GEOTECHNICAL ENGINEERING STUDY
GONZALES COUNTY WELL FIELD
HIGHWAY 97 AND CR 123
SAWS JOB NO. 03-8518-207
GONZALES COUNTY, TEXAS

Prepared For:
CH2M Hill
San Antonio, Texas

Prepared By:
Drash Consulting Engineers, Inc.
San Antonio, Texas

DCE Project № 90045344
May 13, 2005

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Geotechnical • Construction Materials • Environmental
Forensic • Electric Transmission & Distribution

May 13, 2005

Mr. John McNitt, P.E.
CH2M Hill
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San Antonio, Texas 78216

SUBJECT
Geotechnical Engineering Study
Gonzales County Well Field
SAWS Job No. 03-8518-207
Highway 97 and CR 123
Gonzales County, Texas
DCE Project Nº 90045344

Dear Mr. McNitt:

Drash Consulting Engineers, Inc. (DCE) is pleased to submit the enclosed geotechnical engineering report prepared for the new Gonzales County Well Field to be located in the northeast quadrant formed by Highway 97 and CR 123 in Gonzales County, Texas. This report addresses the procedures and findings of our geotechnical engineering study along with our recommendations that may be used to prepare design and construction documents for this project.

If you have any questions regarding our report, please do not hesitate to contact one of the undersigned. We look forward to continuing work on this project.

Very Truly Yours,
Drash Consulting Engineers, Inc.

Stephen G. Urias, E.I.T.
Project Manager
Geotechnical Engineering Division

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SGU/CAG/mad-90045344

Copies Submitted: (8) CH2M Hill; Mr. John McNitt, P.E.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Drash Consulting Engineers, Inc.

INTRODUCTION

Drash Consulting Engineers, Inc. (DCE) is pleased to submit this document which presents the results of our geotechnical engineering study for this project. The project involves the construction of the Gonzales County Well Field which will be located in the northeast quadrant formed by Highway 97 and CR 123 in Gonzales County, Texas.

This geotechnical engineering study was authorized by Mr. John McNitt, P.E., with CH2M Hill through Purchase Order No. 904927, dated on October 14, 2004. The scope of services for this project was outlined in DCE Proposal G041162B, dated April 30, 2004.

PROJECT INFORMATION

The project involves the design and construction of the proposed Gonzales County Well Field located in the northeast quadrant formed by Highway 97 and CR 123. The project involves the design of 14 new production well pumps, eight (8) monitoring wells, approximately 133,000 linear feet of buried collection piping, and about 30,000 linear feet of permanent access road.

PURPOSES AND SCOPE OF SERVICES

The purposes of this study were to evaluate the subsurface conditions within the project limits and to develop geotechnical engineering recommendations and guidelines for use in preparing appropriate design and related construction documents for the installation of the new well field planned for this project. To achieve the objectives of this study, our scope of services consisted of:

- Drilling borings along the project alignment to evaluate subsurface stratigraphy and to observe for the presence of subsurface water;
- Performing geotechnical engineering laboratory tests on the subsurface samples recovered during the drilling exploration program to evaluate their physical, corrosive, and engineering properties;
- Conducting in-situ field resistivity tests (4-probe Wenner method) spaced across the well field;
- Analyzing the field and laboratory data to develop appropriate engineering properties for the subsurface strata encountered at this site;
- Engineering analyses to develop geotechnical recommendations with regard to the pipeline; and

- Preparing this written report which includes a boring location plan, log of each boring, results of the laboratory testing program, description of the subsurface conditions encountered, along with geotechnical engineering recommendations and guidelines for:
  - Corrosivity information for the site soils;
  - Excavating and trenching guidelines including OSHA soil classifications;
  - Allowable bearing capacities of the trench subgrade materials;
  - Modulus of in-situ subsurface materials;
  - Lateral earth pressures of the subsurface materials exerted on the pipe;
  - Sizing the appropriate foundation systems;
  - Low volume roads;
  - Culvert Crossings;
  - Selection and placement of bedding material and backfill within construction limits; and
  - General comments regarding construction methods, sequences, and potential difficulties that may arise during overall construction as it relates to the geotechnical engineering aspects of this project.

A summary of our field program is presented in **Table 1**. A map illustrating the location of the well field and various points is provided in **Figure 1** of this report. The approximate boring locations are overlaid on a map of the area provided to us by CH2M Hill.

Our services did not include addressing any environmental aspects of the site. If environmental liabilities at this site are of concern, an environmental site assessment should be performed. The determination of the environmental risk associated with this site is beyond the scope of this geotechnical study.

SITE CONDITIONS

Area Geology

The Geologic Atlas of Texas San Antonio (1982) and Seguin (1979) sheets were reviewed for information regarding geologic formations along the alignment. These maps indicate the alignment will be located in outcrops of the Cook Mountain Formation, Sparta Sand, Wilcox Formation, Alluvium, and Fluviatile Terrace Deposits.

The Cook Mountain Formation (ECM) consists of clay and sandstone. The clay is slightly silty with lignite deposits and glauconitic. Sandstones are very fine grained, calcareous, and glauconitic. Thickness of the formation is 200 to 230 feet. Thickness of the Cook Mountain Formation is 200 to 230 feet.

The Sparta Sand (Es) consists of very fine to fine grained quartz sands. The sands are well sorted with lignite beds near the top. These soils are moderately indurated near the base and friable toward the top. Some silty clays are found in these soils. Thickness of the Sparta Sand is 130 to 150 feet.

The Wilcox Formation (Ew) is comprised of mostly mudstone with sandstone and lignite. The mudstone is massive to thin bedded with silt and very fine sand. Sandstone is medium to fine grained, moderately well sorted, and cross bedded. Lignite is found mostly near the middle of the formation in seams about one (1) foot to 20 feet thick. Thickness of the Wilcox formation is 1200 to 1300 feet.

Alluvium (Qal) consists of floodplain deposits including low terrace deposits. Clay, silt, sand, gravel, and organic matter comprise the alluvium. The silts and clays are calcareous. Sands are largely quartz and the gravel is mainly chert, quartzite, and petrified wood.

Fluviatile Terrace Deposits (Qt) consists of gravel, sands, silts, and clays and includes terraces along streams. Gravel is more prominent in the older, higher terraces.

Subsurface Stratigraphy

Subsurface conditions were evaluated by drilling borings in the area of the well field. Geographic coordinates, obtained using a handheld GPS unit at the boring locations, are included in **Table 1** and are presented on the boring logs at the end of this report. Our generalization of the subsurface stratigraphy within the project limits, as interpreted from the data obtained during our field exploration activities and laboratory testing program generally consisted of the following:

- CLAY (CH);
- SANDY CLAY (CL);
- CLAYEY SAND (SC); and
- SILTY CLAY (CL – ML).

Boring Identification	Basic Stratigraphy
B-1	Stiff SILTY CLAY (CL – ML) over stiff to hard CLAY (CH)
B-2	Stiff to Very stiff CLAY (CH)
B-3	Hard CLAY (CH)
B-4	Stiff to hard CLAY (CH)
B-5	Very stiff CLAY (CH)
B-6	Stiff to hard CLAY (CH)
B-7	Stiff to hard CLAY (CH)
B-8	Very Stiff to hard CLAY (CH)
B-9	Stiff to hard CLAY (CH)
B-10	Stiff to hard CLAY (CH)
B-11	Medium dense to dense CLAYEY SAND (SC)
B-12	Loose to Medium Dense CLAYEY SAND (SC)
B-13	Very stiff CLAY (CH) over hard SANDY CLAY (CL)
B-14	Very stiff to hard SANDY CLAY (CL) over dense to very dense CLAYEY SAND (SC)
B-15	Very stiff CLAY (CH)
B-16	Stiff to hard CLAY (CH)
B-17	Stiff to hard CLAY (CH)
B-18	Loose to medium dense CLAYEY SAND (SC)
B-19	Stiff CLAY (CH)
B-20	Stiff to hard CLAY (CH)
B-21	Stiff to very stiff SANDY CLAY (CL) over firm CLAY (CH)
B-22	Very stiff to hard SANDY CLAY (CL) over stiff to very stiff CLAY (CH)
B-23	Very stiff to hard SANDY CLAY (CL)
B-24	Hard SANDY CLAY (CL) over very stiff CLAY (CH)
B-25	Hard CLAY (CH)

* Subsurface conditions may vary between boring locations.

Physical and index properties for the subsurface strata were evaluated by performing various field and laboratory tests on the subsurface samples recovered during the drilling operations. The types of tests conducted on the subsurface samples are listed in Appendix B at the end of this report. The results of the tests are tabulated on the Log of Borings which are provided in

Appendix A and graphically depicted in Appendix B. Field tests and the laboratory testing program were directed towards evaluating the shear strength, moisture content, volume change characteristics, plasticity and corrosivity of the subsurface strata for this project. A discussion of the subsurface strata and their related properties are presented herein.

The SILTY CLAY (CL – ML), SANDY CLAY (CL) and CLAY (CH) soils are fine-grained materials. Based on the measured index properties, we anticipate these soils have a moderate to very high potential for significant volumetric changes should they experience fluctuations in their moisture contents. In general, it should be possible to excavate these materials using conventional excavation equipment.

The CLAYEY SAND (SC) soils encountered consist of mostly fine to coarse-grained soils. Therefore, these soils are expected to possess a very low potential for volumetric changes (shrink/swell) should they undergo changes in moisture content. **Some sandy soils encountered at the site were partially cemented.**

Soil pH, sulfate, chloride, sulfides, laboratory resistivity, and redox potential content tests were conducted on selected soil samples in attempt to determine the corrosivity risks associated with the soils encountered at the site. Test results completed to date are included on the boring logs and on the attached **Table 2**.

The **"Logs of Borings"** presenting the stratum descriptions, types of sampling used, laboratory test data, and additional field data, are presented in Appendix A. The **"Symbol Key Sheet"**, which defines the terms and descriptive symbols used on the boring logs, is also presented in this Appendix.

Subsurface Water

The borings were advanced using dry auger drilling methods to their full depths in an attempt to observe for the presence of subsurface water. Subsurface water was not encountered during our exploratory drilling. The boreholes were then backfilled with soil cuttings upon completion of the subsurface water level observations.

The short-term field observations generally do not permit an accurate evaluation of the subsurface water levels at this location. Subsurface water levels are influenced by seasonal and climatic conditions, which generally result in fluctuations in the elevation of the subsurface water level over time. Furthermore, subsurface water may be encountered within the sand soils and sandy seams encountered at the site. **The contractor should check the subsurface water conditions just prior to excavation activities.**

Specific information concerning subsurface water is noted on each boring log presented in Appendix A of this report.

ELECTRICAL EARTH RESISTIVITY

An Electrical Earth Resistivity (EER) test was performed at selected locations across selected points to evaluate the resistivity of the subsurface strata. The EER sounding was conducted at various "A" spacings using the 4-probe Wenner Method. The EER tests were conducted near the specified locations chosen by the client. Results of the EER tests are presented in **Table 3** of the Appendix.

ENGINEERING ANALYSIS AND RECOMMENDATIONS

General

The recommendations, comments and suggestions in this section are provided so drawings, documents, and specifications can be prepared and to make certain the intent of our design recommendations are achieved. Details regarding excavation, dewatering, selection of equipment/machinery, trafficability, project site safety, shoring, and other similar construction techniques requiring "means and methods" to accomplish the work is the sole responsibility of the project contractor. The contractor is responsible for development of an excavation plan which will meet all state and federal requirements with regard to trench safety. *Our comments and opinions do not relieve the contractor's responsibility to establish and maintain all aspects of site safety.*

Borings along the alignment indicate CLAY (CH), SANDY CLAY (CL), SILTY CLAY (CL – ML), and CLAYEY SAND (SC) soils, which means that conventional excavation equipment and excavation techniques should be able to be utilized for pipeline and well field construction. However, as noted earlier, cemented sandy soils were encountered and may require rock excavation techniques when encountered. The contractor should be prepared for various conditions across the site. Historically, the use of trench boxes, shoring, rock excavation equipment, and dewatering (usually with sump pumps) has been adopted by the contractor when these conditions are present. As stated earlier, the purpose of our discussion and general recommendations are to ensure that the contractor is aware of the potential for these conditions to be encountered. The specific "means and methods" used by the contractor to address these conditions are the complete responsibility of the contractor and/or subcontractor.

Geotechnical design parameters for each boring are presented in Tables at the end of this report. The modulus of soil reaction for the in-situ soil, E'_s or E'_n, is provided in these tables. Additionally, the modulus of soil reaction, E_b', of the bedding material is also used in the design of the flexible piping. This value is a function of several variables that include:

- Soil type that comprises the bedding material.
- Degree of compaction of the bedding material.
- Lift thickness of the bedding material.

Values for E_b' range from 0 to 3,000 psi. More specific information regarding this design parameter is included in ASTM D2321 entitled "Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications". Although this standard is in reference to sewer lines, the bedding and trench width are still applicable to the design of buried pipe structures.

Bearing Capacity. Bearing capacities of the subsurface soils may be used to aid in the design of the pipe. The allowable bearing capacities of the subsurface materials are shown in **Tables 4 through 6** at the end of the text. **The bearing pressures also assume that the bearing surface will be free and clean of deleterious materials, soft or moist material, and loose debris.**

Lateral Earth Pressure. Lateral earth pressure criteria presented in this report may be used to aid in the design of the pipe. **We understand that there are different types of laying conditions and bedding materials when embedding the pipeline. The values given are calculated for the "at-rest" condition and are un-factored. It is the responsibility of the pipeline designer to apply a factor of safety to the lateral loads on the pipe if required.** The calculated lateral earth pressure equivalent fluid density on buried pipe for the natural in-situ soils are given in **Tables 4 through 6** at the end of the report text. The calculated lateral earth pressure equivalent fluid density for backfill soils is provided in the following table:

***Backfill* Material Type**	**"At-Rest" Condition Equivalent Fluid Density, pcf**
High Plasticity CLAY (CH)*	120
Low Plasticity Silty or Sandy Clay (CL)	110
Clayey Gravel (Pit-Run Material)	95
Crushed Limestone Base Material	92
Clean Crushed Limestone Aggregate	50

* We do not recommend high plasticity CLAY (CH) bedding or initial (primary) backfill due to its expansive characteristics and corrosion risks.

Corrosivity Risks. Laboratory soil pH, sulfate content tests, chloride content tests, sulfides test, redox potential, and laboratory and in-situ field resistivity tests were conducted on selected soil samples recovered from the borings to assess the corrosivity risk of the soils at the project site. The results of the laboratory and in-situ soil resistivity tests are provided in the **Table 2** at the end of this report, followed by the lab summaries provided by Pollution Control in Appendix C.

The American Water Works Association (AWWA) has developed a corrosivity scale applicable for cast iron alloys. The corrosivity scale is a function of the soil pH, resistivity, and redox (degree of aeration) potential. The corrosivity scale also considers the presence of sulfides (related to sulfate content) in the soil and the drainage condition in the area of the pipe or structure. Other soil variables such as the presence of chlorides in soil can also lead to an increase in corrosion potential.

Another ranking system (Murray 1993) for corrosivity risks for reinforcing steel assesses the general soil aggressivity. The soil aggressivity considers soil composition, groundwater level, resistivity, moisture content, soil pH, soluble sulfate and cinder/coke or fill.

Based on the information obtained from our borings, an unprotected metal pipe may be susceptible to corrosion as result of the soils located at the project site. Corrosion protection for pipelines can vary from encasing or wrapping the pipe in a protective cover to providing cathodic protection. Pipe coatings are sometimes comprised of cement-mortar, bituminous, or other protective material. Furthermore, pipes can also be wrapped with a protective material to aid in resisting corrosion such as a polyethylene wrap.

We suggest that the soil information presented in this report be presented to the pipe product manufacturer to determine which type of pipe and what type of corrosion protection would be best suitable for this project.

Expansive Soils. In addition to the corrosion potential, the CLAY (CH), SILTY CLAY (CL – ML), and SANDY CLAY (CL) soils encountered in the borings have a moderate to very high potential for volumetric changes if fluctuations in soil moisture content occur. As a result, we recommend that where the pipe is founded in CLAY (CH), SILTY CLAY (CL – ML), and SANDY CLAY (CL) materials, the pipe should be designed with some degree of flexibility to resist vertical ground movements associated with wet and dry climatic cycles. A cushioning backfill material such as sand may also be considered to protect against expansive soil movements. Additionally, expansive soils can generally have a high corrosion risk. Therefore, we do not recommend that high plasticity materials such as SANDY CLAY (CL), SILTY CLAY (CL – ML), or CLAY (CH) material be used for bedding or initial (primary) backfill.

Construction and Excavation Activities

Depending on the planned pipe bearing elevation, shallow to deep excavations may be required for pipe installation. The excavation of fine-grained (non-cemented) materials can be accomplished using conventional equipment such as trenchers and backhoes. Some of the materials encountered are very competent and cemented. As a result, rock excavation equipment may be required at some portions of the site.

Shoring, bracing, sloping, benching or a combination of each will likely be required during excavation of the surrounding soils during construction operations. For the site soils encountered in the borings, excavations can be open-cut provided that the side slopes are no steeper than presented later in this report for the respective material type encountered. *The side slopes presented in the "OSHA Guidelines" section are for short-term (24 hours or less) stability only and minor or local sloughing should be expected with time as the excavation remains open.* More significant sloughing will occur if groundwater seepage or surface runoff comes in contact with the cut side slopes. Measures taken to protect the slopes from changes in moisture content from rainfall (such as by covering with plastic) will reduce the chances for sloughing. The excavations may have to be laid back at flatter slopes than recommended herein or benched to achieve a safe slope. If a safe excavation cannot be achieved by means of sloping or benching, then the excavation should be adequately shored or braced. All OSHA Guidelines should be strictly followed during excavation activities.

Subsurface water was not encountered in the borings during our drilling operations. It is possible for a "perched or temporary" subsurface water table to develop during prolonged wet climatic periods even in borings that were dry during our drilling operations. Water which collects in the shallow trenches can most likely be controlled using sumps with pumps along the trench bottom; and, by diverting surface water away from the trench.

Pavement Design Considerations
Pavements are typically designed based on the subgrade support capacity using either a California Bearing Ratio (CBR) value or the modulus of subgrade reaction (k). To evaluate the subgrade CBR values in the project area, we tested selected bulk samples of the subgrade soils in our laboratory in their natural (untreated) state. Based on the results of our laboratory testing program, a CBR value of about three (3) was used in the pavement design analysis for the **natural** clayey subgrade, and a CBR value of about 10 was used for the sandy soils encountered at the project site. If the clayey subgrade is treated sufficiently with hydrated lime and compacted to at least 95 percent of ASTM D 698, this **subbase** layer can be assigned an appropriate structural coefficient in the pavement design analysis. However, the underlying natural clayey **subgrade** should still be considered as having a CBR value of three (3) percent.

With regard to the lime treated soils, treatment will lower the heave potential that leads to rutting and distress with in the pavement section. Addition of a sufficient quantity of hydrated lime to lower the soil Plasticity Index (PI) below 20 percent will provide a better bearing surface and heave potential. Lime treated soils can be assigned a structural coefficient in the design of the pavement section. A lime series test was performed on the natural clayey soils encountered (CBR #3 and CBR #4) with PI's higher than 20 percent to determine the percentage of lime necessary to reduce the PI's below 20 and to produce a pH of at least 12.4. Based on our laboratory tests, about five (5) percent of hydrated lime, by weight, will be required both to produce a pH of 12.4 and to reduce the PI of the clayey samples collected to a value below 20 *under laboratory conditions.* Based on the estimated in-place density of the subgrade soil, four (4) percent hydrated lime is equivalent to about 30 pounds per square yard to treat the clayey soil subgrade to a depth of eight (8) inches. CBR results and lime series test results may be found in **Appendix B** at the end of this report.

Flexible Pavement Design
Flexible pavement systems are planned for this project. Based on discussions with the design group of CH2M Hill, flexible **"low volume pavements"** are anticipated to service the proposed well locations. Flexible pavement sections were designed using the 1993 American Association of State Highway and Transportation Officials (AASHTO) method. We also understand that asphaltic concrete is not favorable for the design of the service roads and will not be recommended in this report. The AASHTO flexible pavement design parameters consist of:

Traffic Design Life and Analysis Period,	t
18-kip Equivalent Single Axle Loads (ESALs),	W_{18}
Reliability,	R
Standard Deviation,	S_o
Initial Serviceability Index,	P_o
Minimum Serviceability Index,	P_t
Total Change in Serviceability Index,	$\Delta_{PSI} = P_o - P_t$
Effective Road Bed Soil Resilient Modulus,	M_r

The Reliability, Standard Deviation and Design Serviceability Loss are generally dictated by the type and use classification of the pavement, while the Equivalent Axle Load Repetitions are generally set by expected traffic. Recommendations for the values of Subgrade Resilient Modulus, and other pertinent information are presented in the following paragraphs.

The Subgrade Resilient Modulus value, M_r, is based on the most common subgrade soil condition encountered in our borings. The California Bearing Ratio (CBR) is often used to aid in approximating M_r. Generally, the CBR and M_r can be related as follows:

M_r = 1,500 times the CBR Value with M_r given in pounds per square inch.

Therefore, with a CBR value of three (3), a value of **4,500 psi for the M_r**, can be utilized when a **clay** subgrade is encountered at the project site.

With a CBR value of 10, a value of **15,000 psi for the M_r**, can be utilized when a **granular sand** subgrade is encountered at the project site.

Access Roads. The roads that are proposed will serve infrequent traffic after construction and will be used for access to the proposed well locations. No details regarding daily traffic counts or design life were provided. **Therefore, we have made assumptions regarding daily traffic using the maximum ESAL value for "Low Volume Roads". We have also assumed a 20-year design service life for the flexible pavement design.** As previously noted in this report, the pavement section will be designed using the 1993 American Association of State Highway and Transportation Officials (AASHTO) method.

If the owner or other members of the design team feel the assumptions and associated ESALs used for design are not appropriate, we should be notified in writing, so we may review any new information, and if necessary, revise the pavement recommendations accordingly.

Based on our experience with similar projects, we have determined that the following AASHTO parameters are most suited for a flexible pavement constructed for the entrance road.
These parameters are as follows:

R	60 percent
S_o	0.45
Δ_{PSI}	1.95
P_t	2.25
P_o	4.2
W_{18}	100,000 ESALs
T	20 year service life
M_r	As recommended previously depending on subgrade type, psi

The next step in the AASHTO method is the determination of the Structural Number (SN), which can either be calculated using formulas in the AASHTO Guide, or by using a nomograph contained in the guide. The total required pavement thickness is then determined based on the following equation:

$$SN = a_1 \bullet D_1 + a_2 \bullet D_2 \bullet m_2 + a_3 \bullet D_3 \bullet m_3$$

Where:

a_n = structural coefficient of material "n",

D_n = thickness of material "n", inches

m_n = drainage coefficient of material "n".

Recommended minimum compacted layer thickness, structural coefficient and drainage coefficients are as follows:

	Minimum Thickness	Structural Coefficient	Drainage Coefficient
Asphalt Treated Base	4 inches	0.34	1.00
Cement Treated Base	6 inches	0.25	1.00
Flexible Base	6 inches	0.14	1.00
Modified Subgrade (Subbase) (Lime-Treated Clay)	6 inches	0.08	1.00

The drainage coefficient, m, is dependent on the quality of drainage in the untreated base and sub-base materials layers of the flexible pavement section. Good drainage (i.e. Drainage Coefficient, m = 1) corresponds to water being removed from each layer in one (1) day; and, that the percent of time the pavement structure is exposed to moisture levels approaching saturation ranges from five (5) to 25. If improper materials are used or standing water can develop due to construction or design deficiencies, the quality of drainage would be fair to very poor and reduce the drainage coefficient, m, and ultimately the structural capacity of the pavement. The AASHTO design procedure provides more guidance and discussion regarding this issue.

Resulting flexible pavement sections are as follows:

CLAY SUBGRADE

FLEXIBLE PAVEMENT SYSTEM
Material Thickness, inches

Pavement Section Component	Without Modified Subgrade			With Modified Subgrade		
	Asphalt Treated Base	Crushed Limestone Base	Cement Treated Base	Asphalt Treated Base	Crushed Limestone Base	Cement Treated Base
Asphalt Treated Base	8.0	---	---	5.5	---	---
Cement Treated Base	---	---	10.0	---	---	7.5
Granular Base Course	---	18.0	---	---	13.0	---
Moisture Conditioned Subgrade	8.0	8.0	8.0	---	---	---
Modified Subgrade (Subbase or Tensar BX1100 Geogrid)	---	---	---	8.0	8.0	8.0
SN Required	*2.40*	*2.40*	*2.40*	*2.40*	*2.40*	*2.40*
SN Actual	*2.72*	*2.52*	*2.50*	*2.51*	*2.46*	*2.51*

- The sections above should be used with a two (2) course surface treatment (chipseal) to provide a wearing surface.

- The modified subgrade (subbase) may be replaced by Tensar BX1100 Geogrid or equivalent Geogrid meeting all of the criteria given in **Table 7.** If asphalt treated base (ATB) is used in conjunction with a geogrid, at least four (4) inches of crushed limestone base must be placed between the ATB and the geogrid.

- As an alternate to replacing the subbase with a geogrid, the crushed limestone base may be reduced by 30 percent of the value listed above if Tensar BX1100 Geogrid, or approved equivalent, is used at the bottom of the crushed limestone base layer. The minimum thickness of crushed limestone base should be six (6) inches.

GRANULAR
SAND SUBGRADE

FLEXIBLE PAVEMENT SYSTEM
Material Thickness, inches

Pavement Section Component	Without Modified Subgrade			With Modified Subgrade		
	Asphalt Treated Base	Crushed Limestone Base	Cement Treated Base	Asphalt Treated Base	Crushed Limestone Base	Cement Treated Base
Asphalt Treated Base	4.5	---	---	4.0	---	---
Cement Treated Base	---	---	6.0	---	---	6.0
Granular Base Course	---	11.0	---	---	7.0	---
Moisture Conditioned Subgrade	8.0	8.0	8.0	---	---	---
Modified Subgrade (Subbase or Tensar BX1100 Geogrid)	---	---	---	8.0	8.0	8.0
SN Required	*1.49*	*1.49*	*1.49*	*1.49*	*1.49*	*1.49*
SN Actual	*1.53*	*1.54*	*1.50*	*2.00*	*1.62*	*2.14*

- The sections above should be used with a two (2) course surface treatment (chipseal) to provide a wearing surface.

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- As an alternate to replacing the subbase with a geogrid, the crushed limestone base may be reduced by 30 percent of the value listed above if Tensar BX1100 Geogrid, or approved equivalent, is used at the bottom of the crushed limestone base layer. The minimum thickness of crushed limestone base should be six (6) inches.

Many of differing flexible pavement sections can be designed using the above combination of materials, provided the actual SN exceeds the required SN. Generally, the most cost effective pavement section can be obtained by maximizing the thicknesses of the materials with the lowest structural coefficient where applicable. If different pavement sections appear to be more desirable than those presented above, we would be happy to evaluate the section to ensure its adequacy for the site.

Construction and Maintenance. The following are some pavement options that may be considered to improve the performance of any planned flexible pavements for this project:

- Proper moisture control and compaction of the subgrade as recommended in this report;

- Proper selection, quality and placement of the pavement section materials;

- Grading the subgrade and final paving surface so that they are sloped to drain and not contain pockets where water can pond; and

- Properly maintaining grades, repairing newly distressed areas (such as potholes and sealing cracks) and periodic applications of chip seal or other surface treatment as needed.

The performance of the pavements will be directly related to the amount of periodic maintenance and the feasibility and selection of some the options presented in this report.

Pavement Section Materials. Presented below are selection and preparation guidelines for various materials that may be used to construct the pavement sections. Submittals should be made for each pavement material. The submittals should be reviewed by the geotechnical engineer and other appropriate members of the design team and should provide test information necessary to verify full compliance with the recommended or specified material properties.

Two (2) Course Surface Treatment. A wearing or all-weather surface comprised of two (2) courses of aggregate (chip seal) is planned for this project. The chip seal process typically involves spraying the surface of the compacted base material with an emulsified asphalt then spreading two (2) layers of aggregate (commonly referred to as chips) that are generally a maximum size of 3/8-inch in diameter, and finally compacting and embedding the aggregate in the asphalt with the use of rubber-tired (pneumatic) rollers. In some cases, the maximum aggregate size in the layers of rock are different to help result in more uniform coverage of the pavement surface. The chip seal process should be conducted in accordance with the specification requirements of 2004 TxDOT Standard Specification Item 316. Precoated aggregates are sometimes preferred to achieve shorter closure times, better chip retention and a darker road appearance. The types of asphalts, oils, emulsions and additives along with any specified aggregates will be dependent upon the desired performance of the pavement and on the feasibility associated with the material costs. We recommend any emulsified asphalt type meet the specification requirements of 2004 TxDOT Standard Specification Item 300. Furthermore, any aggregates used should meet the specification requirements of 2004 TxDOT Standard Specification Item 302.

Asphaltic Base Material. The asphaltic base material should meet the specification requirements of 2004 TxDOT Standard Specification Item 340, Type A or B.

Cement Treated Base. Locally available cement treated base may be used in the pavement section. The untreated material should meet the requirements of the base material presented in the Granular Base Course section below. The material should be treated full depth with Type I Portland cement at a rate of six and one-half (6½) pounds per square yard per inch of base depth. Compaction of the mixture should be completed within four (4) hours after addition of cement. The base should be compacted to at least 95 percent of the maximum dry density determined in accordance with the modified moisture-density relationship (ASTM D 1557) at moisture contents ranging between minus three (-3) and plus three (+3) percentage points of optimum moisture content. The material should be moist cured or cured with an asphaltic membrane for at least three (3) days before opening to light traffic and, at least seven (7) days before opening to all traffic.

Cement treated base will dry, shrink and crack with time. These cracks will propagate up through any asphalt or wearing surface. These cracks should be sealed on an annual basis.

Granular Base Course - Base material may be composed of crushed limestone which meets all of the requirements of 2004 TxDOT Item 247, Type A, Grade 1 or 2, including triaxial strength. **Additionally, the base material should have a maximum of 15 percent material, by weight, passing the Nº 200 Sieve.** The base should be compacted to at least 95 percent of the maximum dry density as determined by the modified moisture-density relation (ASTM D 1557) at moisture contents ranging between minus two (-2) and plus three (+3) percentage points of the optimum moisture content.

Geogrid. The geogrid should meet the criteria given in **Table 7.** *Tensar BX1100 meets these criteria.*

Modified Subgrade - The clayey subgrade may be treated with hydrated lime in accordance with TxDOT Items 260 and 264. The quantity of lime required should be determined after the site is stripped of the loose topsoil and the subgrade soils are exposed. As previously noted in this report, about five (5) percent hydrated lime will be required to adequately treat the site subgrade soils. This lime content is equivalent to about 30 pounds of hydrated lime per square yard for an eight (8) inch treatment depth. The lime should initially be blended with a mixing device such as a pulvermixer, sufficient water added, and be allowed to cure for at least 48 hours. After curing, the lime-soil should be remixed to meet the inplace gradation requirements of Item 260 and compacted to at least 95 percent of the maximum dry density as evaluated by ASTM D 698 at moisture contents ranging from optimum to plus four (+4) percentage points of the optimum moisture content. If gradation requirements can be achieved after the initial mixing, then the second mixing after the curing period can be eliminated.

Please note that there is a relationship between the time of mixing of the lime and soils with the maximum dry density. The maximum dry density decreases with time, therefore, any mixture older than three (3) days will require a new set of compaction curves.

Portland cement may also be considered instead of lime to modify the clay subgrade soils. All performance and compaction recommendations discussed for lime would also apply for cement. Many bid packages specify the use of lime in the base bid and list cement as an alternate on the bid forms. As a result, contractors bidding the project provide cost information for each alternative allowing the owner to make a more informed decision with regards to the pavement subgrade. The cement should be used in accordance with TxDOT Item 275.

Moisture Conditioned Subgrade - The subgrade should be scarified to a depth of eight (8) inches and moisture conditioned between optimum and plus four (+4) percentage points of the optimum moisture content. The subgrade should then be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698.

Box Culverts and Reinforced Concrete Pipe

We understand that low water crossings will be encountered and anticipate that the road way will be designed for low water crossings. Drainage improvements may include box culverts and reinforced concrete pipe that will bear at varying depths across the project. The soils for this project have undrained shear strengths in excess of 1,000 psf, which will provide a net allowable bearing pressure of at least 2,500 psf for any culverts. This bearing pressure includes a factor of safety of about two (2).

Pavement subgrade areas requiring base placement should be scarified to a depth of about eight (8) inches and moisture conditioned between optimum and plus four (+4) percentage points of the optimum moisture content. The moisture conditioned subgrade should then be compacted to at least 95 percent of maximum dry density determined in accordance with ASTM D 698. Subgrade areas should be moisture conditioned and compacted just prior to fill or base placement so the subgrade maintains its compaction moisture levels and does not dry out.
If soils become excessively wet, ripping or scarifying the soils and exposing them to elements such as wind and sunlight can aid in expediting the drying process.

Reduction of Soil Movements

At the time of our field operations, the surface and near surface soils were moist and thus, relatively weak. This relatively high moisture condition would tend to reduce the expansion potential of these soils. However, the moisture condition of these surficial soils at the time of construction is not known. Accordingly, it is prudent to treat these soils as relatively dry for design purposes. The clayey soils at this site exhibit a moderate to high potential to experience volume changes as the result of moisture fluctuation. Based on our laboratory test results, the

PVR in the building area is about one and one half (1½) inches in its present condition. This calculated PVR is above the value of one (1) inch that most structural engineers consider acceptable for a grade supported floor slab for a structure of this type.

Typically, three (3) different methods are used to reduce the PVR beneath a building floor slab. These methods are as follows:

- Excavate expansive clay soils and replace with select fill.
- Chemical injection of expansive clay soils.
- Installation of a subsurface moisture barrier.
- A combination of the use of select fill and chemical injection.

The most cost effective alternate is typically a function of site-specific conditions. For this site, only excavation and replacement method has been considered since we believe it will be the most cost effective. Please contact us if you would like us to investigate the other options further.

The subgrade preparation method provided is intended to reduce the magnitude of soil movements beneath grade supported structures at this site to about one (1) inch and about one and one-half (1½) inches, respectively. If a more or less stringent PVR value is desired, we should be notified in writing so we can reevaluate our recommendations as necessary

Excavation and Replacement for a PVR of about one (1) inch

- Strip vegetation, loose topsoil, and any other deleterious materials from the building areas.
- **Excavate the building area to a depth of nine (9) feet below existing grade.** Subgrade and building pad preparation should extend at least three (3) feet past the limits of the building area.
- Proof roll, over excavate and replace soft yielding zones in the building area as described in the section of this report entitled **Earthwork Recommendations and Guidelines.**
- After proof rolling, scarify and moisture condition the top eight (8) inches of the exposed subgrade soil between optimum and plus four (+4) percentage points of the optimum moisture content. Compact the subgrade to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698.
- Select fill should then be placed in the building area to achieve the finished building pad elevation. The select fill should be placed in compacted lifts not to exceed six (6) inches in thickness. The select fill should be moisture conditioned

between minus three (-3) and plus three (+3) percentage points of the optimum moisture content and then compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698. This should result in at least three (3) feet of select fill beneath the slab. Additional fill required to achieve the FFE should consist of select fill.

Excavation and Replacement for a PVR of about one and one-half (1½") inches

- Strip vegetation, loose topsoil, and any other deleterious materials from the building areas.

- **Excavate the building area to a depth of seven (7) feet below existing grade.** Subgrade and building pad preparation should extend at least three (3) feet past the limits of the building area.

- Proof roll, over excavate and replace soft yielding zones in the building area as described in the section of this report entitled **Earthwork Recommendations and Guidelines.**

- After proof rolling, scarify and moisture condition the top eight (8) inches of the exposed subgrade soil between optimum and plus four (+4) percentage points of the optimum moisture content. Compact the subgrade to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698.

- Select fill should then be placed in the building area to achieve the finished building pad elevation. The select fill should be placed in compacted lifts not to exceed six (6) inches in thickness. The select fill should be moisture conditioned between minus three (-3) and plus three (+3) percentage points of the optimum moisture content and then compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698. This should result in at least three (3) feet of select fill beneath the slab. Additional fill required to achieve the FFE should consist of select fill.

Subgrade preparation and fill placement should extend at least three (3) feet beyond the perimeter of the buildings, **including** ramps, pads and other improvements or flatwork adjacent to the structure. Doweling of any adjacent improvement, especially at building entryways, may be considered to limit differential movements and trip hazards. The final one (1) foot of fill **outside** the building areas should consist of a cohesive clayey (CL) soil. Properly compacted, this clay layer will reduce migration of moisture into the select fill below. This final one (1) foot of cohesive clayey fill may be replaced with an asphalt or concrete pavement covering extending to the edge of the foundation.

Details regarding subgrade preparation and fill placement and compaction are presented in the subsection titled "**Earthwork Recommendations and Guidelines**".

Expansive Soil Considerations

When expansive clay soils are excavated and replaced with more granular select fill soils in the building pad, water may tend to more readily collect in the granular fill. The water usually percolates to the bottom or sides of the granular fill body where it is contained by the natural clay material. This "bath tub" tends to trap water resulting in expansion of the clay subgrade soils and floor slab distress. This concern is lessoned if cohesive soil is used in lieu of crushed limestone base or pit run material as select fill.

One method to address this issue is a combination of the following:

- Slope the clay subgrade in the building area to drain water.
- Lime treat the top eight (8) inches of the sloping clay subgrade.
- Collect the water in an interceptor drain and dispose of the water in a sump or other drainage network as appropriate.

The design of this type of "system" is a site-specific issue which incorporates several factors. Design of this or a similar system was not within the scope of our services. We would be pleased to address this issue in more detail, if requested.

Slab Foundation

Design. Parameters that may be used for design of the slab foundation are provided on **Table 8** at the end of this text. The slab foundation design parameters presented on **Table 8** are based on the criteria published by the Prestressed Concrete Institute (PCI), the Building Research Advisory Board (BRAB) and the Post-Tensioning Institute (PTI). These are essentially empirical design methods and the recommended design parameters are based on our understanding of the proposed project, our interpretation of the information and data collected as a part of this study, our area experience, and the criteria published in the PCI, BRAB, and PTI design manuals.

We recommend that the perimeter grade beams for a slab-on-grade foundation be at least 12 inches in width and at least 30 inches below final exterior grade. These recommendations are for proper development of bearing capacity for the continuous beam sections of the foundation system, to assure that proper concrete cover is achieved between reinforcing steel and soil, and to reduce the potential for water to migrate beneath the slab foundation. These recommendations are **not** based on structural considerations. Grade beam widths and depths for both the exterior and interior grade beams may need to be greater than recommended herein for structural considerations and should be properly evaluated and designed by the structural engineer. The grade beams or slab portions may be thickened and widened to serve as spread footings at concentrated load areas.

For a slab foundation system designed and constructed as recommended in this report, post construction settlements should be less than one (1) inch. Settlement response of a select fill supported slab is influenced more by the quality of construction than by soil-structure interaction.

Therefore, it is essential that the recommendations for foundation construction be strictly followed during the construction phases of the building pad and foundation.

Construction Considerations. Grade beams for the slab foundation should preferably be neat excavated. Excavation should be accomplished with a smooth-mouthed bucket. If a toothed bucket is used, excavation with this bucket should be stopped six (6) inches above final grade and the grade beam excavation completed with a smooth-mouthed bucket or by hand labor.

Debris or loose material in the bottom of the excavation should be removed prior to steel placement. The foundation excavation should be sloped sufficiently to create internal sumps for runoff collection and removal of water. If surface runoff water or subsurface water seepage in excess of one (1) inch accumulates at the bottom of the foundation excavation, it should be collected and removed and not allowed to adversely affect the quality of the bearing surface. Special care should be taken to protect the exposed soils from being disturbed or drying out prior to placement of the concrete or the select fill pad.

Earthwork Recommendations and Guidelines

The comments and suggestions in this section are provided for planning and informational purposes so project specifications can be prepared and to indicate conventional methods to achieve the intent of our design recommendations. Details regarding excavation, dewatering, selection of equipment/machinery, trafficability, project site safety, shoring, and other similar construction techniques that require "means and methods" to accomplish the work is the sole responsibility of the project contractor. It should be recognized that the comments contained in this report are based on the observations of small diameter boreholes and the performance of larger excavations may differ significantly as a result of the differences in excavation sizes. Construction means and methods selected by the contractor may differ from those described in this report. Any variations may significantly impact the anticipated behavior of the subsurface conditions during the construction process.

Site Access. Proper site drainage should be maintained during the entire construction phase so ponding of surface runoff does not occur and cause construction delays and/or inhibit site access, particularly in any cut areas. During construction, it is possible the surficial soils may become excessively wet as a result of inclement weather conditions. When the moisture content of these subgrade soils elevates above what is considered to be the optimum range of moisture for compaction operations, they can become difficult to handle and compact. If such conditions create a hindrance to compaction operations or site access, hydrated lime or Portland cement may be mixed with these soils to improve their workability. The modifier can be mixed in general accordance with TxDOT Items 260, 264 and 275. However, the purpose of the modifier is to dry out the subgrade and allow site workability. The strict requirements for curing and the actual modifier percentage can and should be at the discretion of the contractor. The modified subgrade, however, should be compacted to at least 95 percent of the maximum dry density as evaluated by ASTM D 698 at moisture contents between optimum and plus four (+4) percentage points of the optimum moisture content.

Building and Pavement Subgrade Preparation. The building and pavement areas should be stripped of all vegetation, loose debris or topsoil, and any deleterious materials. Furthermore, all trees and tree root systems should be grubbed and removed from the building area. If any abandoned buried utilities are encountered during stripping operations, we recommend that all elements of these utilities including pipes and backfill be removed from the area of the proposed building pad. These utilities are typically placed with granular backfill and/or bedding material and provide conduits for potentially migrating waters to enter beneath the foundation which can lead to expansive soil-related movements. Subgrade preparation should extend at least three (3) feet beyond the horizontal limits of the pavements and horizontal limits of the building (including all adjacent sidewalks, canopies, and other flatwork). After site stripping and grubbing operations, the exposed subgrade should be proofrolled with appropriate construction equipment weighing at least 20 tons. The purpose of this recommendation is to check the subgrade for **weak zones** prior to fill or base placement and compaction. This operation should be observed and evaluated by qualified geotechnical personnel experienced in earthwork operations.

If weak zones are evidenced during proofrolling operations, the weak material in the subject area should be removed to expose competent subgrade soils in both the horizontal and vertical limits. For the **building** areas, the excavated material should be removed and onsite soil or imported select fill material should be used to restore grade at these isolated areas. **Placement and compaction of select fill in the building areas is described in the "Select Fill Materials" section of this report.**

For the building areas, grade adjustments can be made with on-site soils meeting the requirements for select fill as presented in the **"Select Fill Materials"** section of this report or with imported select fill.

Building subgrade areas requiring fill or base placement should be scarified to a depth of about eight (8), moisture conditioned between optimum and plus four (+4) percentage points of the optimum moisture content and then compacted to at least 95 percent of the maximum dry density as determined by ASTM D 698. Subgrade areas should be moisture conditioned and compacted just prior to fill or base placement so the subgrade maintains its compaction moisture levels and does not dry out.

For the **pavement** areas, replacement of excavated weak zones or grade adjustments can be made with on-site or imported **non-select fill. Non-select fill**, whether on-site or import, should have a Plasticity Index (PI) not greater than 20. All fill, select or non-select, should be free and clean of any deleterious material or material exceeding four (4) inches in maximum dimension. **Non-select fill** material should be placed on prepared surfaces in lifts not to exceed eight (8) inches loose measure, with compacted thickness not to exceed six (6) inches. **Non-select fill** should be moisture conditioned between optimum and plus four (+4) percentage points of the optimum moisture content and then compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698.

Select Fill Materials. All fill, imported or on-site material, used in the building area should consist of select fill. Select fill for the proposed slab foundation should consist of non-expansive (inert) soils such as a low plasticity clayey soil, clayey gravel, or crushed stone base material. All select fill soils should have a Plasticity Index (PI) between seven (7) and 20 percent. The clayey gravel material should meet the gradation requirements of Item 247, Type B, Grades 1 through 3 as specified in the 1993 TxDOT Standard Specifications manual. Crushed stone material should meet the gradation requirements of 1993 TxDOT Item 247, Type A, Grades 1 through 3. The select fill materials should be free of organic material and debris, and should not contain stones larger than three (3) inches in maximum dimension.

It should be noted that gradation requirements for Grade 3 material are much less stringent than for Grade 1 material. As a result, the stability of the Grade 3 may be significantly less than that of the Grade 1 material in an unconfined condition. This may result in sloughing of the fill during trenching or excavations that may be necessary for utility "rough-in" and foundation installation. A well-graded granular material such as a Type A, Grade 1 or 2 crushed stone is generally more resistant to sloughing and the effects of hard rain during construction.

All structural fill (fill that provides load bearing support) should consist of select fill material placed on prepared surfaces in lifts not to exceed eight (8) inches loose measure, with compacted thickness not to exceed six (6) inches. All structural fill should be moisture conditioned between minus three (-3) and plus three (+3) percentage points of the optimum moisture content, and then compacted to at least 95 percent of maximum dry density determined in accordance with ASTM D 698.

Other Design/Construction Considerations

The performance of foundation systems for the proposed structure will not only be dependent upon the quality of construction but also upon the stability of the moisture content of the soils underlying the foundation. The site drainage should be developed so ponding of surface runoff near the structure does not occur during or after construction.

Drainage During Construction As noted previously in the **"Site Access"** section of this report, site drainage should be maintained during construction to help in protecting the foundation soils from excessive moisture. Excessive moisture can create the near surface soils to become weak and result in a difficulty in achieving the required compaction. A modifier such as lime or cement can be added to help dry out the soils and improve their workability. However, we recommend the following be considered to protect the foundation soils from excessive moisture:

- Provide berms or swales to establish positive drainage away from the building area.
- Provide graded low points (sumps) to collect waters that fall or seep into the building area so that they can be readily removed (pumped out).

If soils become excessively wet, ripping or scarifying the soils and exposing them to elements such as wind and sunlight can aid in expediting the drying process.

Drainage After Construction. When establishing final grade around the structures, we recommend that the following be considered:

- The elevation of the ground surface adjacent to the foundations should be at least six (6) inches below the Finished Floor Elevation (FFE) and be sloped sufficiently to provide and maintain positive drainage away from the foundations throughout the life of the structures.

- Gutter downspouts should extend at least five (5) feet away from the structures.

Other Design Considerations

Occupational Safety and Health Administration (OSHA) Guidelines. Occupational Safety and Health Administration (OSHA) Safety and Health Standards (29 CFR Part 1926 Revised, 1989) require that all trenches in excess of five (5) feet deep be shored or appropriately sloped unless the trench sidewalls are comprised of "solid" rock. "Solid" (non-weathered) rock was NOT encountered in the soil borings drilled along the alignment.

State of Texas legislation requires that detailed plans and specifications for trench retention systems meet OSHA standards for a safe construction environment during utilities installation. Our recommendations are intended for use in conjunction with OSHA safety regulations and not as a replacement of those regulations. Based on the laboratory tests results, we feel that the CLAY (CH), SANDY CLAY (CL), and SILTY CLAY (CL – ML) materials be considered as Type B soils according to OSHA soil classification guidelines. The CLAYEY SAND (SC) soils should be considered as Type C soils. *If any soils at this site become significantly wetter, saturated or submerged they should be considered as Type C soils.*

As stated previously, OSHA requires all soil trenches in excess of five (5) feet be shored or appropriately sloped. Currently available and practiced methods for achieving slope and/or trench wall stability includes sloping, benching, combinations of sloping and benching, and installation of shoring systems (hydraulic, timber, etc.). Trench shields may also be considered for use. However, these shields only provide protection to workers; they are not a means for providing slope or trench wall stability. OSHA addresses construction slopes in large excavations that are less than 20 feet deep. The table shown below is a reproduction of the OSHA Table B-1:

OSHA TABLE B-1
MAXIMUM ALLOWABLE SLOPES

Soil or Rock Type	Maximum Allowable Slopes (H:V)[1] for Excavations Less Than 20 Feet Deep[3]	
Stable Rock	Vertical	(90°)
Type A[2]	¾: 1	(53°)
Type B	1: 1	(45°)
Type C	1½: 1	(34°)

initial backfill should not contain materials exceeding three (3) inches in maximum dimension. All site soils should be suitable for secondary backfill provided the soils do not contain particles exceeding four (4) inches in maximum dimension.

Granular materials may damage any pipe protective wrapping during backfilling operations. Damage may also occur to a protective wrapping if the gravelly materials rub against the pipe due to volumetric changes associated with expansive soils located at the base and sidewalls of the trench. Additionally, during construction, wheel or gross loads produced by construction equipment exceeding the pipes design strength should not be driven over or close to the pipeline. Additional cover placed on top of the pipe or an alternate route should be provided for machinery producing excessive loads.

QUALITY CONTROL

Every project and construction site is unique, making it vitally important that all construction drawings, specifications, change orders and related documents be reviewed by the respective design professionals participating in the project. The performance of the foundations, building pads, pipelines, and pavements for this project will depend on correct interpretation of our geotechnical engineering report and proper compliance of construction activities with regard to our geotechnical recommendations and to the construction drawings and specifications.

Review of Documents

We should be provided the opportunity to review the final design and construction documents to check that our geotechnical recommendations are properly interpreted and incorporated in the design and construction documents. This review is not a part of our project scope and would be an additional service. We cannot be responsible for misinterpretations of our geotechnical recommendations if we have not had an opportunity to review these documents.

Construction Materials Testing and Observation Services

DCE should be retained to provide construction materials testing (CMT) and observation services during construction, particularly during all foundation installation and earthwork related activities. As the Geotechnical Engineer of Record, it is important that our technical personnel provide these services to make certain that our design recommendations are interpreted properly and to make certain that actual field conditions are those described in our geotechnical report. As the Geotechnical Engineer of Record, DCE's technical personnel are familiar with the project and can help recognize inconsistencies and anomalies that may occur. Due to our involvement in the project during the construction phase, we can help avoid any potential problems before they become a significant issue. This can only be an effective process if our technical personnel routinely visit the project site and perform appropriate observations and tests during construction. By continuing our involvement on the project after the geotechnical design phase, and by providing the CMT services during construction, a single point of contact is established for the owner regarding DCE's services for the project.

LIMITATIONS

The opinions, conclusions, and recommendations presented in this geotechnical engineering report are based on the borings drilled at the project site and the information we received from our client and other design and construction professionals associated with this project. Should any changes in the nature, design, or location of the project be made, the opinions, conclusions, and recommendations in this report should not be used in the preparation of design and construction documents until we are able to review the changes and respond in writing that our report is still valid for the project or that modifications to the report will be necessary.

Subsurface conditions have been observed and interpreted at the boring location only. We do not anticipate the subsurface conditions will vary substantially from what was encountered at the boring. Everyone should be cognizant that variations may occur due to the areal geologic conditions or previous site use, which would not become evident until construction begins. If subsurface conditions vary significantly from those described in this report, we should be notified immediately to determine if our opinions, conclusions and recommendations need to be reevaluated and to decide if additional field and laboratory tests need to be performed so that supplemental engineering analyses and recommendations can be provided.

This study was performed in accordance with accepted geotechnical engineering practice using the standard of care and skill currently exercised by geotechnical engineers practicing in this area. No warranty, expressed or implied, is made or intended.

TABLES

TABLE 1
SUMMARY OF FIELD PROGRAM
GONZALES COUNTY WELL FIELD
HIGHWAY 97 AND CR 123
GONZALES COUNTY, TEXAS

Soil borings (25) were drilled at the following sites in an attempt to determine the general type of subsurface conditions located along the project alignment.

Boring Nº	GPS Coordinates		Boring Depth (Ft)
B-1	N 29° 22.562	W 97° 38.173	12
B-2	N 29° 22.366	W 97° 39.967	12
B-3	N 29° 20.948	W 97° 37.256	12
B-4	N 29° 23.325	W 97° 39.220	12
B-5	N 29° 23.606	W 97° 37.772	12
B-6	N 29° 22.806	W 97° 36.648	12
B-7	N 29° 21.800	W 97° 36.549	12
B-8	N 29° 20.733	W 97° 38.408	12
B-9	N 29° 21.050	W 97° 39.692	12
B-10	N 29° 21.418	W 97° 40.942	12
B-11	N 29° 21.511	W 97° 42.070	12
B-12	N 29° 22.373	W 97° 41.115	12
B-13	N 29° 21.754	W 97° 38.890	12
B-14	N 29° 23.389	W 97° 40.346	12
B-15	N 29° 22.141	W 97° 39.513	12
B-16	N 29° 21.841	W 97° 40.748	12
B-17	N 29° 21.588	W 97° 40.433	12
B-18	N 29° 21.441	W 97° 41.803	12
B-19	N 29° 22.041	W 97° 38.557	12
B-20	N 29° 21.521	W 97° 38.658	12
B-21	N 29° 22.942	W 97° 37.314	12
B-22	N 29° 422.233	W 97° 37.625	12
B-23	N 29° 21.820	W 97° 36.948	12
B-24	N 29° 21.180	W 97° 37.825	12
B-25	N 29° 19.677	W 97° 38.499	12

Notes:

1. Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.

2. A short-term maximum allowable slope of ½H:1V (63°) is allowed in excavations in Type A soil that are 12 feet or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet in depth shall be ¾H:1V (53°).

3. Sloping or benching for excavations greater than 20 feet shall be designed by a registered professional engineer.

The OSHA regulations define ***short-term*** as a period of 24 hours or less.

Trench Backfill. Appropriate trench backfill is generally determined by several factors including the bearing capacity of the soil supporting the pipe, requirements of the pipe manufacturer regarding support of the pipe and the proposed improvements at the ground surface along the trench. Subsurface soils at and below the proposed bearing depth are competent. Allowable bearing capacities are presented in the **Tables 4 through 6** at the end of this report. Pipe manufacturers generally require a specified bedding and granular material around the pipe.

Typically the bedding and initial (primary) backfill around buried utilities are designed to support and protect the piping. The material above this initial backfill (which we call secondary backfill) also helps to protect the piping and to support any overlying structure or improvement. Inadequate compaction of this material can lead to excessive settlement of the backfill and premature distress to any overlying structures. Therefore, we recommend to place, moisture condition and compact the initial and secondary backfill in accordance with the appropriate project documents or those requirements established by any applicable city or county standard specifications for public works construction.

As a compaction guideline, we recommend that all trench backfill be placed in loose lifts not to exceed eight (8) inches, moisture conditioned between minus three (-3) and plus three (+3) percentage points of the optimum moisture content, and compacted to at least 95 percent of the maximum dry density as evaluated by ASTM D 698.

Flowable fill can be used as an alternative to soil backfill. Flowable fill typically consists of a mixture of sand, portland cement, fly ash and water and is readily available from ready-mixed concrete suppliers. This very low strength cementitious fill is placed in a slurry form and readily takes the shape of the excavation. Properly designed and placed, it can be trenched through by a backhoe for future repairs or modifications as required. Flowable fill should be considered for road crossings and meet the requirements of SAWS specifications.

Backfill along the sides to the top of the pipe should consists of materials that are acceptable to the project civil engineer or materials meeting those requirements established by any applicable city or county standard specifications for public works construction. Excavated CLAYEY SAND (SC) may be acceptable for initial backfill. To avoid potential damage to the pipe, the

TABLE 2
Geotechnical Services – Analytical Lab Test Results
Gonzales County Well Field
Highway 97 and CR 123
SAWS Job Nº 03 – 8518-207
Design Engineer: CH2M Hill.
DCE Project Manager: Stephen G. Urias, E.I.T.
DCE Project Principal: Chuck A. Gregory, P.E.
DCE Project Nº 90045344

Boring Nº	Depth (feet)	Soil Classification	Lab Resistivity In-Situ Ohm-meters	Lab Resistivity Saturated Ohm-meters	Soil pH	Chlorides (ppm)	Sulfates (ppm)	Sulfides	Redox Potential (mV)
B-1	8 – 10	Clay (CH)	16.08	10.62	6.53	50	143	Neg.	263
B-2	8 – 10	Clay (CH)	6.33	3.05	6.95	320	252	Neg.	192
B-3	10 – 12	Clay (CH)	2.57	1,753.88	6.63	1,120	714	Neg.	197
B-4	8 – 10	Clay (CH)	5.36	2.78	6.98	140	1,728	Trace	256
B-5	8 – 10	Clay (CH)	9.57	4.48	6.53	170	92	Neg.	254
B-6	10 – 12	Clay (CH)	3.98	2.78	7.25	340	443	Trace.	267
B-7	6 – 8	Clay (CH)	30.88	3.88	7.22	80	3,493	Trace	276
B-8	8 - 10	Clay (CH)	4.48	3.24	7.12	50	528	Trace	290
B-9	8.5 – 10	Clay (CH)	14.36	3.61	6.60	120	1,214	Trace	293
B-10	8 – 10	Clay (CH)	5.02	3.78	6.88	225	228	Pos.	284
B-11	10 -12	Clayey Sand (SC)	60.32	24.29	6.73	15	292	Trace	348
B-12	8 – 10	Clayey Sand (SC)	10.26	9.86	7.00	80	280	Pos.	315
B-13	10 – 12	Sandy Clay (CL)	10.29	11.77	6.54	118	107	Pos.	251
B-14	10.5 – 12	Sandy Clay (CL)	195.77	37.05	6.44	28	264	Pos.	255
B-15	8 – 10	Clay (CH)	3.30	2.19	7.22	300	2,370	Neg.	258
B-16	8 – 10	Clay (CH)	2.71	1,911.35	7.00	530	618	Pos.	298
B-17	8 – 10	Clay (CH)	7.71	3.02	6.94	260	348	Neg.	142
B-18	6.5 – 8	Clayey Sand (SC)	65.87	73.70	7.23	10	114	Trace	222
B-19	8 – 10	Sandy Clay (CL)	16.13	9.43	7.14	12	170	Trace	303
B-20	10 – 12	Clay (CH)	4.64	2.48	6.90	720	1,031	Trace	241
B-21	8 – 10	Sandy Clay (CL)	3.81	3.88	7.12	50	768	Neg.	236

TABLE 2
Geotechnical Services – Analytical Lab Test Results
Gonzales County Well Field
Highway 97 and CR 123
SAWS Job Nº 03 – 8518-207
Design Engineer: CH2M Hill.
DCE Project Manager: Stephen G. Urias, E.I.T.
DCE Project Principal: Chuck A. Gregory, P.E.
DCE Project Nº 90045344

Boring Nº	Depth (feet)	Soil Classification	Lab Resistivity In-Situ Ohm-meters	Lab Resistivity Saturated Ohm-meters	Soil pH	Chlorides (ppm)	Sulfates (ppm)	Sulfides	Redox Potential (mV)
B-22	6 – 8	Sandy Clay (CL)	2.44	1,766.23	7.36	920	552	Pos.	254
B-23	10 – 12	Sandy Clay (CL)	6.04	5.08	6.99	90	141	Neg.	295
B-24	8 – 10	Sandy Clay (CL)	1,480.09	1,154.84	6.98	1,400	1,774	Neg.	312
B-25	8 – 10	Clay (CH)	3.03	1,748.73	7.08	750	292	Trace	238

TABLE 3

Geotechnical Services – Field Resistivity Test Results and Locations

Gonzales County Well Field
Highway 97 and CR 123
SAWS Job Nº 04 – 8609-207
Design Engineer: CH2M Hill
DCE Project Manager: Stephen G. Urias, E.I.T.
DCE Project Principal: Chuck A. Gregory, P.E.
DCE Project Nº 90045344

Test Number	Actual GPS Coordinates North	West	Electrode Spacing	Average Resistivity OHM-CM	OHM -M
1	29 21.783	97 36.623	5	1,053	10.5
			10	1,570	15.7
			15	919	9.2
			20	651	6.5
2	29 21.679	97 37.114	5	852	8.5
			10	1,302	13.0
			15	517	5.2
			20	460	4.6
3	29 21.363	97 37.528	5	555	5.6
			10	613	6.1
			15	517	5.2
			20	345	3.5
4	29 21.045	97 37.423	5	594	6.0
			10	460	4.6
			15	488	4.9
			20	460	4.6
5	29 21.152	97 37.980	5	814	8.1
			10	575	5.8
			15	488	4.9
			20	460	4.6
6	29 20.888	97. 38.491	5	1,226	12.3
			10	1,283	12.8
			15	919	9.2
			20	536	5.4
7	29 20.572	97 38.904	5	977	9.8
			10	364	3.6
			15	345	3.5
			20	268	2.7
8	29 20.382	97 39.159	5	603	6.0
			10	555	5.6
			15	402	4.0
			20	306	3.1
9	29 19.826	97 38.670	5	1,063	10.6

Test Number	Actual GPS Coordinates North	West	Electrode Spacing	Average Resistivity OHM-CM	OHM -M
			10	345	3.5
			15	259	2.6
			20	153	1.5
10	29 21.023	98 39.101	5	488	4.9
			10	421	4.2
			15	402	4.0
			20	460	4.6
11	29 21.410	97 38.790	5	421	4.2
			10	421	4.2
			15	460	4.6
			20	306	3.1
12	29 21.761	97 38.375	5	297	3.0
			10	345	3.5
			15	345	3.5
			20	345	3.5
13	29 22.125	97 37.898	5	498	5.0
			10	613	6.1
			15	402	4.0
			20	345	3.5
14	29 22.544	97 37.137	5	1,149	12.5
			10	1,800	18.0
			15	1,207	12.1
			20	421	4.2
15	29 22.843	97 36.667	5	1,216	12.2
			10	2,107	21.1
			15	2,844	28.4
			20	728	7.3
16	29 22.919	97 37.298	5	1,159	11.6
			10	1,379	13.8
			15	2,729	27.3
			20	536	5.4
17	29 23.309	97 37.525	5	910	9.1
			10	843	8.4
			15	747	7.5
			20	536	5.4
18	29 23.539	97 37.728	5	919	9.2
			10	1,130	11.3
			15	1,178	11.8
			20	268	2.7

Test Number	Actual GPS Coordinates North	West	Electrode Spacing	Average Resistivity OHM-CM	OHM -M
19	29 22.064	97 38.482	5	900	9.0
			10	766	7.7
			15	804	8.0
			20	728	7.3
20	29 21.738	97 .8.901	5	948	9.5
			10	996	10.0
			15	747	7.5
			20	651	6.5
21	29 21.146	97 39.872	5	575	5.8
			10	1,034	10.3
			15	1,235	12.4
			20	1,111	11.1
22	29 21.415	97 40.259	5	718	7.2
			10	364	3.6
			15	431	4.3
			20	345	3.5
23	29 21.887	97 39.882	5	536	5.4
			10	517	5.2
			15	201	2.0
			20	268	2.7
24	29 22.230	97 29.494	5	1,580	15.8
			10	958	9.6
			15	1,178	11.8
			20	192	1.9
25	29 22.657	97 39.271	5	670	6.7
			10	823	8.2
			15	776	7.8
			20	27	.30
26	29 23.173	97 39.168	5	632	6.3
			10	555	5.6
			15	603	6.0
			20	31	.30
27	29 23.136	97 40.148	5	986	10
			10	479	4.8
			15	373	3.7
			20	268	2.7
28	29 22.620	97 40.148	5	1,044	10.0
			10	613	6.1
			15	517	5.2
			20	383	3.8

Test Number	Actual GPS Coordinates North	West	Electrode Spacing	Average Resistivity OHM-CM	OHM -M
29	29 21.890	97 40.780	5	575	5.8
			10	594	5.9
			15	460	4.6
			20	421	4.2
30	29 21.410	97 41.018	5	661	6.6
			10	555	5.6
			15	546	5.5
			20	536	5.4
31	29 21.388	97 41.642	5	756	7.6
			10	651	6.5
			15	603	6.0
			20	460	4.6
32	29 21.489	97 42.018	5	642	6.4
			10	613	6.1
			15	603	6.0
			20	460	4.6
33	29 21.441	97 41.803	5	44,048	440.5
			10	11,108	111.1
			15	4,022	40.2
			20	2,681	26.8
34	29 19.677	97 38.502	5	833	8.33
			10	440	4.4
			15	316	3.2
			20	192	1.9
35	29 21.828	97 40.726	5	1,207	12.1
			10	823	8.2
			15	575	5.8
			20	383	3.8
36	29 22.562	97 38.173	5	967	9.7
			10	1,072	10.0
			15	977	9.8
			20	843	8.4

TABLE 4
SUMMARY OF SOIL PARAMETERS
BORINGS B-1 TO 10, B-13, 15, 16, 17, 19, B-20 TO B-25
GONZALES COUNTY WELL FIELD
HIGHWAY 97 AND CR 123
GONZALES COUNTY, TEXAS

Layer	Depth (feet)	Cohesion (psf)	Total Unit Weight (pcf)	Effective Unit Weight (pcf)	Lateral Earth Pressures Equivalent Fluid Density (pcf)	FS = 3.0	Friction Angle (degree)	In-Situ Soil Modulus (E'_n) psi
						Allowable Compressive Vertical Bearing Pressure (psf)		
1	0 – 6	1,500	120	---	110	3,000	0	1,000
2	6 – 12	2,500	120	---	110	5,000	0	4,000

NOTES:

1. Design depth to subsurface water is assumed to be below 12 feet.
2. FS indicates the Factor of Safety used on the values in the appropriate column.
3. Parameters may differ away from boring locations.

TABLE 5
SUMMARY OF SOIL PARAMETERS
BORINGS B-11, B-12, AND B-18
GONZALES COUNTY WELL FIELD
HIGHWAY 97 AND CR 123
GONZALES COUNTY, TEXAS

Layer	Depth (feet)	Cohesion (psf)	Total Unit Weight (pcf)	Effective Unit Weight (pcf)	Lateral Earth Pressures Equivalent Fluid Density (pcf)	FS = 3.0 Allowable Compressive Vertical Bearing Pressure (psf)	Friction Angle (degree)	In-Situ Soil Modulus (E'$_n$) psi
1	0 – 5	---	125	---	94	0 – 3,600	30	1,500
2	5 – 12	---	130	---	94	3,600 – 11,000	32	2,500

NOTES:

1. Design depth to subsurface water is assumed to be below 12 feet.
2. FS indicates the Factor of Safety used on the values in the appropriate column.
3. Parameters may differ away from boring locations.

TABLE 6
SUMMARY OF SOIL PARAMETERS
BORING B-14
GONZALES COUNTY WELL FIELD
HIGHWAY 97 AND CR 123
GONZALES COUNTY, TEXAS

Layer	Depth (feet)	Cohesion (psf)	Total Unit Weight (pcf)	Effective Unit Weight (pcf)	Lateral Earth Pressures Equivalent Fluid Density (pcf)	FS = 3.0 Allowable Compressive Vertical Bearing Pressure (psf)	Friction Angle (degree)	In-Situ Soil Modulus (E'_n) psi
1	0 – 4	1,500	125	---	115	3,000	0	1,000
2	4 – 12	---	130	---	94	3,500 – 11,000	32	4,250

NOTES:

1. Design depth to subsurface water is assumed to be below 12 feet.
2. FS indicates the Factor of Safety used on the values in the appropriate column.
3. Parameters may differ away from boring locations.

TABLE 7
SUBGRADE IMPROVEMENT REINFORCEMENT GEOGRID PROPERTIES
GONZALES COUNTY WELL FIELD
HIGHWAY 97 AND CR 123
GONZALES COUNTY, TEXAS

PROPERTY	TEST METHOD	UNITS	VALUES
Geometry			
Aperture Size MD[1] CMD[1]	 I.D. Calipered[2] I.D. Calipered[2]	 in / (mm) in / (mm)	 1.00 / (25) 1.30 / (33)
Open Area	COE Method[3] CW-02215	%	70
Rib Thickness Rib Shape	Calipered Observation	in / (mm) N/A	0.03 / (0.76) Rectangular or Square
Structural Integrity			
Torsional Rigidity (Aperture Stability Modulus) @ 20 cm-kg	COE METHOD[4]	cm-kg/deg.	3.2[5]
Flexural Rigidity (Stiffness) MD	 ASTM D 1388-96[6]	 Mg-cm	 250,000
Tensile Strength MD CMD True Initial Modulus (min.) MD CMD	 ASTM D 6637-01[8] ASTM D 6637-01[8] ASTM D 6637-01[8] ASTM D 6637-01[8]	 lb/ft / (kN/m) lb/ft / (kN/m) lb/ft / (kN/m) lb/ft / (kN/m)	 280 / (4.1) 450 / (6.6) 17,140 / (250) 27,420 / (400)
Junction Strength MD CMD	 GRI GG2-87[7] GRI GG2-87[7]	 lb/ft lb/ft	 765 1170
Junction Efficiency	GRI GG2-87[7]	%	93
Durability			
Resistance to Installation Damage	ASTM D 5818	%SC/%SW/%GP	90/83/70
Resistance to Long Term Degradation	ASTM D 5818 EPA 9090	%	100
Material			
Polypropylene	ASTM D 4101 Group 1/Class 1/Grade 2	%	98
Carbon Black	ASTM D 4218	%	0.5

TABLE 7 (Continued)

SUBGRADE IMPROVEMENT REINFORCEMENT GEOGRID PROPERTIES
GONZALES COUNTY WELL FIELD
HIGHWAY 97 AND CR 123
GONZALES COUNTY, TEXAS

NOTES:

1. MD dimension is along roll length; CMD dimension is across roll width.

2. Maximum inside dimensions in each principal direction measured by calipers.

3. Percent Open area measured without magnification by Corps. Of Engineers method as specified in CW02215.

4. Resistance to in-plane rotational movement measured by applying a 20cm-kg moment to the central junction of a 9" x 9" specimen restrained at its perimeter. (U.S. Army Corps of Engineers Methodology) & Grid Aperture Stability Test developed by Dr. T. Kinney at the University of Alaska, Fairbanks.

5. Secant Aperture Stability Modulus. Value listed is equal to the mean value less approximately one standard deviation.

6. ASTM D1388-96, Option A modified to account for wide specimen testing.

7. Geotextile junction strength and junction efficiency measured by Geosynthetic Research Institute test method GRI-GG2-87 "Geotextile Junction Strength." Geogrid shall not be pre-tensioned prior to testing strength parameter.

8. True resistance to elongation when initially subjected to a load measured using ASTM D6637 without deforming test materials under load before measuring such resistance or employing "secant" or "offset" tangent methods of measurement so as to overstate tensile properties. For single layer products use Test Method A, for multi-layer products use Test Method C.

TABLE 8
SLAB FOUNDATION DESIGN CRITERIA
GONZALES COUNTY WELL FIELD
HIGHWAY 97 AND CR 123
GONZALES COUNTY, TEXAS

Conventional Method:	Existing Conditions	PVR 1"	PVR 1.5"
Net Allowable Bearing Pressure			
Total Load	3,000	3,000	3,000 psf
Dead Load	2,000	2,000	2,000 psf
Potential Vertical Rise (PVR)	about 5 inches	about 1 inch	about 1½ inches
BRAB/PCI Methods:			
Design Plasticity Index (PI)**	56	26	32
Climatic Rating (C_w)	18	18	18
Unconfined Compressive Strength	1.0 tsf	1.0 tsf	1.0 tsf
Soil Support Index, BRAB/PCI	0.63	0.9	0.84
PTI Method:			
Thornthwaite Moisture Index (I_m)	-12	-12	-12
Depth of Constant Soil Suction	7 feet	7 feet	7 feet
Constant Soil Suction	3.4 pF	3.4 pF	3.4 pF
Moisture Velocity	0.7 inches/month	0.7 inches/month	0.7 inches/month
Net Allowable Bearing Pressure			
Total Load	3,000 psf	3,000 psf	3,000 psf
Dead Load	2,000 psf	2,000 psf	2,000 psf
Edge Moisture Variation Distance (e_m):	6 feet	6 feet	6 feet
Center Lift	3 feet	3 feet	3 feet
Edge Lift			
Differential Soil Movement (y_m):			
Center Lift	5.4 inches	1.2 inches	1.8 inches
Edge Lift	1.4 inches	0.3 inches	0.5 inches
Coefficient of Slab-Subgrade Friction (μ):	0.75 to 1.00	0.75 to 1.00	0.75 to 1.00

ILLUSTRATIONS

APPENDIX A

Contents	Page

FIELD EXPLORATION PROGRAM

General

Various drill equipment and procedures are used to obtain soil or rock specimens during geotechnical engineering exploration activities. The drill equipment typically consists of fuel powered machinery that is mounted on a flat bed truck or an all-terrain vehicle. The ground surface conditions at the site generally determine the type of vehicle to use.

Borings can be drilled either dry or wet. The drilling technique depends on the type of subsurface materials (clays, sands, silts, gravels, rock) encountered and whether or not subsurface water is present during the drilling operations. Sometimes a combination of both techniques is implemented.

The dry method can generally be employed when subsurface water or granular soils are not present. The dry method generally consists of advancing the augers without the use of water or drilling fluids. Air can be employed as necessary to remove cuttings from the borehole or cool the drilling bits during some drilling applications. The wet rotary process is generally used when subsurface water, rock or granular soils are present. The wet rotary process utilizes water or drilling fluids to advance the augers, remove cuttings from the borehole, and cool the drilling bits during drilling.

Sampling

Various sampling devices are available to recover soil or rock specimens during the geotechnical exploration program. The type of sampling apparatus to employ depends on the subsurface materials (clays, sands, silts, gravels, rock) encountered and on their consistency or strength. Most commonly used samplers are Shelby tubes, split-spoons or split-barrels, and NX core barrels. Depending on the subsurface conditions, sampling apparatus such as the Pitcher barrel, Osterberg sampler, Dennison barrel, or California sampler are sometimes used. The procedures for using and sampling subsurface materials with most of these samplers are described in detail in the most current edition of the American Society for Testing and Materials (ASTM) book titled Annual Book of ASTM Standards. Sampling is generally performed on a two (2) foot continuous interval to a depth of about ten (10) feet, followed by five (5) foot intervals between the depths of about ten (10) to 50 feet, and on ten (10) foot intervals thereafter to the termination depth of the boring. However, sampling intervals may change depending on the project scope and actual subsurface conditions encountered.

If cohesive soils (clays and some silts) are present during drilling, samples are retrieved by using the Shelby tube sampler (ASTM D 1587) or the split-barrel sampler (ASTM D 1586). The Shelby tube is used to recover "virtually" undisturbed soil specimens that can be returned to the laboratory for strength and compressibility testing. The Shelby tube is a three (3) inch nominal diameter, thin-walled tube that is advanced hydraulically into the soil by a single stroke of the drill equipment.

The split-barrel sampler is used when performing the Standard Penetration Test (SPT). The recovered sample is considered to be a "disturbed" specimen due to the SPT procedure. The split-barrel is advanced into the soil by driving the sampler with blows from a 140-pound hammer free falling 30 inches. The SPT procedure is performed to evaluate the strength or competency of the material being sampled. This evaluation is based on the material sampled, depth of the sample, and the number of blows required to obtain full penetration of the split-barrel sampler. This blow count or penetration resistance is referred to as the "N" value.

The split-barrel is typically used when cohesionless soils (sands, silts, gravels) are encountered or when good quality cohesive soils cannot be recovered with the Shelby tube sampler. The SPT procedure can be employed when rock or cemented zones are encountered. However, the split-barrel may not penetrate the rock or cemented zone if the layer is extremely hard, thus resulting in no sample recovery.

When rock or cemented zones are present, and depending on the type of project and engineering testing required, rock coring may be implemented to recover specimens of the particular layer. Typically an NX core barrel (ASTM D 2113) is used.

Logging

During the drilling activities, one of our geologists or engineering technicians is present to make sure that the appropriate sampling techniques are employed and to extrude or remove all materials from the samplers. The samples are then visually classified by our field representative who records the information on a field boring log. Our field representative may perform pocket penetrometer, hand torvane, or field vane tests on the subsurface materials recovered from the Shelby tube samplers. If the SPT procedure is employed, our field representative will record the N values or blow counts that are germane to that particular field test. If rock coring is utilized, our field representative will calculate the percent recovery and Rock Quality Designation (RQD). The test data for all the field tests will be noted on the appropriate field boring log. Upon completion of the logging activities and field testing of the recovered soil or rock samples, representative portions of the specimens were placed in appropriately wrapped and sealed containers to preserve their natural moisture condition and to minimize disturbance during handling and transporting to our laboratory for additional testing.

When subsurface water is observed during the drilling and sampling operations, drilling will be temporarily delayed so the subsurface water level can be monitored for a period of at least 15 to 30 minutes. Depending on the rise of the subsurface water in the borehole and project requirements, subsurface water measurements may be monitored for periods of 24 hours or more. Generally observation wells or piezometers are installed in the completed boreholes to monitor subsurface water levels for periods longer than 24 hours.

Following completion of drilling, sampling, and subsurface water level observations, all boreholes will be backfilled with soil cuttings from the completed borings unless special backfilling requirements are requested by the client. If there are not enough soil cuttings available, clean sand will be used to backfill the completed boreholes.

Details concerning the subsurface conditions are provided on each individual boring log presented in this Appendix. The terms and symbols used on each boring log are defined in the Symbol Key Sheet which is also presented in this Appendix.

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-1
DATE 3/30/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

FIELD DATA			LABORATORY DATA									
DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	ATTERBERG LIMITS (%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
		P=1.75	12	23	16	7						SILTY CLAY (CL-ML); tan.
		P=1.25	31									CLAY (CH); tan.
5		P=3.25	26	67	19	48						- clay seam from 2 to 6 feet.
		P=4.5	17									
		P=4.5	19				113	4.9	7.9			- with calcareous nodules below 8 feet.
10		P=4.5	15									
												Boring Terminated at 12 Feet.

Drash Consulting Engineers, Inc.
6911 Blanco Road
San Antonio, TX 78216
FAX

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 22.562, W 97° 38.173

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-2
DATE 4/4/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=2.5	20									CLAY (CH); tan.
			P=0.75	29	73	23	50						
			P=3.5	29									- grades to orange and gray below 4 feet.
	5												
			P=4.5	25	88	27	61						
			P=4.5	26				98	4.8	2.2			
	10												
			N=30	24									
													Boring Terminated at 12 Feet.

Drash Consulting Engineers, Inc.
6911 Blanco Road
San Antonio, TX 78216
FAX

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: 29° 22.366, W 97° 39.967

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-3
DATE 3/30/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=3.75	19									CLAY (CH); brown.
			P=3.0	15									
			P=3.25	14	54	15	39						
	5												
			P=4.5	15									- grades to tan with sand pockets below 6 feet.
			P=4.0	21	64	22	42						
	10		P=3.75	17				106	3.9	6.7			
													Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 20.948, W 97° 37.256

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-4
DATE 4/5/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=1.0	17									CLAY (CH); brown.
			P=3.5	23									- grades to tan and gray below 3 feet.
			P=4.5	17				114	6.1	7.9			
	5												
			P=4.5	20	64	22	42						
			P=4.5	22									- with interbedded gypsum particles.
	10		P=4.5	26				101	4.7	4.3			
													Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 23.325, W 97° 39.220

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-5
DATE 4/5/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=2.5	18									CLAY (CH); brown.
			P=3.0	20	50	23	27						- grades to reddish-brown below 2 feet.
			P=3.0	18									
	5		P=4.5	15									
			P=4.5	24				99	4.7	2.9			- grades to orange and gray below 8 feet.
	10		P=4.5	34								85	

Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: 29° 23.606, W 97° 37.772

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-6
DATE 3/29/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	ATTERBERG LIMITS (%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=1.25	22									CLAY (CH); brown.
			P=1.0	24	52	19	33						
			P=1.0	26									- grades to orange and tan below 4 feet.
	5												
			P=4.0	49									
			P=4.25	32	93	29	64						- grades to orange and gray below 8 feet.
	10		P=4.5	30				95	2.6	1.7			
													Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS 29° 22.806, W 97° 36.648

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-7
DATE 3/29/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=2.0	20									CLAY (CH); brown.
			P=1.5	22	44	17	27						- sandy at 2 feet.
			P=1.5	21									
	5												
			P=4.5	19				111	10.2	6.0			
			P=4.5	23									- grades to orange and gray below 8 feet.
	10												
			P=4.5	27	84	26	58						
													Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N29º.800, W 97º 36.549

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-8
DATE 4/5/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=2.25	27									CLAY (CH); brown.
			P=4.5	23									- grades to orange and gray below 12 feet.
			P=4.5	22	73	24	49						
	5		P=4.5	26									
			P=4.5	22				97	1.6	5.1			
	10		P=4.5	31	60	21	39						
													Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: 97° 20.733, W 97° 38.408

LOG OF BORING

PROJECT:	Gonzales County Well Field Highway 97 and CR 123 Gonzales County, Texas	**PROJECT NO.**	90045344
CLIENT:	CH2M Hill San Antonio, Texas	**BORING NO.**	B-9
		DATE	4/1/05
		SURFACE ELEVATION	Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=1.75	25									CLAY (CH); brown.
			P=3.5	26									- grades to orange and gray below 2 feet.
			P=4.5	24	73	26	47						
	5		P=4.5	26				102	6.1	3.6			
			N=23	27									
	10		P=4.5	28									
													Boring Terminated at 12 Feet.

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 21.050, W 97° 39.692

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LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-10
DATE 3/31/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	ATTERBERG LIMITS (%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=4.5	19									CLAY (CH); brown.
			P=1.75	26									
			P=3.5	25	71	23	48						
	5		P=3.5	24									
			P=4.5	22	61	22	39						
	10		P=4.5	23				102	3.7	2.9			
													Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 21.418, W 97° 40.942

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO.	90045344
BORING NO.	B-11
DATE	4/1/05
SURFACE ELEVATION	Existing Grade

PAGE 1 OF 1

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

DEPTH (FT)	N: BLOWS/FT, P: TONS/SQ FT, T: TONS/SQ FT, PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
		3									CLAYEY SAND (SC); tan.
		7								16	
5	N=11	21	63	21	42						- clay seam from 4 to 6 feet.
		18	49	16	33					31	
	P=4.0	11									- grades to orangish-red below 8 feet.
10	P=2.5	11	25	14	11					29	
											Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 21.511, W 97° 42.070

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-12
DATE 4/4/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

DEPTH (FT)	N: BLOWS/FT, P: TONS/SQ FT, T: TONS/SQ FT, PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
		5									CLAYEY SAND (SC); tan.
	N=5	15									
5	N=7	19	23	15	8					33	
	N=9	17									
	N=4.0	16								33	
10	N=4.5	13	28	16	12						
											Boring Terminated at 12 Feet.

This Log is not valid if seperated from original report.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 22.373, W 97° 41.115

LOG OF BORING 90045344.GPJ DRASH.GDT 5/12/05

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-13
DATE 3/30/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=2.5	15									CLAY (CH); reddish-brown.
			P=2.5	24	58	20	38						
			P=3.25	20									- with sand pockets below 4 feet.
	5												
			P=4.25	16				115					
			P=4.5	10	29	19	10	120	6.3	3.0			SANDY CLAY (CL); tan.
	10												
			N=37	15								62	
													Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 21.754, W 97° 38.890

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-14
DATE 4/4/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	ATTERBERG LIMITS (%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=3.0	12									SANDY CLAY (CL); tan.
			P=4.5	10	40	16	24						
	5		N=39	8									CLAYEY SAND (SC); orangish-tan.
			N=43	3								34	
			N=57	4									
	10		N=84/11"	4									- cemented.
													Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 23.389, W 97° 40.346

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-15
DATE 3/30/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=4.0	17									CLAY (CH); brown.
			P=2.0	23									- grades to tan below 2 feet.
			P=2.0	22				106					
	5												
			P=3.5	22	70	24	46						- with calcareous nodules below 6 feet.
			P=3.75	27				99	3.3	4.0			
	10		P=3.0	27									
													Boring Terminated at 12 Feet.

This Log is not valid if seperated from original report.

LOG OF BORING 90045344.GPJ DRASH.GDT 5/12/05

Drash Consulting Engineers, Inc.
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FAX

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 22.141, W 97° 39.513

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-16
DATE 3/31/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

Soil Symbol	Depth (FT)	Samples	N: Blows/FT; P: Tons/SQ FT; T: Tons/SQ FT; Percent Recovery/ Rock Quality Designation	Moisture Content (%)	Atterberg Limits (%) Liquid Limit LL	Plastic Limit PL	Plasticity Index PI	Dry Density (Pounds/CU FT)	Compressive Strength (Tons/SQ FT)	Failure Strain (%)	Confining Pressure (Pounds/SQ IN)	Minus No. 200 Sieve (%)	Description of Stratum
			P=2.75	18									CLAY (CH); brown.
			P=1.5	22	54	18	36						- grades to orange and gray below 2 feet.
			P=4.0	19									
	5												
			P=4.0	18				112	3.4	9.0			
			P=4.5	20	63	19	44						
	10		P=4.5	26									
													Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 21.841, W 97° 40.748

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-17
DATE 3/31/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=2.0	23									CLAY (CH); brown.
			P=1.0	29									- grades to orange and gray below 2 feet.
			P=1.0	26	67	22	45						
	5												
			P=4.5	29									
			P=4.5	27	81	28	53	97	7.4	2.9			
	10		P=4.5										
													Boring Terminated at 12 Feet.

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REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 21.588, W 97° 40.433

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-18
DATE 4/1/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

DEPTH (FT)	N: BLOWS/FT, P: TONS/SQ FT, T: TONS/SQ FT, PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
		4									CLAYEY SAND (SC); tan.
		6								17	
5		9									
	N=6	15									
	N=7	18								28	
10	N=15	15	23	13	10					24	
											Boring Terminated at 12 Feet.

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 21.441, W 97° 41.803

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LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-19
DATE 3/29/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	ATTERBERG LIMITS (%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=1.0	16									CLAY (CH); brown.
			P=1.0	32									- grades to reddish-brown at 2 feet.
			P=1.25	24	58	19	39						
	5		P=4.25	15				120	4.3	5.4			
			P=3.25	15									
	10		P=4.25	14									
													Boring Terminated at 12 Feet.

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FAX

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 22.041, W 97° 38.557

LOG OF BORING 90045344.GPJ DRASH.GDT 5/12/05

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-20
DATE 3/29/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=3.5	24									CLAY (CH); brown.
			P=1.0	30									
			P=3.0	27	78	25	53						- grades to tan and gray below 4 feet.
	5												
			P=4.5	29									- with gypsum particles below 6 feet.
			P=4.5	28	82	27	55						
	10		P=3.5	29				94	4.2	3.4			
													Boring Terminated at 12 Feet.

Drash Consulting Engineers, Inc.
6911 Blanco Road
San Antonio, TX 78216
FAX

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 21.521, W 97° 38.658

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas
CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-21
DATE 4/5/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface waler was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	ATTERBERG LIMITS (%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=1.5	22									SANDY CLAY (CL); brown
			P=2.5	21	46	18	28						
			P=1.5	21									
	5												
			P=1.25	25				100	1.3	9.0			CLAY (CH); orange and gray.
			P=0.5	35									
	10			34	85	29	56						
													Boring Terminated at 12 Feet.

Drash Consulting Engineers, Inc.
6911 Blanco Road
San Antonio, TX 78216
FAX

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 22.942, W 97° 37.314

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-22
DATE 3/30/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

Soil Symbol	Depth (ft)	Samples	N: Blows/ft, P: Tons/sq ft, T: Tons/sq ft, Percent Recovery/Rock Quality Designation	Moisture Content (%)	Atterberg Limits (%): Liquid Limit LL	Plastic Limit PL	Plasticity Index PI	Dry Density (pounds/cu ft)	Compressive Strength (tons/sq ft)	Failure Strain (%)	Confining Pressure (pounds/sq in)	Minus No. 200 Sieve (%)	Description of Stratum
			P=4.5	11									SANDY CLAY (CL); brown; with gravel.
			P=4.5	17									
			P=3.5	22	46	19	27						
	5												
			P=2.0	36									CLAY (CH); orangish-tan.
			P=1.5	43	71	31	40	85	1.2	4.0			
	10		P=3.0	42									
													Boring Terminated at 12 Feet.

Drash Consulting Engineers, Inc.
6911 Blanco Road
San Antonio, TX 78216
FAX

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 22.233 , W 97° 37.625

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-23
DATE 3/30/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

FIELD DATA: N: BLOWS/FT, P: TONS/SQ FT, T: TONS/SQ FT, PERCENT RECOVERY/ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
P=2.25	17									SANDY CLAY (CL); brown.
P=2.5	17									- grades to tan below 2 feet.
P=2.5	16	42	17	25						
P=3.25	17									
P=4.0	17									
P=4.5	19				109	5.1	5.7			

Depth (ft) scale marks: 5, 10

Boring Terminated at 12 Feet.

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 21.820, W 97° 36.948

Drash Consulting Engineers, Inc.
6911 Blanco Road
San Antonio, TX 78216
FAX

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO. 90045344
BORING NO. B-24
DATE 3/30/05
SURFACE ELEVATION Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	ATTERBERG LIMITS (%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=4.5	13	40	17	23						SANDY CLAY (CL); brown.
			P=4.5	11									
	5		P=4.5	10				125	5.7	3.2			
			P=3.0	37									CLAY (CH); orange and gray; with calcareous nodules.
			P=3.0	41				81	1.6	2.8			
	10		P=3.0	40	85	34	51						
													Boring Terminated at 12 Feet.

Drash Consulting Engineers, Inc.
6911 Blanco Road
San Antonio, TX 78216
FAX

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 21.180, W 97° 37.825

LOG OF BORING

PROJECT: Gonzales County Well Field
Highway 97 and CR 123
Gonzales County, Texas

CLIENT: CH2M Hill
San Antonio, Texas

PROJECT NO.	90045344
BORING NO.	B-25
DATE	4/5/05
SURFACE ELEVATION	Existing Grade

DRILLING METHOD(S):
Dry augered from 0 to 12 feet.

GROUNDWATER INFORMATION:
Subsurface water was not encountered either during or upon completion of the drilling operations.

SOIL SYMBOL	DEPTH (FT)	SAMPLES	FIELD DATA: N: BLOWS/FT, P: TONS/SQ FT, T: TONS/SQ FT, PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	ATTERBERG LIMITS (%): LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (POUNDS/CU FT)	COMPRESSIVE STRENGTH (TONS/SQ FT)	FAILURE STRAIN (%)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P=4.5	14									CLAY (CH); brown.
			P=4.5	15									
			P=4.5	20	57	19	38						- grades to tan below 4 feet.
	5												
			P=4.0	20				109	2.6	8.9			
			P=4.0	32	68	26	42						- grades to orange and gray below 8 feet.
	10		P=4.0	27								91	

Boring Terminated at 12 Feet.

Drash Consulting Engineers, Inc.
6911 Blanco Road
San Antonio, TX 78216
FAX

REMARKS
The boring was backfilled with cuttings after completion of the subsurface water level observations. GPS: N 29° 19.677, W 97° 38.499

Symbol Key Sheet

Material Symbols

"FILL"	Clay (CH)	Sandy Clay (CL)	Silty Clay (CL)	Peat
Asphalt	Clayey Sand (SC)	Sand (SP)	Silty Sand (SM)	Organic Soil (OH or OL)
Base	Elastic Silt (MH)	Sandy Silt (ML)	Silt (ML)	Gravelly Silt (ML)
Concrete	Clayey Gravel (GC)	Sandy Gravel (GP)	Silty Gravel (GM)	Gravel (GP or GW)
Claystone	Limestone	Marl	Sandstone	Shale

Strength of Cohesive Soils

Consistency	Undrained Shear Strength, ksf
Very Soft	less than 0.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very Stiff	2.00 to 4.00
Hard	greater than 4.00

Soil Plasticity

Degree of Plasticity	Plasticity Index (PI)
None	0 to 5
Low	5 to 10
Moderate	10 to 20
Plastic	20 to 40
Highly Plastic	more than 40

Density of Granular Soils

Descriptive Term	SPT Blow Count (blows/ft)
Very Loose	less than 4
Loose	4 to 10
Medium Dense	10 to 30
Dense	30 to 50
Very Dense	more than 50

Standard Penetration Test (ASTM D 1586) Driving Record

Note: Driving is limited to 50 blows per interval, or 25 blows for 0.25 inch advancement, whichever controls. This is done to avoid damaging sampling tools.

Blows Per Foot	Description
25	Sampler was seated 6 inches, then 25 blows were required to advance the sampler 12 inches.
50/4"	Sampler was seated 6 inches, then 50 blows were required to advance the sampler 4 inches.
ref/2"	Sampler could only be driven 2 inches of the 6 inch seating penetration before the 50 blow limit was reached.

Terms Characterizing Structure

Soil Terms	Description
Blocky	Contains cracks or failure planes resulting in rough cubes of material.
Calcareous	Contains appreciable quantities of calcium carbonate.
Fissured	Contains shrinkage cracks, which are frequently filled with fine sand or silt. The fissures are usually near vertical in orientation.
Interbedded	Composed of alternating layers of different soil types.
Laminated	Composed of thin layers of varying color and texture.
Nodules	Secondary inclusions that appear as small lumps about 0.1 to 0.3 inch in diameter.
Partings	Inclusion of different material less than 1/8 inch thick extending through the sample.
Pockets	Inclusion of different material that is smaller than the diameter of the sample.
Seams	Inclusion of different material between 1/8 and 3 inches thick, and extends through the sample.
Slickensided	Has inclined planes of weakness that are slick and glossy in appearance. Slickensides are commonly thought to be randomly oriented.
Streaks or Stains	Stains of limited extent that appear as short stripes, spots or blotches.

Rock Terms	
Bedding Plane	A surface parallel to the surface of deposition, generally marked by changes in color or grain size.
Fracture	A natural break in rock along which no displacement has occurred.
Joint	A natural break along which no displacement has occurred, and which generally intersects primary surfaces.
% Recovery	The ratio of total length of recovery to the total length of core run, expressed as a percentage.
RQD - Rock Quality Designation	The ratio of total recovered length of fragments longer than 4 inches to the total run length, expressed as a percentage.
Weathering	The process by which rock is broken down and decomposed.

Sampler Symbols

Flight Auger | Core Barrel (NX) | Disturbed Sample | No Recovery | Piston Sampler | Shelby Tube (3") | Split Barrel (SPT)

APPENDIX B

Contents | **Page**

LABORATORY TESTING PROGRAM

General

Soil mechanics laboratory tests procedures are performed in accordance with accepted geotechnical engineering practice. These procedures are described in detail in the most current edition of the American Society for Testing and Materials (ASTM) book titled Annual Book of ASTM Standards or as outlined in the book titled Soil Testing for Engineers, by T. William Lambe.

Testing Program

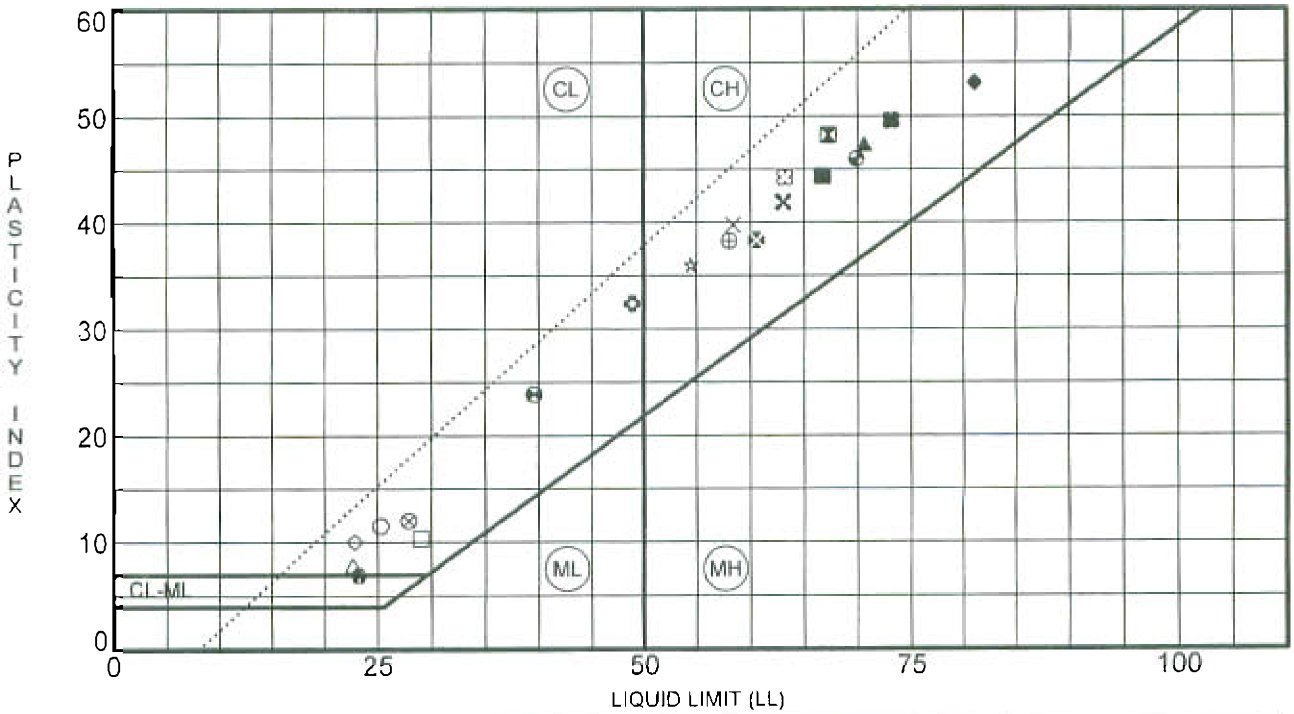
The laboratory testing program was directed towards evaluating the physical and engineering properties of the subsoils. The tests performed for this study consisted of the following:

Laboratory Test	Applicable Test Standard
Moisture Content of Soil	ASTM D 2216
Liquid Limit, Plastic Limit & Plasticity Index of Soil	ASTM D 4318
Percent Passing the Nº 200 Sieve	ASTM D 1140
Unconfined Compressive Strength of Cohesive Soil	ASTM D 2166
Density of Soils In-Place by the Drive Cylinder Method	ASTM D 2937
Soil Resistivity using the Wenner Four Electrode Method	ASTM G57

The laboratory test results are tabulated either adjacent to the corresponding sample depths on the individual boring logs in Appendix A or on attached sheets that may be provided in this Appendix. Laboratory test results were used to classify the soils encountered in substantial accordance with the Unified Soil Classification System.

Sample Disposal

All samples were returned to our laboratory. The samples not tested in the laboratory will be stored for a period of 30 days subsequent to submittal of this report and will be discarded after this period, unless other arrangements are made prior to the disposal period.



	Specimen Identification		LL	PL	PI	Fines	MC%	Classification
	B-1	0.0	23	16	7		12	
	B-1	4.0	67	19	48		26	
▲	B-10	4.0	71	23	48		25	
	B-10	8.0	61	22	39		22	
✕	B-11	4.5	63	21	42		21	
	B-11	6.0	49	16	33	31	18	CLAYEY SAND(SC)
○	B-11	10.0	25	14	11	29	11	CLAYEY SAND(SC)
△	B-12	4.5	23	15	8	33	19	CLAYEY SAND(SC)
⊗	B-12	10.0	28	16	12		13	
⊕	B-13	2.0	58	20	38		24	
□	B-13	8.0	29	19	10		10	
	B-14	2.0	40	16	24		10	
	B-15	6.0	70	24	46		22	
☆	B-16	2.0	54	18	36		22	
	B-16	8.0	63	19	44		20	
■	B-17	4.0	67	22	45		26	
◆	B-17	8.0	81	28	53		27	
◇	B-18	10.5	23	13	10	24	15	CLAYEY SAND(SC)
×	B-19	4.0	58	19	39		24	
	B-2	2.0	73	23	50		29	

A LINE 90045344.GPJ DRASH.GDT 5/9/05

PROJECT Gonzales County Well Field - Highway 97 and CR 123

JOB NO. 90045344

3/30/05

ATTERBERG LIMITS RESULTS

DRASH
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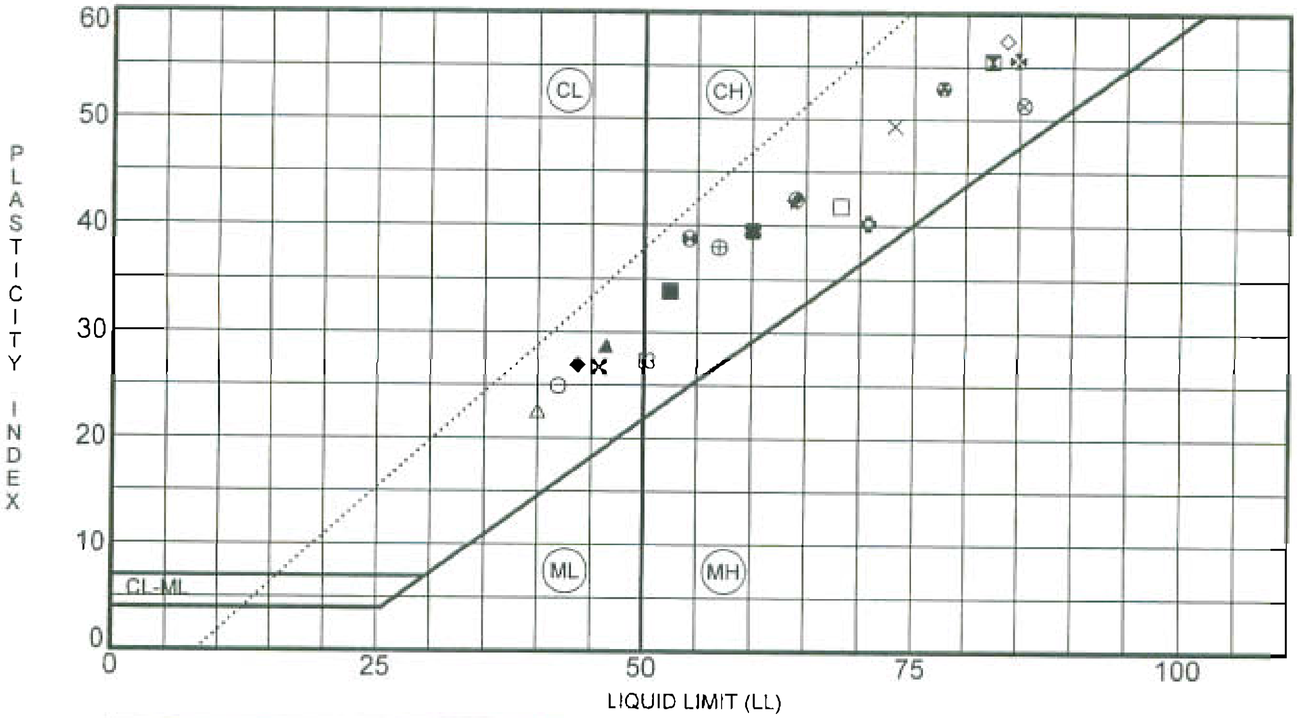


	Specimen Identification		LL	PL	PI	Fines	MC%	Classification
⊕	B-20	4.0	78	25	53		27	
⊠	B-20	8.0	82	27	55		28	
▲	B-21	2.0	46	18	28		21	
⁙	B-21	10.0	85	29	56		34	
✕	B-22	4.0	46	19	27		22	
✿	B-22	8.0	71	31	40		43	
○	B-23	4.0	42	17	25		16	
△	B-24	0.0	40	17	23		13	
⊗	B-24	10.0	85	34	51		40	
⊕	B-25	4.0	57	19	38		20	
□	B-25	8.0	68	26	42		32	
⊖	B-3	4.0	54	15	39		14	
◕	B-3	8.0	64	22	42		21	
☆	B-4	6.0	64	22	42		20	
⊡	B-5	2.0	50	23	27		20	
■	B-6	2.0	52	19	33		24	
◆	B-7	2.0	44	17	27		22	
◇	B-7	10.0	84	26	58		27	
✕	B-8	4.0	73	24	49		22	
✖	B-8	10.0	60	21	39		31	

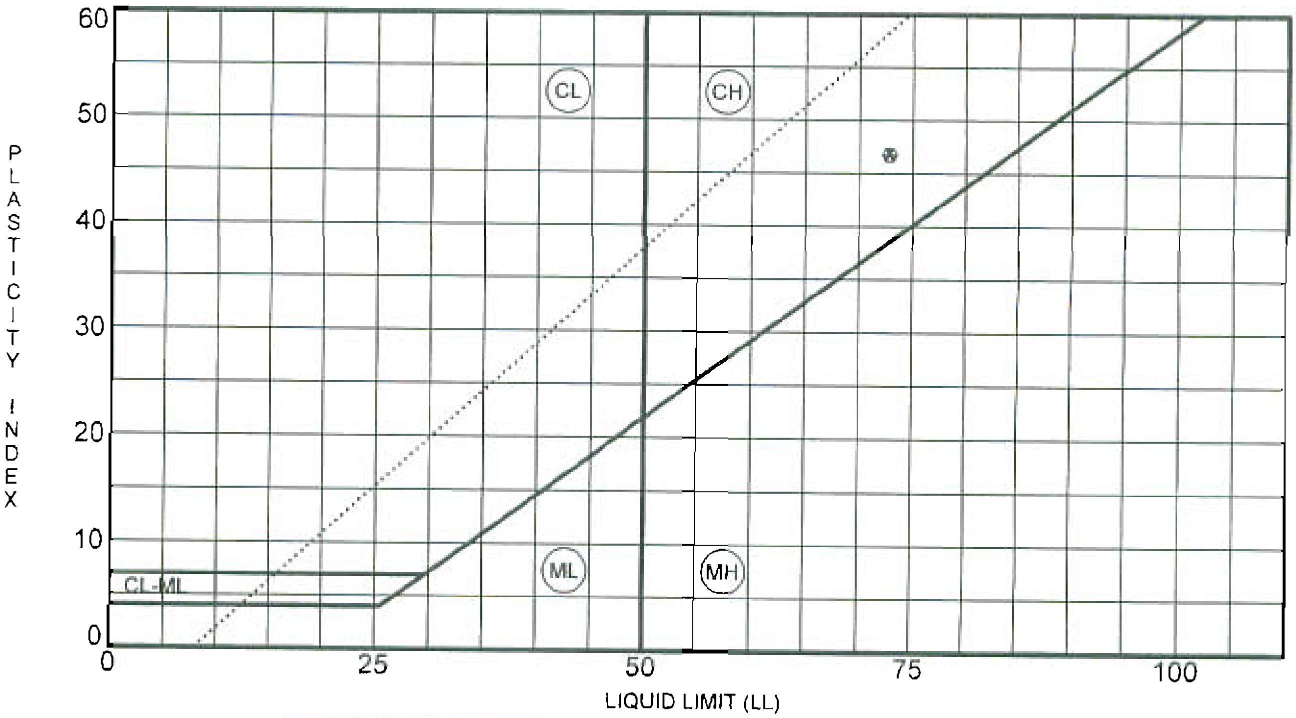
PROJECT Gonzales County Well Field - Highway 97 and CR 123

JOB NO. 90045344

3/30/05

ATTERBERG LIMITS RESULTS

DRASH
CONSULTING ENGINEERS, INC.



	Specimen Identification		LL	PL	PI	Fines	MC%	Classification
⊛	B-9	4.0	73	26	47		24	

PROJECT	Gonzales County Well Field - Highway 97 and CR 123	JOB NO.	90045344
			3/30/05

ATTERBERG LIMITS RESULTS

DRASH
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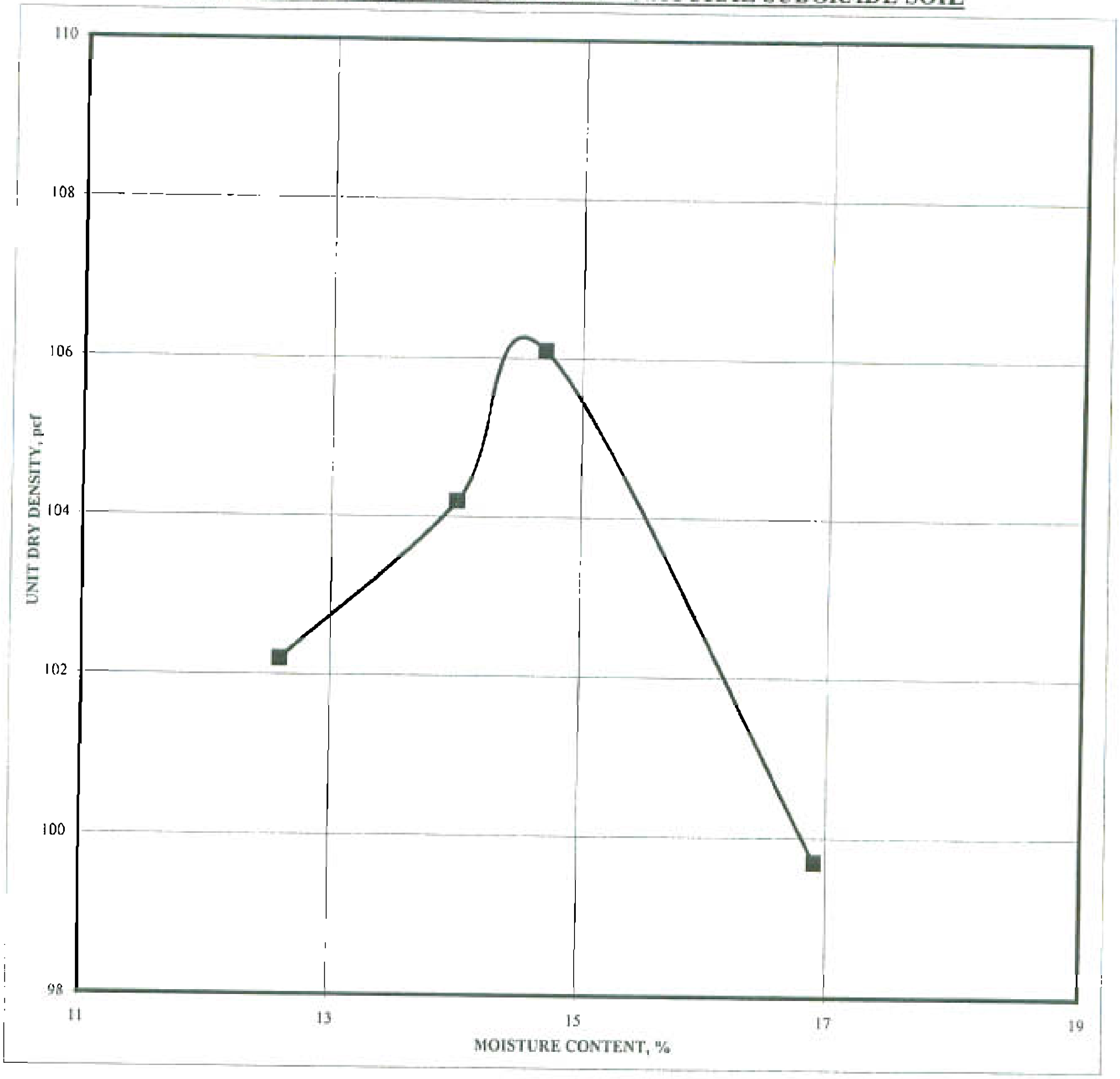
MOISTURE-DENSITY RELATIONSHIP - NATURAL SUBGRADE SOIL



SOIL DESCRIPTION: Orangish-tan Clayey Sand

TEST METHOD: ASTM D 698

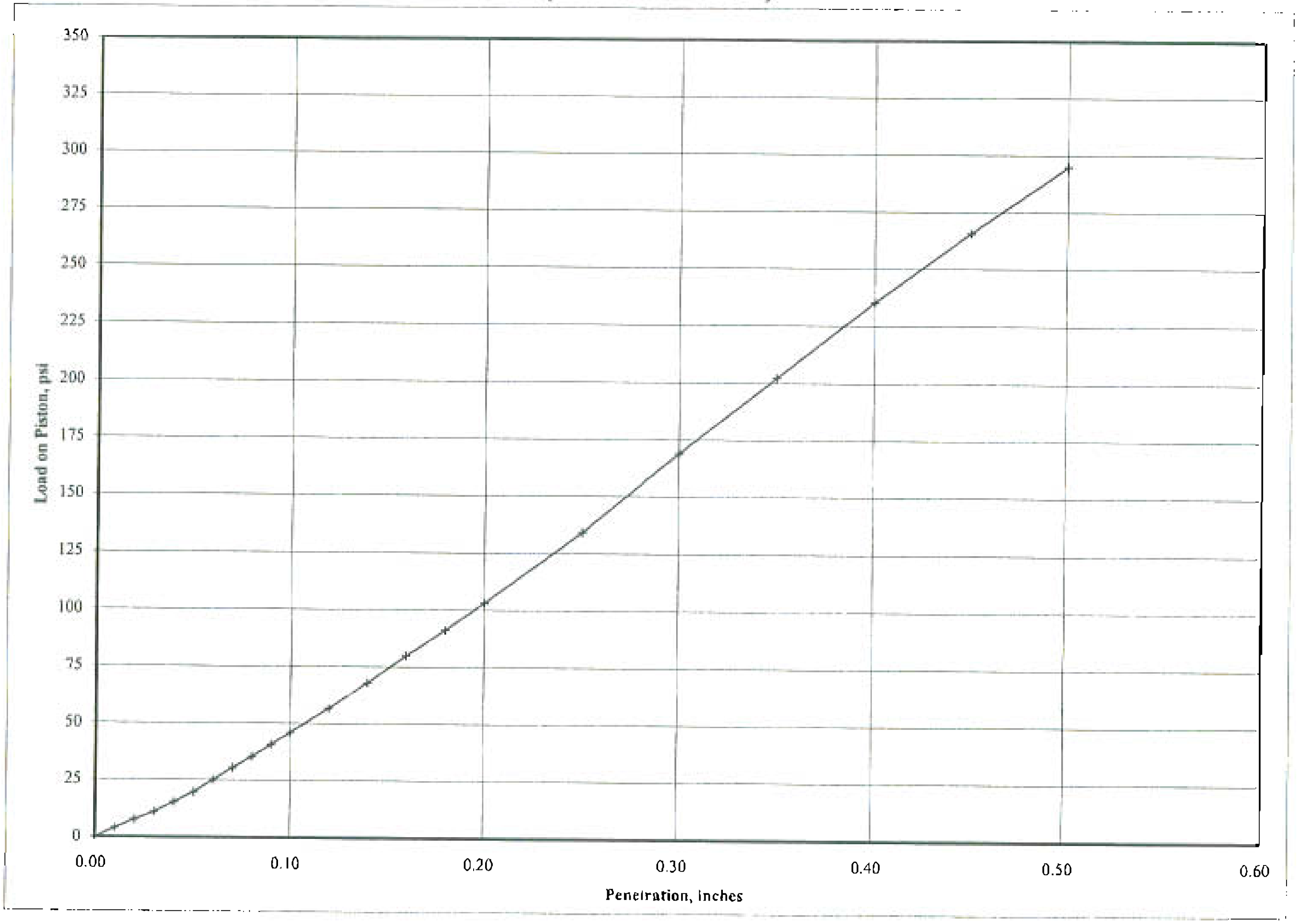
MAXIMUM DRY UNIT WEIGHT: 106.1 pcf

OPTIMUM MOISTURE CONTENT: 14.7 %

ATTERBERG LIMITS:

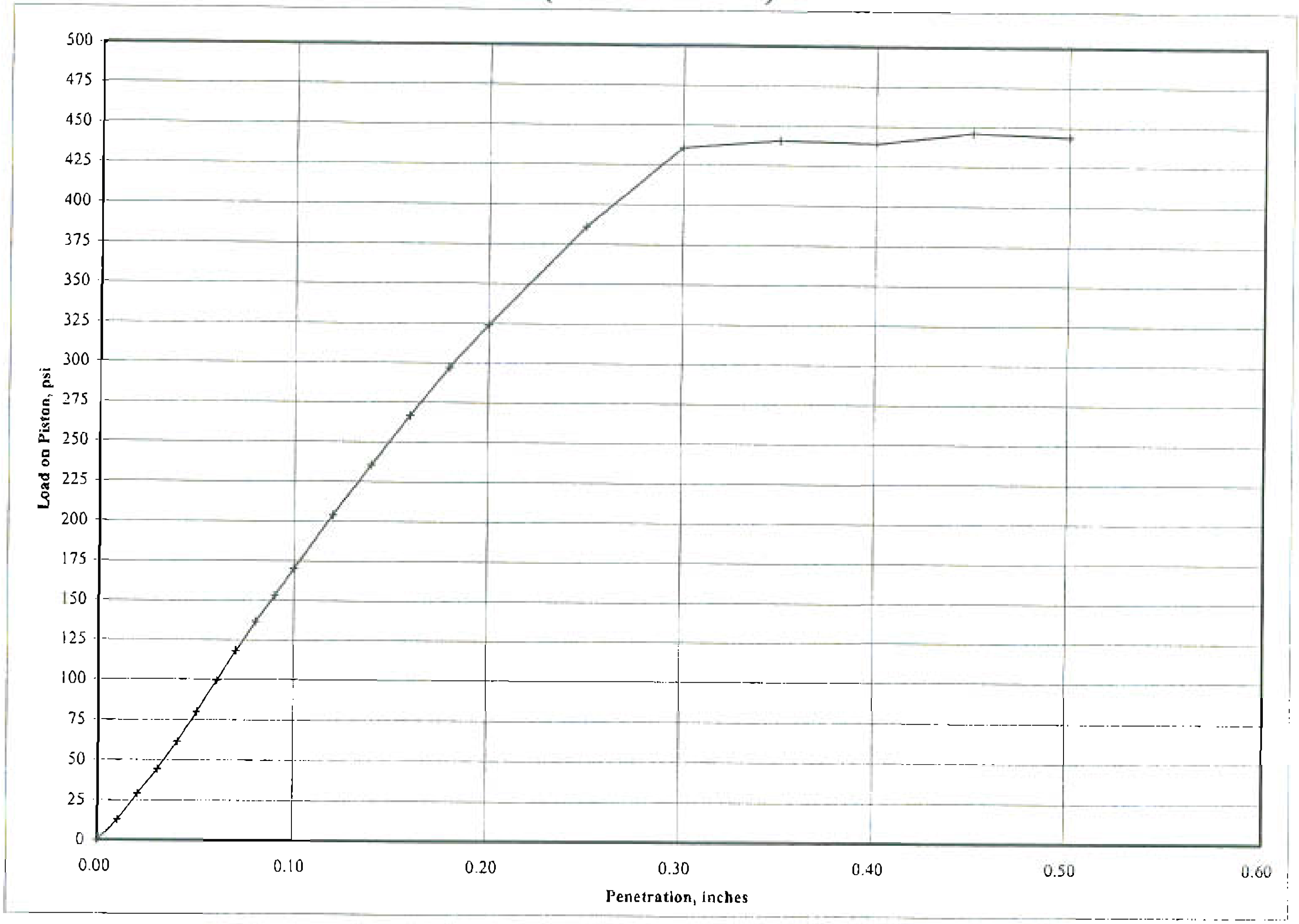
LIQUID LIMIT:	14
PLASTIC LIMIT:	16
PLASTICITY INDEX:	Non Plastic

CBR #1 TEST RESULTS
(ASTM D 1883)



Type of Material	Orangish-tan Clayey Sand		
Compacted Moisture Content (Percent)	16.9	Compacted Dry Density (pcf)	99.7
Compaction Method	ASTM D 698	Percent of Maximum Density	94.0
Moisture Relative to Optimum	2.2 %	Surcharge (lbs)	12.5
Swell (inches)	-0.032	Soaking Period (hours)	96
CBR Value (percent): At 0.1" deflection	4.6	At 0.2" deflection	6.9
Client	CH2M Hill	Client No.	
Project/Lab No.	90045344	Date	April 18, 2005

CBR #1 TEST RESULTS
(ASTM D 1883)



Type of Material: Orangish-tan Clayey Sand

Compacted Moisture Content (Percent): 12.6

Compacted Dry Density (pcf): 102.2

Compaction Method: ASTM D 698

Percent of Maximum Density: 96.3

Moisture Relative to Optimum: -2.1 %

Surcharge (lbs): 12.5

Swell (inches): -0.032

Soaking Period (hours): 96

CBR Value (percent): At 0.1" deflection: 17.0

At 0.2" deflection: 21.6

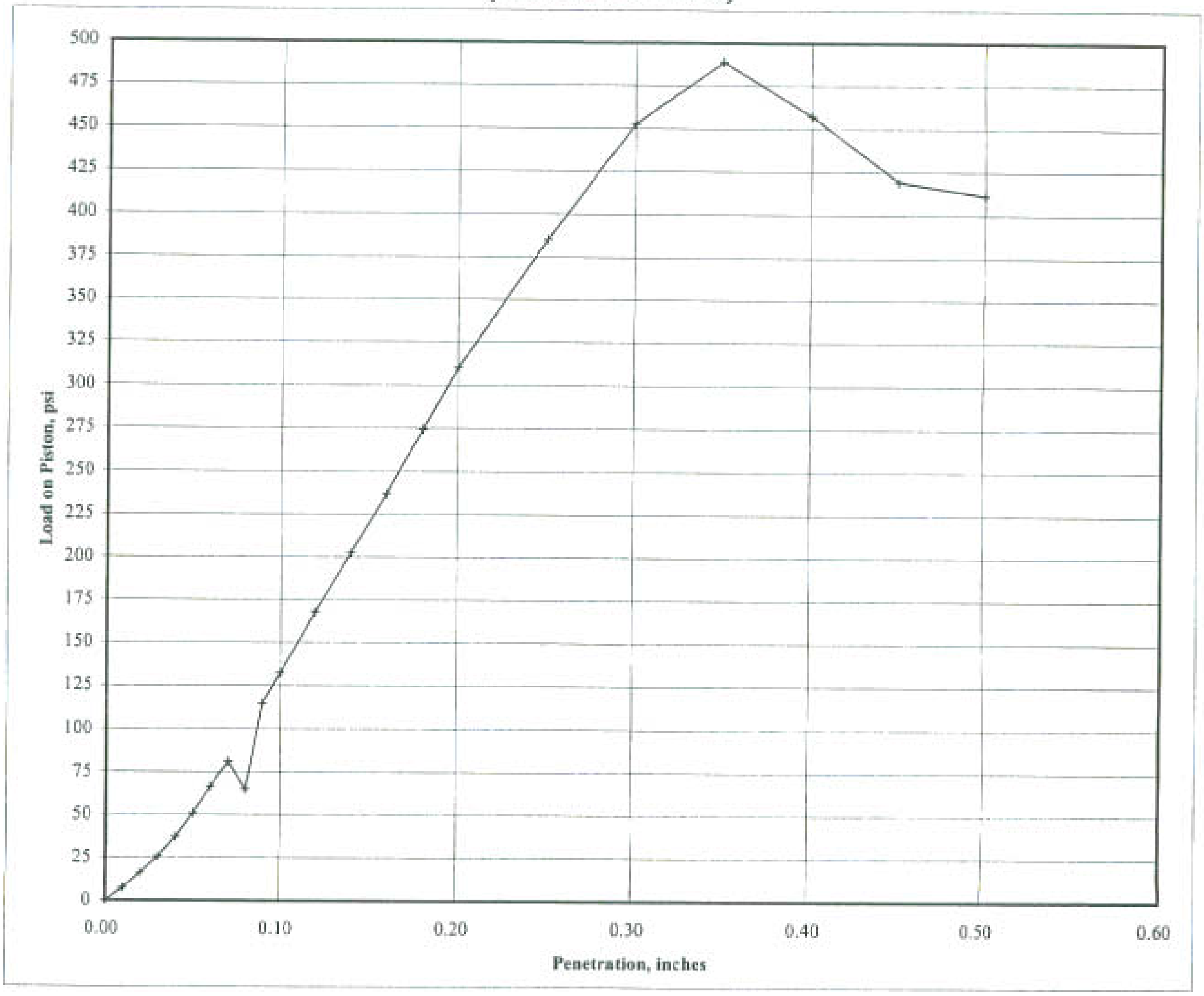
Client: CH2M Hill

Client No.

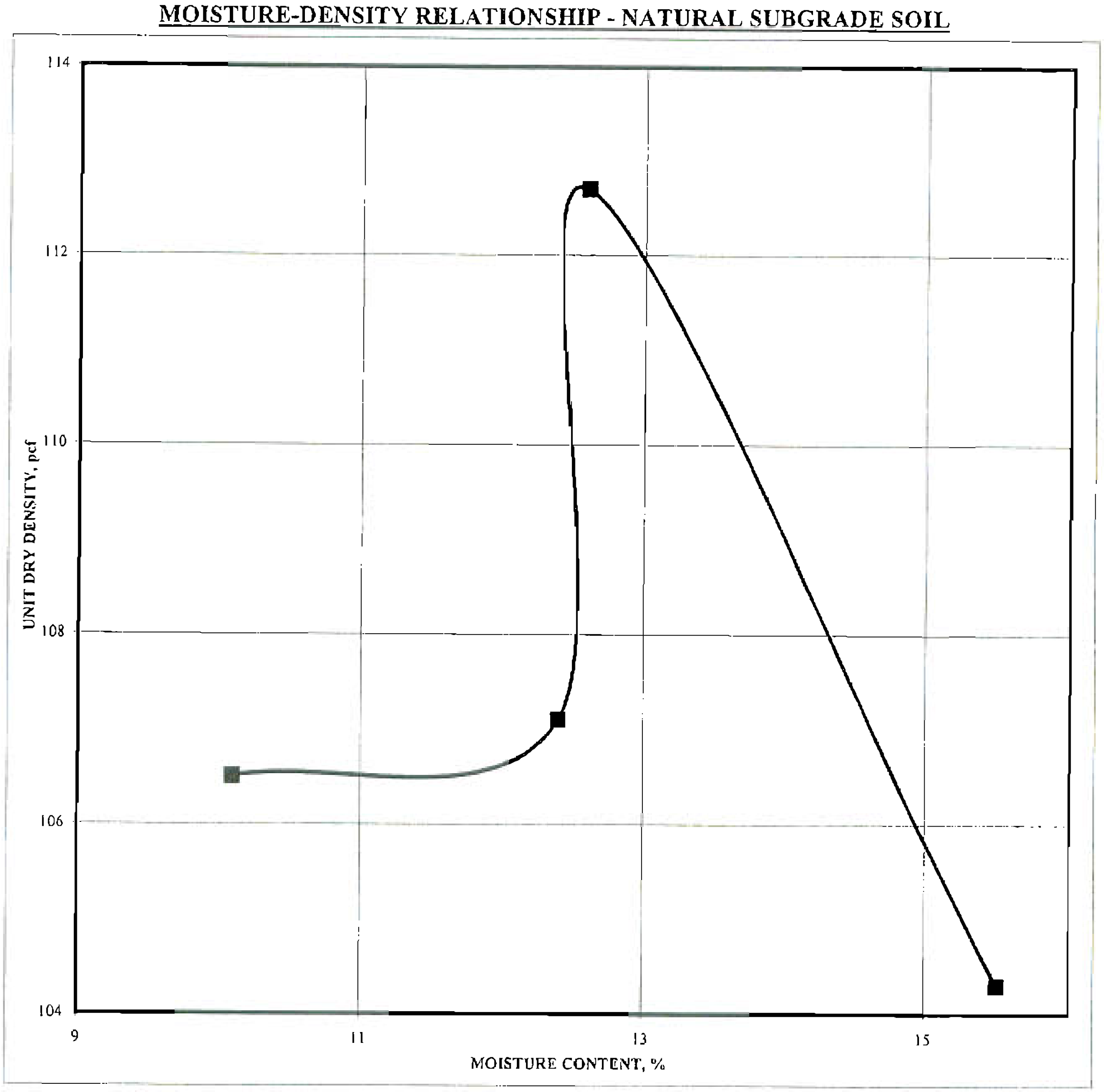
Project/Lab No.: 90045344

Date: April 18, 2005

CBR #1 TEST RESULTS
(ASTM D 1883)



Type of Material	Orangish-tan Clayey Sand		
Compacted Moisture Content (Percent)	14	Compacted Dry Density (pcf)	104.2
Compaction Method	ASTM D 698	Percent of Maximum Density	98.2
Moisture Relative to Optimum	Optimum	Surcharge (lbs)	12.5
Swell (inches)	0.041	Soaking Period (hours)	96
CBR Value (percent): At 0.1" deflection	13.2 %	At 0.2" deflection	20.7
Client	CH2M Hill	Client No.	
Project/Lab No.	90045344	Date	April 18, 2005



SOIL DESCRIPTION: Tan Clayey Sand

TEST METHOD: ASTM D 698

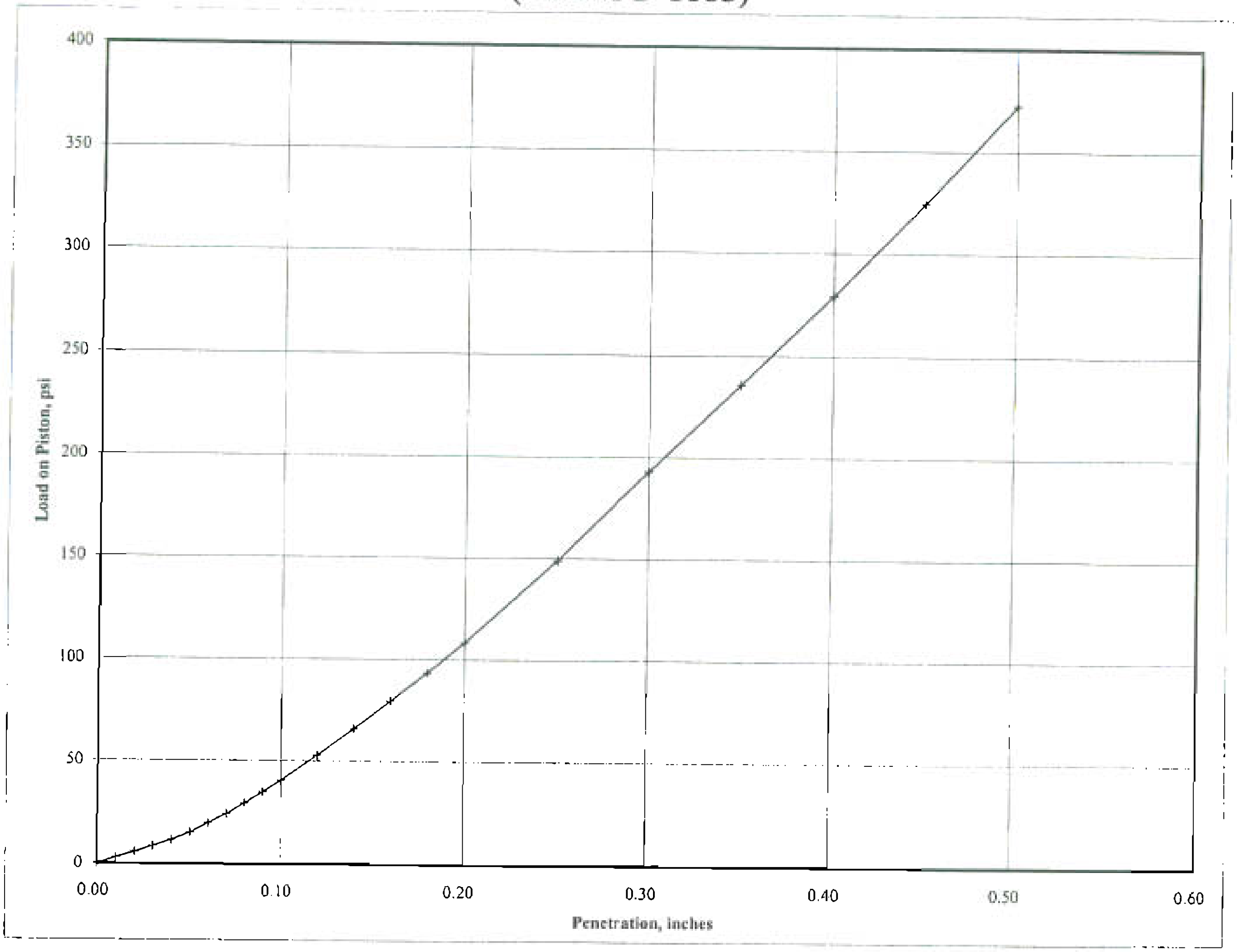
MAXIMUM DRY UNIT WEIGHT: 112.7 pcf

OPTIMUM MOISTURE CONTENT: 12.6 %

ATTERBERG LIMITS:

LIQUID LIMIT: 14
PLASTIC LIMIT: 14
PLASTICITY INDEX: Non Plastic

CBR #2 TEST RESULTS
(ASTM D 1883)



Type of Material: Tan Clayey Sand

Compacted Moisture Content (Percent): 15.5

Compacted Dry Density (pcf): 104.3

Compaction Method: ASTM D 698

Percent of Maximum Density: 92.5

Moisture Relative to Optimum: 2.9 %

Surcharge (lbs): 12.5

Swell (inches): -0.017

Soaking Period (hours): 96

CBR Value (percent): At 0.1" deflection: 4.1

At 0.2" deflection: 7.2

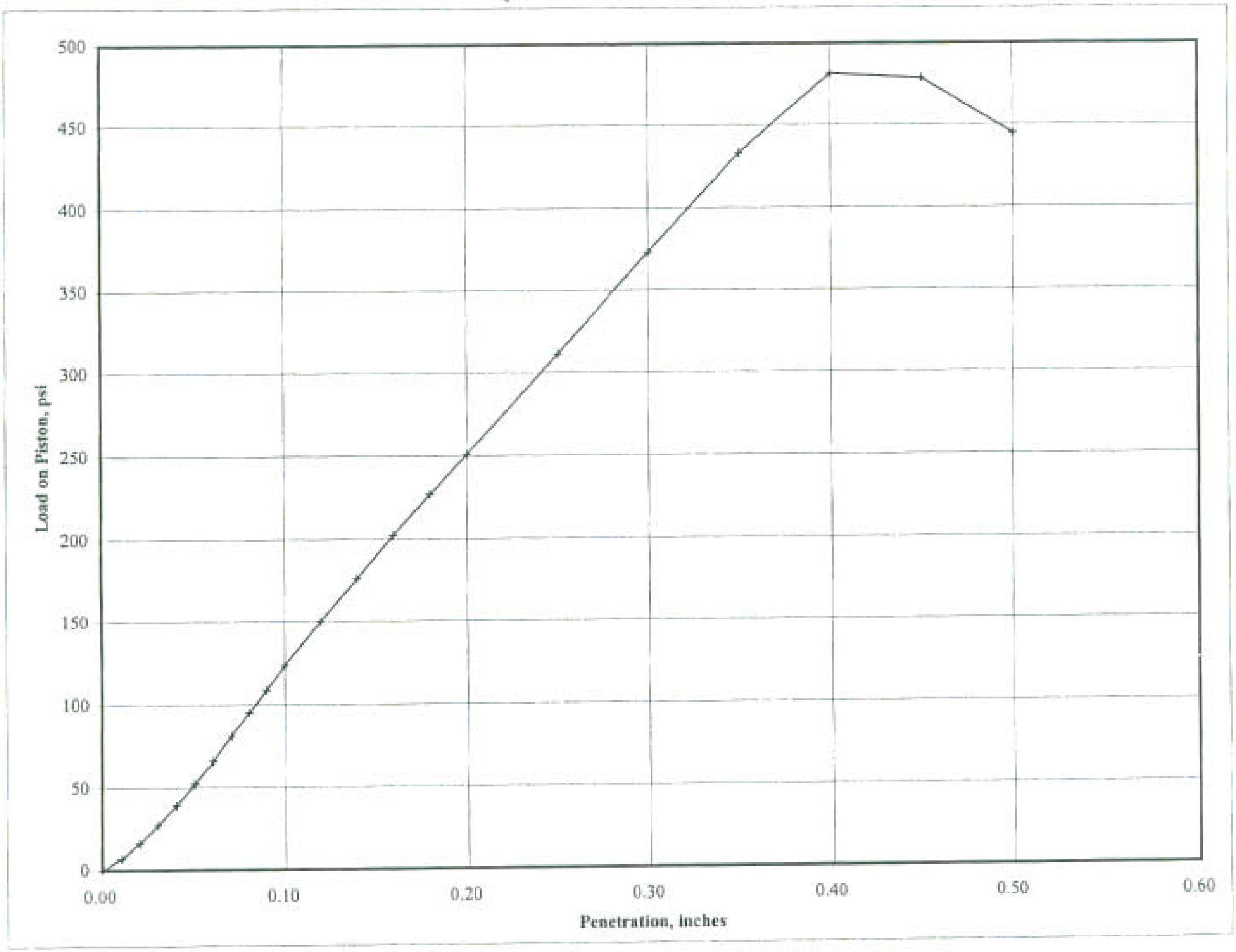
Client: CH2M Hill

Client No.:

Project/Lab No.: 90045344

Date: April 26, 2005

CBR #2 TEST RESULTS
(ASTM D 1883)



Type of Material: Tan Clayey Sand

Compacted Moisture Content (Percent): 10.1

Compacted Dry Density (pcf): 106.5

Compaction Method: ASTM D 698

Percent of Maximum Density: 94.5

Moisture Relative to Optimum: -2.5 %

Surcharge (lbs): 12.5

Swell (inches): -0.063

Soaking Period (hours): 96

CBR Value (percent): At 0.1" deflection: 12.4

At 0.2" deflection: 16.7

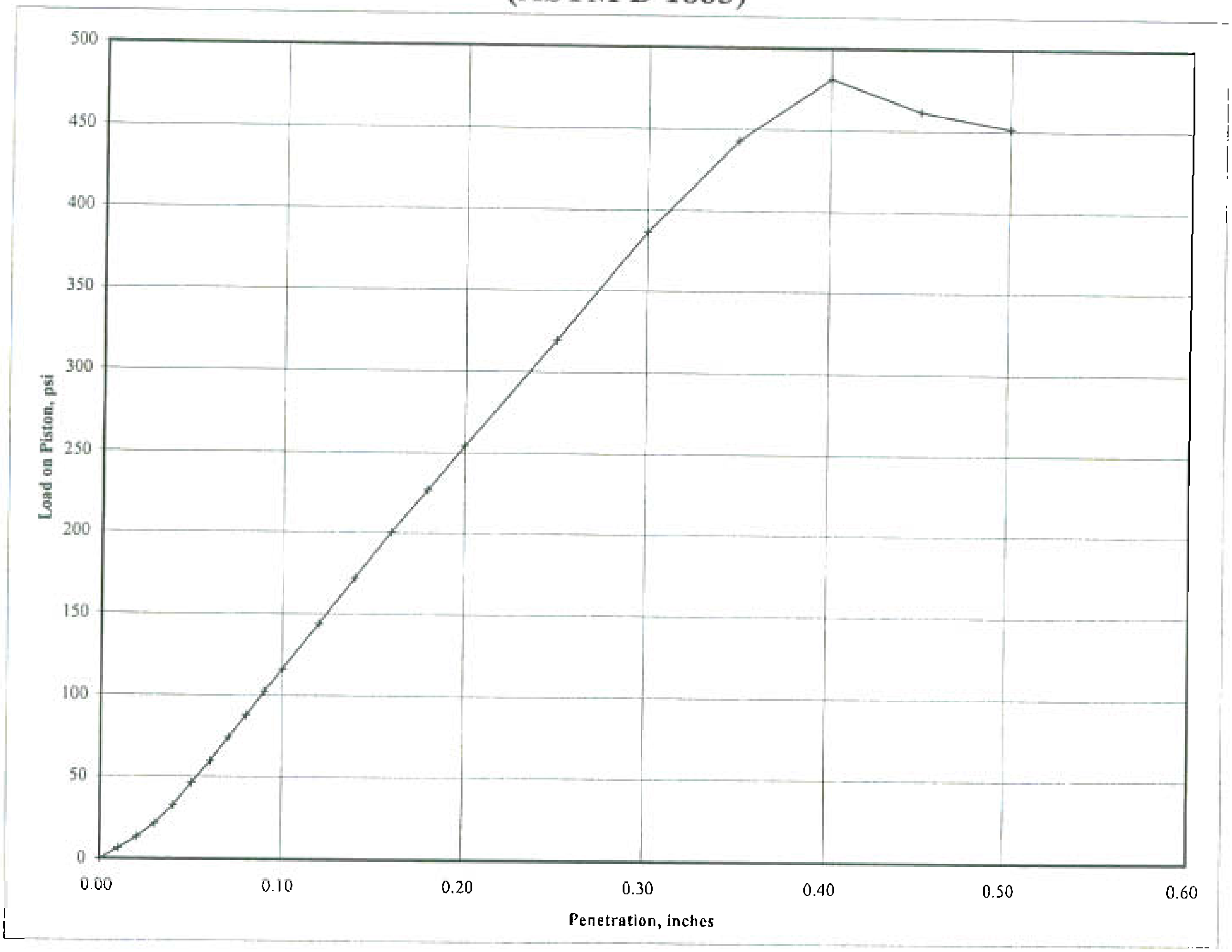
Client: CH2M Hill

Client No.:

Project/Lab No.: 90045344

Date: April 26, 2005

CBR #2 TEST RESULTS
(ASTM D 1883)



Type of Material: Tan Clayey Sand

Compacted Moisture Content (Percent): 12.4

Compacted Dry Density (pcf): 107.1

Compaction Method: ASTM D 698

Percent of Maximum Density: 95.0

Moisture Relative to Optimum: Optimum

Surcharge (lbs): 12.5

Swell (inches): -0.037

Soaking Period (hours): 96

CBR Value (percent): At 0.1" deflection: 11.6 %

At 0.2" deflection: 17.0

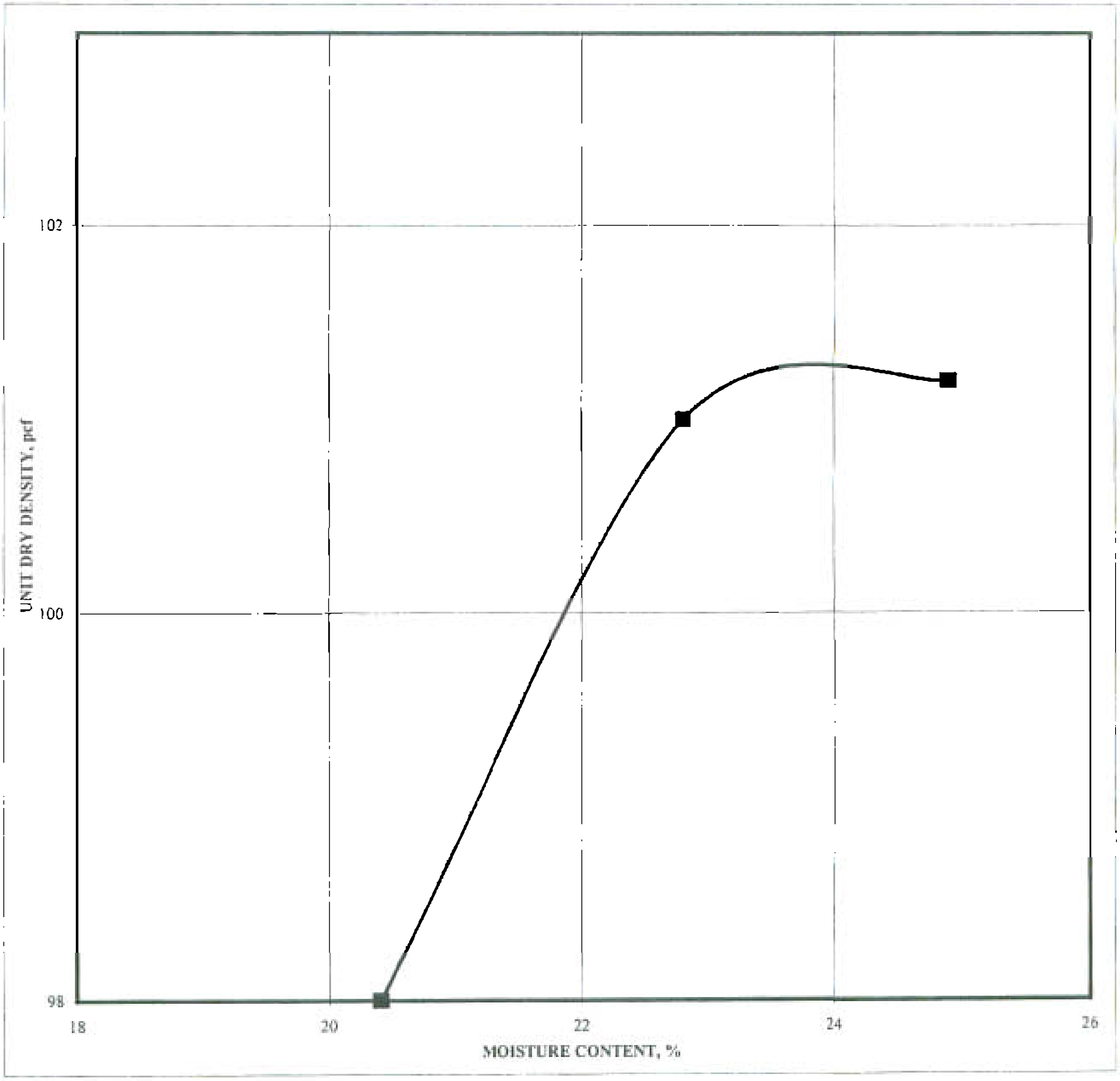
Client: CH2M Hill

Client No.:

Project/Lab No.: 90045344

Date: April 26, 2005

MOISTURE-DENSITY RELATIONSHIP - NATURAL SUBGRADE SOIL



SOIL DESCRIPTION: Reddish-orange Clay

TEST METHOD: ASTM D 698

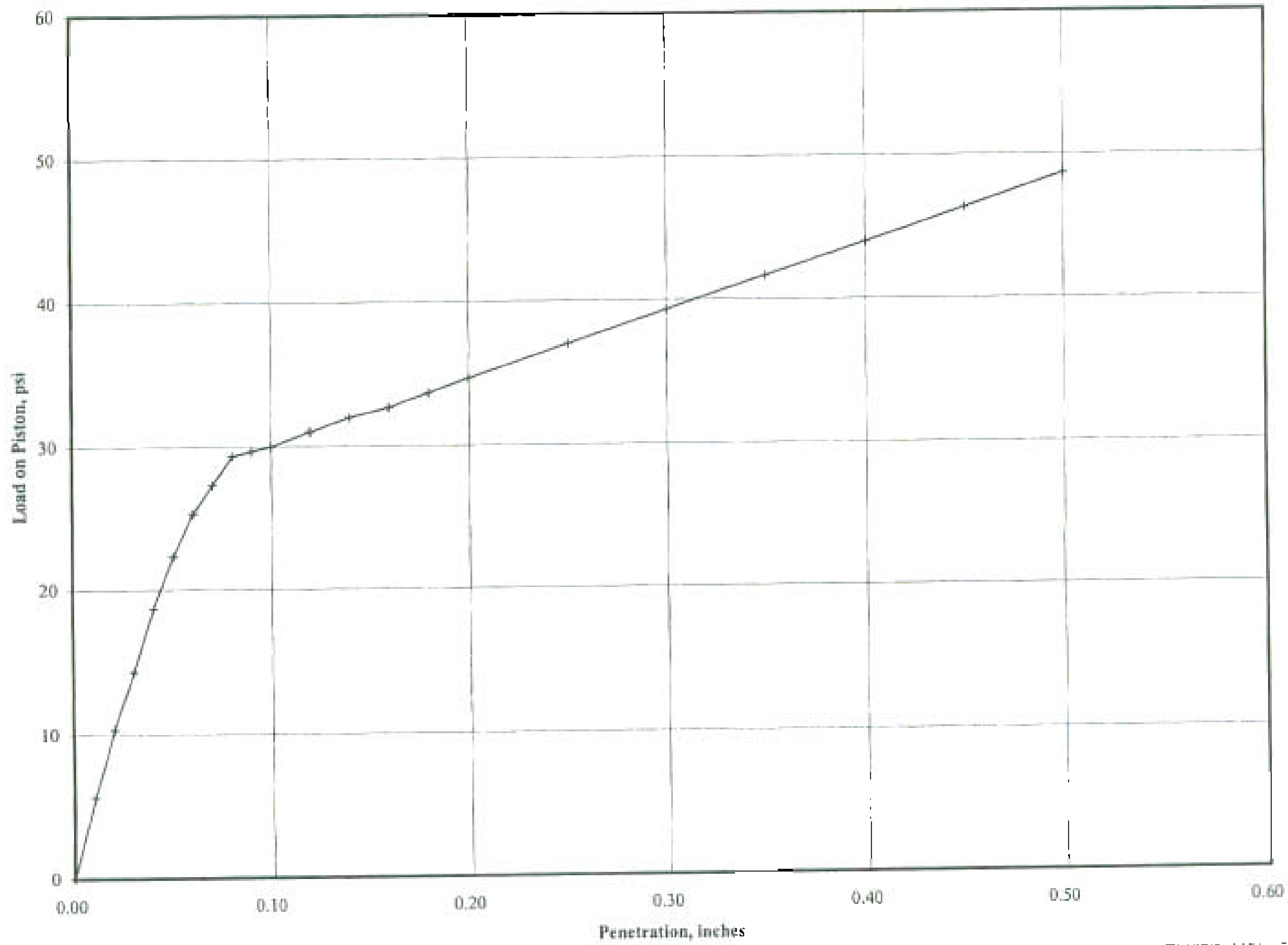
MAXIMUM DRY UNIT WEIGHT: 101.4 pcf

OPTIMUM MOISTURE CONTENT: 24.0 %

ATTERBERG LIMITS:

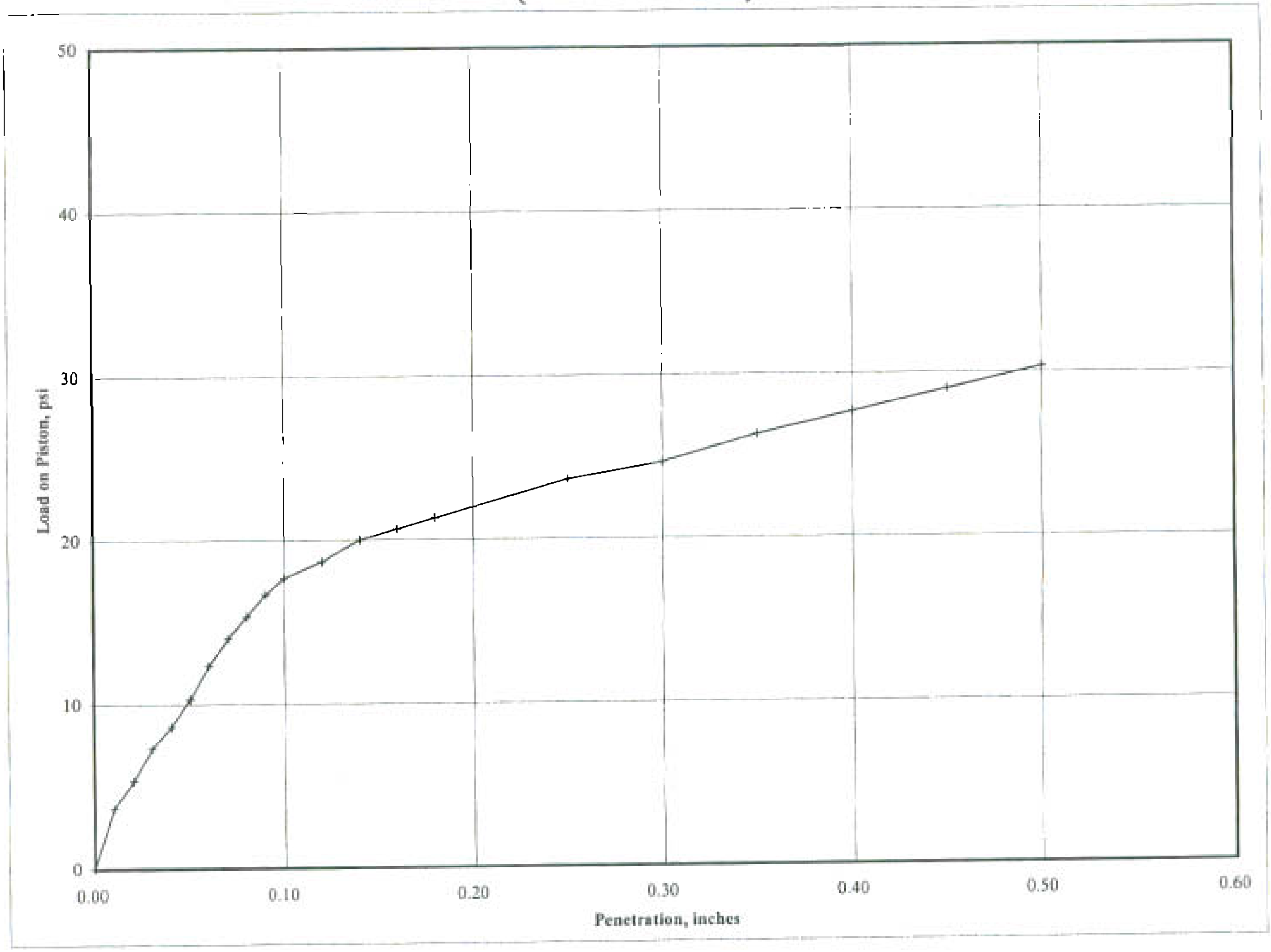
LIQUID LIMIT: 59
PLASTIC LIMIT: 24
PLASTICITY INDEX: 35

CBR #3 TEST RESULTS
(ASTM D 1883)



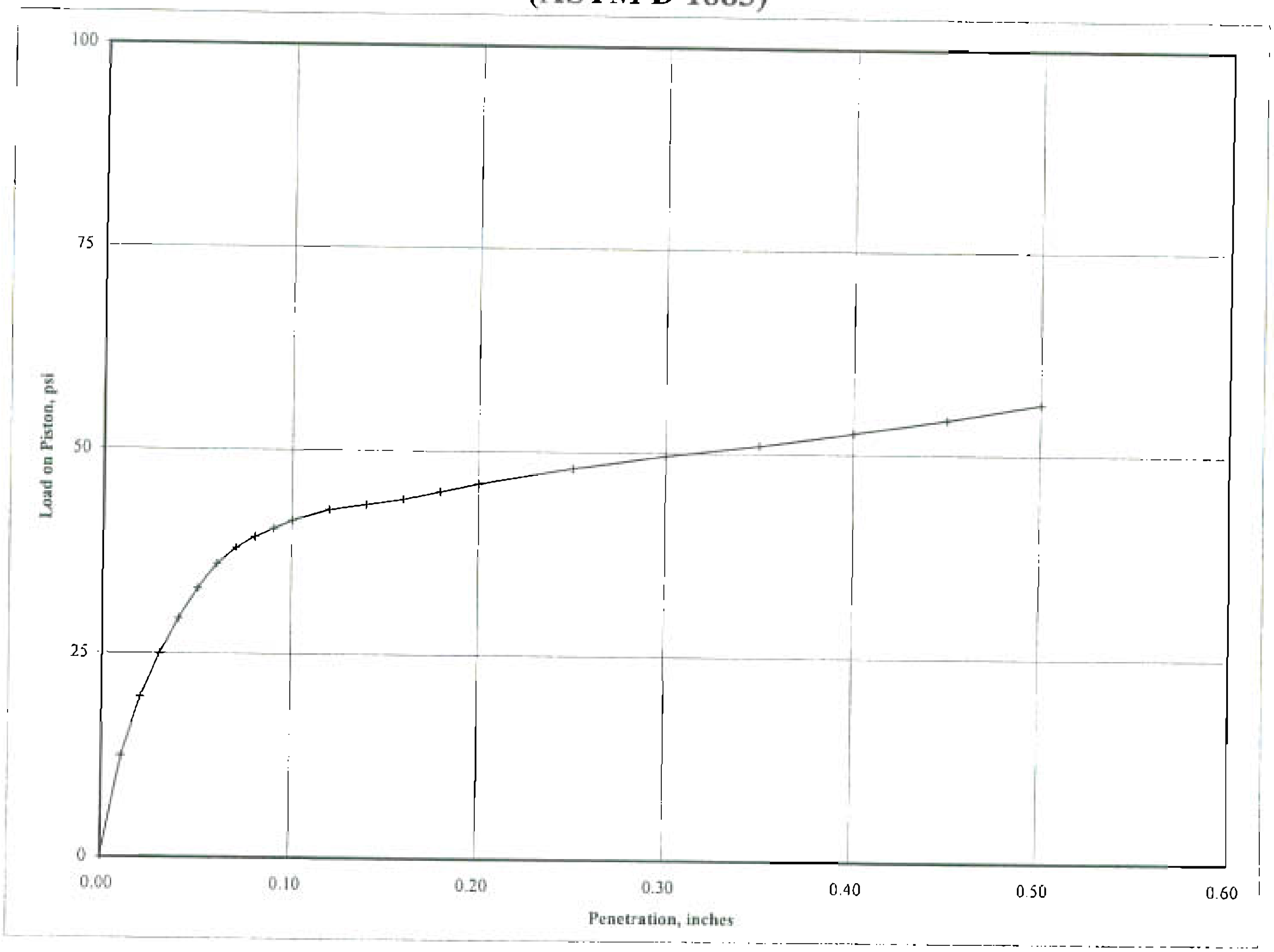
Type of Material	Reddish-orange Clay		
Compacted Moisture Content (Percent)	24.3	Compacted Dry Density (pcf)	89.6
Compaction Method	ASTM D 698	Percent of Maximum Density	88.4
Moisture Relative to Optimum	0.3 %	Surcharge (lbs)	12.5
Swell (inches)	0.006	Soaking Period (hours)	96
CBR Value (percent): At 0.1" deflection	3.0	At 0.2" deflection	2.3
Client	CH2M Hill	Client No.	
Project/Lab No.	90045344	Date	April 16, 2005

CBR #3 TEST RESULTS
(ASTM D 1883)

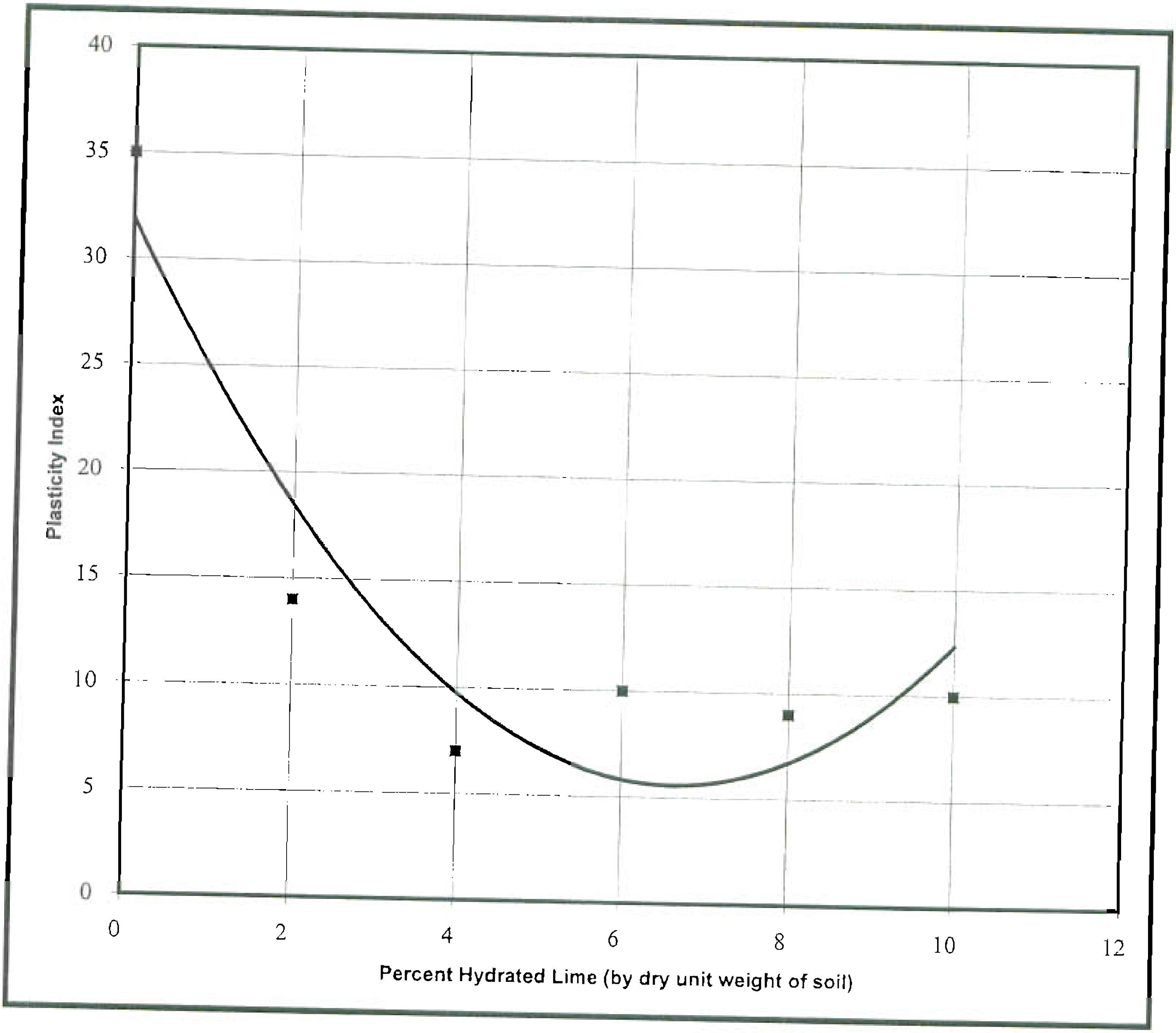


Type of Material	Reddish-orange Clay		
Compacted Moisture Content (Percent)	24.2	Compacted Dry Density (pcf)	96.9
Compaction Method	ASTM D 698	Percent of Maximum Density	95.6
Moisture Relative to Optimum	0.2 %	Surcharge (lbs)	12.5
Swell (inches)	-0.309	Soaking Period (hours)	96
CBR Value (percent): At 0.1" deflection	1.8	At 0.2" deflection	1.5
Client	CH2M Hill	Client No.	
Project/Lab No.	90045344	Date	April 16, 2005

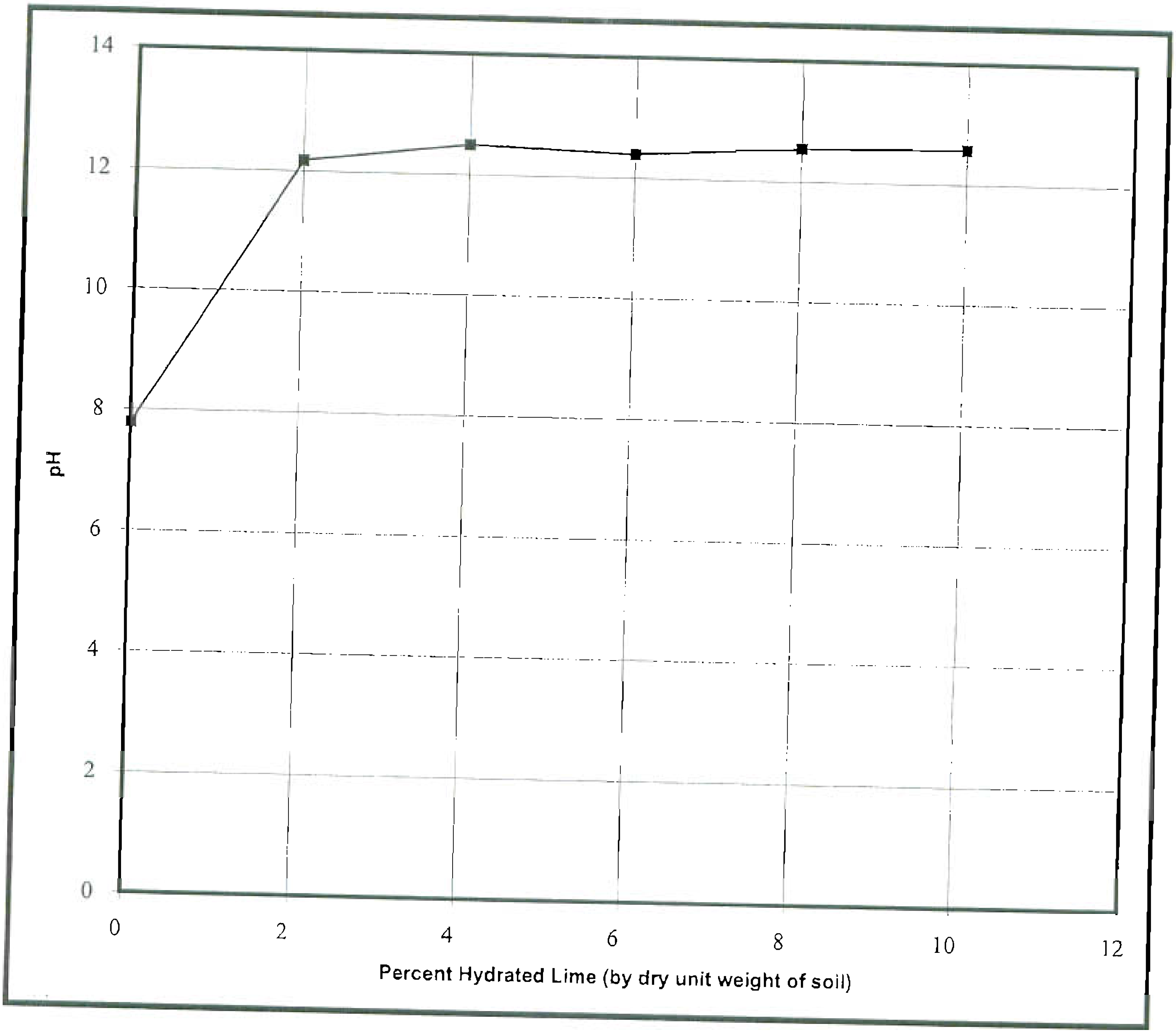
CBR #3 TEST RESULTS
(ASTM D 1883)



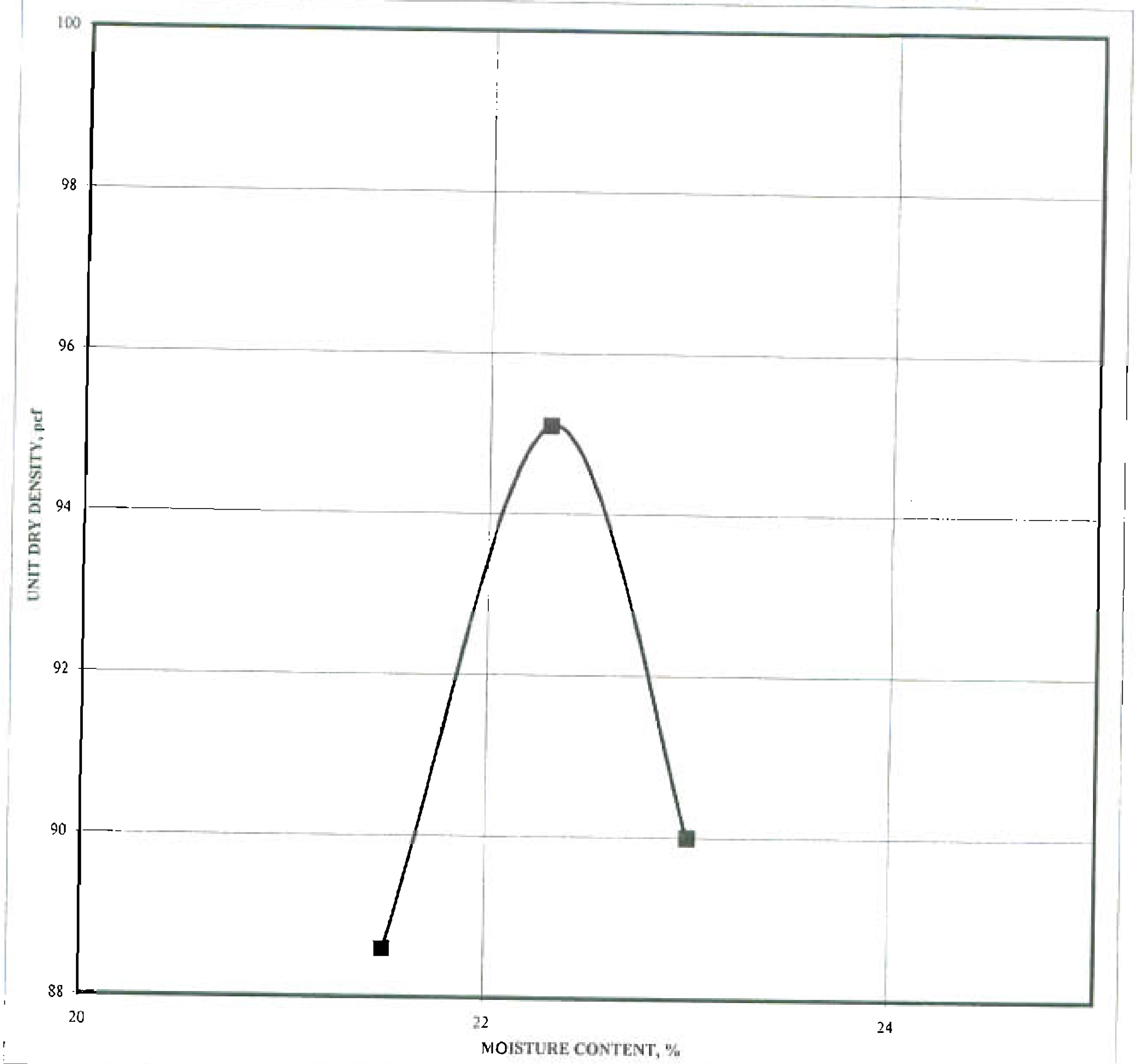
Type of Material	Reddish-orange Clay		
Compacted Moisture Content (Percent)	24	Compacted Dry Density (pcf)	101.4
Compaction Method	ASTM D 698	Percent of Maximum Density	100.0
Moisture Relative to Optimum	Optimum	Surcharge (lbs)	12.5
Swell (inches)	0.024	Soaking Period (hours)	96
CBR Value (percent): At 0.1" deflection	4.1 %	At 0.2" deflection	3.1
Client	CH2M Hill	Client No.	
Project/Lab No.	90045344	Date	April 16, 2005



40
35
30
25
20
15
10
5
0
Plasticity Index
0
2
4
6
8
10
12
Percent Hydrated Lime (by dry unit weight of soil)


14
12
10
8
6
4
2
0
pH
0
2
4
6
8
10
12
Percent Hydrated Lime (by dry unit weight of soil)

MOISTURE-DENSITY RELATIONSHIP - NATURAL SUBGRADE SOIL



SOIL DESCRIPTION: Brown (CH)

TEST METHOD: ASTM D 698

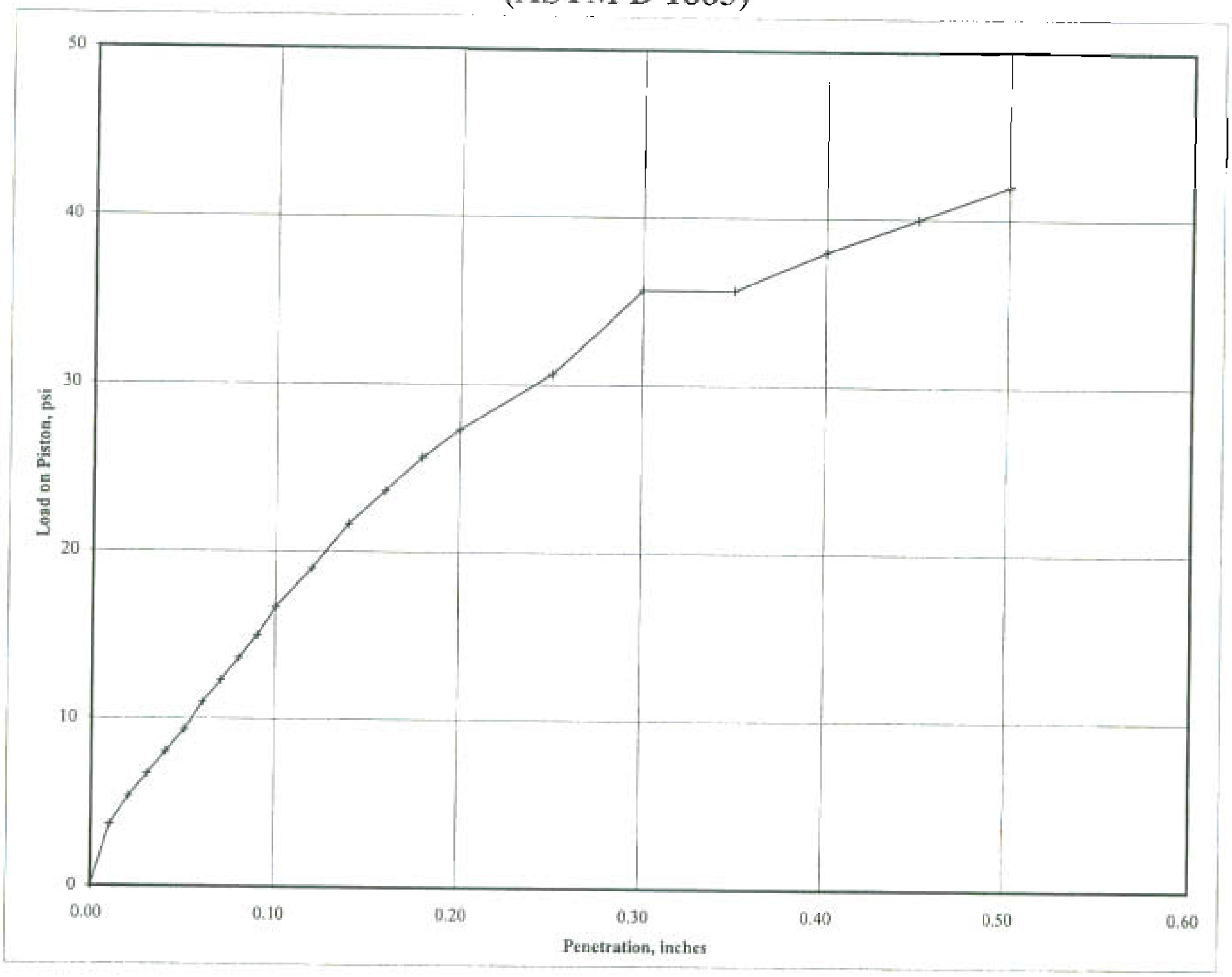
MAXIMUM DRY UNIT WEIGHT: 95.1 pcf

OPTIMUM MOISTURE CONTENT: 22.3 %

ATTERBERG LIMITS:

LIQUID LIMIT:	54
PLASTIC LIMIT:	24
PLASTICITY INDEX:	30

CBR #4 TEST RESULTS
(ASTM D 1883)



Type of Material: Brown (CH)

Compacted Moisture Content (Percent): 21.5

Compacted Dry Density (pcf): 88.6

Compaction Method: ASTM D 698

Percent of Maximum Density: 93.2

Moisture Relative to Optimum: -0.8 %

Surcharge (lbs): 12.5

Swell (inches): 0.208

Soaking Period (hours): 96

CBR Value (percent): At 0.1" deflection: 1.7

At 0.2" deflection: 1.8

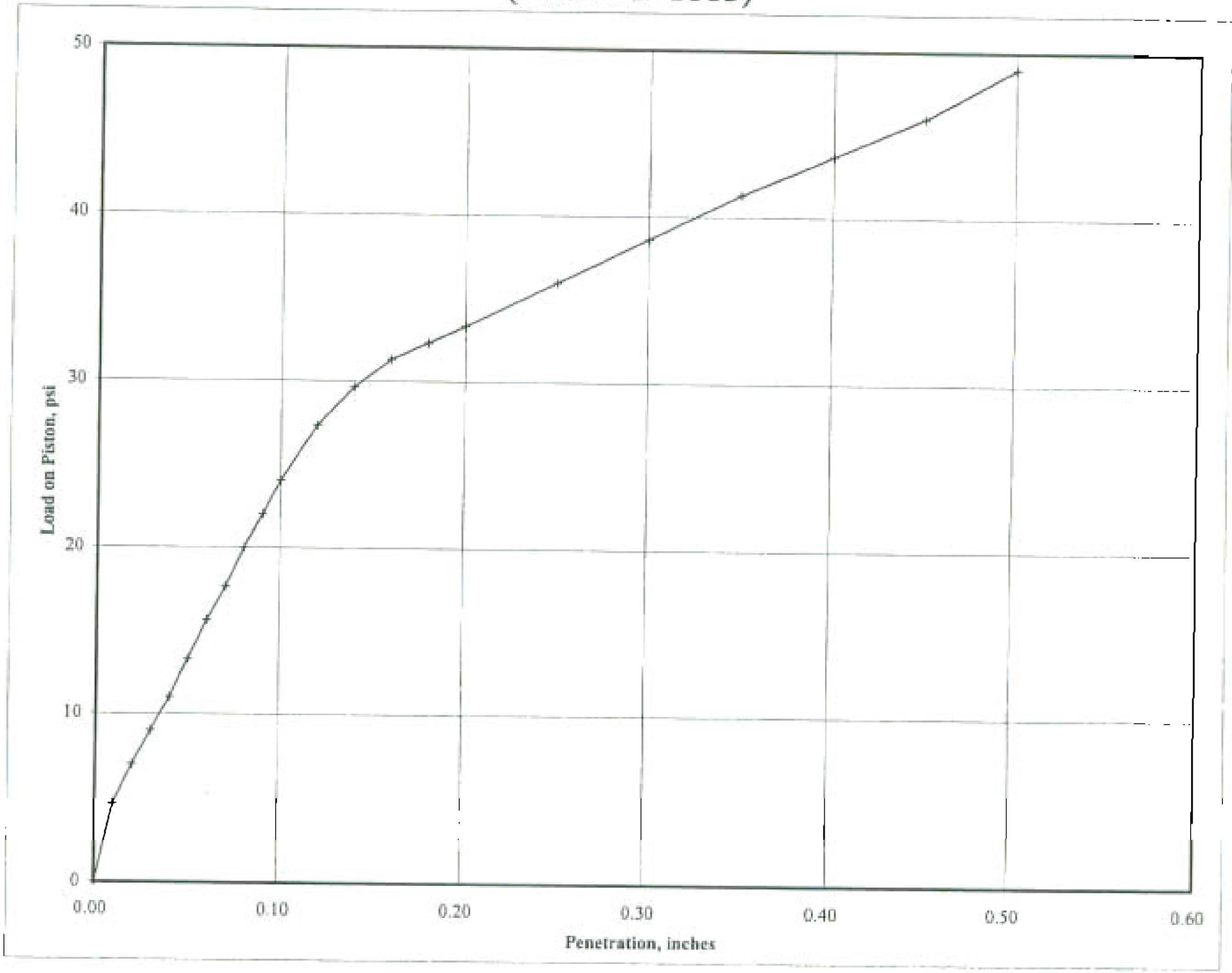
Client: CH2M Hill

Client No.:

Project/Lab No.: 90045344

Date: April 26, 2005

CBR #4 TEST RESULTS
(ASTM D 1883)



Type of Material: Brown (CH)

Compacted Moisture Content (Percent): 23

Compacted Dry Density (pcf): 90.0

Compaction Method: ASTM D 698

Percent of Maximum Density: 94.6

Moisture Relative to Optimum: 0.7 %

Surcharge (lbs): 12.5

Swell (inches): -0.032

Soaking Period (hours): 96

CBR Value (percent): At 0.1" deflection: 2.4

At 0.2" deflection: 2.2

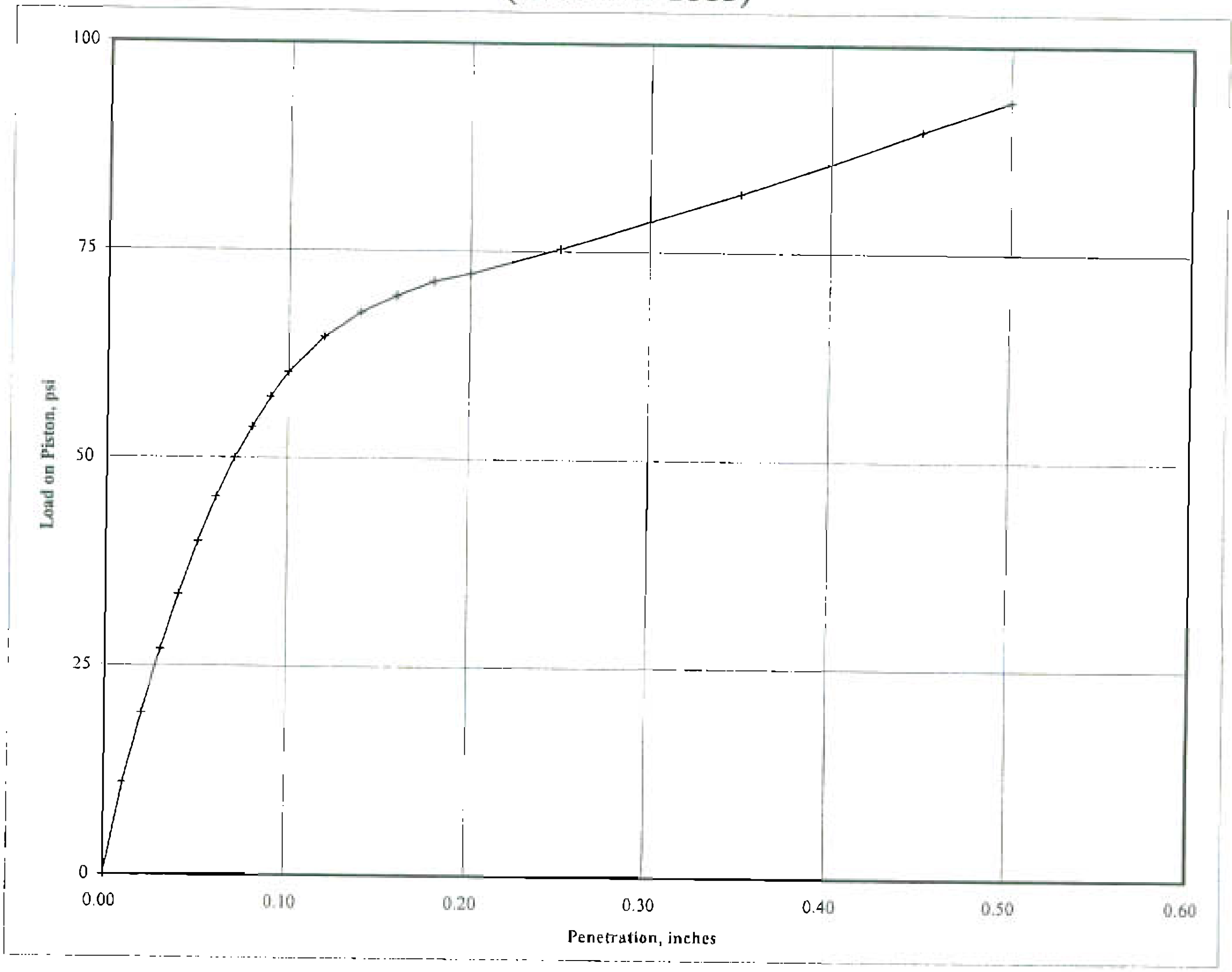
Client: CH2M Hill

Client No.:

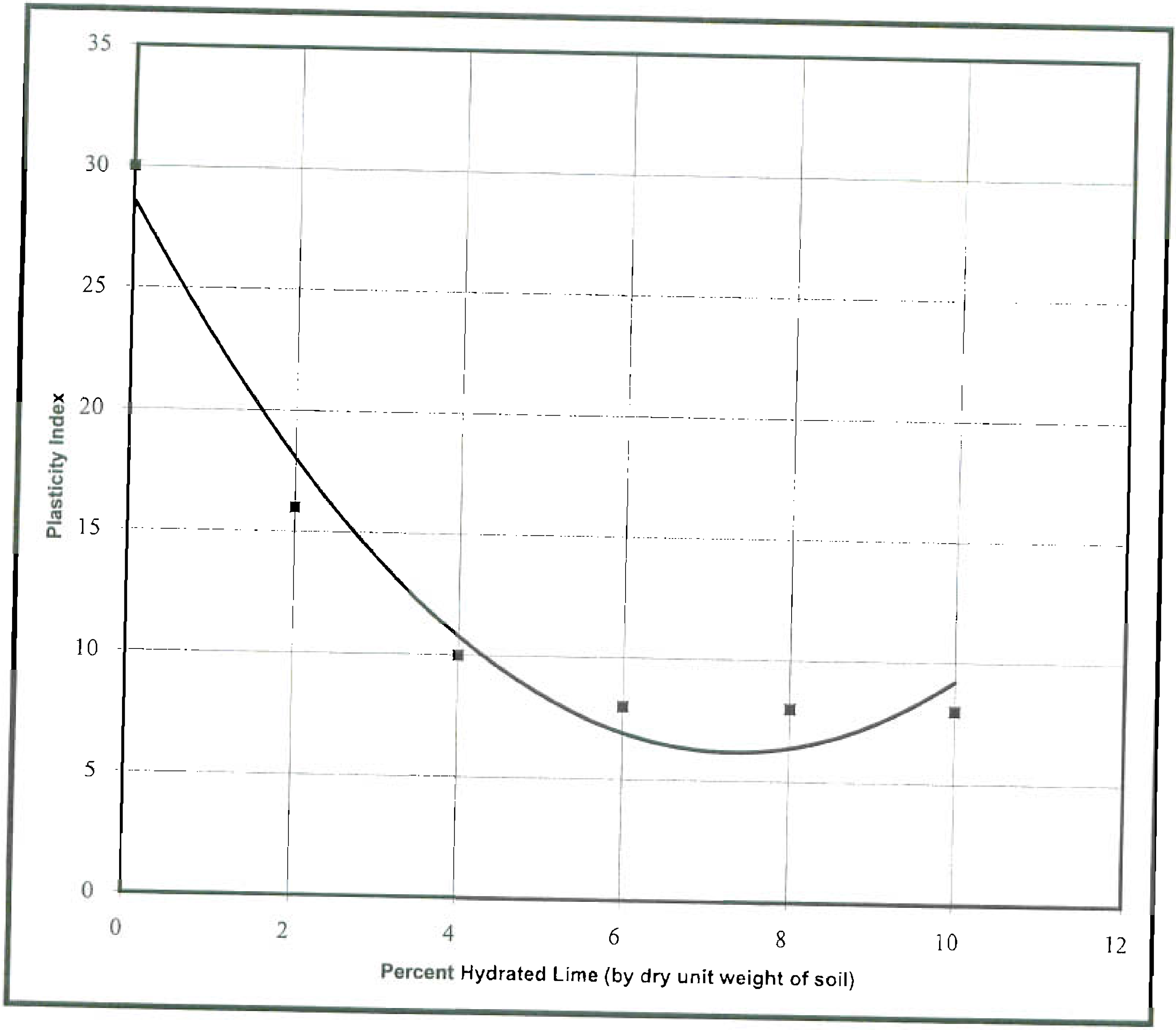
Project/Lab No.: 90045344

Date: April 26, 2005

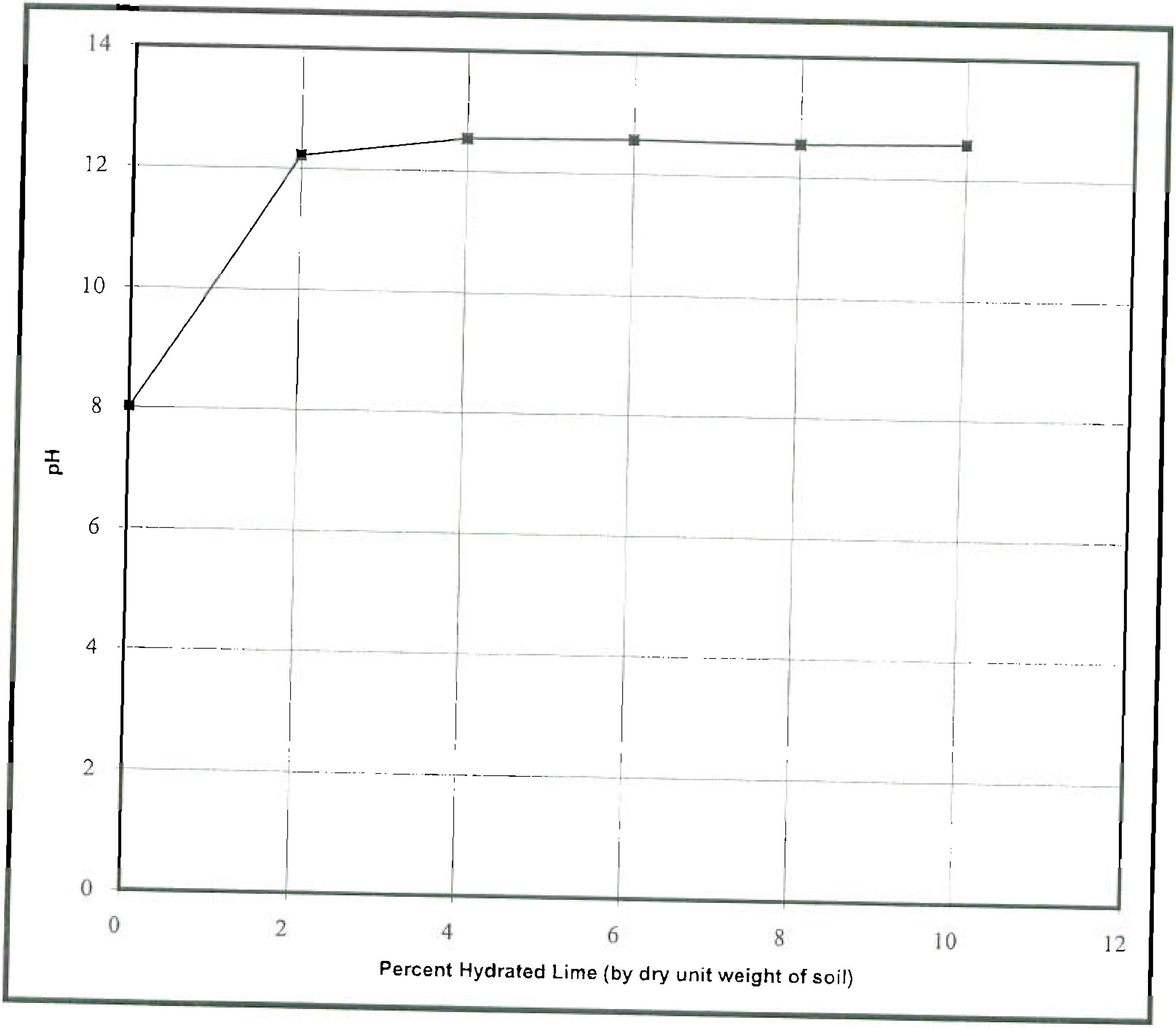
CBR TEST RESULTS
(ASTM D 1883)



Type of Material	Brown (CH)		
Compacted Moisture Content (Percent)	24	Compacted Dry Density (pcf)	93.0
Compaction Method	ASTM D 698	Percent of Maximum Density	97.8
Moisture Relative to Optimum	Optimum	Surcharge (lbs)	12.5
Swell (inches)	0.055	Soaking Period (hours)	96
CBR Value (percent): At 0.1" deflection	6.0 %	At 0.2" deflection	4.8
Client	CH2M Hill	Client No.	
Project/Lab No.	90045344	Date	April 26, 2005



Plasticity Index
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
Percent Hydrated Lime (by dry unit weight of soil)


14
12
10
8
6
4
2
0
pH
0
2
4
6
8
10
12
Percent Hydrated Lime (by dry unit weight of soil)

APPENDIX C

Chemical Laboratory Test Results

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344-Gonzales County	PCS Sample #:	**141447**
Sample ID:	B-1 8-10'	Date Received:	04/01/2005
Date Taken:	03/30/2005	Time Received:	16:00
Time Taken:		Report Date:	04/15/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	143	mg/kg	04/14/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	50	mg/kg	04/11/2005	11:15	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	<1	20	70	105	130
Chloride (Extractable)	1	<1	20	70	102	130

APPROVED BY: [signature]
CHUCK WALLGREN

1-800-880-4616 1532 Universal City Blvd. Universal City, Texas 78148 (210) 340-0343

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	141979
Sample ID:	B-2 8-10'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/27/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	252	mg/kg	04/26/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	320	mg/kg	04/25/2005	20:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	1	20	70	94	130
Chloride (Extractable)	1	2	20	70	100	130

APPROVED BY: [signature]
CHUCK WALLGREN

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344-Gonzales County	PCS Sample #:	**141448**
Sample ID:	B-3 10-12'	Date Received:	04/01/2005
Date Taken:	03/30/2005	Time Received:	16:00
Time Taken:		Report Date:	04/15/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	714	mg/kg	04/14/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	1,120	mg/kg	04/11/2005	11:15	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	<1	20	70	105	130
Chloride (Extractable)	1	<1	20	70	102	130

APPROVED BY: [signature]
CHUCK WALLGREN

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POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	141983
Sample ID:	B-4 6-8'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/28/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	1,728	mg/kg	04/27/2005	16:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	140	mg/kg	04/25/2005	21:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	2	20	70	100	130
Chloride (Extractable)	1	1	20	70	100	130

APPROVED BY: [signature]
CHUCK WALLGREN

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	**141984**
Sample ID:	B-5 10-12'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/28/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	92	mg/kg	04/27/2005	16:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	170	mg/kg	04/25/2005	21:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	2	20	70	100	130
Chloride (Extractable)	1	1	20	70	100	130

APPROVED BY [signature]
CHUCK WALLGREN

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344-Gonzales County	PCS Sample #:	**141449**
Sample ID:	B-6 10-12'	Date Received:	04/01/2005
Date Taken:	03/30/2005	Time Received:	16:00
Time Taken:		Report Date:	04/15/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	443	mg/kg	04/14/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	340	mg/kg	04/11/2005	11:15	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	<1	20	70	105	130
Chloride (Extractable)	1	<1	20	70	102	130

APPROVED BY: [signature]
CHUCK WALLGREN

1-800-880-4616
1532 Universal City Blvd.
Universal City, Texas 78148
(210) 340-0343

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344-Gonzales County	PCS Sample #:	**141450**
Sample ID:	B-7 6-8'	Date Received:	04/01/2005
Date Taken:	03/30/2005	Time Received:	16:00
Time Taken:		Report Date:	04/15/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	3,493	mg/kg	04/14/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	80	mg/kg	04/11/2005	11:15	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	<1	20	70	105	130
Chloride (Extractable)	1	<1	20	70	102	130

APPROVED BY: [signature]
CHUCK WALLGREN

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	141973
Sample ID:	B-8 8-10'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/27/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	528	mg/kg	04/26/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	50	mg/kg	04/25/2005	20:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	1	20	70	94	130
Chloride (Extractable)	1	2	20	70	100	130

APPROVED BY: [signature]
CHUCK WALLGREN

1-800-880-4616
1532 Universal City Blvd.
Universal City, Texas 78148
(210) 340-0343

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	**141974**
Sample ID:	B-9 8.5-10'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/27/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	1,214	mg/kg	04/26/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	120	mg/kg	04/25/2005	20:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	1	20	70	94	130
Chloride (Extractable)	1	2	20	70	100	130

APPROVED BY: [signature]
CHUCK WALLGREN

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	**141971**
Sample ID:	B-10 8-10'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/27/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	228	mg/kg	04/26/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	225	mg/kg	04/25/2005	20:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	1	20	70	94	130
Chloride (Extractable)	1	2	20	70	100	130

APPROVED BY: [signature]
CHUCK WALLGREN

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1532 Universal City Blvd.
Universal City, Texas 78148
(210) 340-0343

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	**141975**
Sample ID:	B-11 10-12'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/27/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	292	mg/kg	04/26/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	15	mg/kg	04/25/2005	20:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	1	20	70	94	130
Chloride (Extractable)	1	2	20	70	100	130

APPROVED BY [signature]
CHUCK WALLGREN

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	141977
Sample ID:	B-12 8-10'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/27/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	280	mg/kg	04/26/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	80	mg/kg	04/25/2005	20:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	1	20	70	94	130
Chloride (Extractable)	1	2	20	70	100	130

APPROVED BY [signature]
CHUCK WALLGREN

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344-Gonzales County	PCS Sample #:	**141451**
Sample ID:	B-13 10-12'	Date Received:	04/01/2005
Date Taken:	03/30/2005	Time Received:	16:00
Time Taken:		Report Date:	04/15/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	107	mg/kg	04/14/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	118	mg/kg	04/11/2005	11:15	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	<1	20	70	105	130
Chloride (Extractable)	1	<1	20	70	102	130

APPROVED BY: [signature]
CHUCK WALLGREN

1-800-880-4616
1532 Universal City Blvd.
Universal City, Texas 78148
(210) 340-0343

POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		LABORATORY INFORMATION	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	141972
Sample ID:	B-14 10.5-12'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/27/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	264	mg/kg	04/26/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	28	mg/kg	04/25/2005	20:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	1	20	70	94	130
Chloride (Extractable)	1	2	20	70	100	130

APPROVED BY: [signature]
CHUCK WALLGREN

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POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344-Gonzales County	PCS Sample #:	**141452**
Sample ID:	B-15 8-10'	Date Received:	04/01/2005
Date Taken:	03/30/2005	Time Received:	16:00
Time Taken:		Report Date:	04/15/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	2,370	mg/kg	04/14/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	300	mg/kg	04/11/2005	12:40	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	<1	20	70	105	130
Chloride (Extractable)	1	<1	20	70	98	130

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San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	**141976**
Sample ID:	B-16 8-10'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/27/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	618	mg/kg	04/26/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	530	mg/kg	04/25/2005	20:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	1	20	70	94	130
Chloride (Extractable)	1	2	20	70	100	130

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POLLUTION CONTROL SERVICES

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To: Stephen Urias
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6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	141978
Sample ID:	B-17 8-10'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/27/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	348	mg/kg	04/26/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	260	mg/kg	04/25/2005	20:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	1	20	70	94	130
Chloride (Extractable)	1	2	20	70	100	130

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POLLUTION CONTROL SERVICES

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To: Stephen Urias
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San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	141980
Sample ID:	B-18 6.5-8'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/27/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	114	mg/kg	04/26/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	10	mg/kg	04/25/2005	20:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	1	20	70	94	130
Chloride (Extractable)	1	2	20	70	100	130

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SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344-Gonzales County	PCS Sample #:	141453
Sample ID:	B-19 8-10'	Date Received:	04/01/2005
Date Taken:	03/30/2005	Time Received:	16:00
Time Taken:		Report Date:	04/15/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	170	mg/kg	04/14/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	12	mg/kg	04/11/2005	12:40	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	<1	20	70	105	130
Chloride (Extractable)	1	<1	20	70	98	130

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REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
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SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344-Gonzales County	PCS Sample #:	141454
Sample ID:	B-20 10-12'	Date Received:	04/01/2005
Date Taken:	03/30/2005	Time Received:	16:00
Time Taken:		Report Date:	04/15/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	1,031	mg/kg	04/14/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	720	mg/kg	04/11/2005	12:40	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	<1	20	70	105	130
Chloride (Extractable)	1	<1	20	70	98	130

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POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	141982
Sample ID:	B-21 8-10'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/28/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	768	mg/kg	04/27/2005	16:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	50	mg/kg	04/25/2005	21:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	2	20	70	100	130
Chloride (Extractable)	1	1	20	70	100	130

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POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344-Gonzales County	PCS Sample #:	141455
Sample ID:	B-22 6-8'	Date Received:	04/01/2005
Date Taken:	03/30/2005	Time Received:	16:00
Time Taken:		Report Date:	04/15/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	552	mg/kg	04/14/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	920	mg/kg	04/11/2005	12:40	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	<1	20	70	105	130
Chloride (Extractable)	1	<1	20	70	98	130

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POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
Drash Consulting Engineers, Inc. (SA)
6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344-Gonzales County	PCS Sample #:	**141456**
Sample ID:	B-23 10-12'	Date Received:	04/01/2005
Date Taken:	03/30/2005	Time Received:	16:00
Time Taken:		Report Date:	04/15/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	141	mg/kg	04/14/2005	13:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	90	mg/kg	04/11/2005	12:40	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	<1	20	70	105	130
Chloride (Extractable)	1	<1	20	70	98	130

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POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: Stephen Urias
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6911 Blanco Road
San Antonio, TX 78216

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344-Gonzales County	PCS Sample #:	**141457**
Sample ID:	B-24 8-10'	Date Received:	04/01/2005
Date Taken:	03/30/2005	Time Received:	16:00
Time Taken:		Report Date:	04/15/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	1,774	mg/kg	04/14/2005	20:15	BVG	SM 4500-SO4 E
Chloride (Extractable)	1,400	mg/kg	04/11/2005	12:40	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	3	20	70	94	130
Chloride (Extractable)	1	<1	20	70	98	130

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SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	90045344/Gonzales Tx	PCS Sample #:	**141981**
Sample ID:	B-25 10-12'	Date Received:	04/14/2005
Date Taken:	03/31/2005	Time Received:	14:20
Time Taken:	0800	Report Date:	04/28/2005

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Sulfate (Extractable)	292	mg/kg	04/27/2005	16:00	MHB	SM 4500-SO4 E
Chloride (Extractable)	750	mg/kg	04/25/2005	21:00	BVG	SM 9252

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Sulfate (Extractable)	1	2	20	70	100	130
Chloride (Extractable)	1	1	20	70	100	130

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ASFE INFORMATION

Important Information About Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. *No one except you* should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one—not even you*—should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, *do not rely on a geotechnical engineering report* that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions *only* at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an *opinion* about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final*, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject To Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce such risks, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations", many of these provisions indicate where geotechnical engineers responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Rely on Your Geotechnical Engineer for Additional Assistance

Membership in ASFE exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE

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