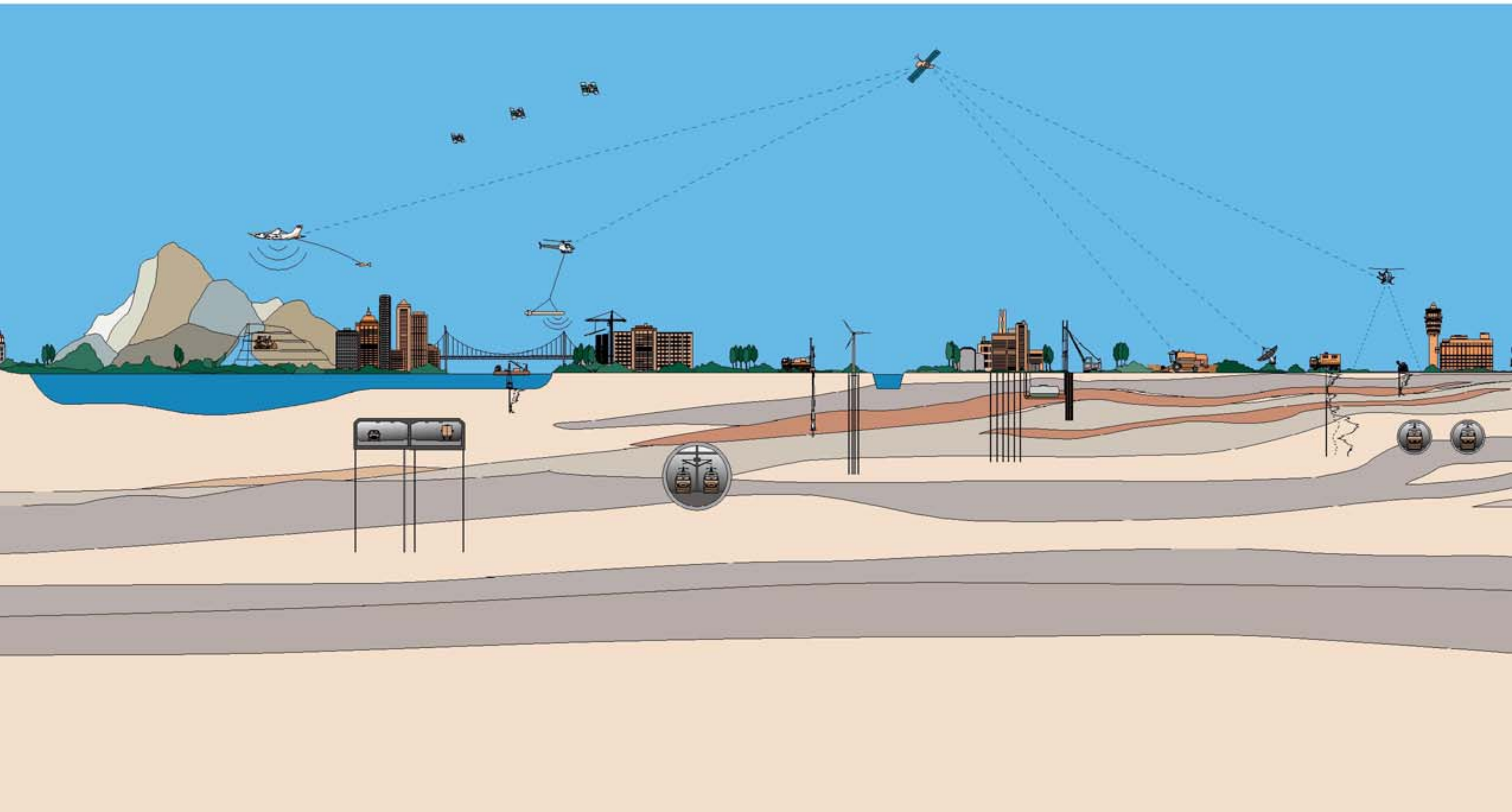
FUGRO CONSULTANTS, INC.

GEOTECHNICAL BASELINE REPORT
WASTEWATER LINE RELOCATION AT WATERLOO PARK
WALLER CREEK TUNNEL INLET FACILITY
AUSTIN, TEXAS

HOLT ENGINEERING, INC.
AUSTIN, TEXAS



FUGRO CONSULTANTS, INC.

8613 Cross Park Drive
Austin, Texas 78754
Phone: 512-977-1800
Fax: 512-973-9966

Holt Engineering, Inc.
2220 Barton Skyway
Austin, Texas 78704

Fugro Project No. 1001-3678
February 14, 2011

Attention: Ms. Linda Holt, P.E.

Geotechnical Baseline Report
Wastewater Line Relocation At Waterloo Park
Waller Creek Tunnel Inlet Facility
Austin, Texas

Fugro Consultants, Inc. (Fugro) is pleased to submit this Geotechnical Baseline Report (GBR) for the Wastewater Line Relocation for the Waller Creek Tunnel project in Austin, Texas. This Geotechnical Baseline Report includes a brief project description, overview of available information, and geologic setting. Based on the findings of the field and laboratory testing, and experience with nearby projects, interpretive geotechnical baseline conditions are presented for the tunnel horizon and access shafts. Our understanding of the proposed construction is based on the information provided by CAS Consulting & Services, Inc. and Brown and Gay Engineering, Inc.

Fugro sincerely appreciates the opportunity to be of service to Holt Engineering, Inc., the City of Austin, and the Waller Creek Tunnel design team. We look forward to our continued association throughout final design and construction of this landmark project.

Sincerely,
FUGRO CONSULTANTS, INC.
TBPE Firm Registration No. F-299

Rebecca

Rebecca A. Russo, P.E.
Project Manager

Peter H. Bush

Peter H. Bush, P.E.
Vice President

REBECCA A. RUSSO
91271

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GEOTECHNICAL BASELINE REPORT
WASTEWATER LINE RELOCATION AT WATERLOO PARK
WALLER CREEK TUNNEL PROJECT
AUSTIN, TEXAS

Report to:

HOLT ENGINEERING, INC.
Austin, Texas

Submitted by:

FUGRO CONSULTANTS, INC.
February 2011

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1.0 INTRODUCTION

1.1. General

This Geotechnical Baseline Report (GBR) is prepared specifically for the 36-inch and 15-inch Wastewater Line Relocation project, part of the Inlet Facility for the Waller Creek Tunnel project in Austin, Texas. The purpose of this report is to present an interpretative summary of results of the geotechnical investigation completed for the Waller Creek Tunnel project in the vicinity of the wastewater line relocation. The interpretative discussions contained herein present the geotechnical baseline conditions for construction of the proposed wastewater utility line. Specific data obtained for this portion of the project is based on the project Geotechnical Data Report (GDR) prepared by Holt Engineering, Inc., dated July 8, 2009, which is included in the Project Manual for the Waller Creek Tunnel Project. Copies of the applicable borings logs are included herein for ease of reference.

This report is intended to present, on behalf of the Owner, the Engineer's informed interpretation of ground conditions for use by the Owner and by the Contractor, and this interpretation is binding upon both parties as described in the Contract Documents. This GBR, in conjunction with the other contract documents, is intended to 1) assist prospective bidders in evaluating requirements for excavating, shoring, dewatering, and constructing the trenchless technology portions of the Project necessary to complete the work; 2) assist the Contractor in planning the work and designing temporary facilities; and 3) assist the Engineer and Construction Manager in reviewing and monitoring the Contractor's submittals and operations.

Fugro Consultants, Inc. (Fugro) and Holt Engineering, Inc. (Holt) were authorized to conduct the geotechnical investigation for the Waller Creek Tunnel project, and to provide engineering services in support of the design to the project team. In addition to Fugro and Holt, the following organizations and consultants have been involved in obtaining and defining the geological and geotechnical aspects of this project:

- City of Austin, Public Works Department, Owner
- City of Austin, Watershed Protection Department, Project Sponsor
- Espey Consultants, Inc., Austin, Texas, Engineers
- Kellogg Brown & Root Services, Inc., Austin, Texas, Engineers
- Jenny Engineering Corporation, Springfield, New Jersey, Tunneling Engineers
- Brown & Gay Engineers, Inc., Austin, Texas
- Woodruff Geological Consulting, Austin, Texas, Geological Consultant

1.2. Authorization and Scope

The geotechnical services were performed in general accordance with the master contract between Espey Consultants, Inc. (Espey) and Holt Engineering, Inc. (Holt). The authorized scope of services are outlined in the Phase 1 proposal dated September 20, 2007 and the Phase 2 proposal dated September 17, 2008. Each proposal shows the proposed scope of work to be performed by the geotechnical consultants. Fugro's geotechnical services have been performed in substantial compliance with the agreed upon scope as outlined in the above listed proposals and additional services as requested by Holt under the master geotechnical contract with Espey.

The geotechnical baselines contained in this report were developed from geotechnical information and data gathered from exploratory borings, laboratory testing, review of existing data, and evaluations of anticipated ground behavior during operations consistent with construction means and methods that are likely to be employed by the Contractor.

The objectives of the baselines set forth herein include but are not limited to:

- Providing a common basis for bidding
- Reducing uncertainty to Contractors

The baselines contained herein are not intended to be a guaranty or warranty that conditions will, in fact, be encountered, since actual conditions in the field can be variable. Rather, baselines are intended to identify anticipated subsurface conditions likely to be encountered during execution of the work and are considered a contractual commitment by The City of Austin that these baselines will be applied in accordance with the Contract Subsurface and Physical Conditions clause of the General Conditions.

We have been provided with a digital copy of the plan set entitled, “Waller Creek Tunnel Project, Inlet Facility at Waterloo Park, COA Project 6521.003” issued on November 29, 2011. We have also discussed the wastewater line relocation project with Brown & Gay Engineers, Inc. (BGE) and CAS Consulting & Services, Inc. (CAS).

This Geotechnical Baseline Report (GBR) includes a brief project description, geologic and geotechnical conditions, and interpretive geotechnical baseline parameters for the tunnel horizon and access shafts (bore pits). This GBR was prepared in substantial compliance with the code requirements for geotechnical projects as specified in Section 2 of the City of Austin, Utilities Criteria Manual, and the suggestions presented by Essex, R.J. (2007), *Geotechnical Baseline Reports for Construction, Suggested Guidelines*.

Baseline statements are presented in **bold text** within Section 2.0, 3.0, 4.0 and 5.0. All other statements contained in this report are not baselines.

1.3. Project Description

The Waller Creek Tunnel project will capture and divert Waller Creek floodwaters from a downtown stretch of the creek extending from an inlet structure at Waterloo Park to the outlet structure at Lady Bird Lake. To facilitate inlet structure construction, a section of existing wastewater line will be removed and relocated outside of the inlet structure and impoundment footprint. The wastewater line relocation alignment is shown relative to the Waller Creek Tunnel Inlet Facility on the Vicinity Map, Plate 1.

The new relocated wastewater line will be approximately 849 linear ft in total length and will consist of 36-inch diameter pipe from Station 9+90.00 to Station 17+08.95, and 15-inch diameter pipe from Station 17+08.95 to 18+39.24. The wastewater line will be installed using trenchless technology techniques in five reaches ranging from approximately 103 to 305 ft in length. Jack and bore trenchless installation technologies are anticipated. The 36-inch diameter carrier pipe is shown to have a 48-inch diameter steel encasement, and the 15-inch diameter carrier pipe is shown to have a 24-inch diameter steel encasement. This GBR pertains to the wastewater line relocation only.

1.4. Related Items

This GBR is part of the Contract Documents and must be read in conjunction with the General and Special Conditions of the Contract, the Technical Specifications and the Drawings, and the GDR. Precedence of the GBR relative to other Contract Documents is defined by the General Conditions. The following documents and specifications are related to this GBR:

1. Geotechnical Data Report for the Waller Creek Tunnel project dated July 8, 2009.
2. Geotechnical Baseline Report – Waller Creek Tunnel Project, Main Tunnel, dated September 2, 2010.
3. Standard Specification Item No. 501S – Jacking or Boring Pipe.
4. Special Specification SS02535 - Fiberglass-Reinforced Polymer-Mortar Pipe for Direct Bury, Gravity Service
5. Special Specification SS02470 – Annulus Grouting for Jack and Bore

1.5. Contractor’s Responsibility

This GBR is not intended to specify ground conditions or behavior to the extent that it relieves the Contractor of responsibility for carefully reviewing all the subsurface information and making their own interpretation of the ground conditions and ground behavior. Different behavior than described herein may occur depending on the means and methods, as well as workmanship, adopted by the Contractor, which are the responsibility of the Contractor. If

Contractor identities data indicating conditions significantly different from baselines presented herein, the Contractor shall immediately notify Owner/Engineer for further evaluation.

1.6. Limitations

The interpretations of soil, rock, and groundwater conditions described in this GBR are based on interpretations of subsurface conditions from widely spaced test borings. Further, predictions of ground behavior have been made based on the test boring data, field observations, and laboratory testing data. The Contractor should account for possible variation in the interpreted contacts between individual strata and some differences in the physical properties and behavior of various soil and rock strata described herein because of the relatively small amount of subsurface material sampled in the geotechnical investigation relative to that which will be encountered during construction.

The scope of services relating to the preparation of this GBR was limited to the geotechnical interpretation based on conventional geotechnical soil and rock sampling and laboratory testing services, and did not include any hazardous materials assessment or any other environmental testing, assessments, or evaluations.

Our scope of work does not include the investigation, detection, or design related to the presence of any biological pollutants. The term “biological pollutants” includes, but is not limited to, mold, fungi, spores, bacteria, and viruses, and the byproducts of any such biological organisms.

Fugro is not responsible for construction site safety. This includes but is not limited to:

- Contractor’s knowledge of and adherence to OSHA standards.
- Final design of the excavation initial support systems.
- Supplying an on-site competent person, as defined by OSHA, to evaluate the ground conditions encountered in the field.

1.7. Tunneling Experience

The tunnel will be constructed in the Austin Group (Limestone), in the upper portion of the unit, near it’s interface with overburden soils. The Austin Group (Limestone) is generally considered as good to excellent tunneling ground with minimal groundwater inflow and good stand-up time. However, the upper portion and surface of the limestone is often weathered and may contain more abundant soil-like seams, fractures, and other defects which will create differing tunneling media.

Similar projects with tunnel excavations through the Austin Group limestone were typically achieved with pattern rock bolting and occasional use of mesh. Full tunnel supports, such as steel liner plate, were typically used in segments with little cover. In previous projects where small unmapped faults were encountered across the tunnel face, the faults were generally tight and did not hinder the operation. However, faults or fractures that extend to the surface of the limestone stratum and are in communication with overburden soils with perched groundwater will introduce potentially significant groundwater infiltration and/or excavation face instabilities.

Excavation of access shafts (bore pits) were typical for excavation through soils and Austin limestone, but there was nuisance water that flowed along the rock/soil interface into the shaft excavations. The quantity of groundwater inflow was dependent on proximity to nearby surface waters and was quite severe in cases near Lady Bird Lake.

2.0 PHYSIOGRAPHIC AND GEOLOGIC SETTING

2.1. Physiography and Land Use

The proposed relocated wastewater line will be constructed across urban parkland with scattered trees. The existing ground surface elevations along the trenchless crossing generally range from about 475 ft at the south end to about 489 ft at the north end. Based on existing ground surface elevations and proposed flow line elevations, bore pit excavations will range from approximately 8 to 23 ft deep. The existing ground surface at the bore pit locations consists of grassed parkland with widely spaced groups of trees, and two are located in close proximity to Waller Creek. Numerous buried utilities are present in the easement along Red River Street.

2.2. Regional Geology

The project is located within the Balcones Fault Zone, a belt of inactive faults, which trends generally southwest to northeast through central Austin. Several small displacement faults and one large displacement fault have been identified in the project area. These faults commonly include a series of fault breaks in stair stepped “echelon” formation fault zones. The large displacement fault, located near 11th Street, and several smaller, secondary faulting north of 11th Street through the Inlet Facility, are likely splay faults normal to the large displacement fault. A Plan of Candidate Faults is presented in the project Geotechnical Data Report (GDR) dated July 8, 2009. The plan shows secondary faults transecting the Inlet Facility site, including a fault that trends down Waller Creek and crosses the proposed 36-inch wastewater line relocation alignment. Proposed mining along the 36-inch wastewater line may occur through faulted offsets within the limestone.

2.3. Geologic Setting

According to geologic mapping,[1] the project alignment is underlain by lower Colorado River terrace deposits (Qlcr), and weathered remnants and limestone of the Austin Group (Kau). Site specific borings indicate the limestone is further underlain by Eagle Ford Shale. The primary geologic units encountered in the subsurface at the alignment depth are: terrace deposits and Austin Group limestone.

2.3.1. Lower Colorado River Terrace Deposits

The terrace deposits consist of unconsolidated clay, silt, and sand with gravel or rock fragments. The terrace deposits were also referred to as alluvium on some of the boring logs. The overburden soil materials also include residual soils and manmade fill. The terrace deposits

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[1] Garner, L.E. and Young, K.P. (1976), “Environmental Geology of the Austin Area: An Aid to Urban Planning,” Report of Investigation No. 86, Bureau of Economic Geology, The University of Texas at Austin, Plate VII (reprinted 1992).

are further described in the Subsurface Conditions and Ground Characterization section of this report.

2.3.2. Austin Group Limestone

The Austin Group limestone consists of light gray to white chalk, marly limestone, and limestone. The limestone varies from hard fine-grained limestone to chalky and clayey limestone. The unweathered Austin limestone is gray to light gray in color. Weathering produces a tan to white color. The Austin Group limestone is further described in the Subsurface Conditions and Ground Characterization section of this report.

2.4. Structural Geology

Regionally, the most dominant structural feature is the Balcones fault zone separating the Edwards Plateau to the west from the Blackland Prairie to the east, as mentioned above. East of the fault zone strata of the Edwards Plateau dip at a rate of 10 to 20 ft per mile in a northeast direction; the strata of the Blackland Prairie dip at a rate of about 100 ft per mile to the southeast.[2] Within the fault zone, dips vary greatly in direction and magnitude. The faulting has been attributed to the subsidence along the margin of the Gulf Coast basin.[3]

As mentioned previously, the Plan of Candidate Faults, presented in the Waller Creek Tunnel GDR, indicates secondary faulting across the Inlet Facility with a structure normal to the major displacement fault located south of 12th Street. Site and nearby borings, as well as observations of nearby rock outcropping and excavations indicate multiple small-displacement local faults, inclined at roughly 45 degrees, with displacements of 1 ft or less, with pronounced slickensides that may be curved (and intersect). Due to this seemingly friable and less durable rock, this may result in less “stand-up” time which should be noted by tunnel contractors. Rock joints and fractures in limestone and shale are generally closed and tight. Joint surfaces are commonly clay coated and slickensides are frequently observed. Due to the faulting, increased rock porosity and permeability should be anticipated.

Although no gas was observed in the geotechnical exploration program, the Eagle Ford Formation may contain source substances that release gas which may migrate into the Austin Group limestone**. The baseline condition is therefore that the rock formations are potentially gassy as defined by OSHA.**

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[2] Garner, L.E. and Young, K.P. (1976), pg. 38.

[3] Rodgers, C.W., “Structural Geology of Round Rock Quadrangle, Williamson County, Texas,” M.A. Thesis, The University of Texas at Austin (August, 1963).

2.5. Environmental Conditions

Fugro did not conduct an environmental assessment for this project. Fugro is not responsible for any environmental review, assessment, or permitting.

3.0 SUBSURFACE CONDITIONS AND GROUND CHARACTERIZATION

3.1. General

The geologic setting and governing subsurface conditions expected to be encountered at the project site are summarized herein and presented in their entirety in the Waller Creek Tunnel project GDR dated July 8, 2009. The following sections provide a summary of subsurface conditions interpretation. The interpretations are based on borings identified as applicable for the wastewater line relocation portion of the project. Also presented is a summary of geotechnical parameters measured and interpreted baseline parameters to be anticipated for the proposed construction.

A plan showing the project alignment and the boring locations applicable for the wastewater line relocation is presented on the Plan of Borings, Plate 2. A Generalized Subsurface Profile along the proposed wastewater alignment is presented on Plate 3.

3.2. Field and Laboratory Data

Boring logs for the six applicable borings are included in the Appendix of this GBR for ease of reference, and are identical to that presented in the Waller Creek Tunnel GDR. The boring indentified as applicable borings are BT-221, BI-511, BI-505, B-2P, BI-516 and BI-513.

Representative index properties, water contents, liquid limits, plasticity indices, percentages of material passing the No. 200 sieve size, slake durability, swell potential, and compressive strengths are either tabulated on boring logs or presented in tables and graphs in the GDR.

3.3. Subsurface Conditions for Trenchless Construction

In general, the borings encountered surficial fill and terrace deposits/alluvium, underlain by tan and gray limestone of the Austin Group. Shale was encountered in boring BT-221 beneath the Austin Group limestone at elevation 429.4 ft, but is well below the planned tunnel horizon of 462 ft and above. Groundwater was encountered in two of the borings at the time of drilling (BT-221 and BI-516), and a piezometer was installed in boring B-2P when drilled in 1985 but is no longer accessible.

The proposed tunnel horizon will be mostly through the upper portion of the Austin limestone stratum and the lower portion of the overburden soils (alluvium/terrace deposits/residual soil). Since both the access shafts (bore pits) and the tunnel excavation will encounter these materials, a description of the subsurface conditions and engineering parameters are summarized in the following sections for overburden soils, limestone, and groundwater.

3.3.1. Overburden Soils

The overburden soils are described as reddish brown fat clay, light brown sandy silt, brown clayey sand, brownish gray lean clay, and brown, gray, and tan fat clay with calcareous particles, limestone gravel and fragments. The overburden soils consist of man-made fill material, alluvium/terrace deposits, and weathered limestone remnants (residual soil). The fill material was 0.5 to 9 ft thick (average 5 ft) at the applicable boring locations and was typically described as clayey sandy silt to silty sand. It should be noted that existing fill material could be deeper at locations associated with existing utility backfill. Borings were drilled in areas clear of underground utilities; therefore, depths of existing fill will likely vary with proximity to utility location and backfill conditions. Alluvium (also referred to as Upper Colorado River terrace deposits on the boring logs) was encountered beneath the fill material and above the limestone stratum.

Due to variations in depositional processes, the composition and consistency of the overburden soils (both fill and alluvium) can be expected to be erratic. The overburden soils extended to depths of 6 to 16 feet below existing grade with approximate corresponding elevations of 464.3 to 477.7 feet. Although not specifically noted on the boring logs, alluvial soils often coarsen with depth and may contain abundant gravel and/or cobble-laden layers at the bottom of the stratum above the limestone, and exhibit high groundwater yield especially if in communication with nearby surface waters. Further, the gravel and/or cobble-laden layers, if present, may be cemented and form a harden conglomerate.

The range of measured data and interpreted baseline conditions for the overburden soils are given below.

- Measured insitu moisture contents of overburden soils were 7, 12, and 22 percent**. For baseline conditions, insitu moisture contents are expected to range from 5 (sandy soils) to 35 (clayey soils) percent.**
- Measured plasticity indices (PI) values were 13, 13 and 24. **Based on nearby boring data and visual classifications, for baseline conditions, the PI are expected to range from NP (non plastic silt and sands) to 40 (high plasticity clay).**
- Percent fines (material passing the No. 200 sieve) were 37, 58, and 42 percent on tested overburden soil samples. **For baseline conditions, the percent fines are expected to range from 15 (sandy soils) to 95 (clayey soils) percent.**
- Standard Penetration Test (SPT) N-values ranged from 6 to 46 blows per ft (bpf) with an average of 22 bpf. One N-value at the overburden soil – limestone contact was 50 blows for 5 inches of penetration. **For baseline conditions, the Standard**

Penetration Test N-values in the overburden soils are expected to range from 5 (loose backfill soils) to 50 (very dense alluvial gravels and weathered residual soils) bpf with possible higher values due to rock content.

- Although no swell tests were performed on samples of the overburden soils, some high plasticity, potentially swelling soils may be encountered. **For baseline conditions, the contractor should anticipate an average swell pressure of 500 psf and a maximum of 2,500 psf. Free swell should range from 0.1 to 2% with an average of 1 percent.**

3.3.2. Austin Group Limestone

Tan and gray limestone of the Austin Group limestone was encountered in all 6 applicable borings at top of interpreted limestone stratum at depths of 6 to 16 ft below existing grade with approximate corresponding elevations of 464.3 to 477.7 feet. The limestone typically consisted of moderately hard to hard, moderately weathered to fresh, with clay partings, bentonite layers, angled and slickensided discontinuities, and fossils. Relatively less weathered gray limestone was encountered in the borings at depths of 7.2 to 17 feet below existing grade with approximate corresponding elevations of 463.3 to 476.5 feet.

A completely weathered soil-like layer, typically consisting of tan lean clay with limestone fragments, was encountered in 3 of the 6 borings above the limestone stratum and was 0.8 to 1 ft in thickness. Oftentimes, the transition from the overburden soils and the underlying limestone is gradual and consists of soil with limestone fragments becoming limestone with clay layers with depth. It is important to note that this interface is gradual in some environments and may be more abrupt in erosional environments where previous alluvial flows may have scoured the soil-like and weathered surface of the limestone thereby exposing fresh limestone beneath the overburden soil stratum. Both a gradual transition and an abrupt transition were indicated by the borings and should be anticipated by the contractor.

The range of measured data and interpreted baseline conditions for the limestone stratum are given below.

- Measured insitu moisture contents of intact limestone core samples (10 tests) ranged from 5 to 14 (average 9) percent. **For baseline conditions, insitu moisture contents are expected to range from 5 to 20 percent.**
- Measured dry densities of intact limestone core samples (10 tests) ranged from 121 to 141 (average 133) pcf. **For baseline conditions, limestone dry densities are expected to range from 120 to 145 pcf.**
- Measured unconfined compressive strengths of limestone core samples (10 tests) ranged from 348 to 3,404 psi. **For baseline conditions, unconfined**

compressive strengths of limestone core samples within the tunnel horizon and 1 to 2 tunnel diameter above and below the horizon, are expected to range from 150 to 3,500 psi.

- Rock quality designation (RQD) ranged from 20 to 100 percent in the borings, with an average of 89 percent. RQD within the tunnel horizon are expected to range from 0 percent near the limestone/overburden soil interface up to 100 percent within less weathered zones. As presented in the subsequent section, five reaches are identified. **For baseline purposes, limestone with an RQD of 0 to 100 percent is expected within Reach 1 (more weathered, soil-like horizon), and limestone with RQD from 70 to 100 percent is expected within Reaches 2 through 5.**
- Bentonite layers were encountered within the Austin limestone and ranged in thickness from several inches to 1 foot. A distinct bentonite layer known as the “marker bed” was noted in 4 of the borings, denoting another 22 to 25 ft of limestone until the underlying Eagle Ford shale contact is present. The marker bed was encountered at elevations of 453.2 to 454.3 ft which is approximately 1 to 2 tunnel diameters below the planned tunnel horizon. Due to some faulting across the tunnel alignment, the contractor should plan for the presence of intermittent bentonite and/or clay layers within the limestone stratum. **For baseline purposes, the bentonite and/or clay layers, where present, are expected to be less than 1 ft in thickness, and occur within the tunnel horizon 10 to 50% of the total tunnel length.** Where encountered in the tunnel excavation, clay layers may be problematic for rock cutter heads and may require localized stabilization within the rock mass.

3.3.3. Fracture Zones and Faults

Fractures and joints are scattered throughout the rock mass, and may be particularly prevalent near the overburden soil/limestone contact. Faults are noted across the Inlet Facility site and may transect the proposed wastewater relocation alignment. **For baseline purposes, fracture zones or faults are expected to be encountered during tunnel excavation through Reaches 1 2, 5 and 6, and are expected to extend on the order of 25 linear feet or less at each location.**

3.3.4. Groundwater

Piezometers BI-501, BI-508 and BI-514 (see GDR report for all data) were installed as part of the Inlet Facility investigation. Piezometer BI-508 was relatively shallow to measure perched groundwater in the overburden soils. Although upgradient of the wastewater relocation project, this piezometer was dry. Piezometers BI-501 and BI-514 were constructed through the

Austin limestone and underlying Eagle Ford Shale and Buda Limestone formations, and were screened within the lower portion of the Austin limestone and lower formations. It is anticipated that artesian (pressure) groundwater conditions are present within the rock stratum, likely the lower portions of the Austin limestone stratum near the Eagle Ford shale contact, and may be recharged through fault sources at higher elevations.

Borehole packer tests were conducted in borings BI-514, BI-501, BI-500 and BI-509 (see GDR report for all data) and yielded field permeabilities on the order of 5.98 x10^{-6} to 5x10^{-7} cm/sec in the Eagle Ford and Austin limestone strata.

The primary source for water inflow into the wastewater line excavation will likely be due to communication and infiltration of surface water from nearby Waller Creek. **For baseline purposes, the following presumptive baseline permeability values were assessed for the soil type / stratum indicated.**

Presumptive Permeability Values	
Soil Type / Stratum	**Permeability**
Overburden Soil – (fat clay, lean clay)	1 x 10^{-6} cm/s to 1 x 10^{-5} cm/s
Overburden Soil – (clayey sand, silty sand)	1 x 10^{-5} cm/s to 1 x 10^{-4} cm/s
Overburden Soil – (clayey gravel, gravel)	1 x 10^{-3} cm/s to 1 x 10^{-1} cm/s
Overburden Soil / limestone contact	1 x 10^{-4} cm/s to 1 x 10^{-2} cm/s
Austin Limestone	1 x 10^{-7} cm/s to 1 x 10^{-5} cm/s

4.0 TUNNEL DESIGN AND CONSTRUCTION

4.1. General

Five reaches of trenchless pipe installation will be done for this Project. The reaches are expected to be completed using trenchless jack and bore installation techniques. A 48-inch grout filled steel encasement pipe is required throughout the tunnel length except for one reach of 24-inch diameter, as shown on the Project plans. This steel encasement may be installed using either one or two pass methods. Tunnel liner plate may not be substituted for the steel encasement pipe.

The Contractor shall be responsible for submitting the trenchless layout, spoil and muck handling procedures, and pipe handling procedures to the Engineer in accordance with Specification 1300 “Submittals” and Standard Specification Item No. 501S Jacking and Boring Pipe. The Contractor is expected to pay careful attention to both line and grade for the trenchless installation reaches and to correct any drift in line or grade that may adversely affect existing utilities and structures as excavation progresses.

4.2. Description

Five separate reaches will be constructed. These are:

Summary of Reaches				
Reach	**Beginning Station**	**Ending Station**	**Length, ft**	**Subsurface Conditions in the Tunnel Horizon**
1	9+90.00	11+6.23	116	Alluvium / Austin Limestone
2	11+6.23	13+1.44	195	Alluvium / Austin Limestone
3	13+1.44	16+6.00	305	Austin Limestone
4	16+6.00	17+8.95	103	Austin Limestone
5	17+8.95	18+39.24	130	Austin Limestone

4.3. Jack-and-Bore

Excavation by jack-and-boring shall be in accordance with the City of Austin Standard Specification Item No. 501S – Jacking or Boring Pipe. Frequent line and grade checks will be needed to maintain lateral and vertical tolerances required for this project.

4.4. Box Culvert Above Reach 2

Referring to the Waller Creek Tunnel Project Plans, a 6 ft by 5 ft concrete box culvert is planned above the proposed wastewater line relocation; however, the box culvert construction is a separate project . The box culvert will cross Reach 2 at approximate station 12+40, and will have a bearing elevation of approximately 471 feet. The top of the steel encasement at this location is approximately 3.5 ft below this elevation. Depending on the sequencing of construction, the contractor may need to be made aware of the potential presence of this structure and reduced cover condition.

4.5. Construction Monitoring

The Contractor shall monitor construction activities, specified structures, and utilities as directed by the Contract Drawings and Specifications. Representatives from the Owner and the Engineer shall be given full site access, including but not limited to all excavations and tunnel sections where man-entry is allowed.

The Contractor shall provide steel encasement pipe as specified and shown on the Contract Drawings. The jacking pipes shall be capable of sustaining the maximum axial jacking forces to be exerted on the pipe, as well as earth and surcharge loads, where appropriate. It is the Contractor’s responsibility to coordinate with the pipe manufacturer to determine the necessary pipe characteristics.

The longest drive for this Project is approximately 305 ft. The Contractor shall evaluate the necessity for an intermediate jacking station and coordinate with the pipe manufacturer if one is required.

4.6. Groundwater Infiltration

Antecedent rainfall conditions will control the elevation of the groundwater level along much of the alignment. Although no permeability tests were performed on overburden soils, presumptive permeability values in the overburden soils and Austin limestone stratum are presented in the previous section based on experience with nearby projects and data from other portions of the project.

Assuming a 10-ft head of groundwater above the tunnel crest, and using presumptive permeabilities presented previously, groundwater infiltration rates into the tunnel excavation are expected to range from 0.5 to 5 gpm per ft of tunnel for Reach 1, and 0.1 to 1.0 gpm per ft of tunnel for Reaches 2 through 5. Higher initial “first-flush” flows may occur immediately upon tunnel advancement and should stabilize within 24 hours. These estimates are based on proper control of surface water and proper stabilization of the tunnel excavation support through rock and/or soil.

5.0 SHAFT DESIGN AND CONSTRUCTION

5.1. General

The five trenchless excavation reaches are expected to be completed using a jack and bore techniques. Shafts or jacking/receiving pits will be required to provide access for the jack and bore machine(s). It is required that the Contractor engage the services of a professional engineer licensed in the State of Texas for shaft design and support. The Contractor shall be responsible for submitting shaft design plans and calculations to the Engineer in accordance with the Project Specifications.

5.2. Description

Six jacking/receiving pits are expected to be constructed for this project, referred to as wastewater manhole WWMH A1 through A6. The purposes of these shafts will be to provide access for the trenchless installation and manhole construction. The shafts will have permanent, 6- to 8-ft diameter, water tight manholes installed in them capable of withstanding 35 ft of external hydraulic head conditions, as specified on the Project plans. The Contractor has the responsibility of laying out the work to suit his own requirements, subject to review and acceptance by the Engineer and the Owner. All excavations are required to be within the designated easements. Manholes and jacking/receiving pits shall be partially backfilled with Class B concrete, as specified on the Project plans.

Summary of Shafts

MH Designation	Station	Depth, ft	Subsurface Conditions
A1	9+90	10.3	Overburden Soils / Austin Limestone
A2	11+6.23	19.8	Overburden Soils / Austin Limestone
A3	13+1.44	23.0	Overburden Soils / Austin Limestone
A4	16+6.00	21.3	Overburden Soils / Austin Limestone
A5	17+8.95	7.7	Overburden Soils / Austin Limestone
A6	18+39.24	16.2	Overburden Soils / Austin Limestone

5.3. Instrumentation

Several of the proposed jacking/receiving pits for the proposed wastewater line excavation are located in areas with existing utilities and surface structures. The Contractor should be made aware of the excavation challenges associated with nearby utilities and their backfill, and with maintaining proper support of adjacent structures.

Three (3) slope inclinometers are recommended at access shaft (bore pit) locations to monitor support conditions. The inclinometer casings should be installed not more than 5 ft from the planned excavation bracing limits of manholes A2, A3 and A4. The slope inclinometer casing should consist of 2.75-inch diameter, Slope Indicator pipe with interior grooves for lowering of the tiltmeter probe to obtain measurements. The inclinometer casing should extend at least 5 ft below the depth of the planned shaft excavation and be embedded at least 5 ft into limestone. The bottom 3 ft of the casing should be grouted in the annular space, and sanded up to within 3 ft of the ground surface where a bentonite/soil mixture may be used to seal the annular space. A baseline measurement should be obtained prior to excavation of the access shaft using a Digitilt Inclinometer Probe or approved equivalent. Calibration records less than 1-year old should be provided with the baseline (initial) reading. Subsequent readings should be made at least once a week following excavation of the shaft and more frequently during shaft excavation to document that adverse lateral displacements are not occurring. If the cumulative lateral movements exceed 2 inches total, the contractor will be required to stop the excavation/construction activity and improve/reinforce temporary bracing so that utilities or structures bearing in the backfill are not compromised.

5.4. Construction and Design Considerations

5.4.1. Shaft Excavations

Rectangular shafts for the jacking/receiving pits will have excavated dimensions ranging from approximately 15 ft by 15 ft to 20 ft by 30 ft, and several of the pits are overlapping. The excavation configuration shall accommodate the size of the tunnel equipment, size of the jacking frame, length of pipe to be jacked into place as the machine advances, in addition to space for worker and appurtenant facilities. The depth of the shafts should allow for excavation of the shaft to a depth corresponding to the appropriate level to allow for the thickness of the pipe, height of the jacking cradle above the shaft floor, and the thickness of the floor itself. A concrete floor shall be placed in the bottom of the excavation to provide a stable and level working platform.

The shafts will involve excavation of approximately 6 to 16 ft of overburden soil materials that may be accomplished using conventional excavation equipment, although occasional boulders and conglomerate layers may also be encountered. Excavation of the tan, weathered limestone and gray, unweathered limestone of the Austin Group will require the use of an excavator equipped with a hydraulic hammer or similar mechanical means. Blasting is not permitted without authorization from the Owner and the Engineer during construction of any portion of this Project.

Measures shall be taken to provide a relatively dry, level working platform at the ground surface at the shaft locations, one capable of accommodating heavy equipment loads. A concrete working slab shall be installed to provide a dry, stable work surface at the shaft invert.

An invert sump shall be designed and constructed for removal of any accumulated ground or surface waters. Temporary slopes or impermeable above ground barricades or walls shall be used to protect the shafts from surface water inflows.

5.4.2. Temporary Excavation Support

The Contractor is solely responsible for selecting, designing, and installing appropriate excavation support and groundwater control for all excavations. All excavation support shall be designed to provide full-face, positive support of the excavation walls. All excavation support systems must be designed to fit within the given construction easements. All excavation support systems must be designed to take into account the potential groundwater levels. All excavation support systems shall be designed and sealed by a professional engineer licensed in the State of Texas. Any damage resulting from the construction of the excavations and/or movement of the support system shall be repaired immediately, at no cost to the Owner, including, but not limited to, financial losses incurred by the Owner due to loss of use.

Circular Shafts. Circular shafts, if selected by the Contractor, can be supported using sheet piling, tunnel liner plate, corrugated steel pipe, structural plate, or soldier piles and wooden lagging. Ring walers shall be used as necessary to hold the sheeting or lagging in place using expanding screw-type jacks. Grouting or installation of geotextile filters will be required below the groundwater table to prevent loss of fine material into the shafts.

Rectangular Shafts. Rectangular shafts in the overburden soils can be supported using steel plating combined with wales and support beams or soldier piles and lagging. Shallow excavations may be supported using stacked trench boxes backfilled with gravel or flowable fill. Grouting or installation of geotextile filters will be required below the groundwater table to prevent loss of fine material into the shafts.

5.5. Groundwater Infiltration

Seepage of groundwater will be expected in the shaft excavation. Groundwater was encountered in two of the investigation borings in the fat clay and clayey sand layers near the limestone interface at depths of 11.9 and 14 ft. The Contractor shall assume that the groundwater level will rise to at least the level of the water in the creek during flood conditions. Packer permeability tests indicate that the limestone has low permeability and the principal zone of groundwater flow will be expected to be in the lower overburden soil materials which are in direct communication with Waller Creek. Special attention to groundwater inflow is required at the soil/rock interface. Permeation grouting or cut-off grouting of transmissive areas in the limestone and soil can be performed to cut off and control the groundwater flow into the shaft.

Based on access shaft (bore pit) dimensions shown on the Project Plans, and presumptive permeability values previously presented for anticipated soil type/strata, we estimate the following “first flush” and steady state (residual) groundwater infiltration rates for the shaft dimensions and depths given on the project plans. These estimates were based on an assumed 10-ft perched groundwater condition atop the limestone stratum.

Summary of Groundwater Infiltration Rates at Shafts

MH Designation	Plan Dimensions, ft	Assumed Excavation Depth, ft	First Flush Flow	Steady State (Residual) Flow
A1	15 x 15	12	20 – 200 gpm*	10 – 100 gpm*
A2	20 x 30 (2 pits)	22	10 – 100 gpm	10 – 50 gpm
A3	20 x 20	25	10 – 100 gpm	5 – 50 gpm
A4	15 x 15	23	10 – 100 gpm	5 – 50 gpm
A5	20 x 30 (2 pits)	10	10 – 100 gpm**	5 – 50 gpm**
A6	15 x 15	18	10 – 100 gpm	10 – 50 gpm

* MH A1 will be near Waller Creek and will require a surface water diversion plan.

** MH A5 will be in Waller Creek and will require a surface water diversion plan.

Residual seepage within permissible discharge limits may be controlled by using sump pumps. Additional groundwater control measures will be expected to be required during flood conditions. Water pumped from the shaft will be treated prior to discharge into any storm sewer or water course, in accordance with the Project Specifications. All shafts shall have sumps, submersible pumps, sedimentation tanks, and other equipment to handle groundwater infiltration as needed.

5.6. Jacking / Receiving Shafts

Prior to tunneling activity, the shafts must be excavated and configured as either jacking (work) or receiving shafts. A reinforced concrete thrust block or thrust wall constructed of rigid materials may be required in the jacking shaft to provide resistance for the forces developed by the main jacking system. The jacking shaft will also require the installation of main jacks, floor beams, and guide rails. The tunnel guidance laser(s) shall be supported independently of the thrust block, main jacks, and jacking frame to keep it from shifting as a result of deformations during pipe jacking.

5.7. Excavation Spoil

The excavation spoil from the shafts will consist of clayey and sandy soil overburden materials, miscellaneous fill, and rock materials.

5.8. Groundwater Discharge

Total groundwater discharge will be controlled within the limits defined in the specifications. All water discharged from shafts and tunnels will be treated as necessary to meet the sediment content discharge criteria in the project specifications. Water pumped from the limestone formation should be expected to have low sediment content. Water pumped from overburden clayey soils and fill materials from the shaft excavations will be expected to require sediment control treatment prior to discharge from the shaft excavations.

5.9. Construction Monitoring

The Contractor shall monitor construction activities, specified structures, and utilities as directed by the Contract Drawings and Specifications. Representatives from the Owner and the Engineer shall be given full site access, including but not limited to all excavations and tunnel sections where man-entry is allowed.

6.0 CONDITIONS

The provision of a baseline in the contract is not a representation nor a warranty that the baseline conditions will actually be encountered; rather the baseline is primarily intended to define, for contractual purposes, those conditions which, if determined to be more adverse than defined, might result in an equitable adjustment of the contract price or time. The Contractor shall not exclusively rely upon the baseline for the planning and performance of any aspect of the work, including the selection, design, or implementation of the means, methods, techniques, sequences, and procedures of construction to be employed by the Contractor, and safety precautions and programs incident thereto.

Since some variation was found in subsurface conditions at the boring locations, all parties involved should take notice that even more variation may be encountered between boring locations. Statements in the report as to subsurface variation over given areas are intended only as estimations from the data obtained at specific boring locations. The design and construction recommendations contained in this report supersede all previous verbal or written geotechnical recommendations provided by Fugro for this project.

The professional services that form the basis for this report have been performed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers practicing in the same locality. No warranty, express or implied, is made as the professional advice set forth. Fugro's scope of work does not include the investigation, detection, or design related to the presence of any biological pollutants. The term 'biological pollutants' includes, but is not limited to, mold, fungi, spores, bacteria, and viruses, and the byproducts of any such biological organisms.

The results, conclusions, and recommendations contained in this report are directed at, and intended to be utilized within, the scope of work contained in the proposal letter executed by Fugro Consultants, Inc. and client. This report is not intended to be used for any other purposes. Fugro Consultants, Inc. makes no claim or representation concerning any activity or condition falling outside the specified purposes to which this report is directed, said purposes being specifically limited to the scope of work as defined in said agreement. Inquiries as to said scope of work or concerning any activity or condition not specifically contained therein should be directed to Fugro Consultants, Inc. for a determination and, if necessary, further investigation.

PLATES

VICINITY MAP

Wastewater Relocation at Waterloo Park

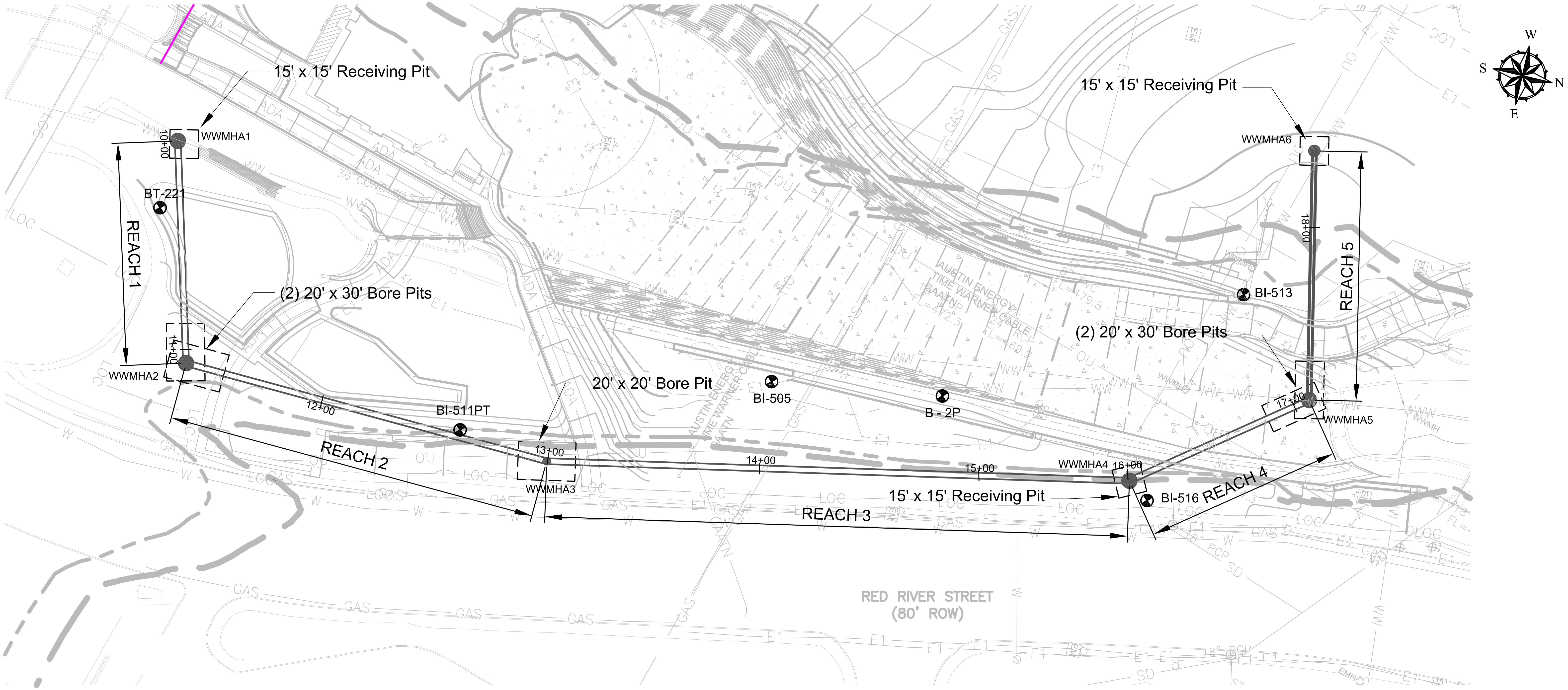
Waller Creek Tunnel

Austin, Texas

PLATE 1

Revised: 2/02/11 13:48

Source: Capital Area Council of Governments (CAPCOG) Digital Orthoimagery Data 2009



▲ PREVIOUS BORING
⊗ COMPLETED PHASE 1 (B1) AND PHASE 2 (B2) BORINGS

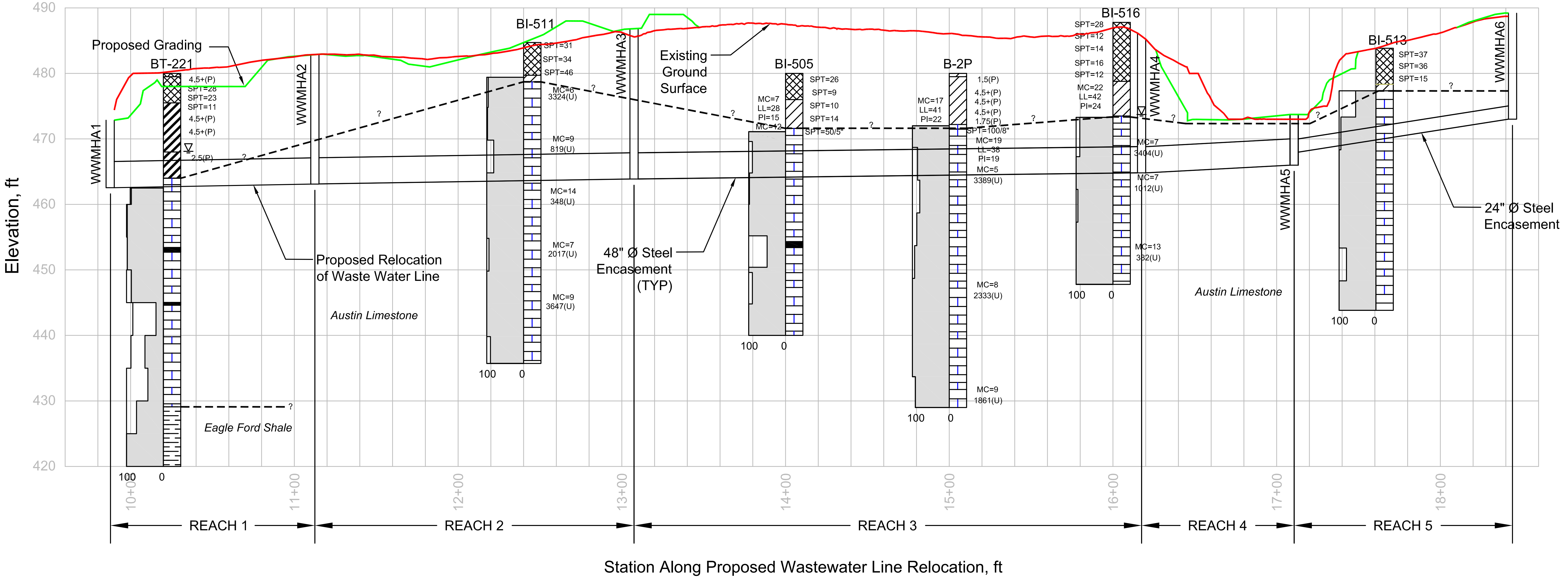
BT	TUNNEL BORING
BO	OUTLET BORING
BI	INLET BORING
BC	CREEK/SIDE OVERFLOW WEIR BORING
PZ	BORING WITH PIEZOMETER
PT	BORING WITH PACKER TESTING

0 50 100
SCALE IN FEET

PLAN OF BORINGS
Wastewater Relocation at Waterloo Park
Waller Creek Tunnel
Austin, Texas

PLATE 2

Revised: 2/11/11 16:00



KEY

SPT Standard Penetration Test, *bpf*
U Unconfined Compression Test, *psi*
Q Unconsolidated Undrained Triaxial Test, *psi*
∇ Water reading at time of drilling
MC Moisture Content, %

% RECOVERY (UNSHADED) & % RQD (SHADED) PER RUN

LITHOLOGY GRAPHICS

▨ Fat Clay High Plasticity
▨ Lean Clay Low Plasticity
▨ Clayey sand
▤ Clayshale
▦ Limestone
☰ Shale
▬ Bentonite Seam
☒ Fill

GENERALIZED SUBSURFACE PROFILE

Waller Creek Tunnel Inlet
Wastewater Relocation at Waterloo Park
Austin, Texas

PLATE 3

Revised: 2/11/11 16:16

APPENDIX

LOG OF BORING BT-221

Waller Creek Tunnel
Austin, Texas

TYPE: Sample/Rock Core LOCATION: See Plate 2

SURF. EL. 480.3 ft± Job No. 1001-3678

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT OR REC/(RQD),%	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	UNIT DRY WEIGHT, PCF	COMPRESSIVE STRENGTH
			28	Brown clayey SAND. (Fill)	479.8 0.5							4.5+(P)
			23 11	Reddish brown to brown gravelly fat CLAY with sand, w/limestone fragments and calcareous particles. (Fill)	475.8 4.5							
5 10				Brown to grayish brown fat CLAY with sand, hard, w/occasional shell fragments and calcareous particles. CH (Upper Colorado River terrace deposits)	468.3 12.0							4.5+(P) 4.5+(P)
15				Gray and tan fat CLAY, very stiff, w/abundant calcareous particles, trace sand and ferrous staining. CH (Upper Colorado River terrace deposits)	464.3 16.0							2.5(P)
				Tan LIMESTONE, weathered. (Austin)	463.3 17.0							
20			90 (87) 100 (98)	Gray LIMESTONE, slightly weathered to fresh, nodular, sound, medium-grained, w/scattered fossil fragments. (Austin) *-calcareous clay, friable, broken from 18.4 to 18.5 ft* *-clayey limestone to 20.5 ft* *-parting at 23.1 ft*								
25			98 (98)	*-clayey limestone from 24.5 to 25.0 ft* *-parting at 24.6 ft* *-calcareous clay, (bentonitic) from 26.5 to 27.3 ft* *-parting at 26.8 ft* *-parting at 27.6 ft*								
30			100 (87)	*-multiple breaks from 30.4 to 31.0 ft* *-parting at 31.5 ft* *-parting at 32.0 ft* *-parting at 33.6 ft*								
35			83 (20)	*-calcareous clay, (bentonitic) from 34.9 to 35.4 ft*								
40			88 (50)									
45			100 (42)	*-parting at 42.1 ft* *-multiple clay partings 42.4 to 43.0 ft* *-clayey limestone from 43.0 to 44.0 ft* *-multiple clay partings (n=8) 45.0 to 45.4 ft* *-calcareous clay, friable, fragmented from 46.5 to 47.0 ft*								

COMPLETION DEPTH: 100.0 ft DEPTH TO WATER: See Note

DRILL DATE: 12/03/07

U = Unconfined (psi)
Q = Unconsolidated Undrained Triaxial (psi)
P = Pocket Penetrometer (tsf)
T = Torvane (tsf)

LOG OF BORING BT-221

Waller Creek Tunnel
Austin, Texas

TYPE: Sample/Rock Core LOCATION: See Plate 2

SURF. EL. 480.3 ft± Job No. 1001-3678

DEPTH, FT	BLOWS PER FOOT OR REC/(RQD),%	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	UNIT DRY WEIGHT, PCF	COMPRESSIVE STRENGTH
	100 (73)	*-Transition Zone - alternating layers of gray limestone and gray shale below 50.3 ft*	429.4 50.9							
		Dark gray SHALE, moderately hard, fissile, w/horizontal bedding. (Eagle Ford - South Bosque)								
55	100 (100)									
60	100 (100)									
										*
65	100 (45)		414.3 66.0							
		Dark gray SHALE, moderately hard, w/alternating limestone seams and layers (flags) and occasional bentonite seams. (Eagle Ford - Bouldin Flags) *-gray bentonitic layer from 66.0 to 66.5 ft* -slickensided joint (60°-terminates to 28°) at 66.2 ft *-gray bentonitic seam from 71.7 to 71.9 ft* -slickensided joint (25°) at 71.8 ft								*
70	100 (87)			13					118	1614(U)
										*
										*
			406.7 73.6							*
75	98 (95)	Dark gray CLAYSHALE, low to moderately hard, fissile, w/discontinuities. (Eagle Ford - Cloice)		14					117	952(Q)
										*
										*
										*
										*
										*
80	93 (93)									*
			395.8 84.5							
85	100 (100)	Dark gray to black CLAYSHALE, low hardness, slightly fissile, unctuous. (Eagle Ford - Pepper Shale) *-bentonitic from 85.7 to 86.3 ft*								
			392.3 88.0	17					113	374(U)
90	100 (100)	Light gray LIMESTONE, moderately weathered, hard, slightly nodular, moderately burrowed, glauconitic, w/numerous shell fragments and numerous dark gray clay-coated discontinuities. (Buda)								
95	100 (100)									
			380.3							

COMPLETION DEPTH: 100.0 ft DEPTH TO WATER: See Note

DRILL DATE: 12/03/07

U = Unconfined (psi)
Q = Unconsolidated Undrained Triaxial (psi)
P = Pocket Penetrometer (tsf)
T = Torvane (tsf)

SHEET 2 of 3

LOG OF BORING BT-221

Waller Creek Tunnel
Austin, Texas

TYPE: Sample/Rock Core LOCATION: See Plate 2

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT OR REC/(RQD),%	STRATUM DESCRIPTION SURF. EL. 480.3 ft± Job No. 1001-3678	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	UNIT DRY WEIGHT, PCF	COMPRESSIVE STRENGTH
					100.0							
105												
110												
115												
120												
125												
130												
135												
140												
145												

NOTES:

1) Boring was advanced dry to the 17.0-ft depth and groundwater was encountered after a 10-minute waiting period at 11.9-ft.

2) After removal of wireline casing, the borehole was open to 98.6 ft and the water level (drilling fluid) was noted at the 10.0-ft depth.

3) Coordinates are Texas State Plane, Central Zone, NAD-83 (CORS 96):

N: 10072499.1180, E: 3116614.0490

COMPLETION DEPTH: 100.0 ft DEPTH TO WATER: See Note

DRILL DATE: 12/03/07

U = Unconfined (psi)
Q = Unconsolidated Undrained Triaxial (psi)
P = Pocket Penetrometer (tsf)
T = Torvane (tsf)

WALLER CREEK TUNNEL
SABINE STREET
AUSTIN, TEXAS

LOG OF BORING BI-511

NOTES : Hole dry prior to coring at 6.3'. No water loss.
Northing: 10072677.9598
Easting: 3116691.9417
ELEVATION : 483.7 FEET

DATE DRILLED : 03-04-09
BORING DEPTH : 50.0 FEET
DRILLER : John Webb
WATER LEVEL :
DRILLING METHOD : 4" Flight Augers to 6.3'; NXB Wireline to 50.0'.
LAT :
LONG. :

DEPTH (feet)	GRAPHIC LOG	SAMPLE	SOIL DESCRIPTION	% CORE RECOVERY	RQD (%)	DRILLING RATE (MIN./FT.)	CORE INTERVAL (FEET)	BLOWS PER FOOT	UCC STR. (PSI)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	LIQUID LIMIT(%)	PLASTICITY INDEX	% PASSING #200 SIEVE
	▩	☒	Fill - Unclassified light brown & tan clayey sandy silt w/scattered small to medium limestone rock					31						
	▩	☒						34						
5	▩	☒	-- Elevation 478.7'					46						
	▨		LEAN CLAY (CL), tan, silty (stiff to very stiff) -- Elevation 477.7'				6.3							
	▦	▮	LIMESTONE, tan - white, hard, fossiliferous, numerous mechanical breaks some along fossils, moderately weathered (6.0'-7.2'), fresh 7.2' to total depth, light gray to gray	100	96				3323.6	6.4	136.1			
10	▦	▮					10.9							
	▦	▮		100	98									
15	▦	▮					15.9		819.0	8.8	135.2			
	▦	▮		100	81									
20	▦	▮					20.9							
	▦	▮	-- Clayey limestone @ 21.3'-21.4'; 21.1'-22.8'	100	100				347.8	14.3	121.0			
25	▦	▮					25.9							
	▦	▮		100	100									
30	▦	▮	-- Clay , bentonite @ 30.5'-31.3' -- 40° Fracture w/slickensides @ 30.9' -- 30° Fracture w/slickensides @ 31.2'				30.9		2016.9	7.2	140.8			
	▦	▮		100	94									
35	▦	▮					35.9							
	▦	▮		100	100									
40														

LOG OF BORING PSI 10-49307-PH 2-WALLER CREEK TUNNEL.GPJ HOLT ENGINEERING.GDT 6/22/09

WALLER CREEK TUNNEL
SABINE STREET
AUSTIN, TEXAS

LOG OF BORING BI-511

NOTES : Hole dry prior to coring at 6.3'. No water loss.
Northing: 10072677.9598
Easting: 3116691.9417
ELEVATION : 483.7 FEET

DATE DRILLED : 03-04-09

BORING DEPTH : 50.0 FEET

DRILLER : John Webb

WATER LEVEL :

DRILLING METHOD : 4" Flight Augers to 6.3'; NXB Wireline to 50.0'.

LAT :

LONG. :

DEPTH (feet)	GRAPHIC LOG	SAMPLE	SOIL DESCRIPTION	% CORE RECOVERY	RQD (%)	DRILLING RATE (MIN./FT.)	CORE INTERVAL (FEET)	BLOWS PER FOOT	UCC STR. (PSI)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	LIQUID LIMIT(%)	PLASTICITY INDEX	% PASSING #200 SIEVE
			LIMESTONE, tan - white, hard, fossiliferous, numerous mechanical breaks some along fossils, moderately weathered (6.0'-7.2'), fresh 7.2' to total depth, light gray to gray*(Continued)* -- Pyrite @ 42.5' -- Pyrite @ 43.3'	100	100		40.9							
45				100	90		45.9		3647.1	8.6	134.8			
50			-- Elevation 433.7'				50.0							
			Terminated @ 50 feet											
55														
60														
65														
70														
75														
80														

WALLER CREEK TUNNEL
SABINE STREET
AUSTIN, TEXAS

LOG OF BORING BI-505

NOTES : Hole dry prior to coring at 8.9'.
Northing: 10072830.84
Easting: 3116630.78

DATE DRILLED : 12-31-07

BORING DEPTH : 40.0 FEET

DRILLER : John Webb

WATER LEVEL :

ELEVATION : 479.9 FEET

DRILLING METHOD : 4" Flight Augers to 8.9'; NXB Wireline to 40'.

LAT :

LONG. :

DEPTH (feet)	SOIL DESCRIPTION	% CORE RECOVERY	RQD (%)	DRILLING RATE (MIN./FT.)	CORE INTERVAL (FEET)	BLOWS PER FOOT	UCC STR. (PSI)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	LIQUID LIMIT(%)	PLASTICITY INDEX	% PASSING #200 SIEVE
	Fill - Unclassified brown & light brown clayey silty sand w/scattered small to medium limestone rock					26						
						9		7.0		28	13	37.0
	-- Elevation 475.9'											
5	LEAN CLAY (CL), brown & light brown, silty, sandy (medium stiff) (Upper Colorado River Terrace Deposits)					10						
	-- with small to medium limestone rock					14		12.0		28	13	58.0
						50/5"						
	-- Elevation 471.5				8.9							
10	LIMESTONE, gray, w/thin to medium clayey layers (medium hard) (Austin Group)	100	100		10.4							
	-- fragmented at 11.0' *-- parting at 11.8'*	100	90									
15					15.2							
	-- multiple clayey limestone beds & clay partings at 17.3'-18.1'	100	98									
20					20.0							
		100	100									
25					24.8							
	-- bentonitic w/slickensides 25.6'-26.6' (36° angle) *-- parting at 27.7'*	100	50									
					29.6							
30		100	100		30.4							
	-- parting at 30.5' *-- five partings at 31.0'-31.6'* *-- parting at 33.0'* *-- parting at 34.2'*	100	90									
35	*-- parting at 35.1'; 35.2'*				35.2							
		100	100									
40	-- Elevation 439.9				40.0							
	Terminated @ 40 feet											

Holt Engineering Inc.

SUBSURFACE EXPLORATION LOG

PROJECT Waller Creek Flood Control Tunnel Austin, Texas
TYPE OF BORING Sample/Core
BORING NO. B-2P
DATE 6/25/85
JOB NO. 5431
SURFACE ELEV. 480.54 ft.

LEGEND — ▼ groundwater table
sample type
◪ thin-walled tube ◩ penetration test ☒ no recovery
■ double tube core barrel ▨ disturbed ☐

DEPTH FT. (ELEV.)	SAMPLE NO. & TYPE	DESCRIPTION OF STRATA	N—blows / ft. R—recovery % P—pock. pen, tsf RQD—rock qual. desig.
(480.0)	1	Light brown, sandy, lean CLAY w/gravel. CL (Fill)	P1.5
	2		P4.5+
	3	Brownish gray, sandy, lean CLAY, calcareous, medium stiff to stiff, w/subangular, coarse limestone gravel and charcoal fragments. CL (Alluvium)	P4.5+
5	4		P4.5+ P1.75
(472.7)	5	residual soil and completely weathered limestone from 7.0 to 7.8 ft.	N100/8"
(471.9)	6		
10	7	Very pale orange LIMESTONE, slightly weathered, moderate hardness, thin- to thick-bedded, massive to nodular, fossiliferous, w/scattered, very thin, shaly limestone beds, thin clayshale laminations, and scattered discontinuities. (Austin/Atco)	R100 RQD100
15	8	Very light to light gray LIMESTONE, fine-grained, moderate hardness, thin- to thick-bedded, massive to nodular, fossiliferous, w/scattered, very thin, shaly limestone beds, thin clayshale laminations, and scattered discontinuities.	R100 RQD86
20	9		R100 RQD80
		(Austin/Atco)	
25	10		R100 RQD88
(454.4)		bentonite layer from 26.1 to 26.6 ft.	
30	11		R100 RQD94
35	12		R100 RQD100
	13		R100 RQD100

SUBSURFACE EXPLORATION LOG

JOB NO. 5431 DATE 6/25/85 BORING NO. B-2P

40	13	Very light to light gray LIMESTONE, fine-grained, moderate hardness, thin- to thick-bedded, massive to nodular, fossiliferous, w/scattered, very thin, shaly limestone beds, thin clayshale laminations, and scattered discontinuities. (continued)	R100 RQD100
45	14	(Austin/Atco)	R100 RQD100
50	15	transition zone to Eagle Ford/South Bosque from 50.1 to 50.9 ft.	R92 RQD92
(429.6)		Total depth of boring, 51.0 ft.	
55			
60			
65			
70			
75			
80			
85			

NOTES:

(1) Boring was advanced dry to the 8.0-ft. depth, and no groundwater was encountered above that depth.

(2) Upon completion of drilling operations, a piezometer was installed with the bottom at 51.0 ft. and the lower 10.0 ft. slotted.

(3) The water surface was noted at the 27.2-ft. depth on 7/23/85, and the piezometer was bailed down to the 46.1-ft. depth.

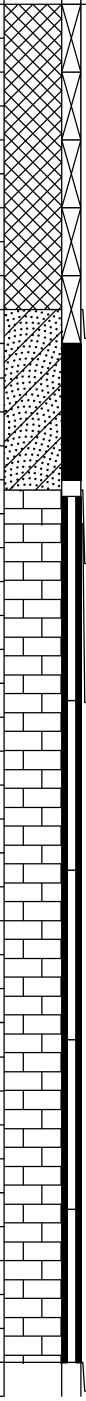
(4) On 7/24/85, the water surface (drilling fluid) was noted at the 44.3-ft. depth (1.8-ft. rise in 24 hours).

WALLER CREEK TUNNEL
SABINE STREET
AUSTIN, TEXAS

LOG OF BORING BI-516

NOTES : Wet on top of limestone at 14.0'. 100% Water loss in fill.
Northing: 10073035.9134
Easting: 3116647.1872
ELEVATION : 487.6 FEET

DATE DRILLED : 03-23-09
BORING DEPTH : 40.0 FEET
DRILLER : John Webb
WATER LEVEL : 14.0 FEET
DRILLING METHOD : 4" Flight Augers to 14.5'; NXB Wireline to 40'
LAT :
LONG. :



DEPTH (feet)	GRAPHIC LOG	SAMPLE	SOIL DESCRIPTION	% CORE RECOVERY	RQD (%)	DRILLING RATE (MIN./FT.)	CORE INTERVAL (FEET)	BLOWS PER FOOT	UCC STR. (PSI)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	LIQUID LIMIT(%)	PLASTICITY INDEX	% PASSING #200 SIEVE
			Fill - Unclassified tan & light brown clayey sandy silt w/small to large limestone rock & gravel					28						
								12						
5								14						
								16						
			-- Elevation 478.6'					12						
10			CLAYEY SAND (SC), brown, very silty, lighter w/depth (medium stiff to stiff) (Upper Colorado River Terrace Deposits)							22.1	100.9	42	24	41.7
15			▽ -- Water Level Elevation 473.6' Water level 14 feet -- Elevation 473.4'				14.5							
			LIMESTONE, tan, w/thin fractured limestone layers, fossiliferous, moderately weathered, w/mechanical breaks along minor clay partings and fossils (medium hard) -- Elevation 472.3'	100	90				3404.4	6.5	140.6			
20			LIMESTONE, gray, w/thin to medium marl layers (medium hard) (Austin Group) -- Reddish brown iron stained lenses @ 16.5'-16.6' -- Pyrite @ 20.2' -- Clay, soft, bentonite @ 22.3'-22.4' -- Clayey limestone @ 23.4'-23.6'	100	100		20.5		1012.6	7.5	137.2			
25				100	95		25.5							
30			-- Clayey limestone @ 30.1'-30.2' -- Bentonite clay @ 31.0'-32.0' -- 15° Angle fracture w/slickensides @ 31.9' -- Clayey limestone @ 32.8'-33.0'	100	100		30.5		382.0	13.3	122.2			
35				100	100		35.5							
40			-- Elevation 447.6'				40.0							

Terminated @ 40 feet

Holt Engineering Inc.

WALLER CREEK TUNNEL
SABINE STREET
AUSTIN, TEXAS

LOG OF BORING BI-513

NOTES : Hole dry prior to coring at 6.5'. No water loss.
Northing: 10073061.3072
Easting: 3116530.8155
ELEVATION : 484.1 FEET

DATE DRILLED : 03-26-09

BORING DEPTH : 40.0 FEET

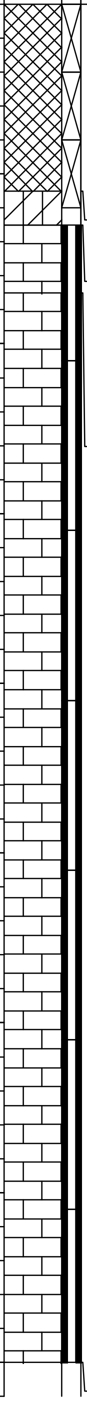
DRILLER : John Webb

WATER LEVEL :

DRILLING METHOD : 4" Flight Augers to 6.5'; NXB Wireline to 40'

LAT :

LONG. :



DEPTH (feet)	GRAPHIC LOG	SAMPLE	SOIL DESCRIPTION	% CORE RECOVERY	RQD (%)	DRILLING RATE (MIN./FT.)	CORE INTERVAL (FEET)	BLOWS PER FOOT	UCC STR. (PSI)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	LIQUID LIMIT(%)	PLASTICITY INDEX	% PASSING #200 SIEVE
			Fill - Unclassified light brown & tan clayey sandy silt w/limestone rock & gravel					37						
								36						
5								15						
			-- Elevation 478.6'				6.5							
			LEAN CLAY (CL), tan, silty (stiff) -- Elevation 477.6'											
10			LIMESTONE, tan, w/thin fractured layers, friable, fossiliferous, moderately weathered, mechanical breaks along minor clay partings & fossils (medium hard) (Austin Group) -- Gray, fresh @ 8.4' (hard) -- Elevation 475.6'	100	55									
							10.5							
15			LIMESTONE, gray, w/thin to medium marl layers (medium hard) (Austin Group) -- Reddish tan, clayey limestone lense @ 11.5'-11.8' -- Clay parting @ 13.8'	100	95									
							15.5							
			-- Clayey limestone @ 17.4'-17.6'; 18.1'-18.7'; 19.8'	100	100									
20							20.5							
25				100	100									
							25.5							
			-- Clayey limestone @ 25.4'-25.5' -- Clayey, Bentonite @ 26.2'-27.2' -- 35° Angle fracture, closed @ 26.9'	100	100									
30							30.5							
				100	80									
35			-- Bentonite @ 34.7' -- Clayey limestone @ 35.2'-35.6'				35.5							
				100	100									
40			-- Elevation 444.1'				40.0							
			Terminated @ 40 feet											

LOG OF BORING PSI 10-49307-PH 2-WALLER CREEK TUNNEL.GPJ HOLT ENGINEERING.GDT 6/22/09

Holt Engineering Inc.

Job No. 10-49307