommendation Comment	Bridge Length (ft)	Culvert Cost	Drainage Cost	Existing Road Type	Demo Cost	Signage	Avg. Fill	Roadway Cost/LF	Roadway Cost	Total Cost	
1	CO RD 2980	Ward Creek	Y	Bridge	1,375	N/A	526.50	534.00	Below Normal Pool	TxDOT Reconstruction	100		\$168,000	1L Dirt			9'	\$443	\$564,825	\$732,825	
2	CO RD 2610	Timber Creek	Y	Bridge	1,971	1,056.00	529.50	534.00	Below Normal Pool	Reconstruct because needed for access and below normal pool	300		\$504,000	1L Dirt	\$25,000		9'	\$443	\$740,253	\$1,269,253	
3	CO RD 2680	Sandy Branch	Y	Bridge	1,400	N/A	532.67	534.00	Below Normal Pool	Reconstruct because needed for access and below normal pool		\$50,000	\$50,000	1L Gravel			6.5'	\$329	\$460,600	\$510,600	
4	CO RD 2655	No Creek Crossing - Edge of Water	N	N/A	852	60	532.00	534.00	Below Normal Pool	Demo because not needed for access and below normal WSE					\$25,000	\$5,000				\$30,000	
5	CO RD 2670	Unnamed	N	small CMP	1,049	0	532.00	534.00	Below Normal Pool	Demo because not needed for access and below normal WSE				1L Gravel	\$25,000	\$5,000				\$30,000	
6	CO RD 2725	Unnamed	N	bridge	95	3701	546.50	545	Above Flood Easement	Not needed for access, new bridge and above Flood easement				1L Gravel						\$0	
7	CO RD 2730	Honey Grove Creek Tributary	N	small crossing	517	926	542.50	539.7	Over 100 Years	Not needed for access and above 100 yr water surface elevation				1L Dirt		\$5,000				\$5,000	
8	CO RD 2770	Honey Grove Creek Tributary	Y	Bridge is out	626	N/A	539.00	539.1	50 Years	TxDOT Reconstruction	100		\$168,000	1L Gravel			3.5'	\$227	\$119,402	\$287,402	
9	CO RD 2745	Honey Grove Creek Tributary	N	Large CMP	540	1180	540.50	539.7	Over 100 Years	Not needed for access and above 100 yr water surface elevation				1L Gravel		\$5,000				\$5,000	
10	CO RD 2745	Bois d'Arc Creek Tributary	Y	small crossing	101	N/A	546.38	545	Above Flood Easement	Needed for access and above Flood Easement				1L Gravel						\$0	
11	FM 1396	Bois d'Arc Creek Tributary	Y	small RCB	441	N/A	543.62	539.7	Above 100 Year	Needed for access and above 100 yr water surface elevation				2L Asphalt		\$5,000				\$5,000	
12	CO RD 2985	Unknown	Y	Large CMP	690	N/A	527.25	534.00	Below Normal Pool	Reconstruct because needed for access and below normal pool, Realign Bridge	100		\$168,000	1-2L Gravel			8'	\$394	\$232,460	\$400,460	
13	CO RD 2980	Yoakum Creek	Y	Unknown	929	N/A	539.50	539.1	50 Years	Reconstruct because needed for access		\$50,000	\$50,000	1L Gravel			2.5'	\$202	\$187,658	\$237,658	
14	CO RD 2955	Unknown	N	Large CMP	1,211	2400	537.75	537.6	over 10 years	Longer detour length, leave in place, possible inundation about 10 year event				1L Dirt		\$5,000				\$5,000	
15	CO RD 2955	Pettigrew Branch	N	Large CMP	1,847	1553	522.75	534.00	Below Normal Pool	Demo because not needed for access and below normal WSE				1L Dirt	\$25,000	\$5,000				\$30,000	
16	CO RD 2950	Bullard Creek	N	bridge and CMP	3,538	8492	526.50	534.00	Below Normal Pool	Demo because not needed for access and below normal WSE				1L Gravel	\$25,000	\$5,000				\$30,000	
17	US 82	Cottonwood Creek	Y	5 multiple RCB	661	N/A	548.20	545	Above Flood Easement	Needed for access and above Flood Easement				2L Asphalt						\$0	
18	CO RD 2917	Bullard Creek	N	Bridge	2,007	0	537.00	534	5-10 Years	Not needed for access and possible inundation about 10 year event				1L Gravel		\$5,000				\$30,000	
19	US 82	Bullard Creek	Y	Bridge	1,901	N/A	545.00	545	Above Flood Easement	Needed for access and above Flood Easement				2L Asphalt						\$0	
20	CO RD 2900	Burns Branch	N	Bridge	146	882	546.50	545	Above Flood Easement	Not needed for access and above Flood Easement				1L Gravel						\$0	
21	CO RD 2900	Onslott Creek	Y	Large RCP	77	N/A	546.94	545	Above Flood Easement	Needed for access and above Flood Easement				1L Dirt						\$0	
22	CO RD 2900	Onslott Creek	Y	Bridge	1,831	N/A	539.00	539.1	Almost 50 Years	TxDOT Reconstruction	100		\$168,000	1L Gravel			3.5'	\$227	\$392,937	\$560,937	
23	CO RD 2610	Bois d'Arc Creek Tributary	Y	Bridge	495	N/A	539.08	539.1	50 Years	Reconstruct because needed for access		\$50,000	\$50,000	1L Gravel			3'	\$214	\$105,930	\$155,930	
24	CO RD 2610	Timber Creek	Y	RCP or CMP	220	N/A	543.50	539.7	Over 100 Years	Needed for access and above 100 yr water surface elevation				1L Gravel		\$5,000				\$5,000	
25	CO RD 2615	Bois d'Arc Creek Tributary	N	Large CMP	376	7826	546.00	545	Above Flood Easement	Not needed for access and above Flood Easement				1L Gravel						\$0	
26	CO RD 2615	Bois d'Arc Creek Tributary	N	Large CMP	297	7826	543.25	539.7	Over 100 Years	Not needed for access and above 100 yr water surface elevation				1L Gravel		\$5,000				\$5,000	
27	CO RD 2625	Bois d'Arc Creek Tributary	Y	2-Large CMP	1,384	N/A	526.50	534.00	Below Normal Pool	Reconstruct because needed for access and below normal pool	100		\$168,000	1L Dirt			8.5	\$417	\$535,428	\$703,428	
																			<b>Total=</b>	<b>\$5,038,493</b>	

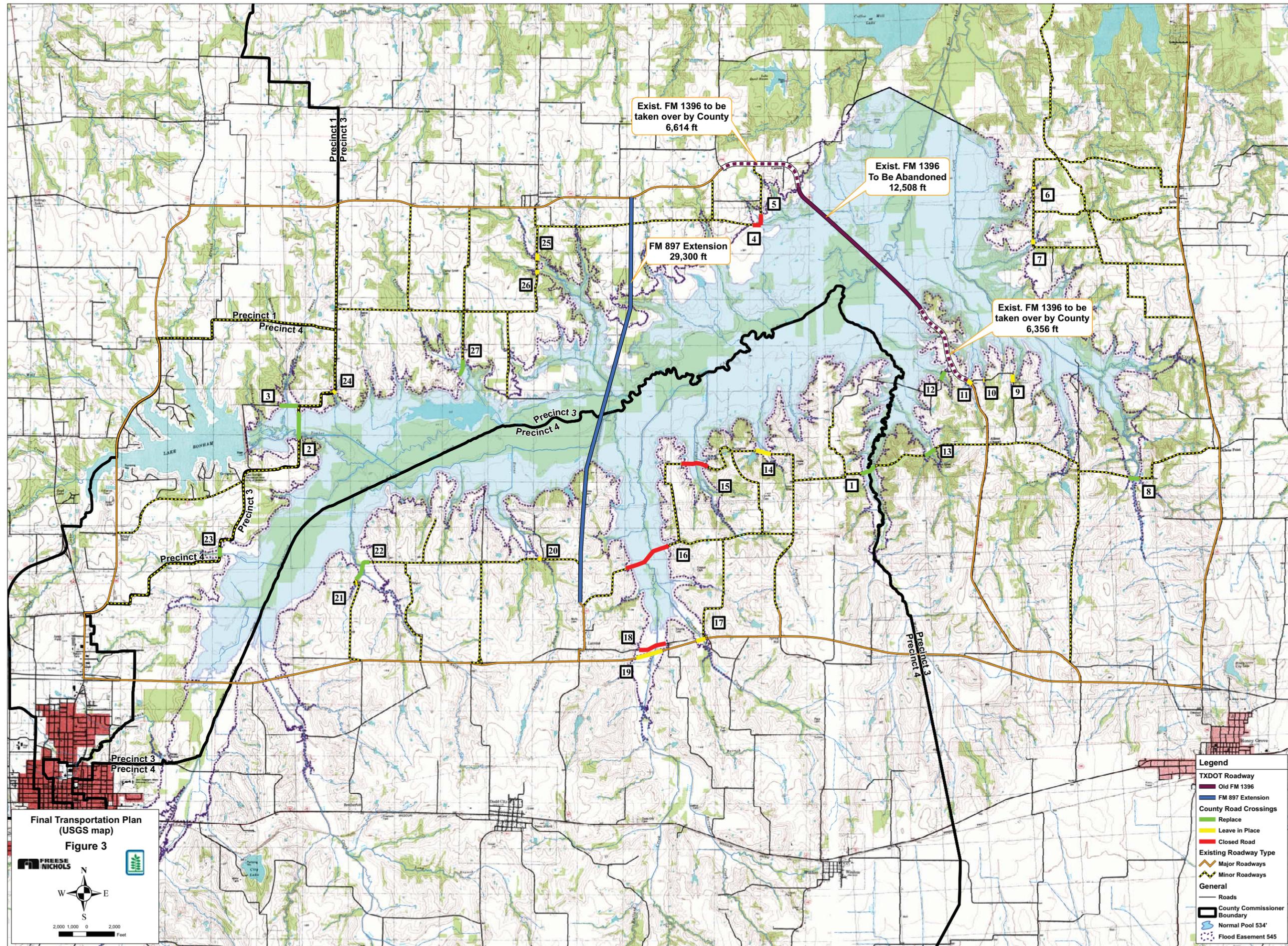
LEGEND	
Needed?=-	Is the roadway needed to provide access to homes or businesses?
Crossing Type=-	Description of the type of creek crossing
Project Length=-	length of road lower than elevation 542 and between flood easements
Add'l Detour Distance=-	Additional distance driven to avoid the closed creek crossing (if crossing was removed)
Road/Bridge Elevation=-	Highest existing elevation along the road or bridge
Event WSE=-	Water Surface Elevation associated with the storm event identified in the storm event possible inundation column

## **4.0 SUMMARY**

Fannin County, TxDOT and NTMWD have developed this Proposed Transportation Plan to provide adequate access to and across the proposed reservoir and surrounding properties. This plan would minimize impacts to the residents while maximizing the transportation and recreational opportunities of the proposed reservoir. Figure 3 shows the proposed improvements on a 7.5-minute USGS topographic map and Figure 4 shows the proposed improvements on an aerial photo.

The total cost of improvements needed would be approximately \$32.14M for the FM 1396 bridge and \$5.1M for the improvements needed on the county roads. These costs are for construction only and do not include engineering, surveying, permitting, etc. These findings are a result of extensive coordination with local governing bodies to provide limited impact to users of the existing Fannin County roadways within and adjacent to the proposed reservoir site.

The associated cost estimates are conceptual in nature and should be refined by completing a preliminary design. This preliminary design should include detailed surveys to better understand the impacts to associated properties and the geometric challenges associated with the roadway realignment. This preliminary design effort would allow a more accurate construction cost to be developed.

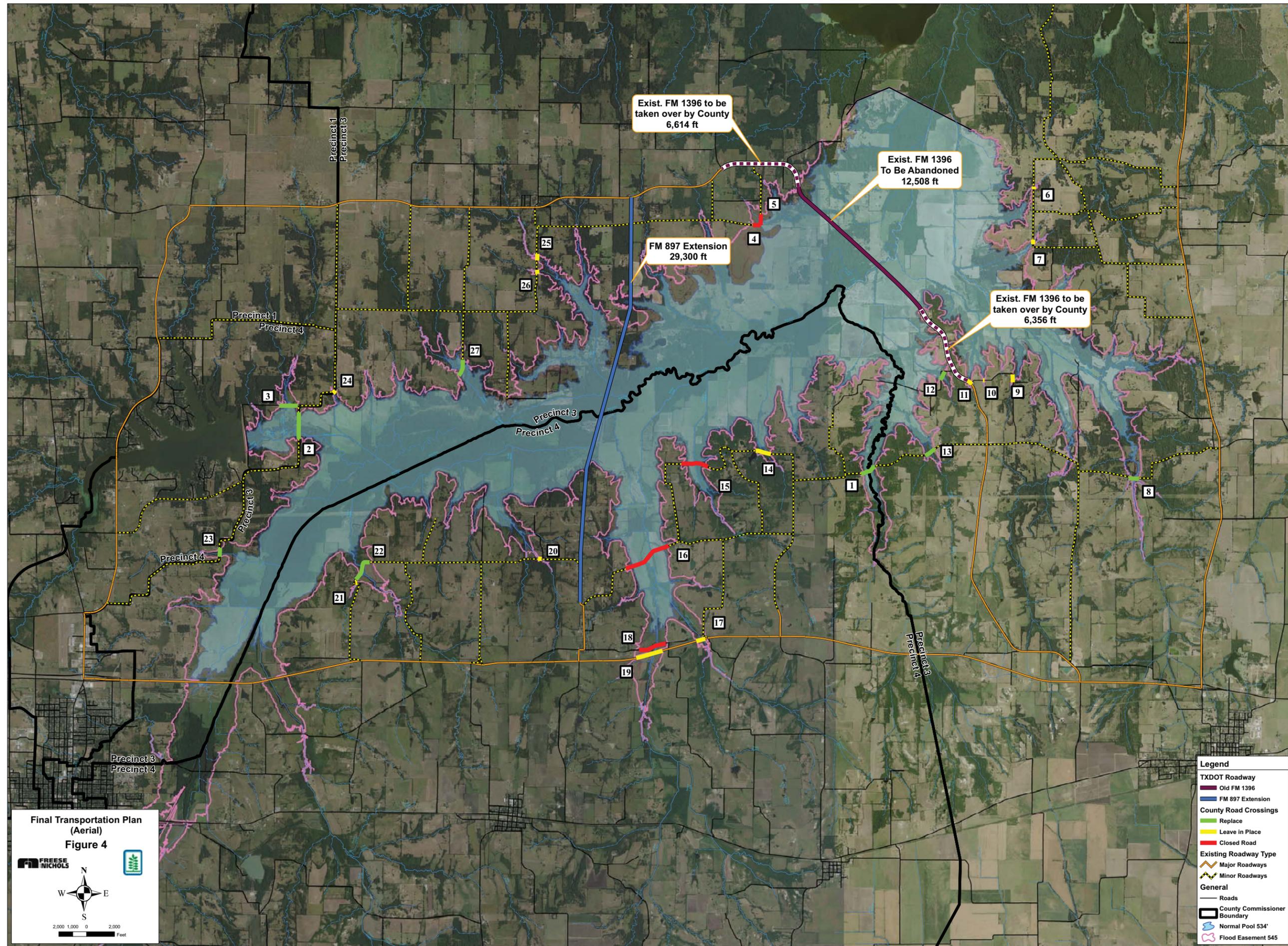


- Legend**
- TXDOT Roadway
  - Old FM 1396
  - FM 897 Extension
  - County Road Crossings
  - Replace
  - Leave in Place
  - Closed Road
  - Existing Roadway Type
  - Major Roadways
  - Minor Roadways
  - General
  - Roads
  - County Commissioner Boundary
  - Normal Pool 534'
  - Flood Easement 545

**Final Transportation Plan  
(USGS map)  
Figure 3**

**Freese Nichols**

Scale: 2,000 1,000 0 2,000 Feet



Exist. FM 1396 to be taken over by County 6,614 ft

Exist. FM 1396 To Be Abandoned 12,508 ft

FM 897 Extension 29,300 ft

Exist. FM 1396 to be taken over by County 6,356 ft

**Final Transportation Plan (Aerial) Figure 4**

**FRESE NICHOLS**

2,000 1,000 0 2,000 Feet

**Legend**

- TXDOT Roadway
  - Old FM 1396
  - FM 897 Extension
- County Road Crossings
  - Replace
  - Leave in Place
  - Closed Road
- Existing Roadway Type
  - Major Roadways
  - Minor Roadways
- General
  - Roads
  - County Commissioner Boundary
  - Normal Pool 534'
  - Flood Easement 545

APPENDIX A

FM 1396 Bridge Cost Estimate

## Option #3 - Project Costs Summary

Pavement Cost      \$            500.00

Segment	Segment length	ROW width	ROW cost	ROW total	Pavement width	Road Cost	Road + ROW Cost
North of Reservoir	4759	120	\$ 0.50	\$ 285,540.00	44	\$ 2,379,500.00	\$ 2,665,040.00
		Bridge (Approximately 6500')					
South of Reservoir	17156	120	\$ 0.50	\$1,029,360.00	44	\$ 8,578,000.00	\$ 9,607,360.00
<b>TOTAL</b>	<b>21915</b>						<b>\$ 12,272,400.00</b>

Bridge height	Cost	Total Project Ccost (bridge + road)
5'	\$ 23,034,081	\$ 35,306,481
10'	\$ 24,894,627	\$ 37,167,027
15'	\$ 27,698,590	\$ 39,970,990
25'	\$ 32,993,417	\$ 45,265,817

## Option #4 - Project Costs Summary

Pavement Cost      \$            500.00

Segment	length	ROW width	ROW cost	ROW total	Pavement width	Road Cost	Road and ROW Cost
North of Reservoir	8994	120	\$ 0.50	\$539,640.00	44	\$ 4,497,000.00	\$ 5,036,640.00
		Bridge (Approximately 6000')					
South of Reservoir	13477	120	\$ 0.50	\$808,620.00	44	\$ 6,738,500.00	\$ 7,547,120.00
<b>TOTAL</b>	<b>22471</b>						<b>\$ 12,583,760.00</b>

Bridge height	Cost	Total Project Cost (bridge + road)
5'	\$ 17,277,441	\$ 29,861,201
10'	\$ 19,559,342	\$ 32,143,102
15'	\$ 22,036,056	\$ 34,619,816
25'	\$ 26,053,587	\$ 38,637,347



LOWER BOIS D'ARC RESERVOIR  
 NORTH TEXAS MUNICIPAL WATER DISTRICT  
 PRELIMINARY BRIDGE COST ESTIMATE

OPINION OF PROBABLE CONSTRUCTION COST

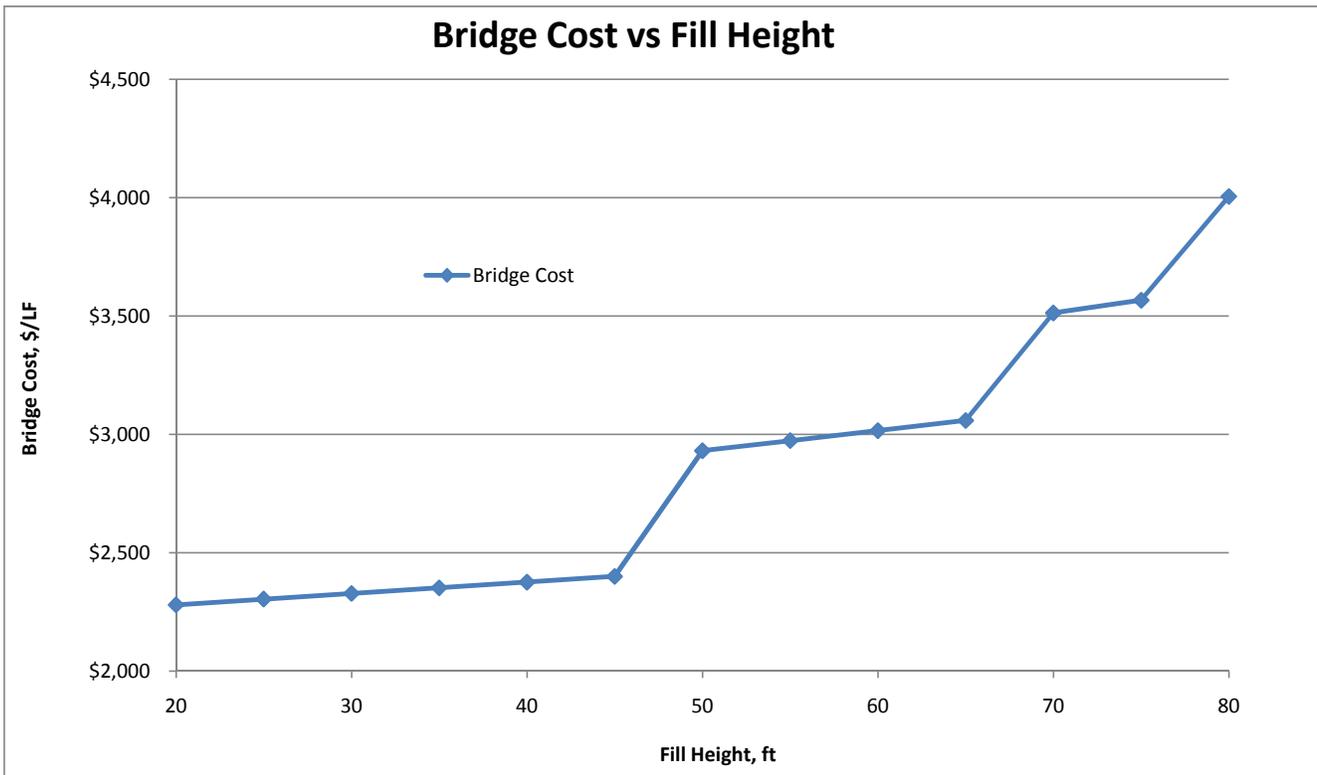
OCTOBER 15, 2009

ESTIMATOR	CHECKED BY	ACCOUNT NO
VBK		NTD06128

Fill Height, ft	Fill Volume, CY/LF	Total Fill \$/LF for \$7/CY Fill	Total Fill \$/LF for \$6/CY Fill	Total Fill \$/LF for \$5/CY Fill	Total Fill \$/LF for \$4/CY Fill	Total Fill \$/LF for \$3/CY Fill	Bridge Cost, \$/LF	% increase / LF of height
20	85.9	\$ 1,006	\$ 890	\$ 774	\$ 658	\$ 542	\$ 2,280	
25	125.9	\$ 1,384	\$ 1,214	\$ 1,044	\$ 874	\$ 704	\$ 2,304	0.21%
30	173.3	\$ 1,832	\$ 1,598	\$ 1,364	\$ 1,130	\$ 896	\$ 2,328	0.21%
35	228.1	\$ 2,350	\$ 2,042	\$ 1,734	\$ 1,426	\$ 1,118	\$ 2,352	0.21%
40	290.4	\$ 2,938	\$ 2,546	\$ 2,154	\$ 1,762	\$ 1,370	\$ 2,376	0.20%
45	360.0	\$ 3,596	\$ 3,110	\$ 2,624	\$ 2,138	\$ 1,652	\$ 2,400	0.20%
50	437.0	\$ 4,324	\$ 3,734	\$ 3,144	\$ 2,554	\$ 1,964	\$ 2,931	4.42%
55	521.5	\$ 5,122	\$ 4,418	\$ 3,714	\$ 3,010	\$ 2,306	\$ 2,974	0.29%
60	613.3	\$ 5,990	\$ 5,162	\$ 4,334	\$ 3,506	\$ 2,678	\$ 3,017	0.29%
65	712.6	\$ 6,928	\$ 5,966	\$ 5,004	\$ 4,042	\$ 3,080	\$ 3,059	0.28%
70	819.3	\$ 7,936	\$ 6,830	\$ 5,724	\$ 4,618	\$ 3,512	\$ 3,514	2.97%
75	933.3	\$ 9,014	\$ 7,754	\$ 6,494	\$ 5,234	\$ 3,974	\$ 3,568	0.31%
80	1054.8	\$ 10,162	\$ 8,738	\$ 7,314	\$ 5,890	\$ 4,466	\$ 4,006	2.46%

AVG = 1.26%

Indicates the approximate break even point between fill option and bridge option.





LOWER BOIS D'ARC RESERVOIR  
 NORTH TEXAS MUNICIPAL WATER DISTRICT  
 PRELIMINARY BRIDGE COST ESTIMATE

OPINION OF PROBABLE CONSTRUCTION COST

SEPTEMBER 28, 2009

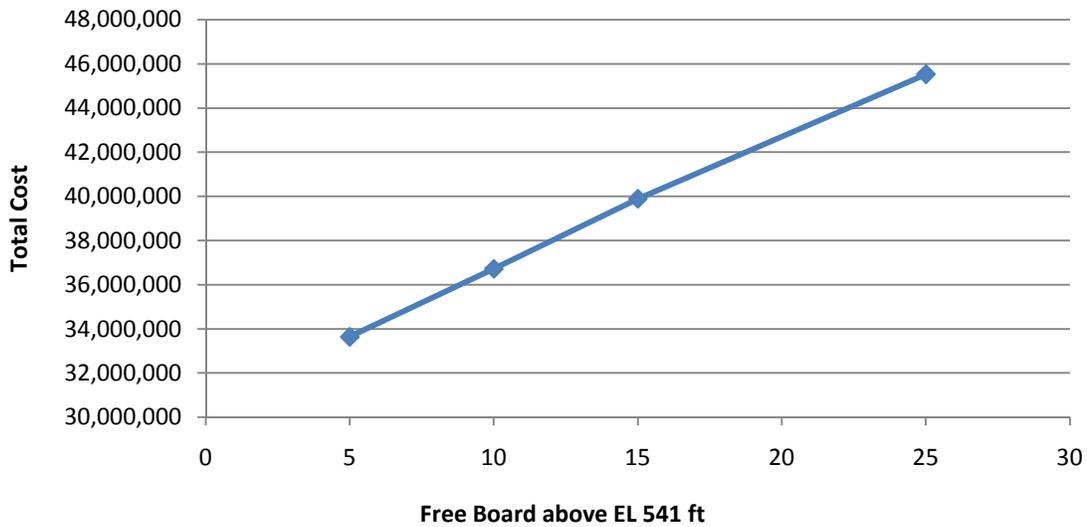
ESTIMATOR VBK	CHECKED BY	ACCOUNT NO NTD06128
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Alignment 2				
Free Board Above EL 541	Bridge Cost	Approaches	Total	% increase / LF of height
5	\$ 31,058,280	\$ 2,586,516	\$ 33,644,796	1.8%
10	\$ 34,244,355	\$ 2,475,311	\$ 36,719,666	1.7%
15	\$ 37,949,310	\$ 1,939,577	\$ 39,888,887	1.4%
25	\$ 43,447,115	\$ 2,078,039	\$ 45,525,154	AVG 1.8%

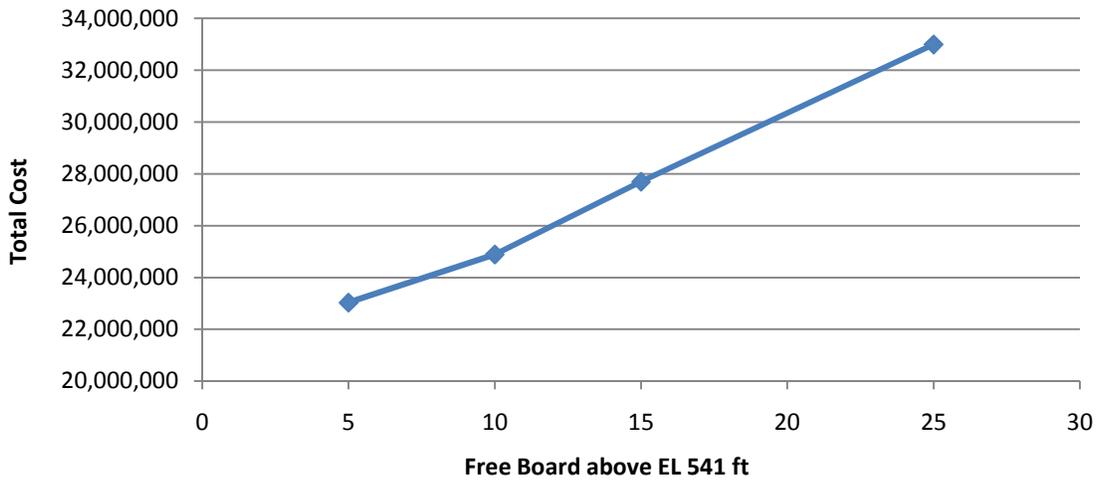
Alignment 3				
Free Board Above EL 541	Bridge Cost	Approaches	Total	% increase / LF of height
5	\$ 17,898,025	\$ 5,136,056	\$ 23,034,081	1.6%
10	\$ 20,392,720	\$ 4,501,907	\$ 24,894,627	2.3%
15	\$ 23,770,155	\$ 3,928,435	\$ 27,698,590	1.9%
25	\$ 30,423,020	\$ 2,570,397	\$ 32,993,417	AVG 2.2%

Alignment 4				
Free Board Above EL 541	Bridge Cost	Approaches	Total	% increase / LF of height
5	\$ 13,208,325	\$ 4,069,116	\$ 17,277,441	2.6%
10	\$ 17,727,940	\$ 1,831,402	\$ 19,559,342	2.5%
15	\$ 20,640,775	\$ 1,395,282	\$ 22,036,057	1.8%
25	\$ 24,621,385	\$ 1,432,202	\$ 26,053,587	AVG 2.5%

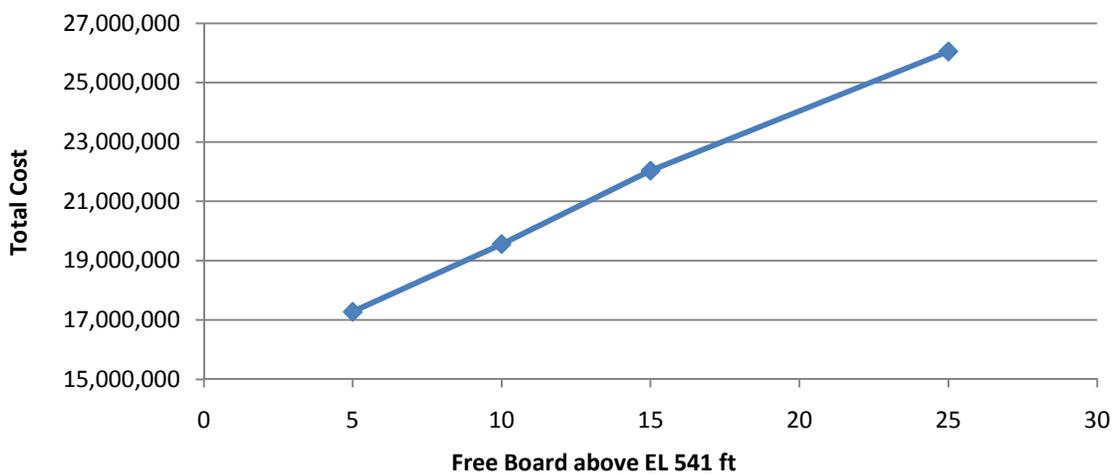
### Alignment Option 2 (Reuse FM1396)



### Alignment Option 3



### Alignment Option 4 (Preferred)





LOWER BOIS D'ARC RESERVOIR  
 NORTH TEXAS MUNICIPAL WATER DISTRICT  
 PRELIMINARY BRIDGE COST ESTIMATE

OPINION OF PROBABLE CONSTRUCTION COST

SEPTEMBER 28, 2009

ESTIMATOR	CHECKED BY	ACCOUNT NO
VBK		NTD06128

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
<b>84" DIA COLUMNS (91FT - 100FT TALL)</b>					
<b>ASSUMPTIONS</b>					
	2300FT BRIDGE				
	36FT BRIDGE DECK WIDTH				
	115FT SPANS				
	19 INTERMEDIATE BENTS, 2 ABUTMENTS				
<b>BRIDGE</b>					
	36' WIDTH BRIDGE DECK	82,800	SF	\$15.00	\$1,242,000
	115' TYPE IV BEAMS, 5/SPAN	11,358	LF	\$130.00	\$1,476,583
	T501 BRIDGE RAILS	4,680	LF	\$50.00	\$234,000
	7.25' x 4' BENT CAPS	734.7	CY	\$750.00	\$551,000
	ABUTMENT CAPS	60.2	CY	\$650.00	\$39,130
	7' DIA. COLUMNS, 3/BENT, AVG 95' TALL. (ADD 4.28 CY/bent FOR 1FT OF H)	7,714.4	CY	\$700.00	\$5,400,059
	7' DIA. DS, 3/BENT, 50' EACH	2,850	LF	\$600.00	\$1,710,000
	3' DIA. DS, 4/ABUT, 50' EACH	400	LF	\$150.00	\$60,000
	1.5' DIA. DS, 2/ABUT, 40' EACH	160	LF	\$80.00	\$12,800
	SEJ-A (4"), 36 LF EVERY OTHER BENT	360	LF	\$100.00	\$36,000.00
SUBTOTAL:					\$10,761,572
CONTINGENCY 25%					\$2,690,400
SUBTOTAL:					\$13,451,980
MOBILIZATION 10%					\$1,345,200
SUBTOTAL:					\$14,797,180

**PROJECT TOTAL \$14,797,200**

**\$178.7/SF**

NOTES:

EXTENSION COST = \$6385/LF \$6434/LF

1. AT EMBANKMENT HEIGHT OF ABOUT 45', BRIDGE COST AND FILL COST IS ABOUT THE SAME, USING \$6/CY AND \$70/SF BRIDGE COST.
2. PVMT COST = \$36/SY, TY C DEN CONT FILL = \$6/CY, AVG EMBANK HT = 25FT 4:1 SLOPE. EMBANK COST = \$900/LF
3. 40FT HT USE 36" DIA, 41-55FT HT USE 48" DIA, 56-65FT HT USE 54" DIA, 66-80FT HT USE 60" DIA, 81-90FT HT USE 72" DIA, 91-100FT USE 84" DIA



LOWER BOIS D'ARC RESERVOIR  
 NORTH TEXAS MUNICIPAL WATER DISTRICT  
 PRELIMINARY BRIDGE COST ESTIMATE

OPINION OF PROBABLE CONSTRUCTION COST

SEPTEMBER 28, 2009

ESTIMATOR	CHECKED BY	ACCOUNT NO
VBK		NTD06128

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
<b>72" DIA COLUMNS (81FT - 90FT TALL)</b>					
<b>ASSUMPTIONS</b>					
	2300FT BRIDGE				
	36FT BRIDGE DECK WIDTH				
	115FT SPANS				
	19 INTERMEDIATE BENTS, 2 ABUTMENTS				
<b>BRIDGE</b>					
	36' WIDTH BRIDGE DECK	82,800	SF	\$15.00	\$1,242,000
	115' TYPE IV BEAMS, 5/SPAN	11,358	LF	\$130.00	\$1,476,583
	T501 BRIDGE RAILS	4,680	LF	\$50.00	\$234,000
	6.25' x 4' BENT CAPS	633.3	CY	\$750.00	\$475,000
	ABUTMENT CAPS	60.2	CY	\$650.00	\$39,130
	6' DIA. COLUMNS, 3/BENT, AVG 85' TALL. (ADD 3.14 CY/bent FOR 1FT OF H)	5,071.1	CY	\$700.00	\$3,549,770
	6' DIA. DS, 3/BENT, 50' EACH	2,850	LF	\$500.00	\$1,425,000
	3' DIA. DS, 4/ABUT, 50' EACH	400	LF	\$150.00	\$60,000
	1.5' DIA. DS, 2/ABUT, 40' EACH	160	LF	\$80.00	\$12,800
	SEJ-A (4"), 36 LF EVERY OTHER BENT	360	LF	\$100.00	\$36,000.00
SUBTOTAL:					\$8,550,283
CONTINGENCY 25%					\$2,137,580
SUBTOTAL:					\$10,687,870
MOBILIZATION 10%					\$1,068,790
SUBTOTAL:					\$11,756,660

**PROJECT TOTAL \$11,756,700**

NOTES:

1. AT EMBANKMENT HEIGHT OF ABOUT 45', BRIDGE COST AND FILL COST IS ABOUT THE SAME, USING \$6/CY AND \$70/SF BRIDGE COST.
2. PVMT COST = \$36/SY, TY C DEN CONT FILL = \$6/CY, AVG EMBANK HT = 25FT 4:1 SLOPE. EMBANK COST = \$900/LF
3. 40FT HT USE 36" DIA, 41-55FT HT USE 48" DIA, 56-65FT HT USE 54" DIA, 66-80FT HT USE 60" DIA, 81-90FT HT USE 72" DIA, 91-100FT USE 84" DIA

EXTENSION COST = \$5063/LF \$5112/LF

**\$142.0/SF**



LOWER BOIS D'ARC RESERVOIR  
 NORTH TEXAS MUNICIPAL WATER DISTRICT  
 PRELIMINARY BRIDGE COST ESTIMATE

OPINION OF PROBABLE CONSTRUCTION COST

SEPTEMBER 28, 2009

ESTIMATOR	CHECKED BY	ACCOUNT NO
VBK		NTD06128

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
<b>60" DIA COLUMNS (66FT - 80FT TALL)</b>					
<b>ASSUMPTIONS</b>					
	2300FT BRIDGE				
	36FT BRIDGE DECK WIDTH				
	115FT SPANS				
	19 INTERMEDIATE BENTS, 2 ABUTMENTS				
<b>BRIDGE</b>					
	36' WIDTH BRIDGE DECK	82,800	SF	\$15.00	\$1,242,000
	115' TYPE IV BEAMS, 5/SPAN	11,358	LF	\$130.00	\$1,476,583
	T501 BRIDGE RAILS	4,680	LF	\$50.00	\$234,000
	5.25' x 4' BENT CAPS	532.0	CY	\$750.00	\$399,000
	ABUTMENT CAPS	60.2	CY	\$650.00	\$39,130
	5' DIA. COLUMNS, 3/BENT, AVG 73' TALL. (ADD 2.18 CY/bent FOR 1FT OF H)	3,024.4	CY	\$700.00	\$2,117,101
	5' DIA. DS, 3/BENT, 50' EACH	2,850	LF	\$400.00	\$1,140,000
	3' DIA. DS, 4/ABUT, 50' EACH	400	LF	\$150.00	\$60,000
	1.5' DIA. DS, 2/ABUT, 40' EACH	160	LF	\$80.00	\$12,800
	SEJ-A (4"), 36 LF EVERY OTHER BENT	360	LF	\$100.00	\$36,000.00
SUBTOTAL:					\$6,756,615
CONTINGENCY 25%					\$1,689,160
SUBTOTAL:					\$8,445,780
MOBILIZATION 10%					\$844,580
SUBTOTAL:					\$9,290,360

**PROJECT TOTAL \$9,290,400**

**\$112.2/SF**

- NOTES:
- EXTENSION COST = \$3991/LF \$4039/LF
- AT EMBANKMENT HEIGHT OF ABOUT 45', BRIDGE COST AND FILL COST IS ABOUT THE SAME, USING \$6/CY AND \$70/SF BRIDGE COST.
  - PVMT COST = \$36/SY, TY C DEN CONT FILL = \$6/CY, AVG EMBANK HT = 25FT 4:1 SLOPE. EMBANK COST = \$900/LF
  - 40FT HT USE 36" DIA, 41-55FT HT USE 48" DIA, 56-65FT HT USE 54" DIA, 66-80FT HT USE 60" DIA, 81-90FT HT USE 72" DIA, 91-100FT USE 84" DIA







LOWER BOIS D'ARC RESERVOIR  
 NORTH TEXAS MUNICIPAL WATER DISTRICT  
 PRELIMINARY BRIDGE COST ESTIMATE

OPINION OF PROBABLE CONSTRUCTION COST

SEPTEMBER 28, 2009

ESTIMATOR	CHECKED BY	ACCOUNT NO
VBK		NTD06128

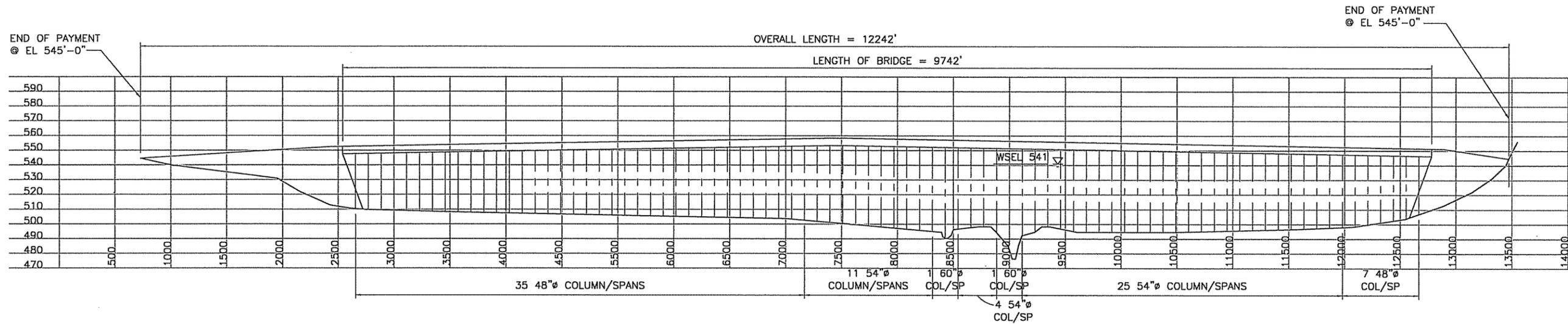
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
<b>36" DIA COLUMNS (UP TO 40FT TALL)</b>					
<b>ASSUMPTIONS</b>					
	2300FT BRIDGE				
	36FT BRIDGE DECK WIDTH				
	115FT SPANS				
	19 INTERMEDIATE BENTS, 2 ABUTMENTS				
<b>BRIDGE</b>					
	36' WIDTH BRIDGE DECK	82,800	SF	\$15.00	\$1,242,000
	115' TYPE IV BEAMS, 5/SPAN	11,358	LF	\$130.00	\$1,476,583
	T501 BRIDGE RAILS	4,600	LF	\$50.00	\$230,000
	3.25' x 3.75' BENT CAPS	308.8	CY	\$750.00	\$231,563
	3' DIA. COLUMNS, 3/BENT, AVG 35' TALL. (ADD 0.79 CY/BENT FOR 1FT OF H)	522.0	CY	\$700.00	\$365,418
	3' DIA. DS, 3/BENT, 4/ABUT, 50' EACH	2,850	LF	\$150.00	\$427,500
	SEJ-A (4"), 36 LF EVERY OTHER BENT	360	LF	\$100.00	\$36,000.00
SUBTOTAL:					\$4,009,063
CONTINGENCY 25%					\$1,002,270
SUBTOTAL:					\$5,011,340
MOBILIZATION 10%					\$501,140
SUBTOTAL:					\$5,512,480

**PROJECT TOTAL \$5,512,500**

NOTES:

1. AT EMBANKMENT HEIGHT OF ABOUT 45', BRIDGE COST AND FILL COST IS ABOUT THE SAME, USING \$6/CY AND \$70/SF BRIDGE COST.
2. PVMT COST = \$36/SY, TY C DEN CONT FILL = \$6/CY, AVG EMBANK HT = 25FT 4:1 SLOPE. EMBANK COST = \$900/LF
3. 40FT HT USE 36" DIA, 41-55FT HT USE 48" DIA, 56-65FT HT USE 54" DIA, 66-80FT HT USE 60" DIA, 81-90FT HT USE 72" DIA, 91-100FT USE 84" DIA

**\$2397/LF**  
**\$66.6/SF**



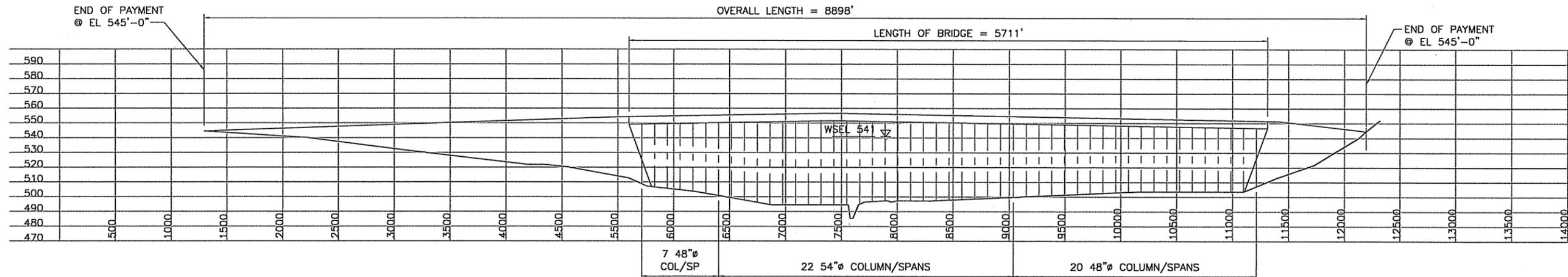
APPROACHES COST =  $(165988CY + 93335CY) \times \$6 \times 1.35 + (2500FT \times 36FT) \times \$4 \times 1.35 = \$2,586,516$

BRIDGE COST =  $(35+7) \times 115' \times 2945 + (11+4+25) \times 115' \times 3460 + (1+1) \times 115' \times 3991 = 31,058,280$

EXTENSION COST =  $\$2397 - \$900 = \$1497/LF$

TOTAL COST =  $\$33,644,796$  OR  $\$2748/LF$

- 36" COLUMN SPANS = \$2597/LF
- 48" COLUMN SPANS = \$2945/LF
- 54" COLUMN SPANS = \$3460/LF
- 60" COLUMN SPANS = \$3991/LF
- 72" COLUMN SPANS = \$5063/LF
- 84" COLUMN SPANS = \$6385/LF

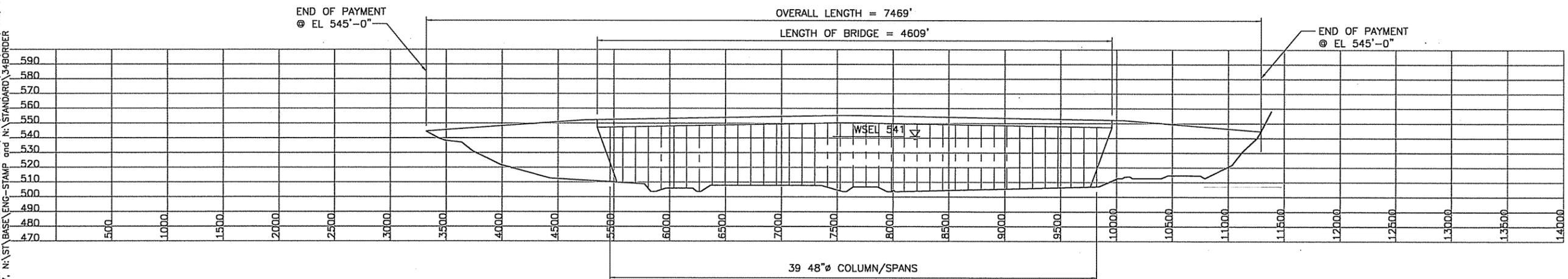


APPROACHES COST =  $(439952CY + 117641CY) \times \$6 \times 1.35 + (3187FT \times 36FT) \times \$4 \times 1.35 = \$5,136,056$

BRIDGE COST =  $(7+20) \times 115' \times 2945 + (22) \times 115' \times 3460 = 17,898,025$

EXTENSION COST =  $\$2397 - \$900 = \$1497/LF$

TOTAL COST =  $\$23,034,081$  OR  $\$2589/LF$



APPROACHES COST =  $(173900CY + 259820CY) \times \$6 \times 1.35 + (2860FT \times 36FT) \times \$4 \times 1.35 = \$4,069,116$

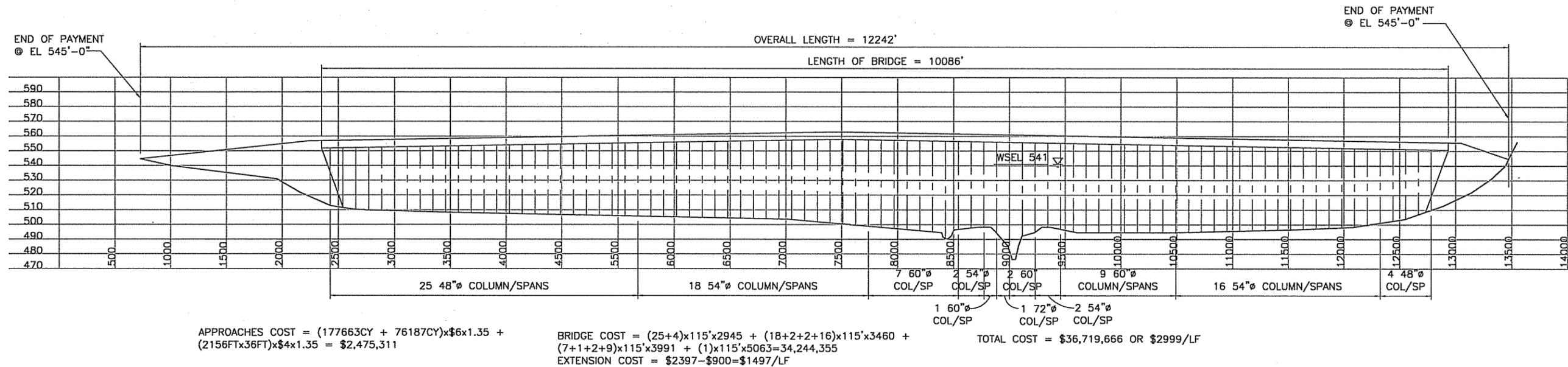
BRIDGE COST =  $(39) \times 115' \times 2945 = 13,208,325$

EXTENSION COST =  $\$2397 - \$900 = \$1497/LF$

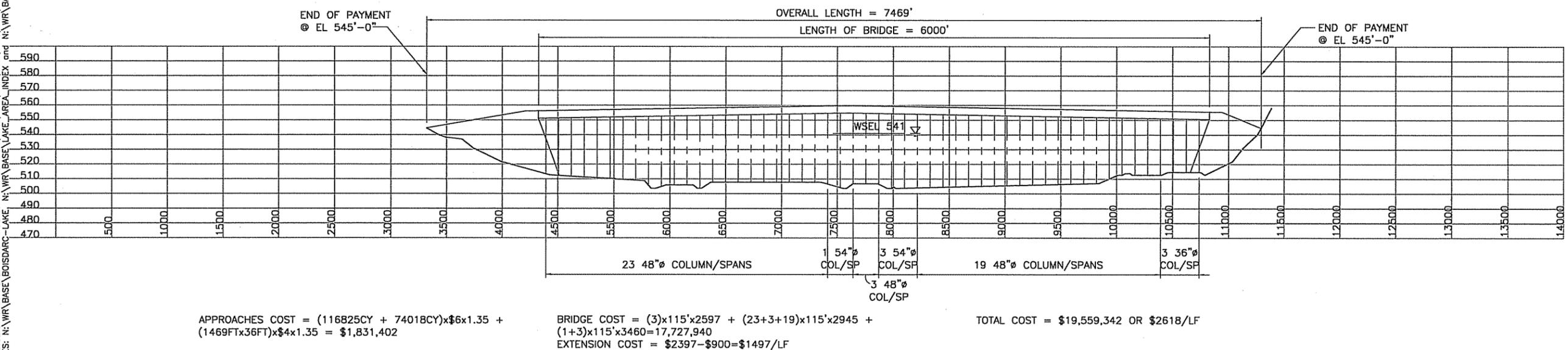
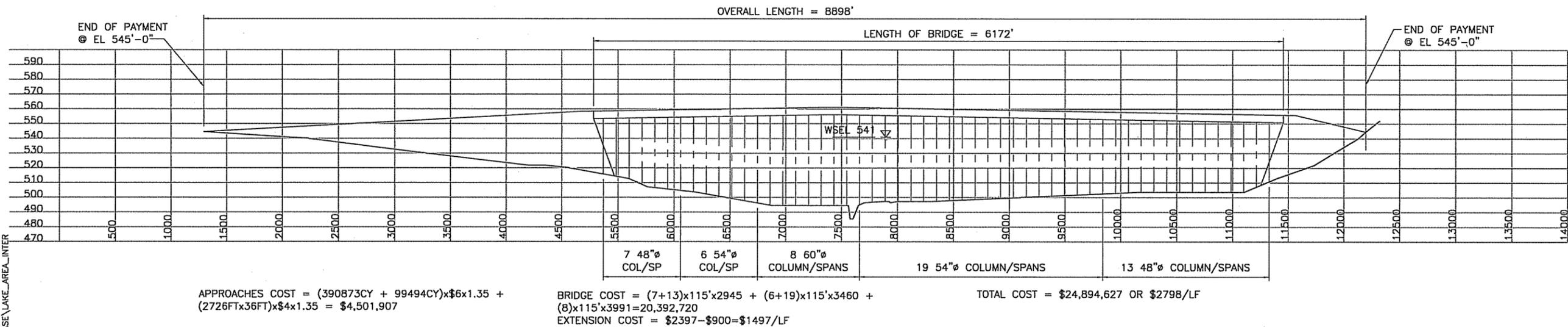
TOTAL COST =  $\$17,277,441$  OR  $\$2313/LF$

5 FT FREE BOARD FROM WSEL 541

User: JAW  
 ACAD Rel 17.0s (LMS Tech)  
 [INTD05387] [FWCAD1] [Z:\TEMPLATES\ACAD2005] [ST-FN-22X34.DWG] LAYOUT: Layout1  
 JUN 30, 2006 2:06:16 P.M. LTS: 1.00 PSLTS: 1 TWIST: 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0  
 4 REFERENCE FILES: 90179, 94677, N:\ST\BASE\ENG-STAMP and N:\STANDARD\34BORDER

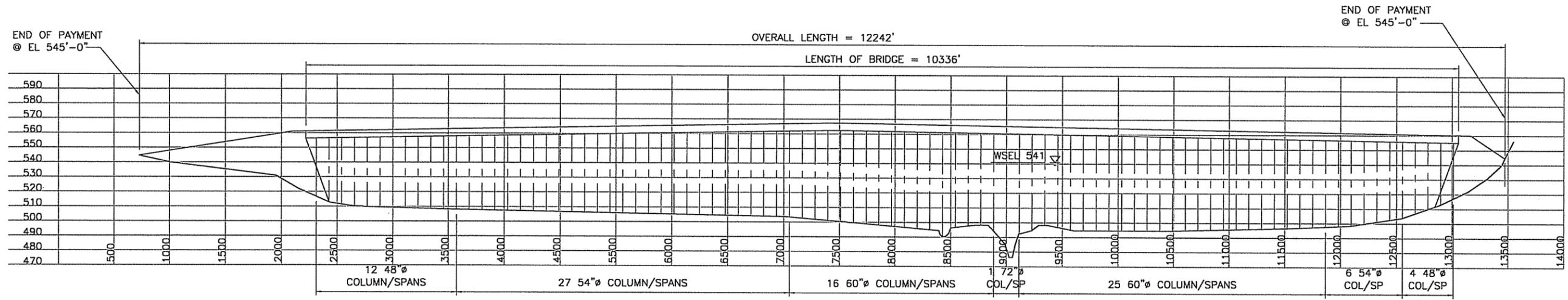


- 36" COLUMN SPANS = \$2597/LF
- 48" COLUMN SPANS = \$2945/LF
- 54" COLUMN SPANS = \$3460/LF
- 60" COLUMN SPANS = \$3991/LF
- 72" COLUMN SPANS = \$5063/LF
- 84" COLUMN SPANS = \$6385/LF



10 FT FREE BOARD FROM WSEL 541

User: KAC  
 ACAD Rel 17.2s (LMS Tech)  
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 OCT 02, 2009 9:02:37 A.M. LTS: 1.00  
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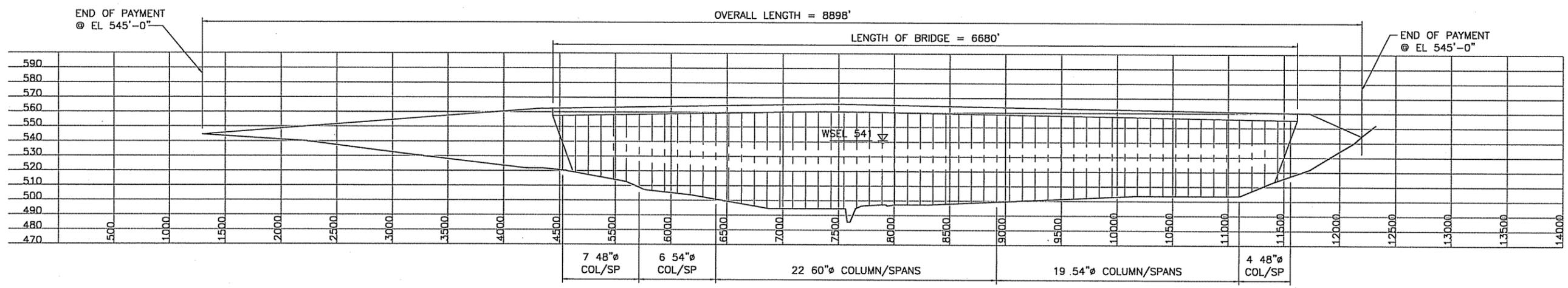
- 36" COLUMN SPANS = \$2597/LF
- 48" COLUMN SPANS = \$2945/LF
- 54" COLUMN SPANS = \$3460/LF
- 60" COLUMN SPANS = \$3991/LF
- 72" COLUMN SPANS = \$5063/LF
- 84" COLUMN SPANS = \$6385/LF

APPROACHES COST =  $(128133CY + 65577CY) \times \$6 \times 1.35 + (1906FT \times 36FT) \times \$4 \times 1.35 = \$1,939,577$

BRIDGE COST =  $(12+4) \times 115' \times 2945 + (27+6) \times 115' \times 3460 + (16+25) \times 115' \times 3991 + (1) \times 115' \times 5063 = 37,949,310$

EXTENSION COST =  $\$2397 - \$900 = \$1497/LF$

TOTAL COST = \$39,888,887 OR \$3258/LF

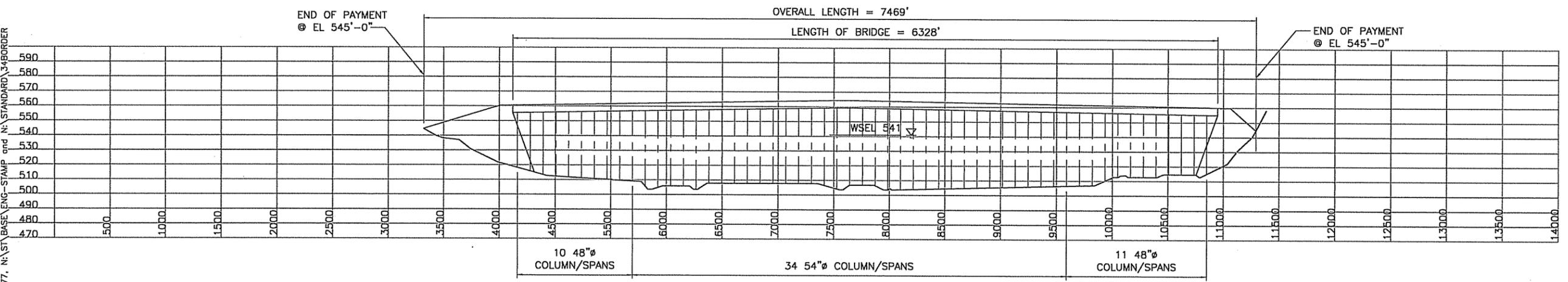


APPROACHES COST =  $(352271CY + 79489CY) \times \$6 \times 1.35 + (2218FT \times 36FT) \times \$4 \times 1.35 = \$3,928,435$

BRIDGE COST =  $(7+4) \times 115' \times 2945 + (6+19) \times 115' \times 3460 + (22) \times 115' \times 3991 = 23,770,155$

EXTENSION COST =  $\$2397 - \$900 = \$1497/LF$

TOTAL COST = \$27,698,590 OR \$3113/LF



APPROACHES COST =  $(93686CY + 51187CY) \times \$6 \times 1.35 + (1141FT \times 36FT) \times \$4 \times 1.35 = \$1,395,282$

BRIDGE COST =  $(10+11) \times 115' \times 2945 + (34) \times 115' \times 3460 = 20,640,775$

EXTENSION COST =  $\$2397 - \$900 = \$1497/LF$

TOTAL COST = \$22,036,056 OR \$2950/LF

15 FT FREE BOARD FROM WSEL 541

User: JAW  
 ACAD Rel 17.0s (LMS Tech)  
 [INTD05367] [FWCAD] [JZ:TEMPLATES\ACAD2005\ST-FN-22X34.DWG LAYOUT: Layout1  
 JUN 30, 2006 2:06:16 P.M. LTS: 1.00 PLOTS: 1 TWIST: 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0  
 4 REFERENCE FILES: 90179, 94677, N:\ST\BASE\ENG-STAMP and N:\STANDARD\4-BORDER



APPENDIX B

Meeting Minutes

**PROJECT:** Lower Bois d’Arc Creek Reservoir  
**NAME OF MEETING:** FM1396 Discussion  
**RECORDED BY:** Kevin Johnson - FNI  
**DATE:** 12/29/09  
**LOCATION:** Fannin County – South Annex Building  
**ATTENDEES:** **TxDOT** – Bobby Littlefield, David Sellman, Kevin Harris, Noel Paramanatham  
**Fannin County** – Commissioner Hilliard, Commissioner Strickland  
**NTMWD** – Mike Rickman, Robert McCarthy  
**Freese and Nichols, Inc.** – Kevin Johnson

*The following reflects our understanding of the items discussed during the subject meeting. If you do not notify us within five working days, we will assume that you are in agreement with our understanding.*

## DISCUSSION ITEMS

1. Discussed two alternative routes for FM 1396. County and TxDOT discussed the pro’s and con’s to each alternative.
  - a. County & TxDOT agreed to pursue the “Lannius” route. This was the westernmost route shown on the map. This will connect to FM 897 in Lannius and extend North to FM1396
  - b. County & TxDOT agreed to switch maintenance of the existing FM1396 and the proposed route. County will maintain the two remaining segments of existing FM1396:
    - i. From the intersection of FM1396 & FM 2029 to the lake.
    - ii. From the creek crossing on FM1396 (near CR 2745, crossing #12 on map) to the lake.
  - c. TxDOT will maintain the new road
  - d. TxDOT requested the lengths of the existing FM1396 and the proposed route. The old Route was 25,550’ and new route is 29,300’. These are shown on the attached map.
2. We briefly discussed the schedule and plan moving forward. It was decided the next step would be to sit down and put everything on paper with regards to the plan. This would include pavement section, ROW, alignment, design standards, etc. This can be summarized in a Design Summary Report (DSR). A public meeting will also be required for the new route.
3. Discussed the 100 year flood elevation at the US 82 bridge over Bois d’Arc Creek. We received the original as-built plans from TxDOT and will get back with TxDOT on our thoughts on the differences in the floodplain elevations. The TxDOT design utilized a flood elevation of 537 and the recent flood study performed by FNI for the reservoir established an elevation of 541.

## ACTION ITEMS

ACTION ITEMS			
WHAT	WHO	WHEN	STATUS
1. Modify maps to show agreed route and lengths	Kevin Johnson	1/6/10	
2. Add Commissioner boundaries to map	Kevin Johnson	1/6/10	
3. Create another map with aerial photo	Kevin Johnson	1/6/10	
4. Coordinate Meeting at TxDOT Paris office for DSR	Kevin Johnson	1/22/10	

**PROJECT:** Lower Bois d’Arc Creek Reservoir  
**NAME OF MEETING:** FM 1396 & FM 897 Discussion  
**RECORDED BY:** Kevin Johnson - FNI  
**DATE:** 2/5/10  
**LOCATION:** TxDOT – Bonham Office  
**ATTENDEES:** **TxDOT** – Bobby Littlefield, David Sellman, Kevin Harris, Noel Paramanatham  
**Fannin County** – Commissioner Hilliard, Commissioner Strickland  
**NTMWD** –Robert McCarthy  
**Freese and Nichols, Inc.** – Kevin Johnson

*The following reflects our understanding of the items discussed during the subject meeting. If you do not notify us within five working days, we will assume that you are in agreement with our understanding.*

## DISCUSSION ITEMS

1. Discussed the proposed alternative route for FM 1396, it will be FM 897 from Lannius on the south to FM1396 on the north.
  - a. County will maintain the two remaining segments of existing FM1396:
    - i. From the intersection of FM1396 & FM 2029 to the lake.
    - ii. From the creek crossing on FM1396 (near CR 2745, crossing #12 on map) to the lake.
  - b. TxDOT will maintain FM 897 from Lannius to FM 1396. The amount of roadway removed from the state system will be 25,550’ and new route will be 29,300’. These are shown on the attached map.
2. TxDOT requested FM 897 be 44’ wide (2-12’ lanes & 2-10’ shoulders). Designed to Farm to Market road TxDOT standards. 120’ – 150’ ROW, 70 mph design speed, etc.
3. Discussed the NEPA process and TxDOT’s desire to follow. Kevin Johnson asked about building road as County/NTMWD Project to TxDOT standards and conveying to TxDOT after construction is completed. Design & construction would follow all state, federal and local requirements and TxDOT would be involved throughout design. Noel stated TxDOT would discuss and find examples of other projects where this has been done before.
4. TxDOT requested the pavement be replaced on two existing sections of their system:
  - a. Existing FM 1396 from Allens Chapel, north to crossing #12 (where County will take over)
  - b. Existing FM 897 through Lannius. TxDOT would like to have 28’ of new pavement vs. the existing 20’
5. Discussed the bridges over Onslott Creek, Ward Creek and Honey Grove Creek. TxDOT has it on the schedule to reconstruct these bridges in the next few years.
  - a. To meet County’s desire of maintaining a passable bridge at 100 yr storm event, the pavement will need to be at 541 per 100 yr elevation of lake.

- b. Based on discussion, TxDOT design would likely be low chord of bridge about 536, with bridge section depth, TxDOT's original design may be close to County's preference.
  - c. NTMWD is interested in partnering with TxDOT in design and construction to raise bridge to the desired pavement elevation of 541, based on 100 yr water surface elevation of lake. TxDOT to look at additional cost of this and submit to NTMWD for consideration (contingent upon TCEQ reservoir permit and NTMWD Board Approval). TxDOT requested a letter stating NTMWD's desired elevation of the bridge's.
  - d. This would include the approaches on each side to elevate roadway above 541.
6. Discussed the 100 year flood elevation at the US 82 bridge over Bois d'Arc Creek. The TxDOT design utilized a flood elevation of 537 and the recent flood study performed by FNI for the reservoir established an elevation of 541. No benchmarks could be located on the as-built drawings. FNI to see if we have survey points of top of existing bridge to compare to TxDOT's original design drawings.
  7. Noel stated we need to begin completing the Design Summary Report (DSR) to agree on roadway design geometrics and process. Next meeting would be in TxDOT Paris Office. Meeting date will be mid March, Noel to send some possible meeting dates that works for TxDOT.

### ACTION ITEMS

ACTION ITEMS			
WHAT	WHO	WHEN	STATUS
1. TxDOT to discuss if road can follow County process per TxDOT design requirements and be conveyed to TxDOT	Noel Paramanatham	2/19/10	
2. Send Noel the GIS files of the map	Kevin Johnson	2/19/10	
3. NTMWD to send TxDOT letter on bridge elevation	Robert McCarthy	2/26/10	
4. Compare Lake survey shots at bridge to TxDOT drawings	Kevin Johnson	2/19/10	
5. Begin DSR	Kevin Johnson	3/5/10	
6. Next meeting, Noel to determine possible meeting dates and distribute	Noel Paramanatham	Mid March	

## APPENDIX C

Draft Design Summary Report (DSR)

<b>Programming Information</b>			
County (s):	<b>Fannin</b>		
Highway (s):	<b>Proposed FM 897</b>		
C-S-J (s):	<b>1175-01-900</b>		
Limits:	From:	<b>US 82</b>	Length:6.31
	To:	<b>FM 1396</b>	
Work Description:	<b>Construct New Location 2 Lane Highway with Shoulders</b>		
Letting Date:	<b>TBD – Projected 2018</b>		
Program Category:	Current:	<b>Local Funds</b>	Expected:
Auth. Funding:	Current:	<b>Local Funds</b>	Required:
Responsible Office Design:	<b>NTMWD</b>	Responsible Office Construction:	<b>NTMWD</b>

<b>Consultants</b>			
<b>Type</b>	<b>Consultant Firm</b>	<b>Oversight</b>	<b>Notes</b>
Land Surveying:			
Aerial Surveying:			
Foundation Exploration:			
Subsurface Utilities:			
Advanced Planning:			
Design:			

<b>Agreements, Permits &amp; Warrants</b>			
<b>Type</b>	<b>With Whom?</b>	<b>Responsible Office</b>	<b>Notes</b>
Advanced Funding			
Right of Way			<b>Coordinate with Tommy Doss (903-510-9140)</b>
Utility Adjustments			<b>TBD</b>
Railroad / Airport			
Illum. Warrants			<b>TBD</b>
Signal Warrants			

<b>Advanced Planning Elements</b>			
<b>Element</b>	<b>Date due to TP&amp;D</b>	<b>Responsible Office</b>	<b>Notes</b>
Schematic		<b>NTMWD</b>	<b>Required</b>
Public Involvement		<b>NTMWD</b>	<b>Required</b>
ROW Map		<b>NTMWD</b>	<b>Required</b>
ROW Plats & Deeds		<b>NTMWD</b>	<b>Required</b>
Utility Adjustments		<b>NTMWD</b>	<b>TBD</b>

<b>Existing Facility</b>			
<b>Element</b>	<b>Number / Slope</b>	<b>Width</b>	<b>Type</b>
Travel Lanes:	<b>2 Lane</b>	<b>12'</b>	<b>Asphalt Surface</b>
Shoulders:	<b>N/A</b>		
Median:			
Front Slopes:	<b>Variable</b>		<b>3:1 Max</b>
Back Slopes:	<b>Variable</b>		<b>3:1 Max</b>
Clear Zone:	<b>16'</b>		
Sidewalks:	<b>N/A</b>		

<b>This proposed project will address the following items of work</b>		
<b>Item</b>		<b>Notes</b>
Travel Lanes	<b>Yes</b>	
Shoulders	<b>Yes</b>	
Median	<b>N/A</b>	
Ditches / Storm Sewers	<b>Yes</b>	
Cross Drainage Culverts	<b>Yes</b>	
Sidewalks	<b>N/A</b>	
ADA Ramps	<b>N/A</b>	
Signals / Illumination	<b>Yes</b>	If meets warrants
Signs / Pvmnt Markings	<b>Yes</b>	
Driveways	<b>Yes</b>	
Driveway Culverts / SETs	<b>Yes</b>	
Mailboxes	<b>Yes</b>	

<b>Proposed Pavement Design Elements</b>			
<b>Element</b>		<b>Element</b>	
Pavement Design Office:	<b>NTMWD</b>	Traffic Data Request Submitted?	<b>No</b>
Current ADT:	<b>460</b>	Functional Classification (#):	<b>Collector</b>
Projected ADT:	<b>500</b>	Urban or Rural?	<b>Rural</b>
% Trucks in ADT:			
Proposed Material Layers:	TBD		
Proposed Riding Surface:	TBD		
Proposed Base:	TBD		
Proposed Base:	TBD		
Proposed Subgrade Treatment:	TBD		
Has existing been cored?	<b>No</b>	Date due to Pavement Engineer:	<b>TBD</b>

Proposed Design Elements		
Element		Notes
<b>Design Standard:</b>	<b>Part IV</b>	
<b>Highway Type:</b>	<b>FM</b>	
<b>Terrain:</b>	<b>Rolling</b>	
<b>Design Speed:</b>	<b>70 mph</b>	
<b>Travel Lanes</b>		
Number:	<b>2</b>	
Width(s):	<b>12'</b>	
Cross Slope:	<b>2.5%</b>	
<b>Shoulders</b>		
Number:	<b>2</b>	
Width(s):	<b>10'</b>	
Cross Slope:	<b>2.5%</b>	
<b>Median</b>		
Type:	<b>N/A</b>	
Width:		
Opening Distance (min):		
Opening Distance (max):		
<b>Slopes</b>		
Front Slope Typical:	<b>6:1</b>	
Front Slope Maximum:	<b>3:1</b>	
Back Slope Typical:	<b>4:1</b>	
Back Slope Maximum:	<b>3:1</b>	
Ditch Bottom Width:	<b>5'</b>	TBD during design phase
<b>Clear Zone Width:</b>	<b>16'</b>	To be verified based on ADT & func. class
<b>Borders</b>		
Border Width:	<b>10'</b>	10' past back slope catch point
Sidewalk Width(s):	<b>N/A</b>	
<b>Geometry</b>		
Horizontal Curve (min):	<b>2050</b>	<b>3405' preferred</b>
Superelevation (max):	<b>6.0%</b>	
k-min (sag):	<b>181</b>	
k-min (crest):	<b>247</b>	
Maximum Grade:	<b>8%</b>	
Minimum Grade:	<b>0.5%</b>	

<b>Structure(s)</b>		
<b>Item</b>		<b>Notes</b>
<b>Cross Culverts</b>		
Design Frequency:	<b>25</b>	
<b>Bridge Structures</b>		
Feature Crossed:	<b>Future Lower Bois d' Arc Reservoir</b>	
Design Frequency:	<b>50</b>	TBD by recreational use
Foundation Type:	<b>TBD</b>	
Sub Structure Type:	<b>TBD</b>	
Super Structure Type:	<b>TBD</b>	
Rail Type:	<b>TBD</b>	
Retaining Walls Type:	<b>TBD</b>	
Prop. Vertical Clearance:	<b>TBD</b>	
Prop. Horizontal Clear:	<b>TBD</b>	
<b>Bridge Approaches</b>		
Approaches exceed 25%?	<b>N/A</b>	
Source of add'l funds	<b>Local</b>	
<b>FEMA</b>		
In FEMA Floodplain?	<b>Yes</b>	
Responsible Office:	<b>NTMWD</b>	

<b>Environmental</b>			
<b>Element</b>	<b>Issue ?</b>	<b>Responsible Office</b>	<b>Notes</b>
Type of Document			
NOI Required?	<b>Yes</b>	<b>NTMWD</b>	<b>To be combined with lake documentation</b>
Permit(s) Required?	<b>YES</b>		
Proposed BMP:	<b>TBD during design phase</b>		
Archeological / Historic?	<b>Yes</b>		
HAZMAT Issues?	<b>Unknown</b>		

<b>This project will require the following</b>		
<b>Item</b>		<b>Reason (s)</b>
<b>Design Exception</b>	<b>TBD</b>	Possible at south end of FM 897
Responsible Office	<b>NTMWD</b>	

<b>Design Waiver</b>	<b>TBD</b>	
Responsible Office		

<b>Additional Notes</b>	
<b>1. Schematic layout required</b>	
<b>2. Pavement design report required</b>	
<b>3. Environmental document as part of overall project or stand alone will be required</b>	
<b>4. ROW transfer documentation requirements TBD later</b>	
<b>5. This project will include rehab. of existing FM 897 and FM 1396 from Allens Chapel to the point of future county maintenance</b>	
<b>6. NTMWD to issue utility permits and driveways on proposed FM 897 according to Txdot guidelines. Use TxDOT forms.</b>	

<b>Concurrence</b>			
<b>Duty Position</b>	<b>Name</b>	<b>Signature</b>	<b>Date</b>
Design Engineer	Kevin Johnson		
Designer			
Construct Area Engineer	David Selman		
Director of Construction	Kevin Harris		
Pavement Engineer	Wade Blackmon (interim)		
Director of Operations	Mykol Woodruff		
District Traffic Engineer	Darius Samuels		
Director of TP&D	Ricky Mackey		
Environment Coordinator	Mike Williams		
Right of Way	Keith Hollje		
District Plan Reviewer	Nancy Russell		

<b>Authorization</b>			
District Engineer	Bobby G. Littlefield, Jr., P.E.		

## APPENDIX D

### Geotechnical Data for Bridge

**TO:** File NTD06128 - 2.12

**FROM:** Russell G. Springer, E.I.T.

**SUBJECT:** Lower Bois D'Arc Reservoir: FM 1396 Relocation Geotechnical Investigation

**DATE:** July 12, 2010

This memo summarizes the results of the geotechnical investigation for the relocation of FM 1396 as part of the Lower Bois D'Arc Reservoir project. This work was provided as part of FNI project number NTD06128, authorized by the contract with North Texas Municipal Water District (NTMWD), dated February 16, 2006.

## PROJECT DESCRIPTION

NTMWD plans to develop a water supply reservoir on Lower Bois D'Arc Creek. The reservoir, Lower Bois D'Arc Reservoir, will be created by an earthen dam located in Fannin County about 14 miles northeast of Bonham, Texas. The reservoir will have a surface area of about 16,500 acres and a storage capacity of about 367,600 acre-feet with a normal pool level at elevation 534 feet msl.

Part of the reservoir development will include the relocation of FM 1396 about 5 miles to the west of the existing road. In addition to the paved roadway, the relocated FM 1396 will include a bridge crossing over the proposed reservoir.

The purpose of this investigation was to provide information for cost estimating purposes and provide soil information for the project.

## SUBSURFACE INVESTIGATION

The four borings (B-1 through B-4) were staked in the field and drilled on May 27 through June 1, 2010. The approximate boring locations were determined in the field using aerial photographs and were offset from proposed locations for drill rig accessibility. The actual boring locations were surveyed using a handheld GPS with sub-meter accuracy and are shown on the attached boring location plan.

GM Enterprises drilled the borings using a truck-mounted CME-55 drilling rig. Boring B-1 was drilled using 6-inch solid-stem augers and sampled using 3-inch I.D. thin-walled tubes. Borings B-2 through B-4 were drilled using 6.25-inch hollow stem augers and were sampled using a 3-inch I.D. by 5-foot long

thin-walled continuous sampling barrel. The borings were logged by Mr. Russell G. Springer, E.I.T. and Mrs. Stephanie Coffman of Freese and Nichols, Inc.

The bedrock was evaluated in the borings using the Texas Highway Department cone penetrometer test (TCP) in which a 3-inch diameter cone is driven using a 140-pound automatic hammer falling 30 inches.

The borings were backfilled with cuttings and topped off with a one-foot concrete plug.

Hand-held penetrometer tests were run in the field on cohesive samples, and the results are shown on the boring logs.

The borings were observed for indications of subsurface water entry during drilling and checked for accumulated water after completion of drilling. Groundwater was encountered in all the borings with the exception of Boring B-4.

The borings were logged in the field from inspection of the samples and later edited based on the laboratory test results. The borings logs are attached to this memo.

## **LABORATORY INVESTIGATION**

Laboratory tests were run on selected samples of soil obtained in the field investigation to help classify the materials and evaluate pertinent engineering properties for use in our analyses. Classification and index property tests included water content, dry unit weight, percent passing the No. 200 sieve, and liquid and plastic limits.

All laboratory tests were run by Mas-Tek Engineering and Associates, Inc. in their Dallas, Texas laboratory. The test results are attached this memo. The test results are also shown on the boring logs.

## **SUBSURFACE CONDITIONS**

### **Geology**

The Sherman Sheet of the Geological Atlas of Texas indicates that the borings are underlain by Quaternary alluvial deposits of Recent age, Blossom Sand, and Bonham Marl. The alluvial deposits are described as *"Flood-plain deposits. Along Red River, drainage system includes low terrace deposits; top surface 8±3 feet above the flood-plain surface."*

The alluvial deposits are underlain by the Blossom Sand and Bonham Marl of Upper Cretaceous Age. The Blossom Sand is described as *“quartz sand grading westward into clay. Sand, very fine grained to fine grained, calcareous, glauconitic, ferruginous, calcareous concretions and septaria, thin clay interbeds, brown; weathers brown and red. Clay, silty, calcareous, interbeds of silt, poorly bedded to massive, medium yellowish gray; weathers light yellowish gray; marine megafossils scarce. Thickness 20 feet, feathers out westward in Fannin County.”*

The Bonham Marl is described as *“marl and clay, silty, progressively more calcareous westward, variable amount of glauconite, most abundant near middle, poorly to thinly bedded, medium to light gray; weathers light gray to yellowish gray with poor fissility; marine megafossils; thickness 400± feet.”*

The USDA Soils Survey of Fannin County identifies the soils encountered at Borings B-1 and B-2 as the Tinn clay. The Tinn clay is generally described as very deep, nearly level, moderately well drained, clayey alluvium of Holocene age, located on broad flood plains along streams.

The survey further identifies the soils encountered at borings B-3 and B-4 as the Dela Loam and Derly Silt Loam, respectively. The Dela Loam soils are generally described as very deep, nearly level, moderately well drained, loamy and/or sandy alluvium of Quaternary age, located on flood plains along creeks and drainageways. The Derly Silt Loam soils are generally described as very deep, nearly level, poorly drained, clayey alluvium of Quaternary age, located on the second terrace level of the Red River.

## **Soils**

The borings typically encountered native moderately plastic to highly plastic clay soils at the ground surface or beneath the road base. The clay soils contained varying amounts of sand. The surface soils encountered in Boring B-3 were slightly less plastic with more sand, increasing in plasticity at about 10 feet below the ground surface (bgs). The subsurface soils in Boring B-4 at about 21 feet bgs also indicated a significant decrease in plasticity from the overburden soils. Possible slickensided surfaces with gray staining and ferruginous staining were observed in boring B-2 at depths ranging from about 20 to 26.3 feet bgs.

At depths ranging from about 13 to 30 feet bgs, the borings indicated an increase in sand content with the clay soils transitioning into sandy clay, clayey sand, and silty sand. Boring B-3 terminated in clayey sand at a depth of about 20 feet bgs. The remaining borings encountered weathered and unweathered shale bedrock at depths ranging from about 34 to 39.3 feet bgs.

Moisture contents for the clay soils ranged from 9 to 25 percent with the lower moisture contents obtained in the subsurface clays of lower plasticity and the higher moisture contents obtained in the high plastic clays and soils nearer to the ground surface. Liquid limits for the clayey materials ranged from 30 to 84 and plasticity indices ranged from 16 to 65.



The weathered shale was encountered in Boring B-4 at a depth of about 39.3 feet bgs and was underlain by unweathered shale at a depth of about 41 feet bgs. The weathered shale contained sand and was brown and gray, calcareous, and fossiliferous. Texas Cone Penetrometer testing performed in the weathered shale indicated a penetration of 12 inches for 83 blows.

The unweathered shale encountered in the borings typically contained sand, was brown and gray to dark gray, calcareous, and fossiliferous. Texas Cone Penetrometer testing performed in the unweathered shale indicated penetrations ranging from 2 to 7 inches for 100 blows. Possible slickensides surfaces were observed in the unweathered shale in Boring B-2 at depths ranging from about 36 to 42 feet bgs. Additionally, a thin bentonite seam was observed at about 36.7 feet bgs in boring B-2.

Groundwater was observed in all borings with the exception of Boring B-4. Groundwater observations are summarized in Table 1 below.

**Table 1**  
**Groundwater Level Readings**

	WLS At Time of Drilling (ATD), feet bgs	WLS After Drilling (AD), feet bgs	WLS After Drilling (AD), feet bgs
B-1	29	6.3 at 0 hrs.	5.0 at 22 hrs.
B-2	28	8.0 at 0 hrs.	--
B-3	14	8.6 at 0 hrs.	--
B-4	Dry	Dry at 0 hrs.	--

WLS = Water Level Surface

bgs = below ground surface

ATD = At Time of Drilling

AD = After Drilling

Please contact me if you have any questions regarding the information in this memo.



FNI Job Number  
NTD06128

NORTH TEXAS MUNICIPAL WATER DISTRICT  
LOWER BOIS D'ARC RESERVOIR



4055 International Plaza  
Suite 200  
Fort Worth, Texas 76109-4895  
Phone – (817) 735-7300  
Fax – (817) 735-7491

FIGURE  
NO.

Date  
July 2010

FM 1396 RELOCATION  
BORING LOCATION PLAN

1

## BORING LOG LEGEND AND NOMENCLATURE

Items shown on boring logs refer to the following:

1. Depth - Depth below ground surface in feet
  2. Sample - Types designated by letter:
    - S - Split barrel sample, obtained by driving a 2-inch split-barrel sampler unless otherwise noted.
    - U - Undisturbed sample, obtained using a 3-inch-diameter thin-walled tube and open sampling head.
    - NX - Core sample, obtained using an NX-sized core barrel with carbide bit.
- Recovery - Sample or Core recovery is the length recovered divided by the total length cored, pushed, or driven, expressed as a percentage.

Resistance - For split-barrel sampling, resistance is designated as follows:

- 3- Numbers indicate blows per 6 inches of penetration of split spoon sampler driven by a 140-pound hammer falling 30 inches. The Standard Penetration Resistance is the number of blows for the last 12 inches of penetration of the split spoon sampler.
- 50/4" - Number of blows to drive sampler distance shown.

PP- Pocket penetrometer reading in tons per square foot.

RQD- Rock Quality Designation, calculated as the total length of unfractured pieces more than 4 inches long divided by the total length cored, expressed as a percentage.

TCP- Texas Cone Penetration or equivalent variation, resistance blow counts per 6 inches of penetration or penetration distance resulting from 50 blows, whichever occurs first, obtained from driving a 3-inch diameter cone with a 2.5-inch long point using a 170-pound hammer falling 24 inches.

3. Description - Description of material according to the Unified Soil Classification: word description giving soil constituents, consistency or density, and other appropriate classification characteristics. A solid line indicates an approximate location of stratigraphic change. Descriptions may include pertinent observations including type of boring, water seepage, fluid loss, boring termination depth, etc.

4. Legend -

AD - After drilling	ND - Not detectable due to drilling method
ATD - At time of drilling	NR - Not recorded
HSA - Hollow stem auger	RWB - Rotary wash boring
CFA - Continuous Flight Auger	
DWR - Drill water return	
NA - Not Applicable	

5. Remarks - may include the results of field tests or other special observations.

6. Rock hardness and strength - descriptors follow recommendations of the Bureau of Reclamation:
  - Extremely hard - Cannot be scratched with a knife; can only be chipped with repeated heavy hammer blows.
  - Very hard - Cannot be scratched with a knife; breaks with repeated heavy hammer blows.
  - Hard - Can be scratched with a knife with heavy pressure; heavy hammer blows are required to break specimen.

Moderately hard	Can be scratched with a knife with light or moderate pressure; breaks with moderate hammer blow.
Moderately soft	Core can be grooved 1/16 <sup>th</sup> inch deep with moderate or heavy pressure; breaks with light hammer blow or heavy manual pressure.
Soft	Can be grooved or gouged easily by knife with light pressure; can be scratched with fingernail; breaks with light to moderate manual pressure.
Very soft	Can be readily indented, grooved, or gouged with fingernail, or carved with a knife; breaks with light manual pressure.

Note that descriptors are independent of rock type; a relatively strong shale and a relatively weak limestone might both be called moderately soft.

#### 7. Limitations

The lines between materials shown on the boring logs represent approximate boundaries between material types. The changes may be gradual. Water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water levels may occur with time. The boring logs in this report are subject to the limitations, explanations and conclusions of this report.



## LOG OF BORING NO. B-1

Project Description: Lower Bois D'Arc Reservoir: FM 1396 Relocation  
 Project Location: Fannin County, Texas  
 Logged By: RGS/SVC  
 Drilled By: GM Enterprises

Sheet 1 of 2  
 Project No.: NTD06128  
 Phase No.: 003A  
 Date: 05/27/2010  
 Method: 6" CFA

Rig: CME 55

DEPTH, feet	SAMPLE			SYMBOL	Elevation: 506 +/- Northing: 7291389.162 Easting: 2713787.670 Total Depth: 54.1 feet	UNC. COMPRESSIVE STRENGTH (tsf)	WATER CONTENT, %	UNIT DRY WEIGHT, lb/ft <sup>3</sup>	% PASSING NO. 200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	ELEVATION	
	TYPE	RECOVERY (%)	RESISTANCE pp (TSF) RGD										MATERIAL DESCRIPTION
0	U1	69	1.2 1.0		LEAN TO FAT CLAY (CL-CH), grayish brown and dark brown, stiff, moist, highly calcareous	2.0						505	
	U2	71	0.8 1.5		FAT CLAY (CH), grayish brown and dark brown, medium stiff to stiff, moist, highly calcareous	504.0							
					- trace medium grained sand at about 4 feet								
5	U3	75	1.2 0.7										
					- more plastic at about 6 feet			25			84	19	500
	U4	83	0.9										
					- more sand at about 8 feet								
	U5	21	1.0										
10													
	U6	85	1.3 2.1			- brown, slightly mottled gray-brown and orange-brown, stiff, trace rootlets, trace small calcareous seams at about 10 feet							495
						- trace gravel at about 12 feet							
	U7	63	1.8 1.7										
15													
	U8	63	2.0 1.8										
						- brown and gray, mottled orange-brown at about 16 feet							490
	U9	52	1.9										
					- trace gray fine gravel at about 18 feet								
	U10	79	1.7 1.7				24						
20													
	U11	67	1.3 1.0		- trace ferruginous staining at about 20 feet							485	
	U12	71	1.1 1.6		- trace sand (medium to coarse grained) and gravel (fine, subrounded to well rounded) at about 22 feet								
	U13	79	1.7 1.9		- siltier, less plastic at about 24 feet								
25													
	U14	75	1.2 2.1			27.0						480	
					LEAN TO FAT CLAY (CL-CH), with fine sand, tan and orange-brown	479.0							
						28.0							
	U15	63	0.7 0.6		SANDY LEAN CLAY (CL), silty, tan and orange-brown, medium stiff, moist	478.0			65	46	17		
30													
					- soft to medium stiff, wet at about 30 feet	31.0						475	
Water Level Surface 29 feet at ATD 6.3 feet at 0 hrs. AD 5.0 feet at 22 hrs. AD					Remarks:								



### LOG OF BORING NO. B-1

Project Description: Lower Bois D'Arc Reservoir: FM 1396 Relocation  
 Project Location: Fannin County, Texas  
 Logged By: RGS/SVC  
 Drilled By: GM Enterprises

Sheet 2 of 2  
 Project No.: NTD06128  
 Phase No.: 003A  
 Date: 05/27/2010  
 Method: 6" CFA

DEPTH, feet	SAMPLE			SYMBOL	Elevation: 506 +/- Northing: 7291389.162 Easting: 2713787.670 Total Depth: 54.1 feet	UNC. COMPRESSIVE STRENGTH (tsf)	WATER CONTENT, %	UNIT DRY WEIGHT, lb/ft <sup>3</sup>	% PASSING NO. 200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	ELEVATION
	TYPE	RECOVERY (%)	RESISTANCE pp (TSF) RQD									
			1.3			475.0						
	U17	75			CLAYEY SAND (SC), fine grained, gray and brown, moist - fine to medium grained at about 32 feet - with fine gravel seams (subrounded to rounded) at about 33 feet	34.0			40			
35	U18 TCP	92	4.5+		SHALE, brown and gray, soft, fossiliferous, with calcite pockets, calcareous	472.0						470
			50/2" 50/2.5"									
40	A19 TCP		50/3" 50/1"		- gray, soft to moderately hard at about 39 feet							465
			50/2" 50/1.5"									460
45	TCP		50/1.5" 50/1.5"									455
			50/1" 50/0.5"		- hard at about 54 feet	54.1						450
55	TCP				Total boring depth 54.1 ft.	451.9						445
60												



## LOG OF BORING NO. B-2

Project Description: Lower Bois D'Arc Reservoir: FM 1396 Relocation  
 Project Location: Fannin County, Texas  
 Logged By: RGS/SVC  
 Drilled By: GM Enterprises

Sheet 1 of 2  
 Project No.: NTD06128  
 Phase No.: 003A  
 Date: 06/01/2010  
 Method: 6.25" HSA

DEPTH, feet	SAMPLE		SYMBOL	Elevation: 500 +/- Northing: 7293613.862 Easting: 2714018.123 Total Depth: 50.2 feet	UNC. COMPRESSIVE STRENGTH (tsf)	WATER CONTENT, %	UNIT DRY WEIGHT, lb/ft <sup>3</sup>	% PASSING NO. 200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	ELEVATION		
	TYPE	RECOVERY (%)										RESISTANCE pp (TSF) RGD	MATERIAL DESCRIPTION
0				11.5" Clayey gravel road base	1.0						500		
	U1	100		LEAN CLAY (CL), with silt seams, dark brown and tan, very stiff, slightly moist, stratified, calcareous, trace rootlets	499.0								
				3.0									
	U2	100		FAT CLAY (CH), dark brown, slightly moist to moist, non-calcareous, trace ferruginous staining	497.0								
				2.6									
5				2.4									495
				2.2									
				- trace sand, very stiff to hard, slightly calcareous, with calcareous nodules, trace ferruginous staining at about 7 feet									
					10.0								
	U3	100		LEAN CLAY (CL), trace sand, orange-brown and brown, hard, slightly moist, slightly blocky and waxy, more calcareous	490.0		11		40	14	490		
				4.5+									
				- very stiff at about 13 feet									
				- less plastic, moist at about 14.5 feet									
15				- brown and gray at about 16 feet							485		
	U4	100											
				2.9									
				- trace gray to gray, less blocky at about 19.7 feet									
				- possible slickensides with gray staining at about 20.8, 21.4, 22.4, 22.9, and 23.1 feet			9		44	15	480		
	U5	100											
				2.8									
				- slightly more sand at about 24 feet									
25											475		
	U6	98		- steep angle slickenside with ferruginous staining from about 26.1 to 26.3 feet.			13		94				
				2.7									
				- tan, with ferruginous staining, less plastic	28.0								
				transition from about 27 to 28 feet	472.0								
				SILTY LEAN CLAY (CL), trace fine sand, tan, stiff, moist, calcareous, with ferruginous staining									
				- siltier, more fine sand, medium stiff to stiff, with ferruginous staining at about 29.4 feet	30.5								
30					469.5						470		

Water Level Surface 28 feet at ATD  
 8 feet at 0 hrs. AD  
 at

Remarks:



## LOG OF BORING NO. B-2

Project Description: Lower Bois D'Arc Reservoir: FM 1396 Relocation  
 Project Location: Fannin County, Texas  
 Logged By: RGS/SVC  
 Drilled By: GM Enterprises

Sheet 2 of 2  
 Project No.: NTD06128  
 Phase No.: 003A  
 Date: 06/01/2010  
 Method: 6.25" HSA

DEPTH, feet	SAMPLE		SYMBOL	Elevation: 500 +/- Northing: 7293613.862 Easting: 2714018.123 Total Depth: 50.2 feet	MATERIAL DESCRIPTION	UNC. COMPRESSIVE STRENGTH (tsf)	WATER CONTENT, %	UNIT DRY WEIGHT, lb/ft <sup>3</sup>	% PASSING NO. 200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	ELEVATION
	TYPE	RECOVERY (%)										
	U7	78			SANDY LEAN CLAY (CL), fine to medium grained, trace fine gravel (sub-angular), brown, moist	32.6			56			
					CLAYEY SAND (SC), medium to coarse grained, gray	467.4						
35	TCP	50/4" 50/3"			SHALE, with sand, dark gray, soft fossiliferous, thinly bedded at top of formation	34.2						465
	U8	100			- thin bentonite seam at about 36.7 feet - steep slickenside at about 37 feet - steep slickenside at about 37.7 feet	465.8						
40	TCP	50/2" 50/1.5"			- moderately hard to hard							460
	U9	100			- possible slickenside at about 42.2 feet							
45	TCP	50/1.5" 50/0.5"			- hard							455
50	TCP	50/1.75" 50/0.75"			Total boring depth 50.2 ft.	50.2						450
						449.8						
55												445
60												440



## LOG OF BORING NO. B-3

Project Description: Lower Bois D'Arc Reservoir: FM 1396 Relocation  
 Project Location: Fannin County, Texas  
 Logged By: RGS/SVC  
 Drilled By: GM Enterprises

Sheet 1 of 1  
 Project No.: NTD06128  
 Phase No.: 003A  
 Date: 05/28/2010  
 Method: 6.25" HSA

Rig: CME 55

DEPTH, feet	SAMPLE		SYMBOL	Elevation: 504 +/- Northing: 7295181.535 Easting: 2714241.557 Total Depth: 20 feet	UNC. COMPRESSIVE STRENGTH (tsf)	WATER CONTENT, %	UNIT DRY WEIGHT, lb/ft <sup>3</sup>	% PASSING NO. 200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	ELEVATION
	TYPE	RECOVERY (%)									
0	U1	100	2.2	CLAYEY SAND (SC), dark brown and brown, very stiff, moist, with rootlets	1.2						
5			1.5		SILTY LEAN CLAY (CL), with fine sand, brown and dark brown, very stiff, moist, with rootlets, non-calcareous - medium stiff from about 2 to 2.7 feet - medium stiff from about 3.1 to 3.5 feet - stiff at about 4 feet	502.8		17		35	19
10	U2	100	0.7	- medium stiff from about 5.6 feet to 8.5 feet		19					495
15			1.5	LEAN CLAY (CL), brown, stiff, moist	10.0		16		44	17	490
20	U3	100	3.0	- trace sand, with ferruginous staining at about 12 feet	494.0						490
25			2.4	- with sand, siltier, medium stiff to stiff, with ferruginous staining at about 13 feet	14.5						485
30	U4	58	1.8	CLAYEY SAND (SC), gray and light brown, moist	489.5						485
35			1.4	- coarse sand seam from about 16.6 to 16.9 feet				45			480
40			1.0	- fine to medium sand seam from about 17.4 to 17.7 feet							475
45			0.5	Total boring depth 20 ft.	20.0						475
					484.0						475

Water Level Surface 14 feet at ATD  
 8.6 feet at 0 hrs. AD  
 at

Remarks:



## LOG OF BORING NO. B-4

Project Description: Lower Bois D'Arc Reservoir: FM 1396 Relocation  
 Project Location: Fannin County, Texas  
 Logged By: RGS/SVC  
 Drilled By: GM Enterprises

Sheet 1 of 2  
 Project No.: NTD06128  
 Phase No.: 003A  
 Date: 05/28/2010  
 Method: 6.25" HSA

DEPTH, feet	SAMPLE		SYMBOL	Elevation: 533 +/- Northing: 7296888.811 Easting: 2714335.883 Total Depth: 50.3 feet	UNC. COMPRESSIVE STRENGTH (tsf)	WATER CONTENT, %	UNIT DRY WEIGHT, lb/ft <sup>3</sup>	% PASSING NO. 200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	ELEVATION
	TYPE	RECOVERY (%)									
0				1" Topsoil/Root zone	0.1						
1.3	U1	92		FAT CLAY (CH), trace fine sand, silty, gray, mottled orange-brown, very stiff, sl. moist to dry, with rootlets, non-calcareous - slightly moist to moist at about 0.5 feet - stiff, moist at about 1.3 feet - end of root zone at about 3 feet - very stiff to hard, slightly moist at about 3.6 feet - blocky, with ferruginous staining at about 5 feet - waxy, more plastic at about 6.2 feet	532.9						530
2.2											
4.5+											
5	U2	100									
4.5+											
10	U3	100		- silty, trace fine sand, orange-brown and tan, dry, less plastic at about 9 feet - more fine sand at about 10 feet		15			68	19	
4.5+											
15	U4	100		- calcareous at about 13 feet - fossiliferous at about 14 feet - trace sand to with sand at about 14.5 feet LEAN CLAY (CL), with sand, orange-brown and tan, hard, slightly moist, calcareous	15.0 518.0						
4.5+											
20	U5	100		SANDY LEAN CLAY (CL), fine grained to trace medium grained, silty, orange-brown, hard, dry, calcareous - siltier, less clay at about 20 feet SILTY SAND (SM), with occasional very thin silt partings, trace clay, tan and orange-brown, dry to slightly moist SILTY LEAN CLAY (CL), trace sand, with occasional thin sand seams, tan, hard, dry, calcareous	19.0 514.0 20.5 512.5 21.0 512.0		10		30	12	
4.5+											
25	U6	100									
4.5+											
30				- more clay at about 29.8 feet - tan and orange-brown, very stiff, slightly moist at							
3.5											

Water Level Surface Dry at ATD  
 Dry at 0 hrs. AD  
 at

Remarks:



## LOG OF BORING NO. B-4

Project Description: Lower Bois D'Arc Reservoir: FM 1396 Relocation  
 Project Location: Fannin County, Texas  
 Logged By: RGS/SVC  
 Drilled By: GM Enterprises

Sheet 2 of 2  
 Project No.: NTD06128  
 Phase No.: 003A  
 Date: 05/28/2010  
 Method: 6.25" HSA

DEPTH, feet	SAMPLE		SYMBOL	Elevation: 533 +/- Northing: 7296888.811 Easting: 2714335.883 Total Depth: 50.3 feet	MATERIAL DESCRIPTION	UNC. COMPRESSIVE STRENGTH (tsf)	WATER CONTENT, %	UNIT DRY WEIGHT, lb/ft <sup>3</sup>	% PASSING NO. 200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	ELEVATION
	TYPE	RECOVERY (%)										
35	U7	98	2.2	31.5	about 30.5 feet							500
				501.5	SILTY SAND (SM), fine grained, trace clay, tan and orange-brown, slightly moist				56			
				32.4	- fine to medium grained at about 32 feet at about 32 feet							
				500.6								
				34.7	SANDY LEAN CLAY (CL), with sand pockets, tan and orange-brown, moist, calcareous							
				498.3	LEAN CLAY (CL), trace sand, brown, moist, with ferruginous staining							
	U8	92		36.5	CLAYEY SAND (SC), gray and tan, moist - with gravel at about 37.2 feet				40			495
				496.5								
				38.7	CLAYEY GRAVEL (GC), rounded to well rounded, with sand, reddish brown, moist							
				494.3	WEATHERED SHALE, with fine sand, brown to gray, soft, calcareous, fossiliferous							
	TCP		33/6" 50/6"	39.3	SHALE, with sand, gray, unweathered - slightly weathered zone from about 41.6 to 42.4 feet							490
				493.7	- thin slightly weathered zone, with calcite granules from about 43 to 43.3 feet							
	A9			41.0	- moderately hard to hard							
				492.0								
	TCP		50/1.75" 50/1.5"	50.3	Total boring depth 50.3 ft.							485
				482.7								480
												475
												470
												465
												460
												455
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												60

# KEY TO SYMBOLS

Symbol Description

Symbol Description

Strata symbols

	Low-high plasticity clays
	High plasticity clay
	Sandy clay
	Clayey sand
	Shale
	Clayey gravel
	Low plasticity clay
	Silty Lean Clay
	Topsoil

	Silty sand
	Weathered Shale

Notes:

1. Exploratory borings were drilled on 05/27/2010 through 06/01/2010 using 6-inch diameter continuous flight power augers for Boring B-1 and 6.25-inch hollow stem augers for the rest of the borings.
2. Approximate boring locations can be found on the Boring Location Diagram. Actual boring locations may differ based on existing conditions in the field. Boring coordinates were determined using a handheld GPS with an accuracy of +/-1 meter. Boring elevations were roughly approximated from Google Earth.
3. These logs are subject to the limitations, conclusions, and recommendations in this report.
4. Results of tests conducted on samples recovered are reported on the logs.

**MAS-TEK ENGINEERING & ASSOCIATES, INC.**  
**GEOTECHNICAL AND CONSTRUCTION MATERIALS TESTING & ENGINEERING**

5132 Sharp Street Dallas, Texas 75247 Phone: 972-709-7384 Fax: 972-709-7385

**REPORT OF ATTERBERG LIMITS, MOISTURE CONTENT AND MATERIAL IN SOILS FINER  
 THAN THE NO. 200 SIEVE**

**(ASTM D 4318), (ASTM D 2216) and (ASTM D 1140)**

**PROJECT NAME:** Lab Testing for Lower Bois D'Arc  
**PROJECT NUMBER:** 17-064-A  
**CLIENT:** Freese and Nichols, Inc.  
**CLIENT CONTACT:** Russell G. Springer, P.E.

**MTE REPORT No.:** 17-064-001  
**REPORT DATE:** 6/29/2010  
**DATE TESTED:** 6/4/2010  
**TECHNICIAN:** D. Randall

**Test Results**

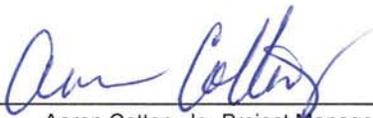
Bore #	Sample Number	Depth	Moisture Content (%)	-200 Sieve (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index
B1	U15	28 - 30	20.8	65	46	17	29 #
B1	U17	32 - 34		40			
B1	U4	6 - 8	25.2		84	19	65
B1	U10	18 -20	23.5				
B2	U7A	31.2 - 31.8		55.9			
B2	U6A	25.7 - 26.7	13	94.1			
B2	U3A	10.4 - 11.1	11		40	14	26
B2	U5A	20.8 - 21.4	9.3		44	15	29
B3	U4A	15 - 15.8		45			
B3	U3A	10.6 - 11.3	15.6		44	17	27
B3	U1B	4-4.6	17.4		35	19	16
B3	U2A	6.9 - 7.4	19.1				
B4	U8A	37 - 38		39.5			
B4	U7B	32.9 - 33.4		56.2			
B4	U5B	22.7 - 23.5	10.4		30	12	18
B4	U2B	9 - 9.5	15.3		68	19	49
B4	U4A	16 - 16.6	9.1				

*Test Results Meet Project Specifications Unless Noted With an \**

Notes:

Note: This report is for the exclusive use of the Client addressed. This report may not be reproduced except in its entirety, without the written consent of MTE. Results apply only to above tests.

**Mas-Tek Engineering & Associates, INC.**

  
 Aaron Cotton, Jr., Project Manager