

City of Houston

Design Manual

Chapter 11

**GEOTECHNICAL AND ENVIRONMENTAL
REQUIREMENTS**

Chapter 11

GEOTECHNICAL AND ENVIRONMENTAL REQUIREMENTS

11.01 CHAPTER INCLUDES

- A. Section I: Includes minimum Geotechnical Investigation Requirements for projects inside the city limits of Houston and within its extra territorial jurisdiction (ETJ).
- B. Section II: Includes minimum Phase I Environmental Site Assessment (ESA I) and Phase II Environmental Site Assessment (ESA II) Requirements for land involved in the City of Houston real estate transactions, interdepartmental transfers, ETJ, and rights-of-way which will be involved in the construction projects.

11.02 REFERENCES

The latest versions of the following references shall be reviewed in conjunction with this chapter:

- A. The American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures.
- B. The American Society for Testing and Materials (ASTM) standard test methods and environmental site assessments processes.
- C. The City of Houston's Standard Construction Specifications.
- D. The Harris County Flood Control District's (HCFCD) Geotechnical Investigation Guidelines.
- E. The Houston Geological Society (HGS) requirements for conducting fault studies.
- F. Rules and regulations published by the Occupational Safety and Health Administration (OSHA).
- G. Rules and regulations published by the Texas Commission on Environmental Quality (TCEQ).
- H. Rules and regulations published by the Texas Department of Licensing and Regulation (TDLR) including Texas Administrative Code (TAC) Chapter 76 – Water Well Drillers and Water Well Pump Installers.
- I. Rules and regulations published by the Texas Board of Professional Engineers (TBPE).
- J. Geotechnical Manual issued by the Texas Department of Transportation (TxDOT).
- K. The Texas Manual on Uniform Traffic Control Devices (TMUTCD).

11.03 DEFINITIONS

- A. Engineer of Record – Project Civil Design Consultant.
- B. Project Manager – An authorized representative of the City of Houston who manages the project or the Engineer of Record for private development.
- C. Geotechnical Consultant – A consultant who is practicing in the field of Geotechnical Engineering in the State of Texas and has a valid status with the TBPE.
- D. Environmental Consultant – An environmental professional who is meeting the education, training, and experience requirements as set forth in 40 CFR 312.10(b).
- E. Licensed Engineer – An engineer currently licensed to practice engineering in the State of Texas and is in good standing with the TBPE.
- F. Licensed Geoscientist – A geoscientist currently licensed to practice geosciences in the State of Texas and is in good standing with the Texas Board of Professional Geoscientists.

SECTION I

11.04 GEOTECHNICAL REQUIREMENTS

- A. A detailed Geotechnical Investigation (by borings) is required for the completion of the design of the proposed facilities. Subsurface information from the earlier project design activities shall be incorporated if it is sufficient and reliable for the current project as determined by the Project Manager in consultation with the Geotechnical Consultant.
- B. The purpose of the Geotechnical Requirements is to outline the minimum recommended procedures for implementing a uniform approach for the preparation of the Geotechnical Investigation Reports on the City of Houston projects including its ETJ.
- C. The scope of the Geotechnical Investigation may need to be expanded or modified on a case by case basis as determined necessary and appropriate by the Project Manager. It is not the intent of the Geotechnical Requirements to specify methods or scope of Geotechnical Investigation for individual projects, or to supplant the judgment of the Licensed Engineer. No provision in these requirements should be construed to constitute a statute, ordinance, or regulation, unless stipulated elsewhere.
- D. In the event that any part of the Geotechnical Requirements should be found to be in conflict with laws or regulations of competent jurisdiction or ruled to be invalid by a court authority of competent jurisdiction, the remainder of the Geotechnical Requirements shall remain in full force and effect, and the conflicting section or item shall be deleted or revised as required and as determined necessary by the City of Houston.

- E. These Geotechnical Requirements are not applicable when another agency (like the HCFCD) will maintain the facility, or the funding source (like the TxDOT) has specific requirements that must be met in order to receive funding for the project. In which case, another agency's requirements shall be applicable.
- F. Not all of the information in this chapter will be applicable to every project, but the investigative scope should be consistent with the sensitivity of the intended use and the physical constraints of the project.

11.05 ENGINEER OF RECORD'S EFFORTS

- A. The Engineer of Record, at the proposal stage of the project, shall work with the Geotechnical Consultant to develop the proper scope of the project.
- B. The Engineer of Record shall inform the Geotechnical Consultant for any changes in the project related to Geotechnical Investigation as soon as possible.
- C. The Engineer of Record shall assist the Geotechnical Consultant in obtaining required permits for drilling, if requested by the Geotechnical Consultant.
- D. The Engineer of Record shall provide survey information of the borings (after drilling) to the Geotechnical Consultant to be used in the Geotechnical Investigation Report.
- E. The Engineer of Record shall provide a base map using engineering scale (showing the alignments and/or structures) of the project to the Geotechnical Consultant that can be used as a Plan of Borings.
- F. The Engineer of Record shall verify the Geotechnical Investigation performed by the Geotechnical Consultant for the conformance with the Geotechnical Requirements and for conformance with project specific conditions and design requirements.
- G. The Engineer of Record shall review the Geotechnical Investigation Report and attach their review comments with the Geotechnical Investigation Report prior to submittal to the City of Houston.

11.06 GEOTECHNICAL CONSULTANT'S EFFORTS

- A. The Geotechnical Consultant shall confirm with the Engineer of Record that the proper scope of the project is proposed in the proposal.
- B. The Geotechnical Consultant shall include the project description, location, and Key Map Number(s) in the geotechnical proposal. Also, a proposed Plan of Boring(s) may be included in the geotechnical proposal, if available.
- C. The Geotechnical Consultant has a responsibility to obtain the latest information of the project from the Engineer of Record before starting the field investigation. If modifications are

required in the original Geotechnical Investigation scope, then the Project Manager shall be contacted by Engineer of Record before commencement of the field investigation.

- D. The planning of field investigation, laboratory testing, engineering analyses, and close supervision of the work shall be performed by a Licensed Engineer of the Geotechnical Consultant who has experience in this type of work.
- E. All Geotechnical Laboratory tests shall be conducted by the Geotechnical Consultant with current accreditation by the American Association of Laboratory Accreditation (A2LA) or any other accreditation agency approved by the City of Houston.
- F. The Geotechnical Consultant is responsible for adhering to all pertinent federal, state, and local regulations and laws throughout the Geotechnical Investigation.

11.07 SITE ACCESS

- A. When the Geotechnical Investigation will be within the public right-of-way and easement, the Geotechnical Consultant shall obtain necessary permits and arrange for access to boring locations from the appropriate governmental agency.
- B. When the Geotechnical Investigation will require entry onto a private property, the Geotechnical Consultant may require assistance from the Engineer of Record in obtaining permission to enter in the private property.
- C. It shall be the ultimate responsibility of the Geotechnical Consultant to ensure necessary permits are obtained before commencement of drilling for the project.

11.08 TRAFFIC CONTROL

- A. The Geotechnical Consultant is responsible for the safety of drilling work area during field operations, including traffic control commensurate with the traffic while working in the street right-of-way.
- B. Traffic control shall be in accordance with the TMUTCD.
- C. Provide a Certified Flagman to control movement of vehicular and pedestrian traffic when field investigation encroaches on public traffic lanes. Provide a Uniformed Peace Officer for work along major thoroughfares and at signalized intersections.

11.09 FAULT INVESTIGATION

- A. As a part of the Geotechnical Investigation, geologic fault maps, aerial photographs, and literature available in Geotechnical Consultant's library shall be reviewed to evaluate the potential for known active faults that may impact the project.

- B. If a review of available existing information suggests that a known fault may impact the project, a Phase I Geological Fault Study shall be performed as defined by the current HGS guidelines.
- C. At a minimum, the Phase I Geological Fault Study shall consist of a detailed literature review, a remote sensing study with examination of historical aerial photographs (including LiDAR and false color infra-red imagery), a study of subsurface geologic structure maps, topographic maps, and a detailed field reconnaissance.
- D. If the project is part of a larger tract for which a Phase I, II, or III Geological Fault Study is available, the results of the study on the larger tract may satisfy this requirement. In this circumstance, the necessity of a Phase I Geological Fault Study shall be decided by the Project Manager.
- E. The Phase I Geologic Fault Study may also be conducted on areas where no faults appear in published literature and maps but when there is evidence that surface faults and possibly blind faults could exist in that area. In this circumstance, the necessity of a Phase I Geological Fault Study shall be decided by the Project Manager.
- F. When required, the Phase I Geological Fault Study shall be performed as a separate study to supplement the Geotechnical Investigation.
- G. The entire Phase I Geological Fault Study, when required, shall be performed by a licensed geoscientist or a Licensed Engineer in the State of Texas who has substantial experience and training in investigating surface faults in the Greater Houston area. At the least, such experience and training should include a general knowledge of the location of known surface faults in the Gulf Coast, an understanding of fault mechanics, and a familiarity with the many subtle ways that surface faults manifest themselves.

Additional criteria that shall be met by a licensed geoscientist or a licensed engineer are as follows:

1. Ability to recognize surface faults on aerial images and topographic maps.
 2. Ability to distinguish surface faults from other natural and man-made features.
 3. Ability to distinguish ground deformation caused by expansive clay soils from that caused by active faults.
 4. Ability to determine and map the width of the zone of disturbed ground along an active fault.
- H. At a minimum, the Phase I Geologic Fault Study shall determine the likelihood of a surface fault impacting the project. If a fault is determined to be present at the project, it should be delineated on a map. In the event that the fault is clearly visible at the Earth's surface, the

width of the fault's associated deformation zone should be determined and mapped. The mapping shall be considered as an additional study.

- I. When a fault is not clearly visible at the surface, its delineation and mapping may require an investigation employing Phase II and III subsurface methods. In this circumstance, the necessity of the Phase II or Phase III shall be decided by the Project Manager.
- J. The qualifications, including specific geologic fault project experience, of the professional performing the Phase I Geological Fault Study shall be included in the fault report.
- K. The draft report of the Phase I Geological Fault Study report shall be submitted before the final report.
- L. The final report of the Phase I Geological Fault Study shall be signed and may be stamped by the professional conducting the study.
- M. The Phase I Geological Fault Study Report, when required, shall be included in the appendix of the Geotechnical Investigation Report.

11.10 GENERAL INVESTIGATION

- A. Some of the facilities in which Geotechnical Investigation may be required are given below:
 - 1. Above ground water storage tanks and associated structures.
 - 2. Bridges (roadway, pedestrian, and pipe support).
 - 3. Clarifiers and associated structures.
 - 4. Detention/Retention basins.
 - 5. Lift stations and associated structures.
 - 6. Open channels.
 - 7. Retaining walls.
 - 8. Street pavement.
 - 9. Traffic signal foundations.
 - 10. Tunnels.
 - 11. Underground utilities using open cut or trenchless methods.
- B. Geotechnical Investigation may also be required for:

1. Construction that could affect the integrity of adjacent structures (with the exception of interconnections such as service connections and meter vault installations).
2. Proposed construction work near ground slopes, such as drainage channels or natural waterway.

11.11 PROTECTION OF UNDERGROUND UTILITIES AND STRUCTURES

- A. On the public rights-of-way and easements, it shall be the responsibility of the Geotechnical Consultant to have existing utility lines marked and boring locations cleared prior to drilling.
- B. On private properties, it shall be necessary to employ the property owner's assistance to estimate the locations of the underground utilities and structures.
- C. Drilling shall not begin until clearance has been provided or notification that all underground utility lines are marked has been received by the Geotechnical Consultant.
- D. If there is any reason to believe that an underground facility exists in an area to be drilled, and its location cannot be determined with reasonable accuracy, then that boring shall be moved from the area of concern.

11.12 FIELD INVESTIGATION NOTIFICATIONS

- A. The Project Manager shall be informed (via email) about the start date of drilling approximately 48 hours prior to beginning drilling.
- B. If any unusual conditions are encountered during the field investigation (e.g., signs of contamination in the boring, cavity, underground utilities, loose or soft soils at the bottom of the planned boring depth, etc.), then the Project Manager shall immediately be informed.

11.13 FIELD INVESTIGATION

- A. The field logging of the soil samples shall be performed by an experienced soils technician of the Geotechnical Consultant.
- B. For the proposed open cut utility construction, the borings shall be drilled along or as close as possible to the center line of the alignment.
- C. For the proposed trenchless construction, the borings shall be drilled outside the planned utility alignment but within 20 feet of the centerline of the alignment.
- D. Soil Sample Methods and Intervals:
 1. Undisturbed cohesive soils samples should be recovered by using a thin-walled tube sampler in general accordance with ASTM D1587. For granular soils, Split-Barrel samplers should be used in general accordance with ASTM D1586.

2. Continuous soil sampling shall be performed at about 2-foot depth intervals to a minimum depth of about 20 feet of the borings and at about 5-foot interval thereafter to the termination depth of borings with the exception for bridge, retaining wall, lift station, and tunnel borings. If the boring depth is less than 20 feet, then continuous sampling shall be performed to the termination depth of the boring.
3. If a soil boring for bridge or retaining wall is within the TxDOT right-of-way, then the current TxDOT guidelines shall be followed including performing Texas Cone Penetration (TCP) testing.
4. If a soil boring for bridge or retaining wall is outside the TxDOT right-of-way, then the TCP testing is not required. However, TxDOT sampling interval guidelines shall be followed.
5. For lift stations, continuous soil sampling shall be performed at 2-foot depth intervals from natural ground to 5-foot below the depth of the excavation.
6. For tunnels, continuous soil sampling shall be performed from one bore diameter (or minimum of 6 feet) above the bore crown to one bore diameter (or minimum of 6 feet) below the bore invert level and at about 5-foot intervals in the remainder of the boring.
7. If unusual soils are encountered (e.g., loose or soft soils, etc) after the depth of 20 feet, then the intermittent soil sampling shall be changed to continuous soil sampling through the anomalous layer.

E. Boring Spacing

1. Soil borings shall be conducted in order to obtain sufficient information about the subsurface soil stratigraphy and water level conditions.
2. The recommended boring spacing is given in Table 11.1 (Page 11-9), unless waived by the Project Manager in writing.
3. For geotechnical features that are not mentioned in Table 11.1, the Project Manager shall be contacted.
4. Based on the reliability of soil information available to the City of Houston from the previous project design activities, the recommended boring spacing may be modified by the Project Manager in consultation with the Geotechnical Consultant.

F. Boring Depth

1. The minimum boring depths are given in Table 11.1, unless waived by the Project Manager in writing.

2. For geotechnical features that are not mentioned in Table 11.1, the Project Manager should be contacted.
3. Boring depth shall be increased by the Geotechnical Consultant if unusual soil conditions are encountered during field investigation (e.g., loose or soft soil at the bottom of the planned boring depth, etc).
4. The depth of borings for paving in conjunction with utility work is governed by utility requirements.

Table 11.1

BORING SPACING AND DEPTH

| Project Type | Approximate Spacing | Minimum Depth |
|-------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| FACILITIES | | |
| Above Ground Water Storage Tank | At center: One (1) boring at the center. At periphery: At a minimum spacing of 100 feet. | At center: one tank diameter. At periphery: 0.75 tank diameter. |
| Electrical or Other Building | Depends on the size of the building and loading. | 20 feet. |
| Clarifier | At center: One (1) boring at the center. At periphery: At a minimum spacing of 100 feet. | At center: one clarifier diameter. At periphery: 0.75 clarifier diameter. |
| Lift Station (Less than 30-foot diameter) | At least one (1) soil boring within the footprint. | Proposed Lift Station depth plus: |
| Lift Station (30-foot or larger diameter) | At center: One (1) boring at the center. At periphery: At a minimum spacing of 100 feet. | <ul style="list-style-type: none"> ○ At center: diameter of lift station ○ At periphery: 0.75 times diameter of lift station. |

| Project Type | Approximate Spacing | Minimum Depth |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DRAINAGE | | |
| Detention / Retention Basin | The HCFCD guidelines should be followed. | |
| Open Channel | The HCFCD guidelines should be followed. In addition, one boring with a minimum depth of 30 feet to be drilled on each side of the channel and as close as safely possible to the channel. | |
| UNDERGROUND UTILITIES | | |
| Open Cut | Minimum distance of 500 feet. | <ul style="list-style-type: none"> ○ 15 feet for trenches up to 10-foot deep. ○ Trench depth plus ten feet for trenches between 10-foot and 25-foot deep. ○ One and one half times the trench depth for trenches greater than 25-foot deep. |
| Augered | Minimum distance of 500 feet. | 5-foot below the proposed invert level. |
| Tunnels and Microtunnels | Minimum distance of 500 feet. | Minimum one tunnel diameter or 15-foot below the proposed invert level (whichever is greater). |
| Shafts for Tunnels | Each Location. | 1.5 times the shaft diameter below the bottom of the shaft but not less than 30 feet. |
| STREET & BRIDGE | | |
| Pavement (Street) only | Minimum distance of 500 feet. | 5 feet. |
| Pedestrian and Pipe Bridge | Each side of drainage channel. | 40 feet below the bottom of drainage channel. |

| Project Type | Approximate Spacing | Minimum Depth |
|-------------------------------------------------------------------------------------|------------------------------------------|---------------|
| Retaining Walls | The TxDOT guidelines should be followed. | |
| Roadway Bridge | The TxDOT guidelines should be followed. | |
| Traffic Signal Foundation | Each location. | 20 feet. |
| OTHER | | |
| Discretion of Geotechnical Consultant, Engineer of Record, and the City of Houston. | | |

G. Piezometers

1. Piezometers may be included in the scope of the Geotechnical Investigation if the project includes any of the following:
 - a. Excavation exceeding 15 feet in depth.
 - b. Crossing underneath a major drainage channel.
 - c. Crossing underneath a major TxDOT or the Harris County Toll Road Authority corridor.
 - d. Tunneling (hand or Tunnel Boring Machine) or Microtunneling installation for an extended length.
2. Piezometers shall be installed in accordance with the applicable rules and regulations of TDLR.
3. A minimum of two water level readings are required on each piezometer. The Geotechnical Consultant shall read water levels at 24 hours and 30 days (long term) after the installation of the piezometer, unless otherwise approved by the Project Manager.
4. For utility lines, spacing between piezometers shall be no greater than 2,500 feet in any direction.
5. One piezometer shall be installed within the footprint of a proposed deep structure, such as wet well or access shaft.
6. The Piezometer Installation Report (as shown on Figure 11.1) shall be included in the Geotechnical Investigation Report.

11.14 SITE RESTORATION

- A. The Geotechnical Consultant shall be responsible for clean up and site restoration upon completion of the field investigation.
- B. If for any reason the borehole must remain open, then appropriate measures shall be taken by the Geotechnical Consultant to protect the safety of the public.
- C. Plugging of Piezometer(s).
 - 1. The Geotechnical Consultant shall plug piezometer(s) installed for the project in accordance with the TDLR (Chapter 76 of TAC) soon after measuring long term water level readings. A copy of Piezometer Installation and Plugging Reports (submitted to the TDLR) shall be included in the Geotechnical Investigation Report.
- D. Backfilling of Borings.
 - 1. All borings under the existing or proposed pavement shall be backfilled with cement bentonite grout using the tremie method.
 - 2. In unpaved areas where boring depth exceeds 10 feet (or if free water is encountered) boreholes shall be backfilled with cement bentonite grout using the tremie method. For depths of 10 feet or less, soil backfill tamped into the borehole is acceptable.
 - 3. Boreholes in known contaminated areas, or in which contamination otherwise has been detected, shall be backfilled with cement-bentonite or non-shrink grout using tremie method.
- E. Restoration of Pavement Cores.
 - 1. Boreholes or cored pavements shall be restored for the full depth of pavement using cold patch in asphalt paved areas and ready-mix concrete in concrete paved areas. Larger penetrations shall be repaired following the current City of Houston guidelines.
 - 2. The pavement shall not be restored until the borehole grout has taken initial set to allow for any settlement or shrinkage of the grout.

11.15 SURVEY REQUIREMENTS

- A. The locations and elevations of boreholes and piezometers shall be surveyed by the Engineer of Record or another member of the project team.
- B. The elevation and coordinates shall be shown on boring and piezometer logs by the Geotechnical Consultant.

- C. The station and offset of boreholes and piezometers may also be shown on boring and piezometer logs (in addition to coordinates) by the Geotechnical Consultant.

11.16 LABORATORY TESTING

- A. The purposes of the laboratory testing are to define the soil classification, soil stratigraphy, and the relevant engineering properties of the soils.
- B. The laboratory tests shall be performed in general accordance with the latest revision of the ASTM standards.
- C. The laboratory tests may include but not limited to the following:
 - 1. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Modified Unified Soil Classification System)
 - 2. ASTM D4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
 - 3. ASTM D1140 – Standard Test Methods for Amount of Material in Soils Finer Than the No. 200 (75- μ m) Sieve
 - 4. ASTM D2216 – Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
 - 5. ASTM D2166 – Standard Test Method for Unconfined Compressive Strength of Cohesive Soil
 - 6. ASTM D2850 – Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils
- D. The selection of appropriate laboratory tests beyond the above tests is left to the discretion of the Geotechnical Consultant in consultation with the Project Manager.
- E. To assist in properly classifying the soils in general accordance with ASTM D2487, the laboratory testing program shall include a minimum of one set of Liquid and Plastic Limits (ASTM D4318) and Percent Passing Number 200 Sieve (ASTM D1140) tests on a representative cohesive soil sample in each boring.
- F. The water content test (ASTM D2216) shall be performed on all cohesive soil samples to determine the moisture profile.
- G. The Unconfined Compression Strength test (ASTM D2166) shall not be performed on a soil sample containing seams or slickensides.

- H. If the invert level of the utility is greater than 5 feet, a minimum of one Unconsolidated-Undrained Triaxial test (ASTM D2850) shall be performed on a representative cohesive soil sample in each boring.
- I. Aggressivity tests (Sulfates, Chlorides, pH, and Electric Resistivity) shall be performed on soil and/or water samples on projects where metallic pipes are used. Geotechnical Consultant shall not discard soil samples without ensuring from Engineer of Record that corrosion monitoring and/or corrosion control recommendations are made and soil samples are not needed.
- J. All the test results shall be summarized in the report in a table format. The Geotechnical Consultant shall include the summary of the test results on the most updated template format (or approved equal), as provided by the City of Houston (as shown on Figure 11.2).

11.17 BORING LOG FORMAT

- A. The Geotechnical Consultant shall submit the boring log on the most updated template format (or approved equal), as provided by the City of Houston and shown on Figure 11.3.
- B. The City of Houston project number shall be written on all boring logs.
- C. Any test data that is not included in boring log shall be reported separately in general accordance with the reporting guidelines mentioned in the ASTM standard of that test.

11.18 BORING LOG PROFILE

- A. When more than one borings are drilled for the project, boring log profile(s) along the project alignments(s) shall be included in the Geotechnical Investigation Report as shown on Figure 11.4.
- B. If the invert depths of utility line are known, then utility line shall be plotted on the boring log profile(s) as shown on Figure 11.4.

11.19 ENVIRONMENTAL CONCERNS

- A. The Geotechnical Consultant shall look for obvious signs of visual staining of the soil samples, note any odors (specifically of hydrocarbon nature) during drilling, and summarize this information in the report.

11.20 GEOTECHNICAL INVESTIGATION REPORT – GENERAL REQUIREMENTS

- A. The Geotechnical Investigation Report shall be an in-depth evaluation that entails a review of available pertinent literature, geologic fault information, field subsurface investigation, laboratory testing, engineering analysis of the data obtained, and recommendations concerning the proposed facilities.
- B. The content of the Geotechnical Investigation Report shall be project specific.

- C. The Geotechnical Consultant shall review any soil information (provided by the Project Manager) that may be available from the previous project design activities. The summary is to be included in the Subsurface Conditions section of the Geotechnical Investigation Report. The borings logs and the plan of borings shall be included in the appendix of the Geotechnical Investigation Report.
- D. Any illustration containing copyright information (e.g., aerial views from the Internet or Key Map for Plan of Borings, Vicinity Map, etc.) shall have proper reproduction permission and credits written on the illustration.
- E. All drawings (including drawings for the slope stability analyses) shall be at a scale available on a standard engineering scale.
- F. The pavement design shall be in accordance with the latest edition of the AASHTO Guide for Design of Pavement Structures.
- G. The Geotechnical Consultant shall perform a quality control review of the Geotechnical Investigation Report before its submittal. The Engineer of Record shall provide a separate review of the Geotechnical Investigation Report prior to its submittal.
- H. For the City of Houston projects, the Geotechnical Consultant shall submit a Draft Geotechnical Investigation Report (hard copy) to the City of Houston for review prior to submitting the Final Geotechnical Investigation Report. The title of the report shall identify if the report is a draft or final report.
- I. The Final Geotechnical Investigation Report shall be signed and sealed by a Licensed Engineer.

11.21 GEOTECHNICAL INVESTIGATION REPORT – RECOMMENDATIONS

The minimum geotechnical recommendations shall address the following:

- A. Open-Cut Installation: Bedding, backfill, excavation wall and bottom stability, thrust restraint, dewatering, and pipe design parameters.
- B. Auger Installation: Soil design parameters, ground stability, auger pit excavation stability, and dewatering.
- C. Tunnels and Shafts: External pressures on primary and permanent liners, wall and bottom stability, and dewatering.
- D. Open Channel: Slope angle or slope ratio, setback distance for structures or appurtenances included in the project, and erosion protection.

- E. Detention Pond: Slope angle or slope ratio, setback distance for structures or appurtenances included in the project, and erosion protection.
- F. Paving:
1. The requirements in Chapter 10 “Street Paving Design Requirements” of the City of Houston Infrastructure Design Manual shall be followed.
 2. For rigid paving: At a minimum, the pavement thickness and minimum subgrade treatment shall be included. All the selected design parameters used in obtaining the pavement thickness shall be provided in the report.
 3. For flexible paving: At a minimum, the design Structural Number (SN), recommended pavement section and its SN, and subgrade treatment shall be included. All the selected design parameters used in obtaining the pavement thickness shall be provided in the report.
 4. For overlay projects, recommendations for rehabilitation shall be provided.

11.22 GEOTECHINICAL INVESTIGATION REPORT – TABLE OF CONTENTS

- A. The Geotechnical Investigation shall be presented in report including the text sections, tables, illustrations, and appendices as shown below:

Transmittal Letter – The transmittal letter in accordance with the TBPE rules.

Executive Summary – Summarize the work performed for the project including findings and recommendations.

Table of Contents (with page numbers)

1. Introduction
 - a. General
 - b. Authorization
 - c. Location and Description of the Project
 - d. Purpose
 - e. Scope
2. Field Investigation
 - a. General
 - b. Geotechnical Borings
 - c. Piezometer Installation
3. Laboratory Testing
4. Subsurface Conditions

- a. Geology
 - b. General Fault Information
 - c. Soils Stratigraphy
 - d. Soils Stratigraphy from the Previous Project Design Activities (if applicable)
 - e. Water Levels
5. Engineering Analyses and Recommendations
 6. Construction Considerations
 7. Limitations
 8. Tables
 - a. Summary of Boring Information (Number, depth, survey information with baseline and datum). The survey coordinates shall be as per Texas South Central Zone No. 4204 State Plane Grid (not surface) Coordinates (NAD83).
 - b. Geotechnical Design Parameters
 - c. Summary of Test Results
 9. Illustrations (varies based on the project requirements, using 8.5 x 11 pages)
 - a. Vicinity Map
 - b. Fault Map
 - c. Plan of Borings
 - d. Boring Log Profile (showing utility lines)
 - e. Earth Pressure Diagrams
 - f. Thrust Force
 - g. Liner Load
 - h. Vertical Stress on the Pipe
 - i. Stability of Bottom for Braced Cut
 - j. Uplift Resistance
 - k. Pile/Shaft Capacity Curves
 - l. Any other relevant illustration
 10. Appendices (several of the following may be combined in one appendix)
 - a. Boring Logs
 - b. Piezometer Installation Report (Figure 11.1 and report submitted to the TDLR)
 - c. Piezometer Plugging Report (report submitted to the TDLR)
 - d. Grain Size Distribution Curves (if applicable)
 - e. CU, Pinhole, or any other test results (if applicable)
 - f. Slope Stability Analyses Information (if applicable)
 - g. Fault Study Report (if applicable)
 - h. Pavement Design Calculation
 - i. Information from the Previous Project Design Activities (if applicable)
 - j. Any other relevant information

- B. When required, a separate Trench Safety Report shall be provided for the City of Houston projects. The Trench Safety Report shall satisfy statutory requirements for contracting for trench safety construction.
- C. The Geotechnical Consultant shall provide an electronic version (in pdf format) of the entire Final Geotechnical Investigation Report (one file).
- D. The Geotechnical Consultant shall also provide electronic files of the final boring logs. The files must be compatible with input files used by “gINT” LogWriter software.

(Continued on next page)

**FIGURE 11.1
 PIEZOMETER INSTALLATION REPORT FORMAT**

PIEZOMETER INSTALLATION REPORT

| | |
|-------------------------|--------------------------|
| PROJECT NAME | PIEZOMETER NUMBER: B-??P |
| GEOTECHNICAL CONSULTANT | DESIGN CONSULTANT |
| CITY OF HOUSTON | |

| | | | |
|------------------------------------------------------------------------------------------------------------------|---------------|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| COMPLETION DATE: _____ DRY AUGERED _____ TO _____ FT WASH BORED _____ TO _____ FT DRILLING FLUID: _____ | DEPTH (FT) | APPROX. ELEV. (FT) | RISER PIPE SHOULD BE SHOWN INSTEAD OF MANHOLE COVER, WHERE APPLICABLE |
| DEVELOPMENT DATE: _____ METHOD OF DEVELOPMENT: _____ BAILING | 0 | | |
| WATER LEVEL READINGS: DATE DEPTH (TOG) APPROX. ELEVATION (FT) | | | TYPE OF BACKFILL CEMENT-BENTONITE RISER PIPE TYPE PVC CASING I.D. 2" TYPE OF COUPLING THREADED TYPE OF SEAL BENTONITE TYPE OF FILTER FILTER SAND SCREEN TYPE SLOT I.D. 2" SLOT SIZE 0.01" TYPE OF BOTTOM CAP THREADED PVC |
| (NOT TO SCALE) | | | |

REMARKS:

| | | | |
|----------------------------------------------------------------------------------|-------------|--------------|---------------------|
| NOTES: 1. DIMENSIONS NOMINAL UNLESS OTHERWISE NOTED 2. TOG = TOP OF GROUND | DRILLED BY: | STARTED: | APPROX. STATION: |
| | LOGGED BY: | COMPLETED: | GROUND LEVEL (MSL): |
| | CHECKED BY: | APPROVED BY: | COORDINATES: |
| | | | |

Company Name (option)

FIGURE

**FIGURE 11.3
 BORING LOG FORMAT**

| LOG OF BORING NO. B- | | | | | | | | | | | | | | | | | | | | |
|----------------------------------------------------------------------|-------------|--------|---------|--------------------------------------------------------------------------------|------------------------|--|--|-------------------------------------------|-------------------------------|----------------------|-----------------------------|-----------------|------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|
| PROJECT : | | | | | PROJECT NO. : | | | | | | | | | | | | | | | |
| LOCATION : N xx,xxx.x, E xx,xxx.x See Plan of Borings (Figure no) | | | | | COMPLETION DEPTH : FT. | | | | | | | | | | | | | | | |
| SURFACE ELEVATION : FT. | | | | | DATE : MM-DD-YY | | | | | | | | | | | | | | | |
| ELEVATION, FEET | DEPTH, FEET | SYMBOL | SAMPLES | SAMPLER : Shelby Tube/Split Spoon DRY AUGER : TO FT. WET ROTARY : TO FT. | | | | STANDARD PENETRATION TEST, BLOWS PER FOOT | PERCENT PASSING NO. 200 SIEVE | DRY UNIT WEIGHT, PCF | NATURAL MOISTURE CONTENT, % | LIQUID LIMIT, % | PLASTIC LIMIT, % | PLASTICITY INDEX, % | UNDRAINED SHEAR STRENGTH, TSF | | | | | |
| | | | | DESCRIPTION OF MATERIAL | | | | | | | | | | | <input type="checkbox"/> HAND PENETROMETER <input checked="" type="checkbox"/> UNCONFINED COMPRESSION <input checked="" type="checkbox"/> UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION <input type="checkbox"/> TORVANE 0.5 1.0 1.5 2.0 2.5 | | | | | |
| | 0 | | | | | | | | | | | | | | | | | | | |
| | 5 | | | | | | | | | | | | | | | | | | | |
| | 10 | | | | | | | | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | | | | | | | | |
| | 20 | | | | | | | | | | | | | | | | | | | |
| | 25 | | | | | | | | | | | | | | | | | | | |
| | 30 | | | | | | | | | | | | | | | | | | | |
| | 35 | | | | | | | | | | | | | | | | | | | |

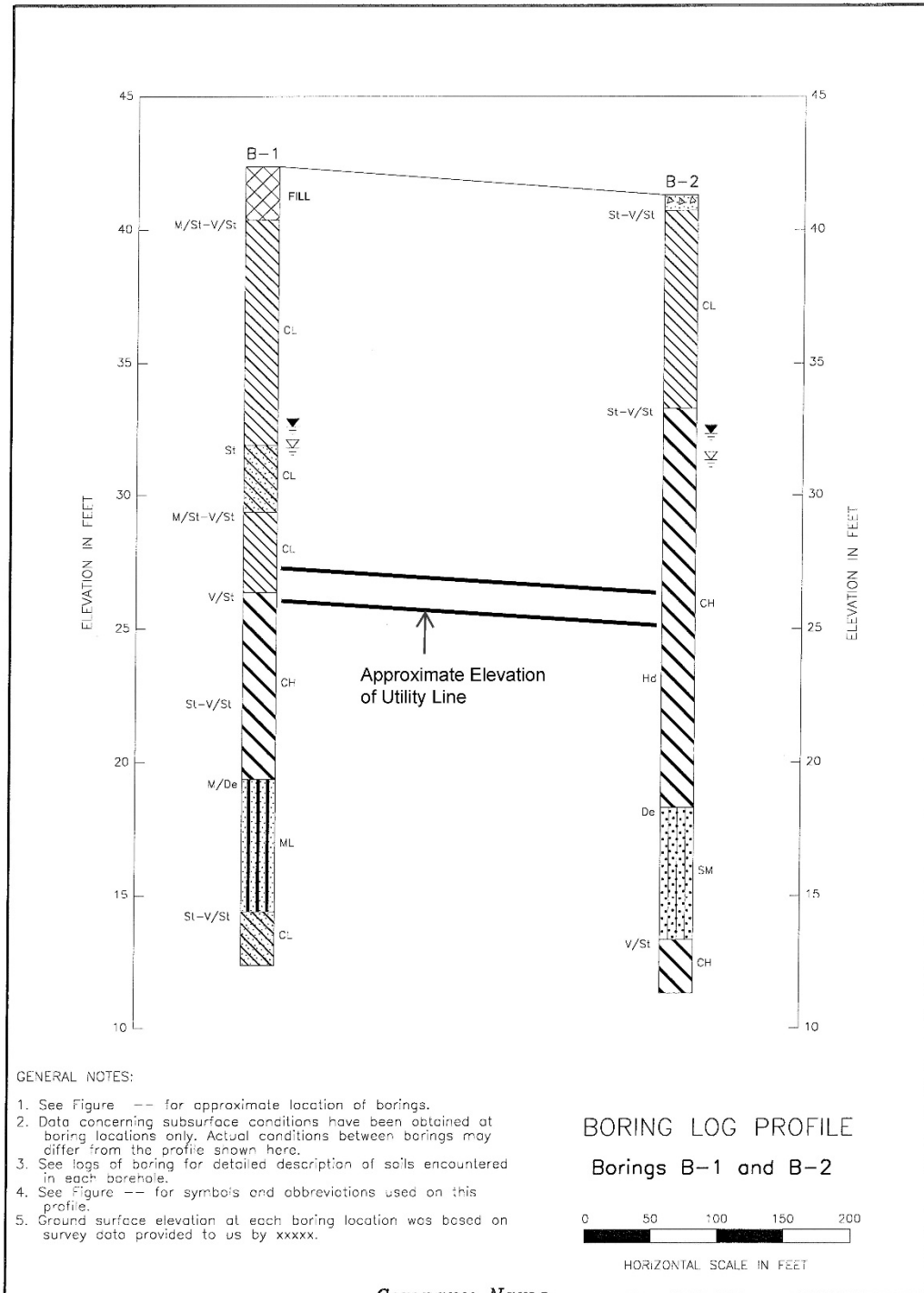
DEPTH TO WATER IN BORING :
 ♣ : FREE WATER 1st ENCOUNTERED AT 10.0 FT. DURING DRILLING; AFTER 15.0 MIN. AT 8.0 FT.
 ♣ : WATER DEPTH AT 7.5 FT., HOLE OPEN TO 35.0 FT. ON mm-dd-yy.

Drilled By: _____ Logged By: _____

Company Name

FIGURE

FIGURE 11.4
BORING LOG PROFILE FORMAT



Chapter 11 (Continued)

SECTION II

11.23 PHASE I ENVIRONMENTAL SITE ASSESSMENT (ESA I) REQUIREMENTS

This section categorizes various types of projects that require an ESA I and sets a minimum scope of work for:

- A. Property to be acquired by the City of Houston and property involved in divestitures and inter-departmental transfers; and
- B. The City of Houston construction projects.

11.24 PROPERTY TO BE ACQUIRED BY THE CITY OF HOUSTON AND PROPERTY INVOLVED IN DIVESTITURES AND INTER-DEPARTMENTAL TRANSFERS

The ESA I conducted on property to be acquired by the City of Houston shall conform to the latest ASTM Standard Practice E1527 with the following stipulations:

- A. The sources of historical data reviewed for a site shall include, at a minimum, historical aerial photographs, fire insurance maps (where available), local city street directories (where available), and United States Geological Survey (USGS) maps. The chain-of-title search is not required as an historical search. Applicable copies of these sources shall be presented in the report. Since City Directories are copyright protected, copies of these should not be presented in the report. One aerial photograph for every five to ten years interval from approximately 1950 to the present shall be obtained of an appropriate scale (1" = 500', or shall not exceed 1" = 700') to clearly indicate site details. Sites inside the IH-610 Loop shall have property usage identified from the present, back a minimum of 100 years (where available), or to the property's obvious first development, whichever is earlier.
- B. If regulatory records indicate that Leaking Petroleum Storage Tank (LPST) facilities are located within approximately 500 feet of the site, the latest comprehensive assessment or monitoring report maintained on the facility by the TCEQ (Houston District Office) shall be reviewed and summarized in the ESA I report. Any review of records shall be conducted during the ESA I.
- C. If regulatory records indicate that a federal/state superfund facility is located within approximately ¼ mile of the site, the files maintained on that facility by the TCEQ shall be reviewed and summarized in the ESA I report.
- D. The TCEQ's Voluntary Cleanup Program (VCP) database shall be searched for facilities that are located within approximately 500 feet of the site.
- E. If the project includes demolition/renovation of buildings/structures, the ESA I report shall include recommendation for asbestos survey.

- F. If the project includes renovation of buildings/structures constructed before 1978, the ESA I report shall include recommendation for lead based paint survey.
- G. If the site includes undeveloped property, available wetlands maps shall be obtained and reviewed, the presence of hydric soil types shall be reviewed using published information, and the presence of standing or flowing water shall be investigated during the site inspection. The environmental professional shall make a statement in the report concerning the potential for the presence of wetlands on the site and whether or not full wetlands determination delineation is needed.
- H. If the site is in an area of known oil and gas production operations, a record search for oil and gas exploration and production wells on or adjacent to the site shall be included in the ESA I.
- I. Flood Insurance Rate Maps (FIRM) available from the Federal Emergency Management Agency (FEMA) shall be reviewed to identify areas of the subject site located within flood plains.
- J. A minimum of five interviews (where applicable) shall be conducted in accordance with the latest ASTM E1527 Standard Practice.
- K. The environmental professional who conducted the ESA I shall make recommendations for an ESA II, as appropriate, which shall be thorough enough to support an ESA II.

11.25 THE CITY OF HOUSTON CONSTRUCTION PROJECTS

The ESA I conducted on rights-of-way which will be involved in City construction projects shall conform to the latest ASTM Standard Practice E1527 with the following stipulations:

- A. The approximate minimum search distance for Standard Environmental Record Sources may be reduced, pursuant to ASTM E1527, to a radius of 500 feet unless there is a justifiable reason to maintain a larger radius; except the minimum search distance for Federal National Priorities List (NPL), Federal Resource Conservation and Recovery Act – Treatment, Storage, and/or Disposal (RCRA TSD) Facilities, and Texas Hazardous Waste Sites (HWS)/Texas State Superfund Sites shall be maintained at the ASTM specified distance of 1.0 mile.
- B. The sources of historical data reviewed for a site shall include, at a minimum, historical aerial photographs, fire insurance maps (where available), local city street directories (where available), and United States Geological Survey (USGS) maps. The chain-of-title search is not required as an historical search. Applicable copies of these sources shall be presented in the report. Since City Directories are copyright protected, copies of these should not be presented in the report. One aerial photograph for every five to ten years interval from approximately 1950 to the present shall be obtained of an appropriate scale (1" = 500', or shall not exceed 1" = 700') to clearly indicate site details.
- C. If the project includes demolition/renovation of buildings/structures, the ESA I report shall include recommendation for asbestos survey.

- D. If the project includes renovation of buildings/structures constructed before 1978, the ESA I report shall include recommendation for lead based paint survey.
- E. If the site includes undeveloped property, available wetlands maps shall be obtained and reviewed. The environmental professional shall make a statement in the report concerning the potential for the presence of wetlands on the site and whether a full wetlands determination or delineation is recommended.
- F. If the site includes undeveloped property, the environmental professional shall make a statement in the ESA I report that “Threatened and Endanger Species”, and “Historical, Cultural, and Archeological” surveys are warranted.
- G. If the project involves construction of any infrastructure crossing or within a waterway easement, the environmental professional shall make a statement in the ESA I report the jurisdictional authority should be consulted prior to construction.
- H. If the site is in an area of known oil and gas production operations, a record search for oil and gas exploration and production wells on or adjacent to the site shall be included and discussed in the ESA I.
- I. The FIRM available from the FEMA shall be reviewed and discussed to identify areas of the subject site located within flood plains.
- J. A minimum of five interviews, where applicable, shall be conducted in accordance with the latest ASTM E1527 Standard Practice.
- K. The environmental professional who conducted the ESA I shall make recommendations for an ESA II, as appropriate, which shall be thorough enough to support an ESA II.
- i. A regulated site listed in the database with impacted soil and/or groundwater shall be considered for ESA II provided it is located adjacent to the alignment/parcel.
 - ii. A historical site (gasoline, filling, and service stations, and dry cleaners) not currently listed in the database shall be considered for ESA II provided it is located adjacent to the alignment/parcel.
 - iii. A regulated site distant for the alignment/parcel can be considered for ESA II provided TCEQ (Houston office) has documents indicating that regulated site has impacted a large area including the alignment/parcel.
- L. The Environmental Consultant shall submit a Draft Environmental Site Assessment Report (hard and an electronic copies) to the City of Houston for review prior to submitting the Final Environmental Site Assessment Report. The title of the report shall identify if the report is a draft or final report. At minimum, hard copies of the executive summary section of the database including radius map and pages pertinent to the sites of recognized environmental

conditions (REC) discussed shall be included in the ESA I report. The ESA I report and the complete set of the database should be in the enclosed electronic copy.

- M. The Environmental Consultant shall provide an electronic version (in pdf format) of the entire Final Environmental Site Assessment Report (one file).

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Chapter 11 (Continued)

11.26 PHASE II ENVIRONMENTAL SITE ASSESSMENT (ESA II) REQUIREMENTS

The primary objective for performing an ESA II is to evaluate the recognized environmental conditions (REC) identified in the ESA I for the purpose of providing information regarding the nature and extent of contamination to assist in engineering design process. The ESA II shall conform to the latest ASTM Standard Practice E1903 with the following stipulations.

11.27 FIELD INVESTIGATION NOTIFICATIONS

The Environmental Consultant or Engineer of Record shall inform the Project Manager (via email) about the start date of drilling approximately 48 hours prior to beginning drilling.

11.28 PROCEDURES

The following are the minimum requirements for an ESA II to be conducted for the City of Houston projects, land acquisitions, and inter-departmental transfers.

A. Field Activities

The location and depth of borings shall be based on the proposed construction activities, and any previous environmental reports pertaining to the project location, if reasonably available.

1. *Frequency of samples* –
 - a. For linear project, the boring shall be advanced incrementally (every one foot) to allow continuous sampling. Three (3) or more borings (approximately 150 feet apart for a rough delineation) shall be drilled along the proposed excavation at each REC location.
 - b. For non-linear project, the frequency and spacing of the borings should be determined by the environmental consultant in consultation with the Project Manager.
2. *Termination of boring* - Borings shall be advanced to a maximum depth of five (5) feet below the planned excavation. Borings may be advanced to greater depths if warranted by site-specific circumstances. If borings are terminated due to field conditions (e.g., obstructions), borings should be relocated at the discretion of the environmental professional.
3. *Cross-contamination* - To prevent cross-contamination, sampling and boring equipment shall be decontaminated prior to drilling each soil boring /collecting samples. Environmental consultant shall follow applicable federal, state, and local regulations to prevent cross-contamination between soil samples.

4. *Sampling procedure:*
 - a. Soil
 - i. Obtain a minimum of one soil sample from each boring for laboratory analysis. Additional soil samples may be collected as deemed necessary by the environmental professional.
 - ii. Perform field screening of all soil samples collected from borings.
 - iii. The sample for laboratory analysis shall be collected from the zone exhibiting the highest Photoionization Detector/Organic Vapor Analyzer (PID/OVA) reading. If the PID/OVA readings are non-detected, the sample shall be collected from the soil-groundwater interface. If no saturated zone exists, then the sample shall be collected from the bottom of the boring.
 - iv. Place all samples in clean pre-labeled containers composed of materials with the appropriate preservatives as required by the respective analytical method. To prevent volatilization, place samples on ice in an insulated cooler prior to and during transportation to the analytical laboratory for analysis.
 - b. Groundwater

If groundwater is encountered during drilling, one (1) groundwater sample shall be collected from each REC location. The groundwater sample shall be collected from a temporary installed sampling well.
 - c. Each boring log shall include the following:
 - i. Soil classification according to ASTM D2488.
 - ii. Detection of hydrocarbon or other odors.
 - iii. Visible hydrocarbon or other contamination (if present, including degree, location, and extent of staining).
 - iv. PID/OVA readings.
 - v. Other field screening as required by the type of contaminations.
 - vi. The depth at which groundwater was first encountered.
 - vii. Location of boring based on GPS X,Y coordination. The coordinates shall be as per Texas South Central Zone No. 4204 State Plane Grid (not surface) Coordinates (NAD83).
 - viii. Boring identification.
 - ix. City project number.
5. *Site Clean up and Restoration* - The environmental professional is responsible for the site clean up upon completion of field operations, commensurate with site conditions.
 - a. Generation of Waste

- i. Wastes may be generated during the assessment implemented as part of the ESA II (for example, drill cuttings and purged groundwater, etc.). The wastes generated during the assessment should be collected and stored in tightly fitted container(s).
- ii. Wastes should be categorized according to the regulatory requirements and disposed at an approved facility within a 60-day time frame. All completed waste manifests are to be included in the ESA II final report or returned to the Project Manager.
- iii. Techniques that minimize the generation of waste shall be utilized to the extent feasible, consistent with the information and data quality objectives of the planned assessment and applicable regulatory requirements.

b. Backfill of Borings

Completed borings shall be backfilled with cement-bentonite or non-shrink grout. Boreholes or other cored penetrations of pavements shall be restored with the same or equivalent materials as the existing pavement.

B. Laboratory Analysis

1. Environmental Consultant shall perform analytical testing in accordance with applicable United States Environmental Protection Agency (USEPA) and the TCEQ procedures.

2. Laboratory Documentation

- a. Chain of Custody

A completed chain of custody record shall accompany each shipment of samples to the analytical laboratory, and shall be included in the report.

- b. Laboratory Results

Laboratory results for samples shall include the following:

- i. Date of collection.
- ii. Date of extraction, analysis, and report.
- iii. Extraction and analytical methods used.
- iv. Method detection limits.
- v. Standard utilized in the analysis.
- vi. Sample identification and depth.
- vii. Laboratory QA/QC report.

C. Report

1. Site Characterization
 - a. The soil characteristics of significance to the design and construction work shall be described with particular emphasis on the occurrence of transmissive soils at or below the elevation in which contamination was detected, or which have potential for providing pathways for contaminant migration. Geologic characteristics, which affect the migration potential of a contaminant, shall be addressed.
 - b. Potential sources of contamination shall be clearly described in the report. Areas of contamination within or adjacent to the project alignment/site which were confirmed, and their spatial relationship to the planned construction activity, shall also be clearly identified.
2. Type of Contamination
 - a. The report shall address the basis for determining which contaminants were potentially present and the methods that were used to verify their presence or absence. Where specific contaminants are present, the report is to describe the concentrations and indicate whether or not they are above relevant action levels.
3. Impact of Planned Construction
 - a. The report shall describe, based on the available information, the estimated vertical extent and lineal extent (station-to-station) of the PPCA at the REC location. The determination of probable extent should be based on reasonable interpretation of both analytical and geological data. The report shall clearly address the following:
 - i. Comparison of contaminant concentration to regulatory criteria.
 - ii. Potential for contaminated runoff entering the work area.
 - b. The report shall address the potential impact of the contamination on the planned construction including the potential for contaminant impact on construction dewatering. Specifically, the report shall address the potential for migration of contamination from the investigated sources and plumes into the construction area, and due to groundwater withdrawal.
 - c. A quality control review of the Environmental Report shall be performed by the Engineer of Record, where applicable, before its submittal to the City of Houston.
4. Recommendations

The report shall provide recommendations for construction phase monitoring which should take into account:

- a. Vertical extent and Lineal extend (station-to-station) of PPCA and action plan.
 - b. Worker protection and general health and safety.
 - c. Potential contaminated media screening, testing, handling, and disposal consistent with Federal, State, and City Regulations and Specifications.
5. Exhibits
- a. Site plan identifying the location of the REC's and boring locations.
 - b. Boring logs for each boring with GPS X,Y coordination. The coordinates shall be as per Texas South Central Zone No. 4204 State Plane Grid (not surface) Coordinates (NAD83).
 - c. Analytical results including tables summarizing analytical results.
 - d. Photographs of drilling activities.
6. The Environmental Consultant shall submit a Draft Environmental Site Assessment Report (hard and electronic copy) to the City of Houston for review prior to submitting the Final Environmental Site Assessment Report. The title of the report shall identify if the report is a draft or final report.
7. The Environmental Consultant shall provide an electronic version (in pdf format) of the entire Final Environmental Site Assessment Report (one file).

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APPENDIX A

Boring Logs

APPENDIX B

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END OF CHAPTER