EXHIBIT C – GEOTECHNICAL REPORTS

DISCLAIMER OF LIABILITY

The Owner and Architect/Engineer disclaim any responsibility for the accuracy, true location and extent of the soils investigation that has been prepared by others. They further disclaim responsibility for interpretation of that data by Bidders. Report of the soils investigation is bound in this project manual for the Bidders’ convenience only and IS NOT AND SHALL NOT CONSTITUTE PART OF THE BIDDING AND CONTRACT DOCUMENTS.
February 14, 2018

Huitt-Zollars, Inc.
1001 Fannin Street, Suite 4040
Houston, Texas 77002

Attn: Chris Casey, AIA. LEED AP, Vice President

Ref: Addendum No. 2 to Report of Geotechnical Consulting Services
Cedar Hill State Park Redevelopment
Comfort Station and Recreation Hall Buildings
Cedar Hill, Dallas County, Texas
TWE Project No. 17.13.182

Dear Mr. Casey,

This report addendum references the geotechnical report dated January 31, 2018 and follows project discussions with Huitt-Zollars and Concept Engineers on February 13, 2018.

This Addendum No. 2 document supersedes previous recommendations presented in the Report Addendum dated February 5, 2018.

In response to the concern regarding the soil potential vertical rise (PVR), laboratory one-dimensional swell tests were performed on selected soil specimens from borings located at the proposed recreation hall and comfort stations.

Shrink/swell behavior is typically considered to be limited to the upper zone of seasonal moisture change within the various soil formations. For the project site, we considered a zone of seasonal moisture change of 10 feet below existing grade. Maximum soil swell values of 1% are considered appropriate for design of shallow foundations without the need to perform soil improvement or moisture conditioning of the bearing soils.

The laboratory swell test results indicate soil swell values as follows:

<table>
<thead>
<tr>
<th>Soil Boring Location</th>
<th>Swell Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-3 (comfort station)</td>
<td>4.4%</td>
</tr>
<tr>
<td>B-10 (comfort station)</td>
<td>1.8%</td>
</tr>
<tr>
<td>B-13 (comfort station)</td>
<td>1.2%</td>
</tr>
</tbody>
</table>
**Boring B-3** represents the subgrade conditions at one of the proposed **comfort station building**. The subgrade swell value is 4.4% which will require undercut and replacement of the natural clay subgrade to a **depth of 7 feet** and extending 5 feet laterally beyond the building footprint.

**Boring B-10** represents the subgrade conditions at another one of the proposed **comfort station buildings**. The subgrade swell value is 1.8% which will require undercut and replacement of the natural clay subgrade to a **depth of 4 feet** and extending 5 feet laterally beyond the building footprints.

**Boring B-13** represents the subgrade conditions at the proposed **recreation hall building**. The subgrade swell value is 1.2% which will require undercut and replacement of the natural subgrade to a **depth of 2 feet** and extending 5 feet laterally beyond the building footprints.

To summarize our recommendations above, there needs to be a minimum of 7, 4 and 2 feet of compacted select fill, placed beneath the entire shallow foundation bases at buildings corresponding to Borings B-3, B-10 and B-13, respectively. Sloping ground condition means that the required undercut depths could vary beneath the building footprint(s).

The above recommendations should result in a PVR value of 1 inch or less for conventionally reinforced shallow foundations and grade slabs as recommended in Sections 6.4 and 6.5 of the January 31, 2108 geotechnical report. Total settlements beneath building footprints are estimated at one inch or less. Differential settlements between adjacent columns are estimated at one-half inch or less.

Replacement soils should consist of select fill as recommended in Section 6.3 of the geotechnical report dated January 31, 2018. The fill should be placed and compacted in lifts as recommended in Section 6.3.

If you have any questions regarding this Addendum No. 2 or if we can be of further assistance, please contact our office.

Sincerely,

**TOLUNAY-WONG ENGINEERS, INC.**
TBPE Firm Registration No. F-124

[Signature]

David Barreiro, P.E.
Senior Manager
REPORT OF GEOTECHNICAL CONSULTING SERVICES
Texas Parks and Wildlife Department
Cedar Hill State Park Flood Repairs
Comfort Stations, Recreation Hall, Utilities and Pavements
Cedar Hill, Dallas County, Texas

Prepared for:
Huitz-Zollars, Inc.
1500 S. Dairy Ashford Road, Suite 200
Houston, Texas 77077

Prepared by:
Tolunay-Wong Engineers, Inc.
10710 S. Sam Houston Pkwy W., Suite 100
Houston, Texas 77031

January 31, 2018

TWE Project No. 17.13.182
January 31, 2018

Huitt-Zollars, Inc.
1500 S. Dairy Ashford Road, Suite 200
Houston, Texas 77077

Attn: Chris M. Casey, AIA. LEED AP, Vice President

Ref: Report of Geotechnical Consulting Services
Texas Parks and Wildlife Department
Cedar Hill State Park Flood Repairs
Comfort Stations, Recreation Hall, Utilities and Pavements
Cedar Hill, Dallas County, Texas
TWE Project No. 17.13.182
HZ Project No. R302179.02

Dear Mr. Casey,

Tolunay-Wong Engineers, Inc. (TWE) is pleased to submit this geotechnical report for the referenced project. This report summarizes the field and laboratory testing programs and presents foundation design and construction recommendations for the proposed comfort stations, recreation hall, utilities and pavements on the project site.

We appreciate the opportunity to work with you on this phase of the project and we look forward to the opportunity of providing additional services as the project progresses. If you have any questions regarding this report or if we can be of further assistance, please contact us.

Sincerely,

TOLUNAY-WONG ENGINEERS, INC.
TBPE Firm Registration No. F-000124

[Signatures]

David Barreiro, P.E.
Senior Geotechnical Manager

Mariam H. Abedelwahab, E.I.T.
Staff Engineer

[Stamp]
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<th>Description</th>
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<td>Soil Boring Location Plan</td>
</tr>
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<td>Appendix B</td>
<td>Boring Logs and Key to Symbols and Terms</td>
</tr>
</tbody>
</table>
1. INTRODUCTION AND PROJECT DESCRIPTION

Huit-Zollars, Inc. (HZ) contracted Tolunay-Wong Engineers (TWE) to perform a geotechnical study for the Cedar Hill State Park Flood Repairs Project at the Cedar Hill State Park grounds located between Belt Line Road and Joe Pool Lake in Cedar Hill, Dallas County, Texas.

The geotechnical study was conducted in accordance with TWE Proposal No. P16-G177 (Revision 2) dated November 28, 2017 and was authorized via Supplement No. 1 to the Subconsultant Agreement dated March 1, 2017 between HZ and TWE. Project information was provided by HZ via email transmittals.

Project Description

HZ initially provided TWE project details via e-mail transmittals dated August 15 and 31, 2016. Updated project information including a preliminary boring exhibit was provided by HZ on November 27, 2017. The structural engineer for the project is Concept Engineers in Houston, Texas.

The project includes installation of a gravity sewer system, water utilities and asphalt pavement construction at the parking lots that sustained damage. Comfort stations and a recreation hall are also planned to be constructed within the project site.

The structural engineer has indicated concern with potential shallow foundation PVM (potential vertical movement) understanding that future flood events could occur at the Park. The use of drilled, underreamed piers should be considered as an alternative foundation system for the proposed new buildings.

We understand the project includes three structural steel buildings; two are comfort stations and the third one is recreational hall. The column dead loads for the recreational hall are anticipated at approximately 50 kips. The comfort stations have column dead loads of approximately 20 Kips. Base moment loadings will be associated with wind loads. The recreational hall building is located on sloping ground. One side of the building slopes as much as 7 feet below the other side.
2. PURPOSE AND SCOPE OF SERVICES

The purpose of the geotechnical study was to explore the soil and groundwater conditions at the project site and to provide geotechnical design and construction recommendations.

The scope of services included the following:

1. Field exploration program utilizing fourteen (14) soil test borings (B-1 to B-13, B-15) advanced to depths of 5 to 20 feet below ground surface to evaluate the subsurface soil and groundwater conditions.

2. Laboratory soil tests on recovered soil samples to evaluate the index and strength properties.

3. Geotechnical report deliverable summarizing the findings and providing technically-sound and cost-effective foundation design and construction recommendations.

The authorized scope of services did not include either an environmental site assessment or a geological fault study.
3. FIELD EXPLORATION

3.1 Subsurface Exploration

The field program was started on January 2 and completed on January 3, 2018. The approximate boring locations are shown on the appended Soil Boring Location Plan.

3.2 Drilling Methods

The field exploration was conducted using a geotechnical drilling rig equipped with a rotary head. The boreholes were advanced in accordance with ASTM Standards using dry-auger drilling methods to the boring termination depths of 5 to 20 feet below ground surface. Upon completion of the soil sampling activities and groundwater level measurements, the boreholes were backfilled with soil cuttings to ground surface.

3.3 Soil Sampling

Continuous soil sampling was conducted in the upper 12 feet of the boreholes and at 5-feet depth intervals thereafter. Disturbed and undisturbed soil sampling was performed in accordance with the applicable ASTM Standards. Undisturbed soil samples were recovered using thin-walled Shelby tube samplers. Disturbed samples were recovered using standard penetration test (SPT) split-spoon samplers. Soil specimens were preserved in the field and transported to the TWE geotechnical laboratory in accordance with ASTM Standards.

Recovered samples were not examined, either visually or analytically, for chemical composition or environmental hazards. The TWE geotechnician visually classified the recovered soils in the field, and obtained strength measurements of recovered undisturbed samples using pocket penetrometer equipment. The SPT N-value, in blows per foot, is the total number of blows required to drive the sampler the second and third 6-inch increments. The N-value provides an indication of in-place soil strength, relative density and consistency.

3.4 Boring Logs

The engineering interpretations of the subsurface findings at the test locations are presented in the appended boring logs. The soil classifications were developed in accordance with ASTM Standards and published correlations. The transitions between various soil strata could actually occur gradually. Actual subsurface soil conditions could vary away from the test boring locations. When reviewing the boring logs reference should be made to the appended Key to Symbols and Terms.
3.5 Groundwater Level Measurements

The soil test borings were dry-augered to the boring termination depths to evaluate the presence of perched groundwater or free-water conditions. The groundwater level was not observed in the borings either during drilling or shortly after completion of drilling. Fluctuations of the groundwater level on this project may be expected to occur seasonally as a result of rainfall, surface runoff and immediate area construction activities.
4. LABORATORY TESTING PROGRAM

Laboratory tests were conducted on selected soil samples to assist with the classification of the recovered soil specimens, and to evaluate the soil index and strength properties. Laboratory tests were performed in general accordance with ASTM Standards. Brief descriptions of the laboratory tests performed are presented in Table 4-1. Results of the laboratory testing are presented in the appended boring logs.

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Soils Finer than No. 200 Sieve</td>
<td>ASTM D 1140</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>ASTM D 2216</td>
</tr>
<tr>
<td>Unit Weight</td>
<td>ASTM D 7263</td>
</tr>
<tr>
<td>Liquid Limit, Plastic Limit and Plasticity Index</td>
<td>ASTM D 4318</td>
</tr>
<tr>
<td>One-Dimensional Swell</td>
<td>ASTM D 4546</td>
</tr>
<tr>
<td>Unconfined Compressive Strength</td>
<td>ASTM D 2166</td>
</tr>
</tbody>
</table>
5. SUBSURFACE CONDITIONS

Interpretations of soil and groundwater conditions at the project site are partly based on information obtained from the soil test borings. Subsurface conditions could vary away from the exploration test sites. Significant subsurface variations that could be identified during the construction-phase of the project will warrant revisiting the engineering analyses and recommendations.

5.1 Regional Geology

The site is located in an area identified with the Eagle Ford Formation. Eagle Ford Formation is primarily north of Hill Country and includes shale, sandstone and limestone. The formation has a thickness of 200 to 300 feet.

5.2 Subsurface Conditions

The appended boring logs should be reviewed for the field and laboratory test results. The generalized subsurface soil conditions are summarized in Table 5-1.

<table>
<thead>
<tr>
<th>Location</th>
<th>Boring</th>
<th>Depth (feet)</th>
<th>Soil Type Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking Lots near Comfort Stations #6, #7 and #9</td>
<td>B-1, B-2, B-4, B-5, B-6, B-7, B-8, B-9</td>
<td>0 to 5</td>
<td>Firm to hard, fat Clay [fill in some borings in upper 2 to 5 ft] [fill intermixed with sand and gravel]</td>
</tr>
<tr>
<td>Comfort Stations #7, #10 and #11</td>
<td>B-3, B-10, B-11</td>
<td>0 to 20</td>
<td>Stiff to hard fat Clay [possible fill at B-10]</td>
</tr>
<tr>
<td>Parking Lot south of Recreation Hall</td>
<td>B-15</td>
<td>0 to 2</td>
<td>Very stiff, fat Clay</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 to 5</td>
<td>Very stiff to hard, sandy lean Clay</td>
</tr>
<tr>
<td>Recreation Hall</td>
<td>B-12</td>
<td>0 to 3</td>
<td>Firm, sandy lean Clay [intermixed with sand and siltstone]</td>
</tr>
<tr>
<td></td>
<td>B-13</td>
<td>0 to 4</td>
<td>Very stiff to hard, fat Clay</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 to 6</td>
<td>Medium dense, clayey Silt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 to 20</td>
<td>Very stiff to hard, lean and fat Clay</td>
</tr>
</tbody>
</table>

Note:
1) B-14 was removed from program.
2) Hard siltstone with intermixed clay was encountered at B-12 resulting in borehole refusal depth of 3 ft.
3) The groundwater was not observed either during drilling or shortly after completion of drilling.
6. RECOMMENDATIONS

The recommendations provided below are based on the project information described herein, the available subsurface data, our engineering evaluation and our experience. If project information or design concepts change, we should be advised of these changes in writing and should be provided with an opportunity to review our recommendations as presented in this report in light of the new design information.

6.1 Geotechnical Site Preparation

Establish locations of existing underground utility and service lines/conduits within the project parcel. Provisions should be made to relocate interfering utilities to appropriate locations.

*It should be noted that (1) if abandoned buried pipes are not properly removed or plugged, they could serve as conduits for subsurface soil raveling which may subsequently lead to excessive settlement of the overlying shallow foundations and pavements, and (2) the performance of active service lines or structures could be compromised by the additional loads and deflections associated with the overlying shallow foundations.*

1. All site vegetation, major roots systems, topsoil, vegetation cover, deleterious materials, concrete slabs, abandoned underground structures/foundation systems and abandoned buried pipelines/conduits should be removed in their entirety from beneath the project areas scheduled for new construction. Site clearing activities should extend 5 feet beyond the new building and pavement perimeters.

2. Following site clearing operations the condition of the exposed subgrades should be observed and documented by the geotechnical engineer or his qualified representative to determine suitability for the proposed construction.

3. Exposed subgrade soils beneath proposed building footprints and pavement areas should be proofrolled with a pneumatic tire roller, or fully loaded tandem-axle dump truck or similar equipment with a minimum weight of 15 tons under observation by the geotechnical engineer or his qualified representative. No less than two complete coverages should be completed, with alternating perpendicular directions, of the proofroll equipment operating at a travel speed of no more than 3 mph. Any ground areas that either deflect, rut or pump under the traffic of the proofroll equipment should be properly mitigated at the direction of the geotechnical engineer. A typical mitigation action would be to over excavate and replace with suitable material.

4. The project areas should be graded to promote positive drainage away from the construction areas.

5. Fill placement operations for general site grading and building pad construction, as appropriate, should be started following proofrolling.
6.1.1 Site Preparation for Conventional Shallow Foundations

At the time of this report preparation the results of laboratory swell tests on shallow clays were not available. If the swell tests indicate soil swell values in excess of 1%, then the clay subgrade will need to be improved directly beneath shallow foundation bearing footprints. If the soil swell values are less than 1%, then the clay subgrade will not require improvement for shallow foundation support.

If required, a practical soil improvement program, to mitigate the risk of shrink-swell foundation issues, would be to undercut the lay subgrade to a specified depth and replaced with compacted, low-plasticity soils as per the recommendations in Section 6.3 of this report. Such improvement would be required beneath the entire building footprints and extending laterally 3 feet beyond the building footprint perimeters.

The depth of subgrade improvement will depend on the results of the laboratory soil swell tests. Appropriate recommendations, including the option of drilled, underreamed footings, will be provided in an Addendum to this report.

6.2 Stormwater Runoff and Surface Water Control

We recommend positive drainage measures be established and maintained on the project parcel during construction and throughout the life of the project. Exterior site grades should be constructed to result in stormwater runoff flow away from the structure exteriors, both during and after construction. Roof runoff should be directed to collect systems designed to discharge at least 10 feet away from the foundation areas or onto pavement areas graded away from the building footprints(s).

6.3 Fill Soils

Fill soils for general site grading, undercut replacements, utility backfill, pavement subgrade construction, foundation bearing support and building pad construction should consist of low-plasticity, clayey sands (SC) or lean clays (CL).

1. Fill soils should be free of organics, debris and deleterious materials. In general, suitable fill soils should have a liquid limit (LL) of less than 40, a plasticity index (PI) between 10 and 20, and no more than 35% of the soil particles passing the No. 200 sieve.

2. The full depth of each lift of fill soil should be compacted to 95% of the Standard Proctor maximum dry density (ASTM D-698).

3. Fill soils should be placed with horizontal loose lift thicknesses of not more than 6 inches. To facilitate obtaining in-place compaction, the moisture content of the fill soils should be maintained within 3% of the optimum moisture content based on ASTM D-698.
4. Fill compaction efforts should be implemented with a surface roller of appropriate size.

5. Representative samples of the fill soils should be collected for classification and compaction testing. The maximum dry density, optimum moisture content, gradation and plasticity should be determined. These tests are needed for quality control of the compacted fill.

6. Field density tests should be performed on the compacted fill at a frequency of one test for each 2,500 square feet of building pad area fill per lift of fill, one test at each shallow foundation location per lift of fill, and one test every 100 linear feet on alternating roadway lanes per lift of fill.

7. Involvement of TWE geotechnical engineering personnel during all site work activities will help to verify that procedures and results are as specified and as anticipated. Any issues identified during this process should be addressed by the geotechnical engineer in the field.

6.4 Conventional Shallow Foundations

Following completion of any required geotechnical site preparation work (see Section 6.1.1), conventional shallow foundations could be used for support of the new building(s) on this project. Foundation loads should be transferred directly and continuously to the prepared bearing soils.

1. Shallow foundation systems should consist of either one or a combination of individual column spread footings, wall footings, grade beams, grade slabs and monolithic grade slabs.

2. Shallow foundation systems should be designed for a maximum allowable ground contact pressure of 4,000 psf with a minimum depth of embedment of 36 inches below adjacent exterior finished grades. This will provide a factor of safety of 3.0 against a bearing capacity failure.

   Except at soil boing B-10 (Proposed Comfort Station #10). A maximum allowable ground contact pressure of 2,000 psf with a minimum depth of embedment of 36 inches below adjacent exterior finished graded with factor of safety of 3.0 should be designed for soil boring B-10. The designer could consider a factor of safety of 2.0 at the comfort stations.

3. A minimum thickness of 6 inches of compacted fill (as specified in Section 6.3) should be provided below the shallow foundation bases (footings and grade beams) and extending a minimum of 12 inches laterally beyond the foundation perimeters.

4. Individual column and wall footings should be sized with minimum widths of 24 inches and 18 inches, respectively.

5. Shallow foundations should be designed to resist uplift (hydrostatic) loads via a combination of foundation concrete dead weight, superstructure dead weight and buoyant weight of fill soils placed directly above the foundation.
6. If unusual or questionable soil bearing conditions are encountered while performing excavations, the geotechnical engineer should be contacted for appropriate recommendations.

7. Foundations excavation bottoms should be level or suitably benched, and free of any loose soils that have been disturbed by seepage or the construction process. Loosened bearing soils should be recompacted prior to placement of reinforcing steel. The foundation excavation bottoms should be stable under the weight of construction equipment and personnel. Remedial actions that could be needed, as directed by the geotechnical engineer, should be implemented prior to proceeding with the foundation construction work.

8. Foundation excavations should be cut to final grade and footings constructed as soon as possible to minimize potential damage to bearing soils as result of exposure to the environment.

9. Shallow foundations could be cast directly against the exposed, vertical and horizontal, excavation faces.

10. Standing surface water in the open excavations should be removed prior to foundation concrete placement.

11. Excavations within the natural site soils could be expected to remain vertical and stable while open only for short periods of time. Excavation collapse due to rainfall or other on-site activities should be repaired to design bearing level prior to reinforcing steel placement.

12. The geotechnical engineer or his qualified representative should observe all shallow foundation excavations work, document the conditions of the exposed subgrade soils within the open excavations and be involved with the field geotechnical observations during construction.

6.5 Grade Slabs

Following completion of any required geotechnical site preparation work (see Section 6.1.1), building ground floor slabs on this project should use slab-on-grade construction methods provided the recommendations presented below are implemented.

1. We recommend that a minimum of 6 inches of fill, as specified in Section 6.3 above, be placed and compacted below scheduled slab-on-grade areas to provide uniform slab support. Prepared building pad should extend a minimum of 2 feet beyond the edges of the proposed slab-on-grade.

2. Grade slabs should be designed with a long-term modulus of subgrade reaction of 75 pci considering the recommended geotechnical site preparation activities.

3. Slab-on-grade loads should be transferred directly and continuously to the prepared fill pad.

4. Standing surface water should be removed prior to slab-on-grade concrete placement.
5. Construction joints should be provided throughout the slab so as to minimize the potential for slab cracking.

6. Involvement of the project geotechnical or his qualified representative during slab-on-grade construction activities will help to verify that procedures and results are as specified and as anticipated.
7. UTILITY LINES CONSTRUCTION RECOMMENDATIONS

It is anticipated that the maximum invert depths for the site utilities to be approximately 5 feet below existing site grades. It is noted that the recommendations are based on an assessment of the observed subsurface conditions at the widely spaced borings. The soil stratigraphy and groundwater conditions encountered during the excavation may vary from those observed in the borings. Excavations and construction dewatering are the responsibility of the contractor. The contractor should collect additional subsurface information, as deemed necessary, to determine if the existing conditions are representative of those described in this report.

7.1 Groundwater Control

Water seepage or surface runoff infiltration in open excavation in clayey subgrades can typically be handled by pumping from sumps. The groundwater level should be maintained a minimum of 24 inches below the pipe bedding depth during construction. The conditions of the pipe bearing surfaces should be carefully monitored during construction to check for possible bottom heave or other instabilities. Undercutting may be employed to achieve competent bearing conditions. Excavation and construction dewatering are the responsibility of the contractor. The contractor should collect additional subsurface information, as deemed necessary, to determine if the existing condition are representative of those describes in this report.

7.2 OSHA Trench Excavation

OSHA regulations do not apply to excavations shallower than 4 feet. Based on the boring findings shallow excavations should not be expected to remain vertical and stable below the perched groundwater level.

We recommend that deeper excavations use trench box construction methods or follow OSHA regulations for maximum allowable slopes. Excavated materials should not be stockpiled at the top of the excavation slopes within a horizontal distance equal to the excavation depth. Construction equipment working near the trench could result in excessive surcharge loads.

OSHA categorizes soil and rock deposits into four types, A through D. The upper 10 feet of the subsurface soils at this project site would be classified as Type C soils. Type C soils include cohesive soils with an unconfined compressive strength of 0.5 tons per square foot or less. This classification also includes granular soils such as gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable. The OSHA maximum side slope for a Type C soil is 1.5:1 (H: V). Flatter slopes will be appropriate in the presence of groundwater seepage on the excavation slopes.
7.3 Utility Bedding and Backfill Criteria

The in-place total unit weight of the backfill material will vary depending on the actual material type, degree of saturation and the level of compaction. The submerged (buoyant) unit weight of soils would be considered for hydrostatic uplift analyses.

The magnitudes of buoyancy forces on the pipelines will be directly related to the groundwater depth along the alignments. The soil test borings (B-1 to B-13, B-15) did not encounter groundwater within the upper 5 to 20 feet of the subsurface profile.

The following recommendations comply with the North Central Texas Council of Governments (NCTCOG) Public Works Construction Standards.

7.3.1 Fill Compaction

The method of compaction is the contractor’s responsibility. The backfill material should be compacted in a manner that does not crack, crush and/or cause the installed pipe to be moved from the established grade and/or alignment. The backfill moisture content during compaction should be at not less than 2% below nor more than 4% above the optimum moisture content of the material. The backfill material should be placed using 6 to 10-inch loose lifts. In-place density testing and moisture content testing should be performed every 100 linear feet on every lift of compacted backfill material.

**Trench Areas Not Subjected to or Influenced By Vehicular Traffic:** Backfill material specifications requirements for trench excavations not influenced by vehicular traffic are as follows:

1. Trench backfill shall be placed and compacted in layers not more than 10 inches loose depth.

2. Compacted to at least 90% of Standard Proctor maximum dry density (ASTM D698).

**Trench Areas Subjected to or Influenced By Vehicular Traffic:** Backfill material specifications requirements for trench excavations influenced by vehicular traffic are as follows:

1. Trench backfill shall be placed and compacted in layers not more than 6 inches loose depth.

2. Compacted to at least 95% of Standard Proctor maximum dry density (ASTM D698).
8. PAVEMENT RECOMMENDATIONS

The performance of flexible pavements is highly dependent on subgrade preparation. Recommendations for pavement subgrade preparation including stripping, proofrolling, subgrade stabilization and fill placement are presented below.

8.1 Subgrade Preparation

Borings B-1, B-2, B-5, B-7, B-8, B-9 and B-10 encountered competent subgrade (fill) soils, consisting of fat clays with sand and gravel content, from ground surface to depths of no less than 2 feet. For this report we assumed that the new roadways are planned with finished elevations no higher than approximately 12 inches above the existing site grades.

Lime stabilization of the upper 6 inches of the exposed subgrades, prior to roadway embankment fill placement, could be considered as a construction-phase option to mitigate construction delays due to inclement weather and increase the modulus of subgrade reaction and thus the pavement life.

For planning purposes, a lime content of 6% by dry weight, should be considered and then later verified in the geotechnical laboratory by trial. TxDOT Item 260 and 263, Lime Treatment addresses lime stabilization. The lime stabilized layer should be compacted to 95% Standard Proctor (ASTM D 698) maximum dry density.

8.2 Fill Placement for Roadway Subgrades

Fill material, placement and compaction recommendations are presented in Section 6.3 of this report.

8.3 Flexible (Asphalt) Pavement Recommendations

Following the recommended subgrade preparation, the parking areas should consist of a minimum 1.5 inches of surface (wearing) course, on 6 inches of compacted base course, on 12 inches of improved subgrade.

Following the recommended subgrade preparation, the light-duty driveway areas should consist of a minimum 2 inches of surface (wearing) course, on 8 inches of compacted base course, on 12 inches of improved subgrade.

Surface Course: The surface course should be hot-mix asphaltic concrete (HMAC) pavement conforming to TxDOT Standard Specifications, Item No. 334. The surface course should provide a minimum Hveem stability value of 40 when tested in accordance with TxDOT Test Method Tex-208-F, and should be compacted at 94 to 98% of the theoretical density as determined from the asphaltic mixture design prepared in accordance with TxDOT Test Method Tex-227-F (Theoretical Maximum Specific Gravity of Bituminous Mixtures).
**Base Course:** The base course should conform to TxDOT Standard Specifications, Item No. 247, Flexible Base. Type A, B, or C, Grade 1 crushed limestone or crushed concrete can be used as base course. The base course materials should be placed using 6-inch loose lifts and be compacted to 95% of Modified Proctor (ASTM D-1557) maximum dry density.

Select fill (SC or CL) as recommended under Section 6.3 of this report could be used for base course construction. In that case, the thickness of the base course should be 8 inches and 10 inches for parking and light-duty driveway areas, respectively. The select fill should be placed using 6-inch loose lifts and be compacted to 95% of Standard Proctor (ASTM D-698) maximum dry density.

**Improved Subgrade:** Improved subgrade is defined as fill material that is placed and compacted in accordance with the recommendations presented under Section 6.3 of this report.

### 8.4 Pavement Maintenance

Surface water infiltration into the subgrade soils can cause early pavement failures. Periodic maintenance should be scheduled to seal surface cracks.
9. LIMITATIONS and PLAN REVIEW

9.1 Limitations

This report has been prepared for the use of Huitt-Zollars, Inc. and other members of the construction teams for specific application to the project discussed herein. This report was prepared in accordance with generally accepted geotechnical engineering practices common to the local area. No other warranty is expressed or implied.

We request the opportunity to revisit and supplement, as necessary, our recommendations as provided in this report, if in fact our assumptions or understandings are incorrect or inaccurate. In such a case, we should be provided with appropriate foundation plans and sections, and system installation procedures for our review and use.

The engineering analyses and recommendations are based on the field and laboratory soil data summarized in the appended documents. The subsurface findings at the field exploration location may not necessarily reflect the actual soil strata vertical and horizontal variations throughout the project area. The analyses and recommendations are also based in part on the geotechnical engineer’s engineering judgment and experience with similar project settings and conditions.

TWE recommendations presented in this report must be revisited if subsurface conditions exposed during construction vary significantly from those described in this report. If any changes in the nature, design or location of the project are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed, and the conclusions modified or verified in writing by TWE.

9.2 Plan Review and Construction Monitoring

TWE should be provided the opportunity to review the foundation design and construction drawings to determine if those documents are in harmony with the intent of the geotechnical design and construction recommendations contained in this report.

TWE should be provided the opportunity to observe and document the field conditions of exposed subgrade soils, geotechnical site preparation activities, placement and compaction of backfill soils and general foundation and pavement construction activities.
APPENDIX A

SOIL BORING LOCATION PLAN
APPENDIX B

BORING LOGS and KEY to SYMBOLS and TERMS
### LOG OF BORING B-1

**PROJECT:** Cedar Hill State Park Redevelopment  
Cedar Hill, Texas  

**CLIENT:** Huit-Zollars, Inc.  
Houston, Texas  

**COORDINATES:** N 6916604.14  
E 2436309.89  

**SURFACE ELEVATION:** -  

**DRILLING METHOD:**  
- Dry Augered: 0 to 5'
- Wash Bored: - to -

**DEPTHS (FT):**

<table>
<thead>
<tr>
<th>DEPTH (FT)</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>Stiff, brown FAT CLAY with SAND (CH) with gravel (possible fill upper 5')</td>
</tr>
<tr>
<td>5</td>
<td>Bottom @ 5'</td>
</tr>
</tbody>
</table>

**MOISTURE CONTENT (%):**

<table>
<thead>
<tr>
<th>MOISTURE CONTENT (%)</th>
<th>DRY UNIT WEIGHT (pcf)</th>
<th>LIQUID LIMIT (%)</th>
<th>PLASTICITY INDEX (%)</th>
<th>COMPRESSION STRENGTH (tsf)</th>
<th>FAILURE STRAIN (%)</th>
<th>CONFINING PRESSURE (psi)</th>
<th>PASSING #200 SIEVE (%)</th>
<th>OTHER TESTS PERFORMED</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>97</td>
<td>72</td>
<td>48</td>
<td>3.39</td>
<td>6</td>
<td>83</td>
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</table>

**NOTES:**

1. Free water was not encountered at time of dry-auger drilling.
2. Open borehole was filled up to the surface with soil cuttings upon completion.

**COMPLETION DEPTH:** 5 ft

**DATE BORING STARTED:** 01/02/18

**DATE BORING COMPLETED:** 01/02/18

**LOGGER:** C. Marlowe

**PROJECT NO.:** 17.13.182

---

TOLUNAY-WONG ENGINEERS, INC.  
Page 1 of 1
## Log of Boring B-2

**Project:** Cedar Hill State Park Redevelopment  
**Location:** Cedar Hill, Texas  
**Client:** Huitt-Zollars, Inc.  
**Location:** Houston, Texas

<table>
<thead>
<tr>
<th>Coordinates</th>
<th>Surface Elevation</th>
<th>Drilling Method</th>
<th>Depth (ft)</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>N 6916479.12 E 2436408.97</td>
<td>-</td>
<td>Dry Augered: 0 to 5'</td>
<td>0</td>
<td>Stiff, brown FAT CLAY with SAND (CH) (possible fill upper 2')</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wash Bored: - to -</td>
<td>5</td>
<td>Very stiff, brown FAT CLAY (CH) -hard from 4'</td>
</tr>
<tr>
<td></td>
<td>Bottom @ 5'</td>
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</tr>
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<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Sample Symbol</th>
<th>Std. Penetration Test Blowcount</th>
<th>Moisture Content (%)</th>
<th>Liquid Limit (%)</th>
<th>Plasticity Index (%)</th>
<th>Compressive Strength (tsf)</th>
<th>Failure Strain (%)</th>
<th>Confining Pressure (psi)</th>
<th>Passing #200 Sieve (%)</th>
<th>Other Tests Performed</th>
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</table>

**Completion Depth:** 5 ft  
**Date Boring Started:** 01/02/18  
**Date Boring Completed:** 01/02/18  
**Logger:** C. Marlowe  
**Project No.:** 17.13.182  
**Notes:** 1. Free water was not encountered at time of dry-auger drilling.  
2. Open borehole was filled up to the surface with soil cuttings upon completion.

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**Tolunay-Wong Engineers, Inc.**

---

Page 1 of 1
**LOG OF BORING B-3**

**PROJECT:** Cedar Hill State Park Redevelopment  
Cedar Hill, Texas

**CLIENT:** Huitt-Zollars, Inc.  
Houston, Texas

---

| COORDINATES: | N 6918354.49  
| E 2435649.11 |

| SURFACE ELEVATION: | - |

| DRILLING METHOD: | Dry Augered: 0 to 20', Wash Bored: - to - |

---

**ELEVATION (FT)** | **DEPTH (FT)** | **SAMPLE SYMBOL** | **MATERIAL DESCRIPTION** | **MOISTURE CONTENT (%)** | **DRY UNIT WEIGHT (pcf)** | **LIQUID LIMIT (%)** | **PLASTICITY INDEX (%)** | **COMPRESSIVE STRENGTH (tsf)** | **FAILURE STRAIN (%)** |
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<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>(P)4.50</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>(P)4.50</td>
<td>-silt seams from 6' to 8'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>(P)4.50</td>
<td>-brown-gray from 8'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>(P)4.50</td>
<td>-gray from 10'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>(P)4.50</td>
<td>Bottom @ 20'</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

---

**COMPLETION DEPTH:** 20 ft

**DATE BORING STARTED:** 01/02/18

**DATE BORING COMPLETED:** 01/02/18

**LOGGER:** C. Marlowe

**PROJECT NO.:** 17.13.182

---

**NOTES:**
1. Free water was not encountered at time of dry-auger drilling.
2. Open borehole was filled up to the surface with soil cuttings upon completion.
LOG OF BORING  B-4

PROJECT: Cedar Hill State Park Redevelopment
Cedar Hill, Texas

CLIENT: Huit-Zollars, Inc.
Houston, Texas

COMPLETION DEPTH: 5 ft

DATE BORING STARTED: 01/02/18
DATE BORING COMPLETED: 01/02/18
LOGGER: C. Marlowe
PROJECT NO.: 17.13.182

<table>
<thead>
<tr>
<th>ELEVATION (FT)</th>
<th>SAMPLE TYPE</th>
<th>SYMBOL</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td>Stiff, brown FAT CLAY (CH)</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>Bottom @ 5'</td>
</tr>
</tbody>
</table>

NOTES: 1. Free water was not encountered at time of dry-auger drilling.
2. Open borehole was filled up to the surface with soil cuttings upon completion.
<table>
<thead>
<tr>
<th>ELEVATION (FT)</th>
<th>DEPTH (FT)</th>
<th>SAMPLE TYPE</th>
<th>SYMBOL</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Bottom @ 5'</td>
<td>Stiff, brown FAT CLAY (CH) mixed with gravel (possible fill upper 5')</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. Free water was not encountered at time of dry-auger drilling.
2. Open borehole was filled up to the surface with soil cuttings upon completion.
# Log of Boring B-6

**Project:** Cedar Hill State Park Redevelopment  
**Client:** Huitt-Zollars, Inc.  
**Location:** Cedar Hill, Texas  
**Houston, Texas**

**Log Details:**  
**Coordinates:** N 6915758.25  
**E 2435752.47**

**Surface Elevation:** -

**Drilling Method:**  
- Dry Augered: 0 to 5'  
- Wash Bored: - to -

**Material Description:**

<table>
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<tr>
<th>Elevation (ft)</th>
<th>Sample Symbol</th>
<th>Material Description</th>
<th>Compaction Test</th>
<th>Other Tests</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>(P)</td>
<td>Stiff, brown FAT CLAY (CH)</td>
<td>Moisture (%)</td>
<td>Failure Strain (%)</td>
</tr>
<tr>
<td></td>
<td>2.50</td>
<td>39</td>
<td>93</td>
<td>66</td>
</tr>
<tr>
<td>5</td>
<td>(P)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Completion Depth:** 5 ft

**Date Boring Started:** 01/02/18  
**Date Boring Completed:** 01/02/18  
**Logger:** C. Marlowe  
**Project No.:** 17.13.182

**Notes:**
1. Free water was not encountered at time of dry-auger drilling.
2. Open borehole was filled up to the surface with soil cuttings upon completion.
| ELEVATION (FT) | DEPTH (FT) | SAMPLE SYMBOL | MATERIAL DESCRIPTION                          | (P) POCKET PEN (tsf) | STD. PENETRATION TEST BLOWCOUNT | DRY UNIT WEIGHT (pcf) | MOISTURE CONTENT (%) | LIQUID LIMIT (%) | PLASTICITY INDEX (%) | COMPRESSIVE STRENGTH (tsf) | FAILURE STRAIN (%) | CONFINING PRESSURE (psi) | PASSING #200 SIEVE (%) | OTHER TESTS PERFORMED |
|----------------|------------|---------------|-----------------------------------------------|----------------------|------------------|------------------------------|----------------------|----------------------|-----------------|---------------------|-----------------------------|------------------|------------------|----------------------|---------------------|
| 0              | 0          |               | Firm, brown FAT CLAY (CH) (possible fill upper 4') | (P)1.25              | -                |                              |                      |                      |                 |                     |                            |                  |                  |                      |                     |
| 0              | 5          |               | - hard with sand pockets and gravel from 2'      | (P)4.50              | 29               |                              | 91                   | 65                   |                 |                     |                            |                  |                  |                      |                     |
| 5              | 5          |               | Stiff, brown FAT CLAY (CH)                       | (P)2.00              |                  |                              |                      |                      |                 |                     |                            |                  |                  |                      |                     |

**NOTES:**
1. Free water was not encountered at time of dry-auger drilling.
2. Open borehole was filled up to the surface with soil cuttings upon completion.
**LOG OF BORING B-8**

**PROJECT:** Cedar Hill State Park Redevelopment  
Cedar Hill, Texas

**CLIENT:** Huitt-Zollars, Inc.  
Houston, Texas

---

**COORDINATES:** N 6915466.32  
E 2435574.55

**SURFACE ELEVATION:** -

**DRILLING METHOD:**
- Dry Augered: 0 to 5'
- Wash Bored: - to -

**MATERIAL DESCRIPTION**

<table>
<thead>
<tr>
<th>ELEVATION (FT)</th>
<th>DEPTH (FT)</th>
<th>SAMPLE SYMBOL</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
</table>
| 0              | -          | *(P)*1.25     | Firm, brown FAT CLAY with SAND (CH)  
(possible fill upper 5') |
|                |            | *(P)*2.00     | -stiff from 2' |
|                | 5           | *(P)*4.50     | -hard from 4' |
|                | 5           |               | Bottom @ 5' |

**SAMPLE TYPE:**

- *(P)* POCKET PEN (tsf)
- *(T)* TORVANE (tsf)

**TEST RESULTS**

- MOISTURE CONTENT (%): 38
- DRY UNIT WEIGHT (pcf): 78
- LIQUID LIMIT (%): 85
- PLASTICITY INDEX (%): 52
- COMPRESSIVE STRENGTH (tsf): 0.51
- FAILURE STRAIN (%): 6
- CONFINING PRESSURE (psi): 82
- PASSING #200 SIEVE (%): 82

**COMPLETION DEPTH:** 5 ft

**DATE BORING STARTED:** 01/03/18
**DATE BORING COMPLETED:** 01/03/18
**LOGGER:** C. Marlowe
**PROJECT NO.:** 17.13.182

**NOTES:**
1. Free water was not encountered at time of dry-auger drilling.
2. Open borehole was filled up to the surface with soil cuttings upon completion.

---

**TOLUNAY-WONG ENGINEERS, INC.**

---

Page 1 of 1
<table>
<thead>
<tr>
<th>ELEVATION (FT)</th>
<th>DEPTH (FT)</th>
<th>SAMPLE TYPE</th>
<th>SYMBOL</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0</td>
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<td>Firm, brown FAT CLAY (CH)</td>
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<td>(possible fill upper 5')</td>
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<td>-very stiff from 2'</td>
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<td>-stiff from 4'</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
<td></td>
<td>Bottom @ 5'</td>
</tr>
</tbody>
</table>

**COMPLETION DEPTH:** 5 ft

**NOTES:**
1. Free water was not encountered at time of dry-auger drilling.
2. Open borehole was filled up to the surface with soil cuttings upon completion.

**COORDINATES:**
- N 6915190.73
- E 2435636.71

**SURFACE ELEVATION:** -

**DRILLING METHOD:**
- Dry Augered: 0 to 5'
- Wash Bored: - to -
# LOG OF BORING B-10

**PROJECT:** Cedar Hill State Park Redevelopment  
Cedar Hill, Texas  
**CLIENT:** Huitt-Zollars, Inc.  
Houston, Texas

**COORDINATES:**  
N 6914786.52  
E 2435655.81

**SURFACE ELEVATION:** -

**DRILLING METHOD:**  
Dry Augered: 0 to 20'  
Wash Bored: - to -

## MATERIAL DESCRIPTION

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<thead>
<tr>
<th>ELEVATION (FT)</th>
<th>DEPTH (FT)</th>
<th>SAMPLE TYPE</th>
<th>SYMBOL</th>
<th>MATERIAL DESCRIPTION</th>
<th>STD. PENETRATION TEST BLOW COUNT</th>
<th>MOISTURE CONTENT (%)</th>
<th>DRY UNIT WEIGHT (pcf)</th>
<th>LIQUID LIMIT (%)</th>
<th>PLASTICITY INDEX (%)</th>
<th>COMPRESSIVE STRENGTH (tsf)</th>
<th>FAILURE STRAIN (%)</th>
<th>CONFINING PRESSURE (psi)</th>
<th>PASSING #200 SIEVE (%)</th>
<th>OTHER TESTS PERFORMED</th>
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<td>-firm from 2'</td>
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<td>(P)1.50</td>
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<td>10</td>
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<td>-very stiff from 8'</td>
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<td>Hard, brown-gray FAT CLAY (CH)</td>
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<td>-brown-tan from 18'</td>
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</table>

**COMPLETION DEPTH:** 20 ft

**DATE BORING STARTED:** 01/03/18  
**DATE BORING COMPLETED:** 01/03/18  
**LOGGER:** C. Marlowe  
**PROJECT NO.:** 17.13.182

**NOTES:**  
1. Free water was not encountered at time of dry-auger drilling.  
2. Open borehole was filled up to the surface with soil cuttings upon completion.
## LOG OF BORING B-11

**PROJECT:** Cedar Hill State Park Redevelopment  
Cedar Hill, Texas  

**CLIENT:** Huitt-Zollars, Inc.  
Houston, Texas  

### MATERIAL DESCRIPTION

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<thead>
<tr>
<th>ELEVATION (FT)</th>
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<th>SAMPLE TYPE</th>
<th>SYMBOL</th>
<th>COORDINATES: N 6913886.37 E 2435001.13</th>
<th>SURFACE ELEVATION: -</th>
<th>DRILLING METHOD:</th>
<th>MOLAR PEN ET</th>
<th>P. PENETRATION TEST BLOWCOUNT</th>
<th>MOISTURE CONTENT (%)</th>
<th>DRY UNIT WEIGHT (psf)</th>
<th>LIQUID LIMIT (%)</th>
<th>PLASTICITY INDEX (%)</th>
<th>COMPRESSIVE STRENGTH (tsf)</th>
<th>FAILURE STRAIN (%)</th>
<th>PASSING #200 SIEVE (%)</th>
<th>OTHER TESTS PERFORMED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>-</td>
<td></td>
<td>Stiff, brown-gray FAT CLAY (CH)</td>
<td>(P)2.50</td>
<td>Dry Augered: 0 to 20'</td>
<td>(P)4.50</td>
<td>0.50</td>
<td>35</td>
<td>73</td>
<td>49</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>-</td>
<td></td>
<td>-hard from 2'</td>
<td>(P)4.50</td>
<td>Wash Bored: - to -</td>
<td>(P)4.50</td>
<td>0.50</td>
<td>35</td>
<td>73</td>
<td>49</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>-</td>
<td></td>
<td>-tan-gray with silt lenses from 6'</td>
<td>(P)4.50</td>
<td></td>
<td>(P)4.50</td>
<td>0.50</td>
<td>35</td>
<td>73</td>
<td>49</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>13</td>
<td>-</td>
<td></td>
<td>-gray from 13'</td>
<td>(P)4.50</td>
<td></td>
<td>(P)4.50</td>
<td>0.50</td>
<td>35</td>
<td>73</td>
<td>49</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>18</td>
<td>-</td>
<td></td>
<td>-dark gray from 18'</td>
<td>(P)4.50</td>
<td></td>
<td>(P)4.50</td>
<td>0.50</td>
<td>35</td>
<td>73</td>
<td>49</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottom @ 20'</td>
<td>20</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**COMPLETION DEPTH:** 20 ft  
**DATE BORING STARTED:** 01/03/18  
**DATE BORING COMPLETED:** 01/03/18  
**LOGGER:** C. Marlowe  
**PROJECT NO.:** 17.13.182  

**NOTES:**  
1. Free water was not encountered at time of dry-auger drilling.  
2. Open borehole was filled up to the surface with soil cuttings upon completion.
**LOG OF BORING B-12**

**PROJECT:** Cedar Hill State Park Redevelopment  
Cedar Hill, Texas

**CLIENT:** Huitz-Zollars, Inc.  
Houston, Texas

<table>
<thead>
<tr>
<th>ELEVATION (FT)</th>
<th>DEPTH (FT)</th>
<th>SAMPLE SYMBOL</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td></td>
<td>Firm, brown SANDY LEAN CLAY (CL) with organics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- intermixed with sand from 1'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- with siltstone fragments from 2'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- auger refusal at 3'</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td>Bottom @ 3'</td>
</tr>
</tbody>
</table>

**COORDINATES:**  
N 6913742.18  
E 2433718.56

**SURFACE ELEVATION:** -

**DRILLING METHOD:**  
Dry Augered: 0 to 3'  
Wash Bored: - to -

**COMPLETION DEPTH:** 3 ft

**DATE BORING STARTED:** 01/03/18

**DATE BORING COMPLETED:** 01/03/18

**LOGGER:** C. Marlowe

**PROJECT NO.:** 17.13.182

**NOTES:**  
1. Free water was not encountered at time of hand-auger drilling.  
2. Open borehole was filled up to the surface with soil cuttings upon completion.  
3. Refusal to advance at 3-ft.
# LOG OF BORING B-13

**PROJECT:** Cedar Hill State Park Redevelopment  
Cedar Hill, Texas  

**CLIENT:** Huit-Zollars, Inc.  
Houston, Texas  

**COORDINATES:**  
N 6913657.46  
E 2433755.77  

**SURFACE ELEVATION:**  

**DRILLING METHOD:**  
Dry Augered: 0 to 20'
Wash Bored: - to -

**MATERIAL DESCRIPTION**

<table>
<thead>
<tr>
<th>ELEVATION (FT)</th>
<th>DEPTH (FT)</th>
<th>SYMBOL</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td></td>
<td>Very stiff, brown FAT CLAY (CH)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-with sand seams</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-hard, brown-gray from 2'</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
<td>Medium dense, tan CLAYEY SILT (ML)</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td></td>
<td>Very stiff, tan LEAN CLAY (CL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-with silt seams</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-hard, tan-light gray from 10'</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td></td>
<td>Very stiff, tan-light gray SILTY CLAY (CL-ML)</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td></td>
<td>Very stiff, tan FAT CLAY (CH)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bottom @ 20'</td>
</tr>
</tbody>
</table>

**Notes:**  
1. Free water was not encountered at time of dry-auger drilling.  
2. Open borehole was filled up to the surface with soil cuttings upon completion.
**LOG OF BORING B-15**

**PROJECT:** Cedar Hill State Park Redevelopment  
Cedar Hill, Texas  

**CLIENT:** Huitt-Zollars, Inc.  
Houston, Texas  

**COORDINATES:** N 6913534.02  
E 2433439.48  

**SURFACE ELEVATION:** -  

**DRILLING METHOD:**  
- Dry Augered: 0 to 5'  
- Wash Bored: - to -  

**MATERIAL DESCRIPTION**

<table>
<thead>
<tr>
<th>ELEVATION (FT)</th>
<th>DEPTH (FT)</th>
<th>SAMPLE TYPE</th>
<th>SYMBOL</th>
<th>MATERIAL DESCRIPTION</th>
<th>STD. PENETRATION TEST BLOWCOUNTER</th>
<th>MOISTURE CONTENT (%)</th>
<th>DRY UNIT WEIGHT (pcf)</th>
<th>LIQUID LIMIT (%)</th>
<th>PLASTICITY INDEX (%)</th>
<th>COMPRESSIVE STRENGTH (tsf)</th>
<th>FAILURE STRAIN (%)</th>
<th>CONFINING PRESSURE (psi)</th>
<th>PASSING #200 SIEVE (%)</th>
<th>OTHER TESTS PERFORMED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td>(P)</td>
<td>Very stiff, tan FAT CLAY (CH)</td>
<td>4.00</td>
<td>32</td>
<td>79</td>
<td>54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>(P)</td>
<td>Very stiff to hard, tan-light gray SANDY LEAN CLAY (CL)</td>
<td>4.00</td>
<td>16</td>
<td>39</td>
<td>22</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bottom @ 5'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**COMPLETION DEPTH:** 5 ft  

**DATE BORING STARTED:** 01/03/18  
**DATE BORING COMPLETED:** 01/03/18  
**LOGGER:** C. Marlowe  
**PROJECT NO.:** 17.13.182  

**NOTES:**  
1. Free water was not encountered at time of dry-auger drilling.  
2. Open borehole was filled up to the surface with soil cuttings upon completion.
**KEY TO SYMBOLS AND TERMS USED ON BORING LOGS FOR SOIL**

<table>
<thead>
<tr>
<th>Most Common Unified Soil Classifications System Symbols</th>
<th>Sampler Symbols</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Symbol" /> Lean Clay (CL)</td>
<td><img src="image2" alt="Symbol" /></td>
<td>Pavement core</td>
</tr>
<tr>
<td><img src="image3" alt="Symbol" /> Lean Clay w/ Sand (CL)</td>
<td><img src="image4" alt="Symbol" /></td>
<td>Thin walled tube sample</td>
</tr>
<tr>
<td><img src="image5" alt="Symbol" /> Sandy Lean Clay (CL)</td>
<td><img src="image6" alt="Symbol" /></td>
<td>Standard Penetration Test (SPT)</td>
</tr>
<tr>
<td><img src="image7" alt="Symbol" /> Fat Clay (CH)</td>
<td><img src="image8" alt="Symbol" /></td>
<td>Auger sample</td>
</tr>
<tr>
<td><img src="image9" alt="Symbol" /> Fat Clay w/ Sand (CH)</td>
<td><img src="image10" alt="Symbol" /></td>
<td>Sampling attempt with no recovery</td>
</tr>
<tr>
<td><img src="image11" alt="Symbol" /> Sandy Fat Clay (CH)</td>
<td><img src="image12" alt="Symbol" /></td>
<td>TxDOT Cone Penetrometer Test</td>
</tr>
<tr>
<td><img src="image13" alt="Symbol" /> Silty Clay (CL-ML)</td>
<td><img src="image14" alt="Symbol" /></td>
<td>Field Test Data</td>
</tr>
<tr>
<td><img src="image15" alt="Symbol" /> Sandy Silty Clay (CL-ML)</td>
<td><img src="image16" alt="Symbol" /></td>
<td>2.50</td>
</tr>
<tr>
<td><img src="image17" alt="Symbol" /> Silty Clayey Sand (SC-SM)</td>
<td><img src="image18" alt="Symbol" /></td>
<td>(T)1.13</td>
</tr>
<tr>
<td><img src="image19" alt="Symbol" /> Clayey Sand (SC)</td>
<td><img src="image20" alt="Symbol" /></td>
<td>8/6&quot;</td>
</tr>
<tr>
<td><img src="image21" alt="Symbol" /> Sandy Silt (ML)</td>
<td><img src="image22" alt="Symbol" /></td>
<td>Observed free water during drilling</td>
</tr>
<tr>
<td><img src="image23" alt="Symbol" /> Silty Sand (SM)</td>
<td><img src="image24" alt="Symbol" /></td>
<td>Observed static water level</td>
</tr>
<tr>
<td><img src="image25" alt="Symbol" /> Silt w/ Sand (ML)</td>
<td><img src="image26" alt="Symbol" /></td>
<td>Laboratory Test Data</td>
</tr>
</tbody>
</table>

**Miscellaneous Materials**

- Fill
- Concrete
- Asphalt and/or Base

**RELATIVE DENSITY OF COHESIONLESS & SEMI-COHESIONLESS SOILS**

The following descriptive terms for relative density apply to cohesionless soils such as gravels, silty sands, and sands as well as semi-cohesive and semi-cohesionless soils such as sandy silts, and clayey sands.

<table>
<thead>
<tr>
<th>Relative Density</th>
<th>Typical N_{60} Value Range*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Loose</td>
<td>0-4</td>
</tr>
<tr>
<td>Loose</td>
<td>5-10</td>
</tr>
<tr>
<td>Medium Dense</td>
<td>11-30</td>
</tr>
<tr>
<td>Dense</td>
<td>31-50</td>
</tr>
<tr>
<td>Very Dense</td>
<td>Over 50</td>
</tr>
</tbody>
</table>

* N_{60} is the number of blows from a 140-lb hanging weight to break a free fall of 30-in. required to penetrate the final 12-in. of an 18-in. sample interval, corrected for field procedure to an average energy ratio of 60% (Terzaghi, Peck, and Meiri, 1966).

**CONSISTENCY OF COHESIVE SOILS**

The following descriptive terms for consistency apply to cohesive soils such as clays, sandy clays, and silty clays.

<table>
<thead>
<tr>
<th>Typical Compressive Strength (tsf)</th>
<th>Consistency</th>
<th>Typical SPT &quot;N_{60}&quot; Value Range**</th>
</tr>
</thead>
<tbody>
<tr>
<td>q_{u} &lt; 0.25</td>
<td>Very soft</td>
<td>≤ 2</td>
</tr>
<tr>
<td>0.25 ≤ q_{u} &lt; 0.50</td>
<td>Soft</td>
<td>3-4</td>
</tr>
<tr>
<td>0.50 ≤ q_{u} &lt; 1.00</td>
<td>Firm</td>
<td>5-8</td>
</tr>
<tr>
<td>1.00 ≤ q_{u} &lt; 2.00</td>
<td>Stiff</td>
<td>9-15</td>
</tr>
<tr>
<td>2.00 ≤ q_{u} &lt; 4.00</td>
<td>Very Stiff</td>
<td>16-30</td>
</tr>
<tr>
<td>q_{u} ≥ 4.00</td>
<td>Hard</td>
<td>≥ 31</td>
</tr>
</tbody>
</table>

** An "N_{60}" value of 31 or greater corresponds to a hard consistency. The correlation of consistency with a typical SPT "N_{60}" value range is approximate.
REPORT of GEOTECHNICAL CONSULTING SERVICES
Cedar Hill State Park Flood Repairs
Project Infrastructure - Box Culvert Crossings
Cedar Hill, Dallas County, Texas

Prepared for:
Huitz-Zollars, Inc.
1001 Fannin Street, Suite 4040
Houston, Texas 77002

Prepared by:
Tolunay-Wong Engineers, Inc.
10710 S. Sam Houston Pkwy W., Suite 100
Houston, Texas 77031

October 4, 2018

TWE Project No. 17.13.182
October 4, 2018

Huitt-Zollars, Inc.
1001 Fannin Street, Suite 4040
Houston, Texas 77002

Attn: Gregory R. Wine, PE, LEED AP, Senior Vice President

Ref: Report of Geotechnical Consulting Services
Cedar Hill State Park Flood Repairs
Project Infrastructure – Box Culvert Crossings
1570 West FM 1382
Cedar Hill, Dallas County, Texas
HZ Project No. R302179.02
TWE Project No. 17.13.182

Dear Mr. Wine,

Tolunay-Wong Engineers is pleased to submit this geotechnical report for the referenced project. This report summarizes the field and laboratory testing programs and presents geotechnical recommendations for the proposed project infrastructure.

We appreciate the opportunity to assist you on this phase of the project and we look forward to the opportunity to provide additional services as the project progresses. If you have any questions regarding this report or if we can be of further assistance, please contact our office.

Sincerely,

TOLUNAY-WONG ENGINEERS, INC.
TBPE Firm Registration No. F-124

Mariam Abedelwahab, E.I.T.
Geotechnical Staff Engineer

David Barreiro, P.E.
Senior Manager

10-4-2018
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TABLE and APPENDICES

TABLE

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<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-1</td>
<td>Laboratory Testing Program</td>
<td>4-1</td>
</tr>
<tr>
<td>5-1</td>
<td>Groundwater Level Measurements</td>
<td>5-1</td>
</tr>
</tbody>
</table>

APPENDICES

Appendix A: Soil Boring Location Plan

Appendix B: Boring Logs and Key to Symbols and Terms
1 INTRODUCTION

Huitt-Zollars (HZ) contracted Tolunay-Wong Engineers (TWE) to perform a geotechnical study for two box culvert bridge locations within the Cedar Hill State Park. The project site is located within Cedar Hill State Park, between Belt Line Road and Joe Pool Lake in Cedar Hill, Dallas County, Texas.

This study was performed in accordance with TWE Proposal No. P18-G135 dated June 19, 2018 and was authorized by Gregory R. Wine, P.E., LEED AP Senior Vice President via an HZ Supplement No. 2 to Subconsultant Agreement on August 2, 2018. Project information was provided to TWE by Huitt-Zollars.

1.1 Project Information

The project addressed in this report involves the design and construction of box culvert bridges, one on Loop Road “F” (Station 9+12) with foundation bearing depth of approximately 13 feet below the road centerline, and the other one on East Spine Road Station 203+90) with foundation bearing depth of over 7 feet below the road centerline.
2 PURPOSE AND SCOPE OF SERVICES

The purpose of the geotechnical exploration was to identify subsurface conditions at the project site to facilitate engineering evaluations and development of geotechnical recommendations for the proposed infrastructure.

The scope of services included the following:

1. Field exploration program using 4 soil test borings advanced to depths of 20 feet below ground surface to evaluate the subsurface soil and groundwater conditions.
2. Laboratory tests on recovered soil samples to evaluate the soil index and strength properties.
3. Geotechnical report deliverable summarizing the findings and providing technically-sound and cost-effective geotechnical design and construction recommendations.

The authorized scope of services did not include either an environmental site assessment or a geological fault study.
3 FIELD EXPLORATION PROGRAM

3.1 Subsurface Exploration

The subsurface exploration program included four soil test borings and was performed on August 29, 2018. The approximate boring locations are shown on the appended Soil Boring Location Plan. Test borings were performed close to the existing roadway pavements to avoid site clearing and steep ground slopes. Estimated ground elevations at the boring locations are indicated on the appended boring logs.

3.2 Drilling Methods

The field exploration was conducted using a truck-mounted geotechnical drilling rig. The boreholes were advanced in accordance with ASTM Standards, using dry-auger drilling methods to the termination depths of 20 feet below ground surface. Upon completion of the soil sampling activities and groundwater level measurements, the boreholes were backfilled with soil cuttings to the ground surface. Borings were logged by an experienced field geologist under the direction of a geotechnical engineer.

3.3 Soil Sampling

Continuous soil sampling was conducted in the upper 12 feet of each borehole and then at 5-feet intervals to the boring termination depths. Soil sampling was performed in general accordance with the applicable ASTM standards. The recovered soil and rock samples were initially visually classified in the field. Following visual classification and logging, soil specimens were preserved in the field and transported to the TWE geotechnical laboratory in general accordance with ASTM standards.

Undisturbed soil samples were recovered using thin-walled Shelby tube samplers. Strength measurements were obtained in the field using pocket penetrometer equipment. Recovered samples were not examined, either visually or analytically, for chemical composition or environmental hazards.

3.4 Boring Logs

The engineering interpretations of the subsurface findings at the test locations are presented in the appended boring logs. The soil classifications were developed in accordance with ASTM Standards and published correlations. The transitions between various soil and rock strata could occur gradually. Actual subsurface soil conditions could vary away from the test boring locations. When reviewing the boring logs reference should be made to the appended Keys to Symbols and Terms.
3.5 Groundwater Measurements

Groundwater level measurements were initially obtained in the open boreholes during dry auger drilling and after 30 minutes. The groundwater level measurements are summarized in Section 5.3 of this report.
4 LABORATORY TESTING PROGRAM

Laboratory tests were conducted on selected soil samples to assist with the classification of the recovered soil specimens, and to evaluate the soil index properties. Laboratory tests were performed in general accordance with ASTM Standards. The unconfined compression and shear strengths of clay specimens were also evaluated using pocket penetrometer equipment. Results of the laboratory testing are presented in the appended boring logs. Corresponding ASTM laboratory testing protocols are presented in Table 4-1.

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of Material Finer than No. 200 Sieve</td>
<td>ASTM D 1140</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>ASTM D 2216</td>
</tr>
<tr>
<td>Unit Weight</td>
<td>ASTM D 7263</td>
</tr>
<tr>
<td>Atterberg Limits</td>
<td>ASTM D 4318</td>
</tr>
<tr>
<td>Unconfined Compressive Strength</td>
<td>ASTM D 2166</td>
</tr>
</tbody>
</table>
5 SUBSURFACE CONDITIONS

Interpretations of soil and groundwater conditions at the project site are partly based on information obtained from the soil test borings and TWE local experience. Subsurface conditions could vary away from the exploration test sites. Significant subsurface variations that could be identified during the construction-phase of the project will warrant revisiting the engineering analyses and recommendations.

5.1 Regional Geology

The site is located in an area identified with the Eagle Ford formation. Eagle Ford formation is primarily north of Hill County and includes shale, sandstone and limestone. The formation has a thickness of 200 to 300 feet.

5.2 Subsurface Conditions

The appended boring logs should be reviewed for the field and laboratory test results, soil classifications and subsurface stratifications.

In general, the upper 2 to 4 feet are interpreted as possible fill soils consisting of stiff to hard sandy fat clays (CH) sometimes intermixed with limestone fragments. It is noted that it is sometimes difficult to differentiate fill from similar natural soils.

The underlying natural soil profile is composed of stiff to hard, fat and lean clays (CH, CL) with varying sand content and interlayered with soft to hard, highly weathered shale. Laterally discontinuous, loose to medium dense clayey sand (SC) layers could be present within the upper 20 feet below ground surface.

5.3 Groundwater Level Observations

Groundwater level measurements taken in the open boreholes are summarized in Table 5-2.

<table>
<thead>
<tr>
<th>Soil Boring</th>
<th>Freewater Depth (feet)</th>
<th>Groundwater Level at Time (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>Dry</td>
<td>Dry (30 minutes)</td>
</tr>
<tr>
<td>B-2</td>
<td>13</td>
<td>10 (30 minutes)</td>
</tr>
<tr>
<td>B-3</td>
<td>Dry</td>
<td>Dry (30 minutes)</td>
</tr>
<tr>
<td>B-4</td>
<td>Dry</td>
<td>Dry (30 minutes)</td>
</tr>
</tbody>
</table>
Short-term groundwater level measurements in the open boreholes may not accurately reflect the stabilized groundwater condition due to caving and time dependent recharge in primarily clay soil profiles. Where appropriate, standpipe piezometers can be used to evaluate long-term groundwater levels.
Excavation stability and construction dewatering are considered means-and-methods and are the responsibility of the contractor. The contractor should collect additional subsurface information as necessary to determine if the conditions reported herein are representative of those at site locations away from the culvert crossings.

6.1 Groundwater Control

Groundwater level should be maintained at least 2 feet below the bottom of open excavations. Dewatering should be performed in a manner such that the strength of the bearing soils is preserved throughout the construction. Dewatering should not cause instability of the open excavations.

Prevalent groundwater levels should be verified just prior to the start of construction. The contractor is responsible for assessing the need for groundwater control at the site and for developing appropriate dewatering procedures. The installation of observation wells or piezometers could be considered as part of dewatering systems.

6.2 Box Culvert Bearing Capacity

We anticipate that the foundation depth of embedment will place the bottom of the reinforced concrete box culverts on the hard fat clays on East Spine Road, and on stiff lean clays and/or loose to medium dense clayey sands on Loop Road F.

The box culverts along East Spine Road and Loop Road F can be designed for an allowable ground contact pressure of 5,000 psf and 2,200 psf, respectively. These bearing capacity values should provide factors of safety of at least 3.0 against soil shear failure.

The excavations should be extended to depths that allow for the placement of 6 inches of compacted fill directly beneath the concrete culvert structures. The fill soils should be placed and compacted to extend laterally no less than 12 inches beyond the edges of the culvert structures, and continuously beneath the entire culvert footprints. Fill soil type recommendations are presented in Section 6.3 of this report.

6.3 Fill Soils

Fill soils for undercut replacements, backfill and box culvert bearing should consist of cohesive materials with low expansion potential and classified as lean clays (CL). Cohesive sand well-compacted fill soils will be less prone to erosion under the influence of surface and channel water flow.

1. Fill soils should be free of organics, debris and otherwise deleterious materials. In general, suitable fill soils should have a liquid limit (LL) of less than 40, a plasticity
index (PI) between 10 and 20, and at least 65% of the soil particles passing the No. 200 sieve.

2. The full depth of each lift of fill soil should be compacted to 95% of the Standard Proctor maximum dry density (ASTM D-698).

3. Fill soils should be placed with horizontal loose lift thicknesses of not more than 6 inches. To facilitate obtaining in-place compaction, the moisture content of the fill soils should be maintained within 3% of the optimum moisture content based on ASTM D-698.

4. Fill compaction efforts should be implemented with surface compaction equipment of appropriate size.

5. Representative samples of the fill soils should be collected for classification and compaction testing. The maximum dry density, optimum moisture content, gradation and plasticity should be determined. These tests are needed for quality control of the compacted fill.

6. Field density tests should be performed on the compacted fill at a frequency of one test every 100 square feet of foundation excavation per lift of fill.

7. Involvement of TWE geotechnical engineering personnel during all site work activities will help to verify that procedures and results are as specified and as anticipated. Any issues identified during the construction process should be addressed by the geotechnical engineer in the field.

6.4 Excavation Stability

OSHA regulations do not apply to excavations shallower than 4 feet. Based on the boring findings open and unsupported excavations could be expected to remain vertical and stable while open only for short periods of time.

We recommend that all deeper excavations follow OSHA regulations for maximum allowable slopes. Excavated materials should not be stockpiled at the top of the excavation slopes within a horizontal distance equal to the excavation depth. Construction equipment working near the trench could result in excessive surcharge loads.

OSHA categorizes soil and rock deposits into four types, A through D. The clayey sands and the lean clays encountered in the soil test borings would be classified as Type C soils. The fat clays and highly weathered shales would be classified as Type B soils.
7 LIMITATIONS AND PLAN REVIEW

7.1 Limitations

This report has been prepared for the use of Huitt-Zollars and other members of the project design and construction teams for specific application to the project discussed herein. This report was prepared in accordance with generally accepted geotechnical engineering practices common to the local area. No other warranty is expressed or implied.

We request the opportunity to revisit and supplement, as necessary, our recommendations as provided in this report, if in fact our assumptions or understandings are incorrect or inaccurate. In such a case, we should be provided with appropriate site plans, and system installation procedures for our review and use.

The recommendations are based on the field and laboratory soil data summarized in the appended documents. The subsurface findings at the field exploration location may not necessarily reflect the actual soil strata vertical and horizontal variations throughout the project area. The analyses and recommendations are also based in part on the geotechnical engineer’s engineering judgment and experience with similar project settings and conditions.

TWE recommendations presented in this report must be revisited if subsurface conditions exposed during construction vary significantly from those described in this report. If any changes in the nature, design or location of the project are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed, and the conclusions modified or verified in writing by TWE.

7.2 Plan Review and Construction Monitoring

TWE should be provided the opportunity to review the construction drawings to determine if those documents are in harmony with the intent of the geotechnical design and construction recommendations contained in this report.

TWE should be provided the opportunity to observe and document the field conditions of exposed subgrade soils, geotechnical site preparation activities, and placement and compaction of fill soils and general infrastructure construction activities.
APPENDIX A

SOIL BORING LOCATION PLAN
APPENDIX B

BORING LOGS and KEY to SYMBOLS and TERMS
<table>
<thead>
<tr>
<th>ELEVATION (FT)</th>
<th>DEPTH (FT)</th>
<th>SAMPLE TYPE</th>
<th>SYMBOL</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td>Hard, brown SANDY FAT CLAY (CH)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(P)4.50</td>
<td>(P)2.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(possible fill soils in upper 4')</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-with limestone fragments in upper 2'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-stiff with shale fragments from 2'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soft to hard, brown-gray, highly weathered SHALE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(P)4.50</td>
<td>(P)1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-fat clay from 4' to 6'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stiff, brown LEAN CLAY with SAND (CL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(P)1.50</td>
<td>(P)2.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-very stiff from 18'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(P)3.00</td>
<td></td>
</tr>
</tbody>
</table>

**Bottom @ 20'**

**NOTES:**
1. Freewater was not encountered at time of dry-auger drilling.
2. Open borehole was backfilled to ground surface with soil cuttings upon completion.
**LOG OF BORING B-2 (Main Road)**

**PROJECT:** Cedar Hill State Park Flood Repairs - Box Culverts  
Cedar Hill, Dallas County, Texas  

**CLIENT:** Huitt-Zollars, Inc.  
Houston, Texas  

**COORDINATES:** N 32° 37' 28.81"  
W 96° 58' 50.99"  

**SURFACE ELEVATION:** +531 ft-MSL  

**DRILLING METHOD:**  
- Dry Augered: 0 to 20'  
- Wash Bored: to  

**ELEVATION (FT)** | **DEPTH (FT)** | **SAMPLE TYPE** | **SYMBOL** | **MATERIAL DESCRIPTION** | **(P) POCKET PEN (tsf)** | **STD. PENETRATION TEST BLOWCOUNT** | **MOISTURE CONTENT (%)** | **DRY UNIT WEIGHT (pcf)** | **LIQUID LIMIT (%)** | **PLASTICITY INDEX (%)** | **COMPRESSIVE STRENGTH (tsf)** | **FAILURE STRAIN (%)** | **CONFINING PRESSURE (psi)** | **PASSING #200 SIEVE (%)** | **OTHER TESTS PERFORMED**  
---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|  
0 | 0 | Stiff, brown SANDY FAT CLAY (CH) with limestone fragments  
(possible fill soils in upper 2') | (P)2.50 | 14 |  
528 | 20 | Stiff, brown FAT CLAY (CH)  
-hard from 4' | (P)2.00 | 80 | 38 | 92 |  
524 | 18 | Soft to hard, brown-gray, highly weathered, SHALE  
(P)4.50 | 31 |  
520 | 12 | Loose, brown CLAYEY SAND (SC)  
-medium dense from 18' | (P)1.50 | 34 | 40 | 22 | 38 |  
516 | 16 | Bottom @ 20'  
512 | 20 |  
508 | 24 |  
504 | 28 |  

**COMPLETIONDEPTH:** 20 ft  

**DATE BORING STARTED:** 08/29/2018  
**DATE BORING COMPLETED:** 08/29/2018  

**LOGGER:** J.P.  
**PROJECT NO.:** 17.13.182  

**NOTES:**  
1. Freewater was encountered at 13 ft and rose to 10 ft after 30 minutes.  
2. Open borehole was backfilled to ground surface with soil cuttings upon completion.
# LOG OF BORING  B-3 (East Spine Road)

**PROJECT:** Cedar Hill State Park Flood Repairs - Box Culverts  
Cedar Hill, Dallas County, Texas  

**CLIENT:** Huitt-Zollars, Inc.  
Houston, Texas  

**COORDINATES:**  
N 32° 37’ 31.49”  
W 96° 58’ 44.69”  
SURFACE ELEVATION: +539 ft-MSL  

**DRILLING METHOD:**  
Dry Augered: 0 to 20’  
Wash Bored: to  

---

<table>
<thead>
<tr>
<th>ELEVATION (FT)</th>
<th>DEPTH (FT)</th>
<th>SAMPLE SYMBOL</th>
<th>MATERIAL DESCRIPTION</th>
<th>COORDINATES:</th>
<th>DRY PENETRATION TEST BLOW COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td>Hard, brown FAT CLAY with some limestone fragments (CH) (possible fill soils in upper 4’)</td>
<td>N 32° 37’ 31.49” W 96° 58’ 44.69”</td>
<td>(P)4.50</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Hard, brown FAT CLAY (CH)</td>
<td></td>
<td>(P)4.50</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>Hard, brown FAT CLAY with SAND (CH)</td>
<td></td>
<td>(P)4.50</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td>Hard, gray, highly weathered, SHALE</td>
<td></td>
<td>(P)4.00</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td>Bottom @ 20’</td>
<td></td>
<td>(P)4.50</td>
</tr>
</tbody>
</table>

---

**COMPLETION DEPTH:** 20 ft  
**DATE BORING STARTED:** 08/29/2018  
**DATE BORING COMPLETED:** 08/29/2018  
**LOGGER:** J.P.  
**PROJECT NO.:** 17.13.182  

**NOTES:**  
1. Freewater was not encountered at time of dry-auger drilling.  
2. Open borehole was backfilled to ground surface with soil cuttings upon completion.
### Material Description

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Depth (ft)</th>
<th>Sample Type</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>(P)4.50</td>
<td>Hard, brown FAT CLAY with SAND (CH) (possible fill soils in upper 4')</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>(P)4.50</td>
<td>Hard, brown FAT CLAY (CH)</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>(P)4.50</td>
<td>-with limestone fragments from 13' to 15'</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>(P)4.50</td>
<td>-very stiff from 18'</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>(P)4.50</td>
<td>Bottom @ 20'</td>
</tr>
<tr>
<td>28</td>
<td>28</td>
<td>(P)3.00</td>
<td></td>
</tr>
</tbody>
</table>

### Notes
1. Freewater was not encountered at time of dry-auger drilling.
2. Open borehole was backfilled to ground surface with soil cuttings upon completion.
KEY TO SYMBOLS AND TERMS USED ON BORING LOGS FOR SOIL

**Most Common Unified Soil Classifications System Symbols**
- Lean Clay (CL)
- Lean Clay w/ Sand (CL)
- Sandy Lean Clay (CL)
- Fat Clay (CH)
- Fat Clay w/ Sand (CH)
- Sandy Fat Clay (CH)
- Silty Clay (CL-ML)
- Sandy Silty Clay (CL-ML)
- Silty Clayey Sand (SC-SM)
- Clayey Sand (SC)
- Sandy Silt (ML)
- Silty Sand (SM)
- Silt w/ Sand (ML)

**Sampler Symbols**
- Pavement core
- Thin - walled tube sample
- Standard Penetration Test (SPT)
- Auger sample
- Sampling attempt with no recovery
- TxDOT Cone Penetrometer Test

**Field Test Data**
- 2.50 Pocket penetrometer reading in tons per square foot
- (T)1.13 Torvane Measurement in tons per square foot
- 8/6" Blow count per 6 - in. interval of the Standard Penetration Test
- Observed free water during drilling
- Observed static water level

**Laboratory Test Data**
- Wc (%) Moisture content in percent
- Dens. (pcf) Dry unit weight in pounds per cubic foot
- Qu (tsf) Unconfined compressive strength in tons per square foot
- UU (tsf) Compressive strength under confining pressure in tons per square foot
- Str. (%) Strain at failure in percent
- LL Liquid Limit in percent
- PI Plasticity Index
- #200 (%) Percent passing the No. 200 mesh sieve
- (%) Confining pressure in pounds per square inch
  - * Stickensided failure
  - ** Did not fail @ 15% strain

**RELATIVE DENSITY OF COHESIONLESS & SEMI-COHESIONLESS SOILS**
The following descriptive terms for relative density apply to cohesionless soils such as gravels, silty sands, and sands as well as semi-cohesive and semi-cohesionless soils such as sandy silts, and clayey sands.

<table>
<thead>
<tr>
<th>Relative Density</th>
<th>Typical N_60 Value Range*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Loose</td>
<td>0-4</td>
</tr>
<tr>
<td>Loose</td>
<td>5-10</td>
</tr>
<tr>
<td>Medium Dense</td>
<td>11-30</td>
</tr>
<tr>
<td>Dense</td>
<td>31-50</td>
</tr>
<tr>
<td>Very Dense</td>
<td>Over 50</td>
</tr>
</tbody>
</table>

* N_60 is the number of blows from a 140-lb weight having a free fall of 30-in. required to penetrate the final 12-in. of an 18-in. sample interval, corrected for field procedure to an average energy ratio of 60% (Terzaghi, Peck, and Meiri, 1996).

**CONSISTENCY OF COHESIVE SOILS**
The following descriptive terms for consistency apply to cohesive soils such as clays, sandy clays, and silty clays.

<table>
<thead>
<tr>
<th>Typical Compressive Strength (tsf)</th>
<th>Consistency</th>
<th>Typical SPT &quot;N_60&quot; Value Range**</th>
</tr>
</thead>
<tbody>
<tr>
<td>q_u &lt; 0.25</td>
<td>Very soft</td>
<td>≤ 2</td>
</tr>
<tr>
<td>0.25 ≤ q_u &lt; 0.50</td>
<td>Soft</td>
<td>3-4</td>
</tr>
<tr>
<td>0.50 ≤ q_u &lt; 1.00</td>
<td>Firm</td>
<td>5-8</td>
</tr>
<tr>
<td>1.00 ≤ q_u &lt; 2.00</td>
<td>Stiff</td>
<td>9-15</td>
</tr>
<tr>
<td>2.00 ≤ q_u &lt; 4.00</td>
<td>Very Stiff</td>
<td>16-30</td>
</tr>
<tr>
<td>q_u ≥ 4.00</td>
<td>Hard</td>
<td>≥ 31</td>
</tr>
</tbody>
</table>

** An "N_60" value of 31 or greater corresponds to a hard consistency. The correlation of consistency with a typical SPT "N_60" value range is approximate.
### SYMBOLS AND TERMS USED ON BORING LOGS FOR ROCK

<table>
<thead>
<tr>
<th>Rock Types</th>
<th>Rock Quality Designation (RQD)</th>
<th>RQD</th>
<th>Rock Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metamorphic Rocks</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schist</td>
<td>Gneiss</td>
<td>0 to 25 percent</td>
<td>Very Poor</td>
</tr>
<tr>
<td><strong>Igneous Rocks</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basalt</td>
<td>Granite</td>
<td>25 to 50 percent</td>
<td>Poor</td>
</tr>
<tr>
<td><strong>Sedimentary Rocks</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shale</td>
<td>Coal</td>
<td>50 to 75 percent</td>
<td>Fair</td>
</tr>
<tr>
<td>Mudstone</td>
<td>Claystone</td>
<td>75 to 90 percent</td>
<td>Good</td>
</tr>
<tr>
<td>Sandstone</td>
<td>Siltstone</td>
<td>90 to 100 percent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Limestone</td>
<td>Dolomite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conglomerate</td>
<td>Cobbles</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Weathering Grades

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh</td>
<td>No discoloration or oxidation.</td>
</tr>
<tr>
<td>Slightly Weathered</td>
<td>Discoloration or oxidation is limited to near fractures.</td>
</tr>
<tr>
<td>Moderately Weathered</td>
<td>Mostly discolored. Less than half the rock is decomposed.</td>
</tr>
<tr>
<td>Highly Weathered</td>
<td>Completely discolored. More than half the rock is decomposed.</td>
</tr>
<tr>
<td>Decomposed</td>
<td>Residual soil.</td>
</tr>
</tbody>
</table>

### Rock Hardness

<table>
<thead>
<tr>
<th>Hardness</th>
<th>Field Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft</td>
<td>Broken by hand. Scratched with fingernail.</td>
</tr>
<tr>
<td>Hard</td>
<td>Broken by two hands. Scratched with knife.</td>
</tr>
<tr>
<td>Very Hard</td>
<td>Broken by rock hammer. Cannot be scratched with knife</td>
</tr>
<tr>
<td>Extremely Hard</td>
<td>Chipped by rock hammer. Cannot be scratched with knife.</td>
</tr>
</tbody>
</table>