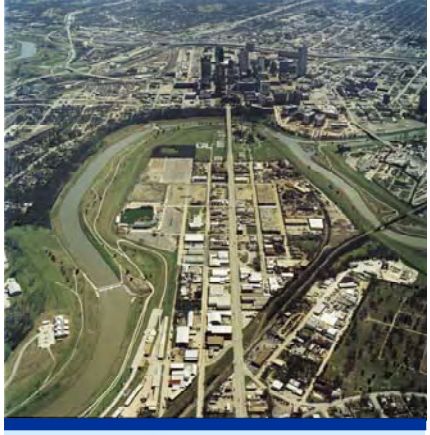
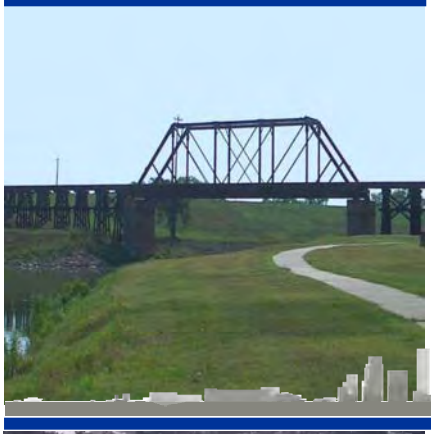
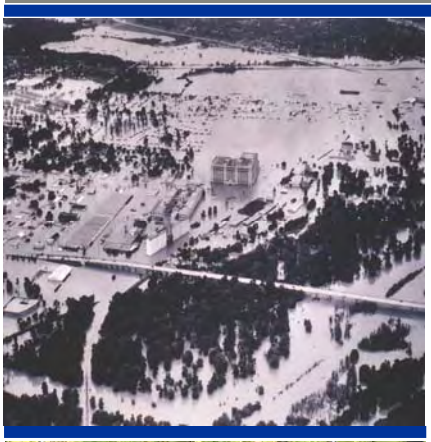




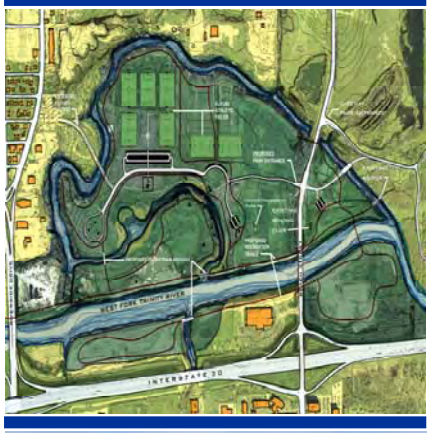
Fort Worth Central City Preliminary Design

Geotechnical



Draft Supplement No. 1 to the Final Environmental Impact Statement

Appendix B



January 2008

Images courtesy of CDM, Gideon Toal, and Bing Thom Architects

CENTRAL CITY / RIVERSIDE OXBOW COMBINATION PROJECT
Fort Worth, TX

Appendix B, Geotechnical

1. DESCRIPTION of PROPOSED PROJECT.

The authorized Central City Project in Fort Worth, TX includes a by-pass channel approximately 8,400 feet long that will divert high flows from the Clear Fork of the Trinity directly to the West Fork of the Trinity in the vicinity of Samuels Avenue. A dam just upstream of Samuels Avenue was proposed to provide a constant water level of 525 msl to allow small craft access from the West Fork into Marine Creek. Isolation gates are included upstream of the confluence of the by-pass and the Clear Fork channel (the Clear Fork Gate), near the midpoint of the by-pass channel (the Trinity Point Gate), and downstream of the confluence of the by-pass channel and the West Fork (the TRWD Gate). Three new vehicular bridges; designed by others, which would cross the by-pass channel, and two pedestrian bridges (one across the by-pass channel downstream of Henderson Street, and one across the West Fork upstream of the existing FW&W Railroad Bridge) were included. Hydraulic mitigation was included in the Riverbend area where the levee would be breached to allow storage of flood water and habitat restoration.

The approved Riverside Oxbow Ecosystem Restoration Project (RSO) encompasses about 1,060 acres just east of downtown Fort Worth on the West Fork of the Trinity River at the downstream end of the Fort Worth Floodway. The restoration project will help to restore the ecological integrity, function and dynamic processes that were disrupted when the West Fork channel was realigned in the 1950's. Ecosystem restoration of this area includes reestablishment of low flows through the old oxbow, reforestation; creation of emergent wetlands, and habitat improvement including the establishment of a riparian buffer along the West Fork. Replacement of the Beach Street Bridge and construction of an access bridge over the oxbow will be required. Other improvements in the RSO include 9,000 feet of concrete trail for Operations and Maintenance (O&M) and recreation access, 1,400 feet of crushed aggregate trail, and 7,600 feet of wood mulch equestrian trail. Associated access points, parking and restroom facilities will also be provided.

Because of the proximity of the two projects, the City of Fort Worth requested that the US Army Corps of Engineers (USACE) investigate the possibility of modifying the Central City Project to incorporate the Riverside Oxbow Projects features in order to analyze areas within the Riverside Oxbow project as replacement hydraulic mitigation to the Riverbend area. A change in the location of Samuels Avenue Dam upstream of Marine Creek confluence is also being analyzed and would include a lock chamber to provide small craft permitted access to Marine Creek. A low water dam added across Marine Creek would be required to support the water craft access to Marine Creek. This report documents the geotechnical design considerations of the following proposed actions: 1) re-location of the Samuels Avenue Lock and Dam, 2) construction of a low water dam at Marine Creek and 3) to replace 5250 acre-feet of hydraulic mitigation valley storage from a mix of 25 alternatives identified to allow flexibility to assure the valley storage requirements could be achieved as planning and design progresses.

2. GENERAL GEOLOGY and PHYSIOGRAPHY.

A. Physiography. The combined Central City and Riverside Oxbow project is located entirely in Tarrant County in north central Texas. Tarrant County is located near the southeastern boundary of the Great Plains physiographic province and the Atlantic and Gulf Coastal Plains province. Located within the Grand Prairie sub-province of the Great Plains, surface expressions are flat. Valley slopes are angular with scarps and terraces in evidence. The residual soils and regolith are shallow and dark brown to brown in color. The Grand Prairie sub-province is underlain by alternating beds of limestone and calcareous clay shales of the Washita and Fredericksburg Groups. In the study area, these materials are represented by the Goodland, Kiamichi, Duck Creek and Fort Worth Formations. A generalized geologic map of the project area is provided as Figure 1.

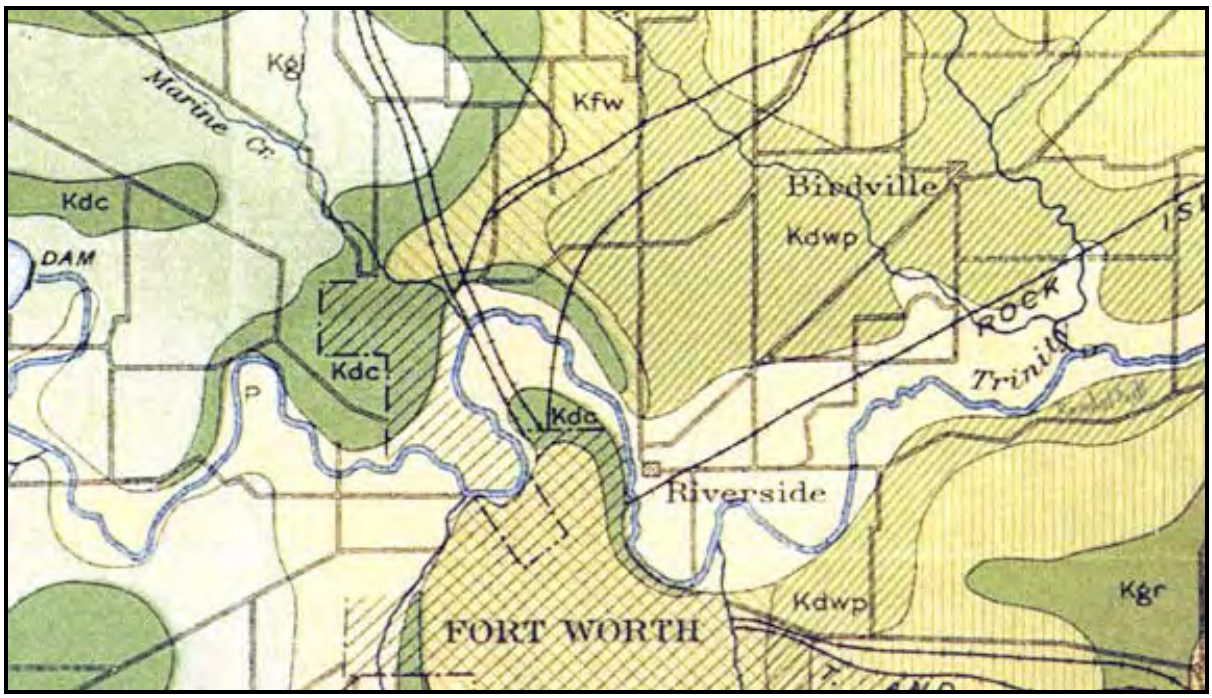


Figure 1. *Geologic Map of the Central City and Riverside Oxbow Project Area [Source: Geology of Tarrant County, UT Austin Bulletin No. 1931, circa 1919]*

B. Geologic History. The geologic history of the Tarrant County region is complex. During the Triassic and Jurassic periods, withdrawal of the seas from north central Texas along with subsidence of the Gulf Coast Embayment reversed the direction of drainage. This, in turn, led to extensive truncation of the Pennsylvanian strata in the Fort Worth Basin. At the close of the Jurassic, the rocks of the Paleozoic era had been reduced to a nearly flat surface. This eroded surface was covered with marine sediments during the Cretaceous period. Throughout Tarrant County, the truncated Pennsylvania strata dip westward, while the succeeding Cretaceous strata dip to the southeast. Two major invasions of the Cretaceous Age are represented by the Comanche Series and the younger Gulf Series. Tarrant County lies between these two major geologic series. Minor pulsations of the seas during the Comanche period are indicated by the separate limestone and marl sequences of the Fredericksburg and Washita groups of the Comanche series. As the sea withdrew

toward the Gulf at the end of the Cretaceous, the surface of Tarrant County was exposed [Sellards, 1932].

During the deposition of the Fredericksburg Group, sea heights varied from 40 to 120 feet in depth. The sedimentary rocks of the Fredericksburg are mainly limestone and marl with lesser amounts of sandstone, shale and shell agglomerate. The thickness of the Fredericksburg Group varies from 135 to 185 feet, increasing southward, with the rock dipping southeastward at a rate of 38 feet per mile. The Kiamichi wedges out toward the south between the Goodland and the overlying Washita Group. Members of the Fredericksburg Group which are exposed in the project area provide the primary geologic formation for construction of the project. This includes the Goodland Limestone, the Kiamichi Formation, the Washita Group, the Duck Creek Formation and the Fort Worth Formation.

Much of the project area is covered with alluvium and terrace materials of Quaternary Age. Bottom-land gravels have formed terraces or benches closer to the stream valleys. These terraces become more distinct as proximity to the current stream channels gets closer. The lowermost terrace is the present floodplain and includes alluvium a few feet above the present stream bed. The alluvial deposits were derived from formations that outcrop within the drainage basin, and range in thickness from a feather-edge to approximately 45 feet. The upland gravels in the area consist of angular gravels, clay and silt. The sand and gravel are mostly poorly sorted fragments of platy limestone. The lower terrace and floodplain deposits consist of rounded gravel, sand and clay. These deposits are generally well sorted and not well cemented.

In the project area, Quaternary Age deposits provide a deeper profile than the residual soils. The depth of the soils controls the major vegetation types; therefore, tree growth in the Grand Prairie sub-province is sparse except in the areas where moderate tree growth is supported by alluvial and terrace deposits [Sellards, 1932].

C. Seismicity. The Fort Worth area is located in Uniform Building Code (U.B.C.) Seismic Zone Zero, the lowest earthquake hazard region in the United States. There are no known active geological faults within the North-Central Texas region, although inactive normal faults of the Balcones fault system do occur throughout the southern and eastern North-Central Texas. *[Source: http://www.hazmap.nctcog.org/risk_assessment/Chapter8.asp]*

3. SUBSURFACE INVESTIGATIONS.

Preliminary geotechnical investigations have been performed for both the original Central City study and the Riverside Oxbow Restoration project. Investigations will be conducted during design stage to develop final design parameters and to further define conditions within the combined project area, including the various valley storage mitigation sites, the low water dam at Marine Creek, and for the Samuels Avenue Lock and Dam. For purposes of this supplemental EIS, available geotechnical data obtained by USACE for other projects in the area has been reviewed, as has data obtained by others in support of the design of other structures near the Fort Worth Floodway. These investigations are described below.

A. Central City.

1. Phase 1A Geotechnical Investigation. USACE, September – November 2006. In order to obtain feasibility level geotechnical data for this project, a Phase 1 investigation plan was developed. Due to issues associated with obtaining rights-of-entry for drilling, and potential environmental contamination on several of the drill sites, the Phase 1 investigation was originally split into two phases: 1A and 1B. Phase 1A was completed in Fall 2006, while Phase 1B was initiated in July 2007.

Twenty-two borings were advanced for the Phase 1A investigation in order to obtain data for design of the by-pass channel, evaluation of structures, and to investigate alternative locations for the Samuels Avenue Dam. The location of each of these borings is shown on Exhibit 1A, with the logs of each boring provided in Exhibit 2. Borings in Phase 1A were considered by Camp, Dresser, McKee Engineers (CDM) to have the lowest potential for soil and/or groundwater contamination due to current and previous site usage (see Table 1 for a summary of the investigation). Sixteen of the Phase 1A borings included the installation of monitoring wells for periodic observation of groundwater fluctuations during the design phase.

Central City, Phase 1A Geotechnical Investigation			
Boring Number	**Project Feature**	**Boring Number**	**Project Feature**
CC06-002*	Samuels Avenue Dam Relocation	CC06-030*	Clear Fork Isolation Gate SE Abutment
CC06-006*	Samuels Avenue Dam Relocation	CC06-031*	Clear Fork Isolation Gate NW Abutment
CC06-007*	Samuels Avenue Dam Relocation	CC06-032*	General Geotechnical Data
CC06-009*	Samuels Avenue Dam Relocation	CC06-033*	General Geotechnical Data
CC06-012*	Samuels Avenue Dam Relocation	CC06-035	Trinity Point Isolation Gate
CC06-014*	TRWD Isolation Gate North Abutment	CC06-036	Trinity Point Isolation Gate
CC06-015	TRWD Isolation Gate South Abutment	CC06-037*	West Fork Pedestrian Bridge NW Abutment
CC06-016	General Geotechnical Data	CC06-038*	West Fork Pedestrian Bridge SE Abutment
CC06-027	Water Feature General Geotechnical Data	CC06-039*	Pedestrian Bridge Northwest Abutment
CC06-028	Water Feature General Geotechnical Data	CC06-040*	Pedestrian Bridge Southeast Abutment
CC06-029*	General Geotechnical Data	CC06-042*	General Geotechnical Data
** - monitoring well installed*			

Table 1. Summary of Phase 1A Subsurface Explorations

The Phase 1A investigation was performed by the Core Drill Unit of the Fort Worth District of the US Army Corps of Engineers using a Failing 1500 conventional truck-mounted drilling rig. Advancement of the boreholes and sample recovery were accomplished using short flight augers, Shelby tube samplers, nominal two-inch diameter split-spoon samplers, carbide tip roller rock bits, and four-inch diameter diamond core barrels. Specific drilling information for each boring is provided on the boring logs in Exhibit 2.

Overburden samples were generally obtained at five-foot intervals over the soil column, with 4-inch diameter core samples obtained from the underlying rock primary. Standard Penetration Tests in accordance with ASTM D 1586 were performed during the investigation in order to determine the relative density of the granular materials that were encountered. Shelby tube, split spoon, and four-inch diameter rock core samples that were collected during the investigation were sealed in airtight containers and taken to the laboratory of TEAM Consultants, Incorporated in Arlington, Texas for testing.

2. Central City Feasibility Environmental Impact Statement (FEIS). CDM, May – June 2005. In support of the FEIS for the original Central City project, twenty borings were drilled by the Core Drill Unit of the Fort Worth District of the US Army Corps of Engineers. Nine borings were drilled along the by-pass channel alignment with additional borings in the vicinity (within 500 feet) of the proposed locations of the Samuels Avenue Dam, the three isolation gates; and bridges at Main Street, Henderson Street and White Settlement Road. The location of these borings is shown on Exhibit 1. Details of this investigation are located in the 'Draft Environmental Impact Statement, Appendix B: Initial Geotechnical Investigation for the Preliminary Design of the Fort Worth Central City Project' [CDM, April 2006], and are summarized in Table 2.

Central City, FEIS Geotechnical Investigation			
Boring Number	**Project Feature**	**Boring Number**	**Project Feature**
B-1	Main Street Bridge NW Abutment Vicinity	C-6	By-Pass Channel
B-2	Main Street Bridge SE Abutment Vicinity	C-7	By-Pass Channel
B-3	Henderson Street Bridge NW Abutment Vicinity	C-8	By-Pass Channel
B-4	Henderson Street Bridge SE Abutment Vicinity	C-9	By-Pass Channel
B-5	White Settlement Bridge NW Abutment Vicinity	C-10	By-Pass Channel
B-6	White Settlement Bridge SE Abutment Vicinity	D-1*	Samuels Dam Right Abutment Vicinity
C-1	By-Pass Channel	D-2*	Samuels Dam Left Abutment Vicinity
C-2	By-Pass Channel	F-1*	TRWD Gate Vicinity
C-3	By-Pass Channel	F-2*	Trinity Point Gate Vicinity

C-4	By-Pass Channel	F-3*	Clear Fork Gate Vicinity
** - monitoring well installed adjacent these boreholes*			

Table 2. Summary of FEIS Subsurface Explorations [CDM, 2006]

As part of CDM's investigation, five monitoring wells were installed in or adjacent to the boreholes for observation of groundwater fluctuations at the original dam site, and in the vicinity of the isolation gates.

3. Marine Creek. USACE, May 1987. Rone Engineers performed preliminary geotechnical investigations for evaluation of a proposed flood control and channel improvement project along Tony's Creek and Marine Creek. Ten borings were drilled across the area at depths ranging from 17 to 50 feet. As part of the investigation, Rone also provided boring logs from other projects in the Marine Creek area. Although all the borings from this investigation were obtained at least 0.5-mile from the location of the proposed Marine Creek low water dam, they are helpful in characterizing the overall geology and ambient groundwater conditions of this portion of the project. Of particular significance is the large amount of fill encountered along the creek banks, and the presence of significant sand seams underlying more impervious overburden. These conditions raise concerns with respect to seepage and stability along the channel, concerns that were evident when the investigation was performed 20-years ago.

B. Riverside Oxbow.

1. Riverside Oxbow Ecosystem Restoration Project. USACE, May 2003. Under contract to USACE, TetraTech NUS performed subsurface investigations of the original Riverside Oxbow project in May 2002. Seven borings were advanced from which jar, tube and rock core samples were collected for testing; and 24-hour water level readings were obtained. Drilling information, laboratory test data, and water level readings with complete information, discussions and recommendations from this investigation can be found in Appendix C of the 'Interim Feasibility Report and Integrated Environmental Assessment, Riverside Oxbow, Upper Trinity, Fort Worth, TX' [USACE, 2003].

Summary of Drilling for the Original Riverside Oxbow Project			
Boring Number	**Project Feature**	**Depth (Elevation*)**	**Remarks**
8A4C-1	Riverside Drive Bridge Vicinity of South Abutment	63' (442.75*)	TOR 63'.
8A4C-2	Riverside Drive Bridge Vicinity of North Abutment	70' (435.78*)	TOR 60'
8A4C-3	Riparian Corridor	60' (442.45*)	Rock was not encountered.
8A4C-4	Beach Street Bridge Vicinity of Northeast Abutment	35' (470.74*)	TOR 25'
8A4C-5	Beach Street Bridge Vicinity of Southwest Abutment	60' (452.03*)	Rock was not encountered.
8A4C-6	Levee Bridge	60' (466.95*)	Rock was not encountered.

8A4C-7	Parkroad Access Bridge	52' (454.08*)	Rock was not encountered.
** - Elevations obtained with GPS. Vertical accuracy is 5'±)*			

Table 3. Summary of Feasibility Subsurface Explorations for RSO [USACE, 2003]

2. Riverside Oxbow, Waste Water Treatment Plant. As part of the closure of the Riverside Waste Water Treatment Plant (RWTTP), several investigations of this site have been performed. The location of portions of this site generally corresponds to the south and eastern limits of valley storage mitigation site 17, so geotechnical data from the subsurface investigation and groundwater data collected since monitoring wells were installed were reviewed to evaluate conditions in this area.

The monitor well borings ranged from between 20 and 50 feet deep, however, only one encountered rock (MW-15 encountered limestone at 35 feet below top of ground). The overburden in this area appears to be clay and clayey sands with significant lenses of sand and gravel throughout. A generalization of conditions documented on the monitoring well logs and borings is provided in Table 4.

Valley Storage Mitigation Site 17	
Well Number	**Borehole Depth and Overburden Characteristics**
MW-1	Depth 27'. Sand throughout (hydrocarbon contamination noted)
MW-2	Depth 20'. Sand throughout
MW-3	Depth 20'. Sand throughout
MW-4	Depth 25'. Sandy clay to 5'. All sand and gravel from 5' to 25'
MW-5	Depth 32.5'. All sand and gravel, except sandy clay from 2' to 11'
MW-6	Depth 32.5'. Sand and gravel, except sandy clay from 7' to 11' (chemical odor noted)
MW-7	Depth 35'. Sand throughout
MW-8	Unknown
MW-9	Unknown
MW-10	Depth 45'. Clayey overburden throughout
MW-11	Depth 35'. Clayey overburden to 23'. Sands and gravels from 23' to 35'.
MW-12	Depth 50'. Clayey overburden with Sand 10' to 18', 23' to 27', and 44' to 50'.
MW-13	Depth 35'. Clayey overburden to 25'. Sandy gravel from 25' to 35'.
MW-14	Depth 35'. Clayey overburden throughout (concrete rubble from 3' to 4').
MW-15	Depth 35'. Clayey overburden with Sands and gravels 30' to 34'. Marl at 34'.

Table 4. Summary of Explorations for RWTTP Monitoring Wells [Kleinfelder, et al, 2003]

It is noted that there was no lab test data provided with monitoring wells MW-1 through MW-7, so it is assumed that the classifications shown on the boring logs were made by the field geologist. Importantly, it is noted that the soil descriptions that accompany the monitoring well logs for MW-1 through MW-7 sometimes vary from those reported on the boring log.

C. Currently USACE Subsurface Investigations, July 2007. A work order to perform subsurface investigations of the combined project using contract drilling services was awarded in July 2007. In addition to sampling for geotechnical design considerations, sampling to determine the presence of hazardous, toxic or radioactive wastes (HTRW) is also being performed in specified boreholes. This work order includes drilling for Phases 1B, 1C and 1D as described below.

1. USACE, Phase 1B. Thirty-one borings will be advanced in the Phase 1B investigation. Phase 1B borings are located primarily within the footprint of the original Central City project and include investigations on properties that CDM determined to have medium to high potential for HTRW contamination. In addition, areas to be drilled include the potential site for the Samuels Avenue Lock and Dam and the abutments of the proposed Marine Creek Low Water Dam. Twenty-eight monitoring wells will be installed as part of this investigation for monitoring groundwater fluctuations during design.

2. USACE, Phase 1C. Phase 1C investigations are located within the footprint of the Riverside Oxbow project. Data from these borings will be used to evaluate soil and groundwater conditions for valley storage mitigation sites, reforestation areas, oxbow reestablishment and the design of access roads, trails, and miscellaneous structures and facilities. Twenty-seven borings will be drilled, with monitoring wells installed in each borehole for long-term monitoring.

3. USACE, Phase 1D. Investigations for Phase 1D are generally concentrated on the valley storage mitigation sites associated with the combined project. Twenty-nine borings will be drilled, one of which will become a monitoring well.

Soil and rock samples obtained from the Phase 1B, 1C and 1D borings will be submitted for laboratory testing. Groundwater levels in the boreholes will also be measured during drilling and 24 hours after completion of the drilling. HTRW sampling will be performed in specified boreholes. (*NOTE: Reporting of HTRW project impacts is not specifically addressed in this Geotechnical Appendix*)

4. LABORATORY TESTING.

All samples from the Phase 1A investigation were delivered to TEAM Consultants, Incorporated in Arlington, Texas for testing. Property testing, consolidation, direct shear, unconfined compression on soft rock samples, and unconsolidated-undrained testing of soil samples were performed by TEAM. Consolidated-undrained triaxial tests, and rock testing was performed by Fuller, Mossbarger, Scott and May Engineers in Lexington, KY.

Testing requirements for each sample were specified by USACE based upon

examination of each of the samples by the project geotechnical engineer, and included the following procedures listed in Table 5.

Test Method	Parameter	Number of Tests
ASTM D 422	Gradation	38
ASTM D 2166	Unconfined Compression (Soft Rock)	8
ASTM D 2216	Moisture Content	123
ASTM D 2435	Consolidation	8
ASTM D 2487	Visual Classification (USCS)	all samples
ASTM D 2488	Visual Classification (Visual-Manual)	all samples
ASTM D 3080	Consolidated Drained Direct Shear	122
ASTM D 3148	Unconfined Compression w/Elastic Moduli and Poisson's Ratio	14
ASTM D 4318	Atterberg Limits	120
ASTM D 2938	Unconfined Compression Strength	8
EM 1110-2-1906 ASTM D 4767	Consolidated-Undrained Triaxial Strength	8
EM 1110-2-1906	Permeability	16
RTH 203	Rock Direct Shear	3

Table 5. Phase 1A Soil and Rock Testing Summary

Results of laboratory visual classification and moisture content tests are shown on the individual boring logs that are included with this Appendix as Exhibit 2. Actual test data from this investigation are voluminous. Summary of test data is provided in Exhibit 3. Complete test data is available upon request.

5. GENERAL CHARACTERIZATION of the COMBINED PROJECT AREA.

Subsurface investigations were conducted in order to make preliminary characterizations of the geotechnical conditions across the area of the original Central City Project [CDM, 2006] and the original Riverside Oxbow Environmental Restoration Project [USACE, 2003]. The borings drilled as part of the FEIS study for the preliminary design of isolation gates and other structures were drilled in the proximity of the structures (boreholes were from 200 to 500 feet away from the proposed structure locations). Once design stage investigations are complete, the preliminary design recommendations based on the initial investigation effort that are documented in both the Central City FEIS and the original Riverside Oxbow report will be modified to reflect the additional information.

As described below, information obtained from the Phase 1A investigation enhances our understanding of the subsurface conditions for this project.

A. Central City Area.

1. Samuels Avenue Lock and Dam. The newly proposed location of this structure near the confluence of two streams, suggests that the problematic granular soils found at other previously investigated sites will most likely be present at the new location as well. These problematic granular soils will be addressed during design stages.

a. Overburden. Phase 1A borings obtained since the CDM investigation included 2 potential dam site locations (see Exhibit 1A). Unfortunately, due to the unavailability of rights-of-entry for drilling access purposes, only borings to define the right abutment conditions at each of these sites have been made at this time. Additional borings to evaluate conditions on the left descending bank are part of the Phase 1B investigation.

Two borings made downstream of Samuels Avenue (CC06-02 and CC06-06) indicate that the overburden in the area that would constitute the right abutment of the dam consists of low plasticity clays overlying sands and gravels. Overburden in this area is 48 to 51 feet thick. Sands and gravels from 7 to 28 feet thick directly overlay the shale and limestone primary.

Borings CC06-07 and CC06-09 were made downstream of the Northside Bridge. Soil conditions here are similar to borings made downstream of Samuels Avenue (CC06-02 and CC06-06), with 32 to 36 feet of low plasticity clays overlying 15 to 23 feet of sands and gravels.

b. Primary Material. The four borings made along the right bank of the potential dam relocation sites indicate that the top of rock is variable. Unweathered, massive gray to dark gray limestone was encountered in each of the four borings at depths of between 51 and 59 feet. In borings CC06-02 and CC06-06, the limestone was overlain by two to three feet of unweathered dark gray shale.

c. Groundwater Levels. Groundwater readings obtained during the drilling process are recorded on the boring logs provided in Exhibit 2. Readings obtained periodically from the monitoring wells installed during the Phase 1A investigation are provided in Exhibit 5.

2. Marine Creek Low Water Dam. Investigations for this project feature will be completed during design stage. Although we have no borings at the proposed location it is expected that subsurface conditions will be very similar to those encountered at Samuel Avenue Lock and Dam.

3. Investigations Completed. Since additional subsurface investigations have been completed since the FEIS, those borings are presented as part of this SEIS. Preliminary subsurface profiles of the generalized geologic conditions along the right and left banks of the by-pass channel have been prepared using the information available to date. These profiles are included with this report as Exhibit 4.

a. Overburden. Examination of the subsurface profiles indicates that the overburden across the area generally consists of low to medium plasticity clays with occasional high plasticity clays. In general, the overburden becomes coarser with depth.

Lenses and layers of sands and gravels are found across the area at various depths and thicknesses. A layer of coarse to fine gravel is generally found at the top of rock contact. The borings indicate that this layer varies in thickness from approximately three feet along the Clear Fork channel (Borings CC06-029, 031 and 033) to as much as 36 feet near the confluence of the Clear and West Forks.

b. Primary Material. The rock primary in the by-pass channel area generally consists of massively bedded unweathered limestone and unweathered shale. As shown on Table 6, the top of rock varies significantly across the channel alignment.

	Approximate Station (Boring Number)	Primary Rock Material	TOR Elevation (approximate)
DOWNSTREAM ↓	Station 78 (CC06-032)	Unweathered limestone	494
	Station 58 (B-4)	Unweathered shale	493
	Station 44 (CC06-040)	Unweathered shale	484
	Station 42 (CC06-036)	Unweathered limestone	472
	Station 40 (CC06-035)	Unweathered limestone with shale	476
	Station 29 (C-4)	Unweathered limestone	516
	Station 21 (C-3)	Unweathered limestone with shale zone	512
	Station 7 (C-2)	Unweathered limestone with shale zone	513

Table 6. Approximate Top of Rock, Right Bank of By-Pass Channel

c. Groundwater Levels. Groundwater readings obtained during the drilling process are recorded on the boring logs provided in Exhibit 2. Readings obtained periodically from the monitoring wells installed during the Phase 1A investigation are provided in Exhibit 5.

B. Riverside Oxbow Area. Current data available from subsurface investigations for the Beach Street bridge, pavements, and the riparian corridor made in the previous report [USACE, 2003] are unchanged at this time.

1. Subsurface Conditions at the Low Water Dam Downstream of Beach Street. The Interim Feasibility Study [USACE, 2003] shows that the low water dam will be a rip-rap structure with an embedded concrete overflow weir at Elevation 492. The geotechnical discussion in that study refers to a subsurface investigation performed in the vicinity of the abutments for this structure. Although boring logs and subsurface information were not included with that report, the following information has been excerpted:

> *Mas-Tek Engineering & Associates performed a subsurface investigation at the low water dam site. Two boreholes were drilled at the dam site, one on each side of the Trinity River. The boring drilled on the north side of the river was advanced to a depth of 50 feet and the boring drilled on the south side was advanced to a total depth of 40 feet. Undisturbed cohesive soil samples were collected using seamless tube samplers and standard penetration testing was performed within the non--*

cohesive materials encountered in each test hole. Representative soil samples were subjected to laboratory testing for identification, moisture content, grain size distribution, Atterberg limits, and dry unit weight. Undisturbed samples were subjected to shear strength and consolidation testing as well.

Soils encountered in the boring drilled on the north side of the river consist of an initial 6 foot layer of very stiff to hard, dark brown clay. Underlying the clay is a 3 foot layer of tan to light brown sandy gravel and a deeper deposit of dark brown to brown clay. The clay transitions from hard to soft with increasing depth and is present to depths of 9 to 43 feet. The last soil feature is a gray, soft, and very wet sand that was present to the total depth investigated, 50 feet.

Subsurface conditions encountered on the south side of the river consist of a surface layer of hard, dark brown gravelly clay to a depth of 3 feet. Beneath the clay is a brown, very stiff to hard clay deposit that extends to an approximate depth of 20 feet. From depths of 20 to 30 feet, the clay becomes slightly sandy and soft, and below 30 feet, the clay becomes very moist to wet. The final soil feature encountered is a tan to light brown sandy clay/clayey sand. This material was penetrated at a depth of 37 feet and is present to the total depth investigated, 40 feet. Source: 'Interim Feasibility Report and Integrated Environmental Assessment, Riverside Oxbow, Upper Trinity, Fort Worth, TX' [USACE, May 2003]

2. Mitigation Site 17. USACE has not performed investigations of this area, however, data obtained from previous investigations of the area made by Freese and Nichols, Kleinfelder, and others offers the following:

a. Overburden. Based on data obtained from monitoring well installations across the site, overburden in this area appears to be clay and clayey sands with significant lenses of sand and gravel throughout. Fifteen monitoring wells were installed at depths ranging 20 to 50 feet deep, however, only one encountered rock (see Table 3).

b. Primary Material. MW-15 encountered limestone at 35 feet below top of ground. None of the other monitoring wells installed in the area encountered rock.

c. Groundwater Levels. Ongoing groundwater studies associated with the closure of the waste water treatment plant in the Riverside Oxbow area include the monitoring of the hydraulic gradient across the wastewater treatment site. Review of this data indicates that groundwater levels across the site increase with distance from the river, indicating a perched aquifer or aquiclude.

Groundwater maps were developed from June 2003 and November 2005 data. These particular maps reflect groundwater conditions during a year with average spring precipitation (2003) and a year of drought (2005). On the June 2003 map, groundwater approximately 300 feet from the left bank of the West Fork of the Trinity River was at Elevation 482. Groundwater levels rose to Elevation 492 approximately 900 feet northwest of the river. On the November 2005 map, the effects of the drought were clearly evident. Approximately 900 feet from the river, groundwater levels had dropped ten feet to Elevation 482. New wells added approximately 3,200 feet northwest of the river indicated groundwater levels of 492.

6. GEOTECHNICAL ENGINEERING CONSIDERATIONS for PRELIMINARY DESIGN.

A. Central City.

1. **Samuels Avenue Lock and Dam.** Although subsurface investigation for the current proposed site of this structure have not been completed it is expected that the sands and gravels encountered at each of the 2 other proposed dam locations will also be encountered at the newest dam location (several hundred feet upstream of the confluence of the West Fork of the Trinity and Marine Creek). The presence of these granular soils is considered problematic since their relatively high permeability will complicate both design and construction. Locating a dam at a site with such permeable soils will require substantial measures to control seepage around, under and through the abutments. With seepage control measures in place, seepage will not be eliminated entirely, so analyses will be required during final design to assure design addresses these conditions. For cost estimating purposes it can be assumed that concrete diaphragm walls socketed into rock and extending laterally a distance of at least 100 feet at both abutments will be required for permanent seepage control.

2. **Marine Creek Low Water Dam.** Based on other borings in the general project area, it is expected that the top of rock surface will vary from one abutment to the other, and that relatively permeable soils will necessitate the use of seepage cutoffs to accommodate lateral and under seepage. Construction phasing will incorporate temporary cofferdams and dewatering methods to control the surface water and under seepage to allow foundation preparation and construction of the dam in the dry.

B. Riverside Oxbow. The available geotechnical data is minimal, but is sufficient enough to indicate that the valley storage mitigation features are feasible. Subsurface conditions indicate that required excavations for valley storage will be in clay and sand overburden and will be above the static water levels.

7. FUTURE INVESTIGATIONS and STUDIES.

A. Additional Geotechnical Investigations. Investigations performed to date are considered to be feasibility level only, so additional investigations will be required to support final design and preparation of plans and specifications for all project features. It is expected that extensive investigations will be required for the Samuels Avenue Lock and Dam, the Marine Creek Low Water Dam, the low water dam in the Riverside Oxbow, and all three isolation gates. All future subsurface investigations and laboratory investigation undertaken for this project will be performed in accordance with the USACE standards. All laboratories utilized for geotechnical testing for this study will be certified in accordance with requirements made in ER 110-1-261, “Quality Assurance of Laboratory Testing Procedures”.

B. Design Requirements. The development of the designs will be in accordance with USACE standards. Specifically, all design work to be performed in completion of this study, including underseepage and stability analyses, and assessment of dewatering requirements

for construction purposes, will be performed in accordance with requirements made in the Southwest Division AEIM and the Department of the Army engineering manuals and regulations. Other engineering manuals and engineering regulations cited in the AEIM or these standards are incorporated by reference. Copies of these manuals may be downloaded from the following websites:

- http://www.usace.army.mil/inet/usace-docs/
- http://www.army.mil/usapa/eng/

9. REFERENCES.

The following references were used in the development of the geotechnical design for this Supplemental Draft Environmental Impact Statement.

CDM [April 2006]. 'Draft Environmental Impact Statement, Appendix B: Initial Geotechnical Investigation for the Preliminary Design of the Fort Worth Central City Project'

Geology of Tarrant County [circa 1919], UT Austin Bulletin No. 1931

Sellards, et al [1932]. The Geology of Texas., Bureau of Economic Geology, University of Texas Bulletin No. 3232

USACE [June 1987]. 'Special Project Report, Tony's Creek and Marine Creek, Tarrant County, TX'

USACE [May 2003]. 'Interim Feasibility Report and Integrated Environmental Assessment, Riverside Oxbow, Upper Trinity, Fort Worth, TX'

http://www.hazmap.nctcog.org/risk_assessment/Chapter8.asp