Report

Shoreline Containment Wall Investigation
Cascade Pole Site
Port of Olympia, Washington

December 27, 2000

Prepared for

Port of Olympia
915 Washington Street
Olympia, WA 98501

Prepared by

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Landau
Associates
Environmental and Geotechnical Services

December 27, 2000

Mr. Don Bache
Port of Olympia
915 Washington Street
Olympia, WA 98501

RE: SHORELINE CONTAINMENT WALL INVESTIGATION
CASCADE POLE SITE
OLYMPIA, WASHINGTON

Dear Don:

This letter describes the findings of a subsurface investigation conducted along the proposed alignment for the shoreline containment wall for the sediments remedial action at the Cascade Pole site (Site) in Olympia, Washington. The field services and associated laboratory testing were carried out between late August and October, 2000. The investigation was conducted in general accordance with Landau Associates' scope of services dated and submitted to the Port of Olympia (Port) on May 31, 2000. The primary objectives of this investigation were to:

- Collect geotechnical data necessary for final design of the proposed shoreline containment wall
- Assess the vertical and lateral extent of nonaqueous phase liquids (NAPL) along the proposed wall alignment
- Assess the general suitability of the proposed alignment relative to the above conditions.

This investigation focused on the latest proposed alignment for the shoreline containment wall, as shown on Figure 1. This alignment reflects recent modifications that were made to the previously proposed alignment to address regulatory concerns for protection of shoreline habitat. The new alignment has been selected to maintain a zero net loss of intertidal habitat area, defined as shoreline area below the mean higher high water line (MHHW) [elevation 14.6 ft mean lower low water (MLLW)].

A previous investigation of the shoreline area was conducted in 1997, which focused primarily on characterizing the extent of NAPL adjacent to the existing sheetpile wall (Landau Associates 1997a). The 1997 investigation provides supplemental information useful in characterizing the stratigraphy and NAPL presence in the shoreline area, although only limited geotechnical data were collected. The location of the 1997 borings are shown on Figure 1.

BACKGROUND

The Port and Ecology have agreed on the scope and approach to implementation of the final cleanup action for the Cascade Pole site sediments operable unit (SOU). The sediment portion of the cleanup will consist of excavating and dredging contaminated sediments and backfilling dredged areas to restore existing mudline grades. Sediments will be dredged within an area approximating Ecology's "multiple benefits line", which is defined, in part, by the outward extent of the presence of NAPL in sediment. The estimated dredge depths associated with the proposed cleanup action are expected to range from about 1 to 5 ft below the existing mudline.

Shoreline contaminated fill and sediments extend up to the existing sheetpile cutoff wall and NAPL has been identified above the aquitard between the wall and the shoreline. It is recognized that removal or containment of the contaminated fill and the NAPL would be required to prevent recontamination of remediated sediment areas and to meet the objectives of the site cleanup action. In recognition of stability issues associated with the existing sheet pile wall, the selected remedy in this area consists of partial removal of contaminated fill and NAPL, to the extent practicable, and containment of the remaining shoreline contaminated fill by means of a second sheet pile cutoff wall.

SUBSURFACE CONDITIONS

Subsurface conditions were explored by five borings (B-1 through B-5) at the locations indicated on Figure 1. Borings B-2 through B-4 were terminated within the aquitard. Boring B-5 was advanced through the aquitard and into the underlying soil. Also, boring B-1 was advanced through a thin remnant of the aquitard and into the underlying soil. The results of the field explorations are contained in Appendix A along with a description of the field procedures. Detailed geologic and environmental information is presented in the boring logs on Figures A-2 to A-6.

GEOLOGIC CONDITIONS

The subsurface conditions along the proposed containment wall alignment are summarized in a geologic profile presented on Figure 2. The subsurface conditions along the proposed containment wall alignment consist of fill over native tidal flat sediments. The fine-grained, native tidal flat sediments act as an aquitard between the overlying fill soil and underlying "lower aquifer".

The depth of fill ranges from about 15 ft at the west end of the alignment, to about 35 ft in a localized depression (identified in the 1997 investigation) at the east end of the alignment. The fill generally consists of loose to medium dense, brown and gray, sandy, silty gravel and gray sand with varied amounts of silt, gravel, and shells with occasional silt lenses. Within the upper 2 to 3 ft, the fill

contains varying amounts of cobbles and debris (concrete, wood). The shoreline slope is generally covered with 1 to 2 ft of riprap consisting of large angular cobbles, boulders, and concrete debris. In boring B-3, an obstruction, possibly a buried log, was encountered at approximately 13 ft below the ground surface (BGS). Based on historical aerial photographs and records research, much of the shoreline fill along the proposed containment wall alignment is interpreted to be granular fill placed to build a dike in the early 1980's for dredge spoils containment (Landau Associates 1993).

Based on the deeper borings, along with information from the 1997 investigation, it appears that the thickness of aquitard along the proposed containment wall alignment ranges from about 10 to 15 ft. To the immediate east of the proposed alignment, the thickness of the aquitard decreases to about 4 to 5 ft (see boring B-1). With the exception of B-1, the aquitard material consists of very soft to soft, olive gray-colored, silty clay or clayey silt with a trace of fine sand, and trace to abundant shell fragments and a trace of wood. This is similar to what was encountered in explorations during the 1997 investigation, but with noticeably more shells and shell fragments in some samples than had previously been observed. The SPT resistance of the aquitard soils was generally lower than previous SPT results for the aquitard material. The remnant of the aquitard encountered at B-1 was a hard sandy silt or very dense silty sand with clay and shell fragments; this area may have been dredged during construction of the small boat harbor in about 1980 and part of the aquitard removed.

The lower aquifer material encountered in borings B-1 and B-5 consisted of a medium to very dense, gray sand with trace gravel.

NAPL Occurrence

Soil samples were carefully screened for presence of NAPL using three techniques: odor testing for indication of hydrocarbon presence, sheen testing in a jar with distilled water, and observation for fluorescence under an ultraviolet light. Results for the three tests were recorded as either no indication, slight indication, or strong indication of odor, sheen, or UV fluorescence. For odor testing, a slight odor response was recorded if a hint of hydrocarbon or creosote-like odor was detected. A strong odor response was determined by an obvious, pungent odor that was immediately recognized upon examining the sample. For sheen tests, a slight sheen response was characterized by one or more small specks of sheen observed during the test while a strong sheen response was recorded if a significant amount of the water surface in the sample jar was covered by petroleum sheen. UV response was considered slight if one or more small areas of the sample fluoresced under UV light, and a strong UV indication was recorded when large areas of the sample fluoresced. Results of the screening are presented on the boring logs and are summarized on the cross section shown on Figure 2.

Samples S-2, S-6, and S-7 in boring B-2 and sample S-1A in boring B-3 showed strong signs of NAPL presence based on odor, sheen, and/or UV testing. However, visual evidence of free product (NAPL) was only noted in boring B-2, sample S-6, where the sand and gravel particles appeared to be coated with product. The stronger presence of NAPL in this area may be associated with the former log pond channel, which was believed to be one of the primary NAPL migration pathways prior to installation of the existing cutoff wall and NAPL recovery system. It is worth noting, however, that the extent and degree of NAPL along the proposed shoreline containment wall alignment appears to be less significant than observed in the 1997 borings, located closer to the existing wall.

Slight indications of possible NAPL (as evidenced by a slight sheen, slight UV response, and/or slight odor) were also observed in isolated samples at each of the borings, including a few locations within the aquitard (borings B-3 and B-5). However, given the slight nature of the detections, coupled with the absence of any signs of free product, the detections within the aquitard could be associated with soil vapor diffusion or organics decomposition rather than NAPL migration.

GEOTECHNICAL TESTING

Geotechnical testing included both laboratory soil classification tests and strength testing, and field vane shear strength testing.

LABORATORY TESTING

Laboratory tests were performed on representative samples to determine appropriate geotechnical index properties and strength characteristics to use for design of the shoreline containment wall. Testing included moisture content, grain size analyses, Atterberg limits, and triaxial compression testing. The laboratory test results and a description of the laboratory test procedures are presented in Appendix B.

SUMMARY OF LABORATORY STRENGTH TEST RESULTS

The triaxial test results were evaluated by Landau Associates, which involved development of Mohr's stress circles for each of the test specimens in order to derive design strength parameters (e.g. friction angle and undrained shear strength [S_U]). Results of the testing indicated peak undrained shear strengths between 750 and 1230 psf at the test confining pressures. Based on the total stress Mohr-Coloumb failure envelope, a peak undrained friction angle of 12 degrees with approximately 460 psf of soil cohesion were determined. Total stress strength parameters are generally conservative and simulate an undrained condition which will be similar to the critical stability condition expected during excavation of the contaminated fill and sediments along the shoreline side of the wall.

SUMMARY OF DOWN-HOLE VANE SHEAR TEST RESULTS

Down-hole vane shear tests were performed at various depths within the aquitard soil in borings B-2 through B-5. The tests were carried out in general accordance with ASTM D 2573-94. Vane shear testing was performed by extending a steel, 50 x 110 mm, tapered-end, four-bladed vane into the undisturbed soil at the base of a boring and rotating it to produce a cylindrical failure surface within the soil. The torsional resistance force required to shear the soil was correlated to a unit shearing resistance, the undrained vane shear strength, VS_U.

Results of the vane shear tests indicated unfactored, undrained vane shear strengths ranging from 720 to 2100 psf, with an average of about 1300 psf. Das (1994) recommends applying a correction factor to vane shear data, which is dependent on the plasticity index of the subject soil as determined by Atterberg limits testing. Based on the Atterberg limits test results, a conservative correction factor for the vane shear data would be 0.84, resulting in factored, undrained vane shear strengths ranging from 600 to 1800 psf, with an average of about 1100 psf. Based on these results, it appears that the undrained vane shear strengths correlate well with the triaxial testing undrained shear strengths and generally verify the results of the triaxial testing.

The results of the vane shear test in boring B-5 at 33.9 feet were discarded because split-spoon sampling of the shear zone at this location indicated a sand material, for which vane shear strength correlations are not reliable.

CONCLUSIONS AND SHORELINE WALL ALIGNMENT EVALUATION

Geologic data indicate a depression in the top of the aquitard near the east end of the proposed containment wall alignment, at boring B-1, where there is only an approximately 4-ft thick remnant of the aquitard. Accordingly, the final alignment for the wall will need to be maintained at least as far west as B-5, where the thickness of the aquitard is approximately 10 ft, or greater. To the west of B-5, the aquitard appears to be reasonably competent and of sufficient thickness for embedment of the wall.

The presence of an obstruction at the location of boring B-3 would indicate the potential for construction conditions along the wall alignment, which may impede installation of the sheet pile wall. It is also possible that the dike fill contains some concrete or other debris that could impede wall installation, although the obstruction at B-3 was the only obstruction noted during both this investigation and the 1997 investigation. Depending on the depth and nature of obstructions encountered, if any, the contractor may elect to excavate and remove the obstructions, attempt to drive the sheets through the obstructions, or request a minor modification to the alignment.

The investigation indicates that NAPL, or residual NAPL, is largely limited to the central portion of the proposed wall alignment. Only one sample, S-6 from boring B-2, contained indications of significant NAPL. Some minor indications of NAPL were observed in the other borings, but, based on a review of the 1997 shoreline investigation data, there appears to be less overall NAPL presence along the proposed wall alignment than closer to the existing sheet pile wall, where the 1997 data was collected. This seems to confirm that the rise, or lip, in the aquitard surface, which was identified based on the results the 1997 investigation and previous investigations, has limited the extent of NAPL migration toward the shoreline.

Laboratory analyses of the aquitard soils indicate design shear strengths ranging from 750 to 1230 psf, with a Mohr-Coloumb total stress envelope resulting in approximately 460 psf cohesion and a 12 degree friction angle. The vane shear testing results correlated well with the laboratory results. Additionally, the laboratory results correlate well with assumed strength parameters used for the preliminary stability analyses for the proposed containment wall (Landau Associates, 1997b). While the aquitard has limited shear strength, the most critical conditions will occur during construction and therefore the weaker aquitard material does not pose a significant long-term stability concern. During construction, stability concerns can be addressed by means of carefully staged excavation and backfill sequencing, possibly coupled with internal bracing.

CLOSING

The objectives of this site investigation were achieved. The results indicate that the proposed containment wall alignment should be satisfactory, and that construction should be feasible with design and construction provisions to accommodate possible isolated obstructions.

LIMITATIONS

This report has been prepared for the exclusive use of the Port of Olympia for specific application to the Cascade Pole Site. The reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

We appreciate the opportunity to provide these services and look forward to assisting you in subsequent phases of the project. Please contact us if you have any questions regarding the information in this report.

LANDAU ASSOCIATES, INC.

By:

FOR

Lawrence D. Beard, P.E.
Principal

and:

Mark E. Ahlstrom
Project Geotechnical Engineer

MEA/jzs
cc: Anita Lovely

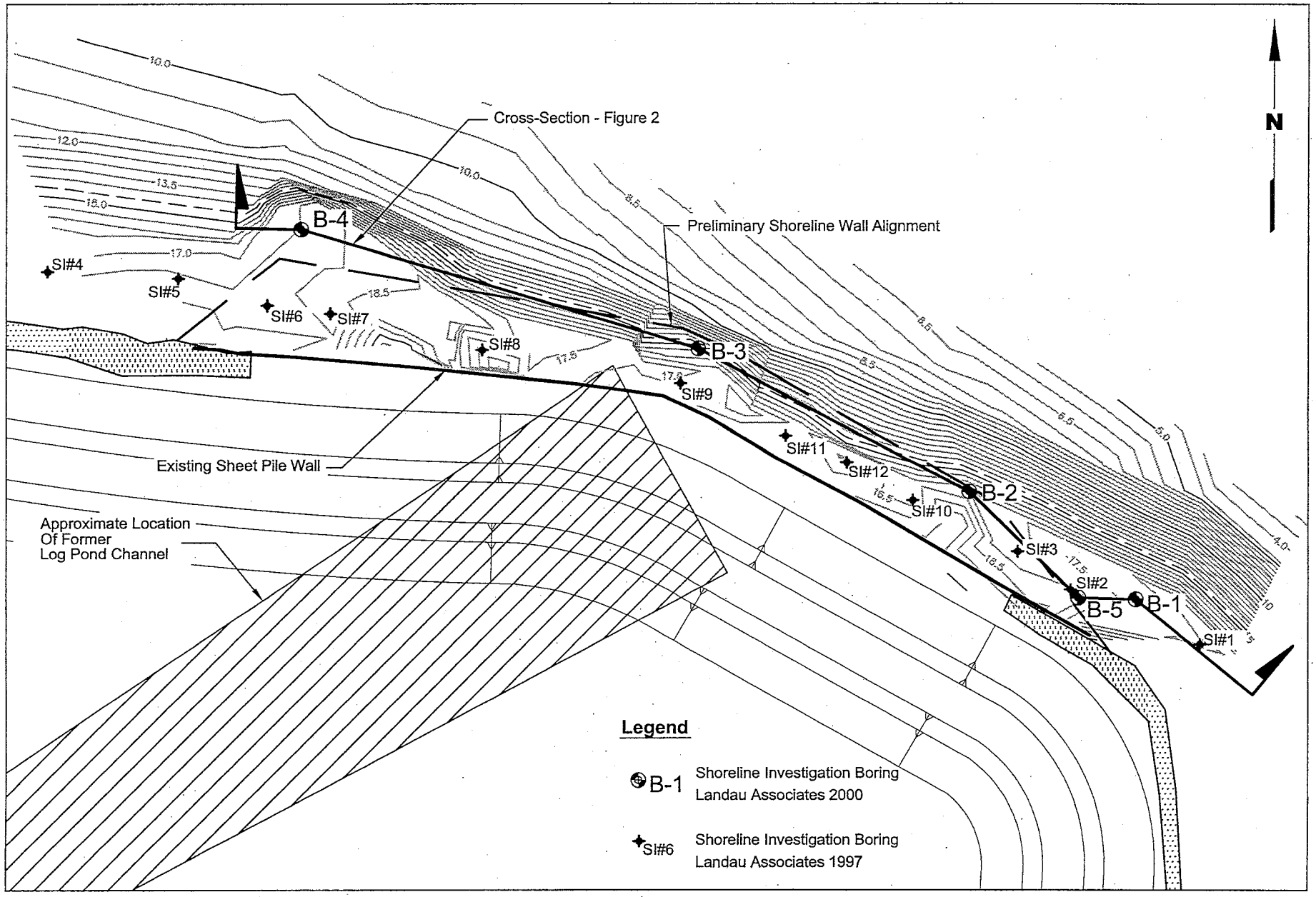
Attachments: Figure 1 – Shoreline Containment Wall Boring Locations
Figure 2 – Shoreline Investigation Geotechnical Profile
Appendix A – Field Explorations
Appendix B – Laboratory Testing

REFERENCES

Landau Associates. 1993. *Remedial Investigation Report Sediments Operable Unit, Cascade Pole Site, Port of Olympia, Washington.* January 22.

Landau Associates. 1997a. *Technical Memorandum to Charles Pitz, Department of Ecology. Re: Shoreline Area Investigation, Cascade Pole Site, Olympia, Washington.* April 22.

Landau Associates. 1997b. *Technical Memorandum to Charles Pitz, Department of Ecology. Re: Evaluation of Existing Sheet Pile Wall for Sediment Dredging Purposes.* January 21.



0 50 100
Scale in Feet

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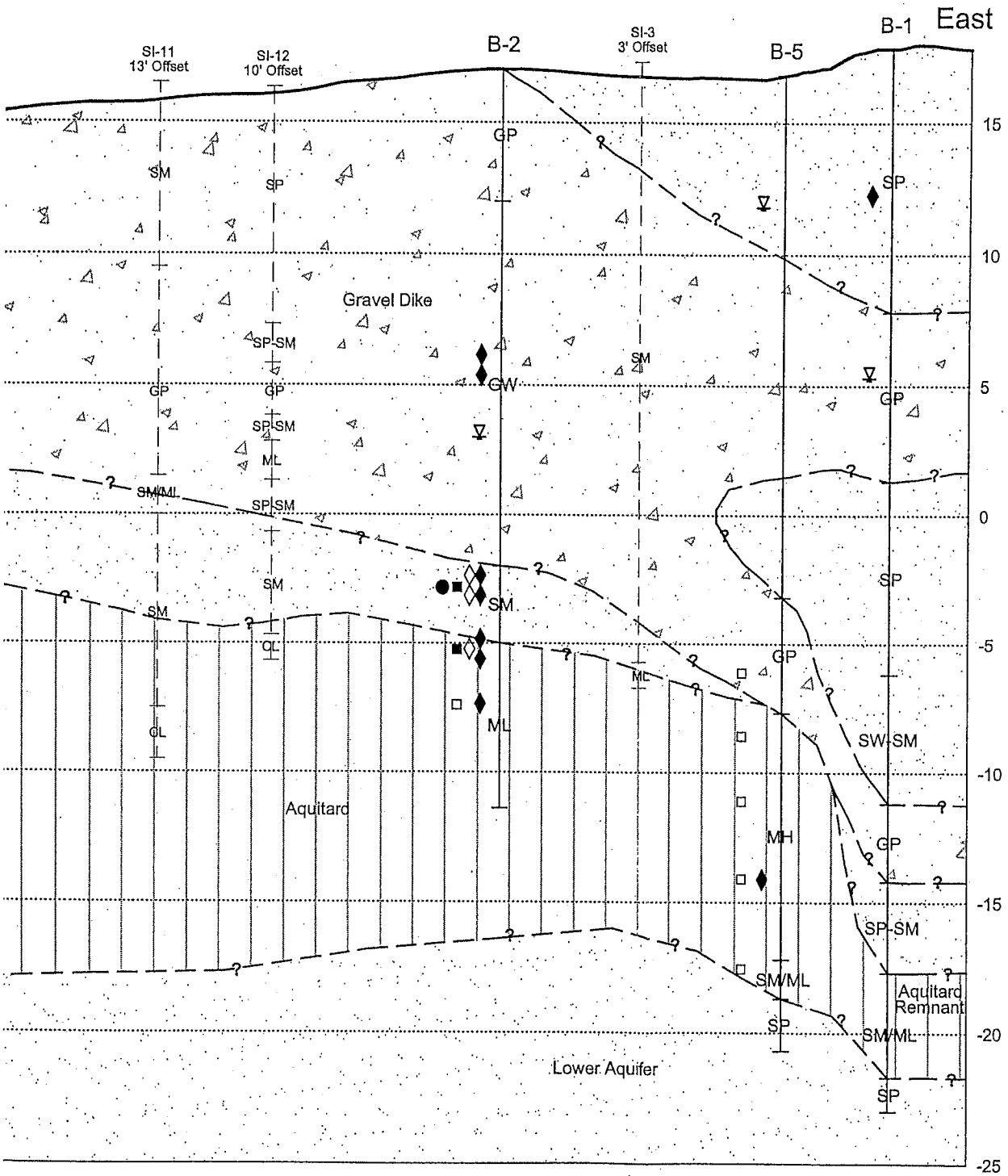
Shoreline Containment
Wall Investigation Report

Shoreline Investigation Boring Locations

Figure
1



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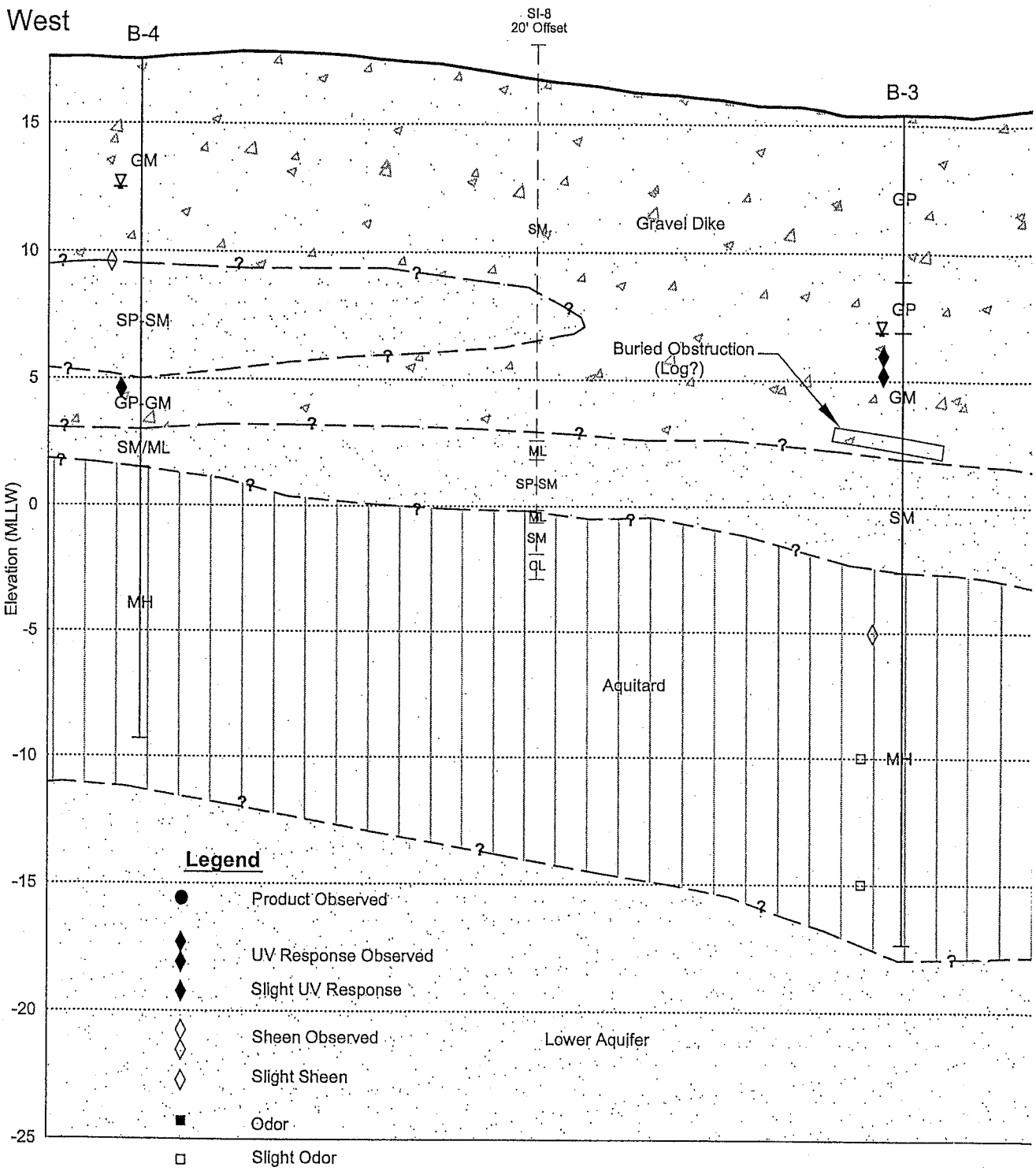
Shoreline Containment Wall Investigation Report	**Shoreline Investigation Geologic Profile**	Figure 2



0 30

Horizontal Scale in Fe

Vertical Exaggeration =

Landau Associates

Cascade Pole/Shoreline Investigation | T:\021\01\5\1641\xsection.dwg (A) "Figure 2" 11/9/2000

APPENDIX A

Field Explorations

APPENDIX A

FIELD EXPLORATIONS

Subsurface conditions were explored by five borings at the locations shown on Figure 1. Borings were drilled with a small, limited-access, hollow-stem auger drill rig and a truck-mounted, hollow-stem auger drill rig to depths ranging from 26.8 to 40.8 ft BGS. The field explorations were coordinated and monitored by a geotechnical engineer from Landau Associates who maintained detailed records of the investigation findings, obtained representative soil samples, described the soil based on visual and textural properties, monitored geotechnical testing including Standard Penetration tests (SPT) and down-hole vane shear tests, and visually screened the soil for presence of NAPL.

To provide access to the proposed boring locations, temporary drilling pads were constructed at some of the boring locations. The pads were constructed by removing the existing shoreline protection and then placing imported clean sand and gravel out over the edge of the existing shoreline. The pad surface was kept above the MHHW line, at about elevation 15 ft. Upon completion of the drilling, the pad materials were excavated and the shoreline restored to its original condition. The pads were constructed and removed by Wilder Environmental, Inc., the earthwork contractor for the upland sediment containment berm, under a change order arrangement with the Port.

Borings B-2 through B-4 were backfilled with bentonite chips and borings B-1 and B-5 were backfilled with bentonite grout. In boring B-3, an obstruction, possibly a buried log, was encountered at approximately 13 ft BGS. The drill rig was moved approximately 5 ft to the west to avoid the obstruction and complete the boring.

Soil samples were collected from each boring at approximately 5-ft intervals in the upper 10 ft of each boring and at approximately 2.5-ft intervals below 10 ft. No sampling was performed in the upper 20 ft of boring B-5, due to its proximity to B-1 and boring SI-2 from the 1997 investigation. However, below 20 ft, samples were collected at 2.5-ft intervals at B-5 to locate and characterize the aquitard.

Sampling was accomplished using a driven, 2-inch outside diameter (OD), split-spoon sampler and a 3-inch OD, ring-lined, split-spoon sampler. The 3-inch OD split-spoon sampler was used at selected locations to increase the amount of sample recovery within the loose fill soils at the site. The samplers were driven into the undisturbed soil ahead of the auger bit using either a 140-lb or 300-lb hammer falling a distance of approximately 30 inches. The sampler and hammer type used to obtain the soil sample is identified on the attached boring logs. The number of blows required to drive the sampler for the final foot of soil penetration (N-value) is noted on the boring logs adjacent to the appropriate sample notation.

At selected locations, stainless steel Shelby tubes were used to collect relatively undisturbed samples of the aquitard soil. The Shelby tube samples were obtained by hydraulically pushing the tube into the soil ahead of the auger bit.

Soil samples collected during drilling were described and classified in general accordance with ASTM D 2488, *Standard Recommended Practice for Description of Soils (Visual-Manual Procedures)*, as summarized on Figure A-1. Logs of the explorations are presented on Figures A-2 through A-6. These logs represent our interpretation of subsurface conditions identified during the explorations. Surveys of the boring elevations and locations were performed by Huit-Zollars, Inc., a surveying consultant for the Port.

In addition to the penetration testing mentioned previously, down-hole vane shear tests were performed at various depths within the aquitard in borings B-2 through B-5 using a calibrated vane shear device which was rented from Subterranean Inc. of Puyallup, Washington. Results of these tests are described in a following section.

Soil samples were evaluated for presence of NAPL by a combination of field and laboratory screening methods including visual observations of product, sheen testing, odor testing, and response to ultraviolet light. No chemical analysis was planned or conducted. All sampling and downhole drilling equipment was decontaminated between uses. Drill cuttings were moved to the disposal cell in the uplands portion of the site.

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS[2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

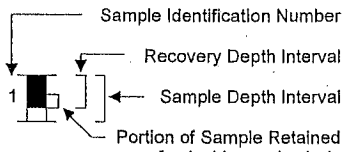
OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to the symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM) for a sand or gravel indicate a soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, as outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the *Standard Test Method for Classification of Soils for Engineering Purposes*, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50%	- "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50%	- "very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30%	- "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15%	- "with gravel," "with sand," "with silt," etc.
	≤ 5%	- "trace gravel," "trace sand," "trace silt," etc., or not noted.

Drilling and Sampling Key

SAMPLE NUMBER & INTERVAL



SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Other - See text if applicable

Groundwater

▽ ATD — Approximate water elevation at time of drilling (ATD) or on date noted. Groundwater levels can fluctuate due to precipitation, seasonal conditions, and other factors.

Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

21015.164 12/14/00 S:\MODELING\GINTWPROJECTS\21015-16.GPJ SOIL CLASS SHEET

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Shoreline Containment Wall Investigation
Cascade Pole Site

Soil Classification System and Key

Figure A-1

B-1

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Mobile B-61, 4" ID HSA Ground Elevation (ft): 17.8 (MLLW)	Water Level
0						SP	Brown, gravelly SAND with trace silt (medium dense, moist) (fill) (slight UV response, no odor, no sheen)	
5	S-1	b2	18					
		b2	19					
10	S-2	a1	11			GP	Brown, sandy GRAVEL with trace silt (medium dense, wet) (fill) (no UV response, no odor, no sheen)	▽ ATD
		a1	27					
15	S-3	a1	8					
	S-4	a1	10	W = 14 GS		SP	Brown, gravelly, medium to coarse SAND and trace silt (medium dense to loose, wet) (fill) (no UV response, no odor, no sheen)	
20		a1	9					
	S-5	a1	6					
25	S-6	a1	9	W = 22 GS		SW-SM	Gray, fine to coarse SAND with silt and trace gravel (medium dense, wet) (fill) (no UV response, no odor, no sheen)	
	S-7	a1	14					
30	S-8	a1	55			GP	Gray, sandy GRAVEL with trace silt (very dense, wet) (fill) (no UV response, no odor, no sheen)	
	S-9	a1	36	W = 20 GS		SP-SM	Gray, medium to coarse SAND with silt and trace gravel (dense, wet) (fill) (no UV response, no odor, no sheen)	
35	S-10A S-10B	a1	51	W = 17 W = 30		SM/ML	Gray, gravelly, silty SAND/ sandy SILT with marine shells (very dense/hard, wet) (aquitard remnant) (no UV response, no odor, no sheen)	
	S-11A S-11B	a1	100/5"					
40	S-12	a1	63/9"	W = 16 GS		SP	Gray, fine to medium SAND with trace gravel (very dense, wet) (lower aquifer) (no UV response, no odor, no sheen)	
45								

Boring Completed 08/29/00
Total Depth of Boring = 40.8 ft.

Point located at Local Coordinates:
North: 638095.7
East: 402294.9

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

21015.164 12/14/00 S:\MODELING\GINT\WPROJECTS\21015-16.GPJ SOIL BORING LOG

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Shoreline Containment Wall Investigation
Cascade Pole Site

Log of Boring B-1

Figure
A-2

B-2

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Mobile B-61, 4" ID HSA Ground Elevation (ft): 17.0 (MLLW)	Water Level
0						GP	Crushed rock drill pad - installed by Wilder 08/2000; removed 09/2000.	
5						GW	Brown, sandy GRAVEL with trace silt (medium dense to dense, wet) (fill) (UV response in sample S-2, no odor, no sheen)	
10	S-1	b2	38					
	S-2	b2	49					
	S-3	b2	30					
15	S-4	b2	16	W = 7 GS				ATD
	S-5	b2	14					
20	S-6	b2	38			SM	Gray, silty, medium to coarse SAND (dense, wet) (UV response, strong odor and sheen, free product on sample S-6) (fill)	
	S-7	b2	34					
25	S-8	b2	7	W = 47 AL		ML	Gray SILT with trace sand, marine shells, and gravel (soft to medium stiff, wet) (UV response, strong odor and slight sheen) (aquitard)	
30				GT GT				
35								
40								
45								

Boring Completed 08/28/00
Total Depth of Boring = 28.4 ft.

Point located at Local Coordinates:
North: 638135
East: 402235.2

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

21015.164 12/14/00 S:\MODELING\GINT\PROJECTS\21015-16.GPJ SOIL BORING LOG

Landau Associates

Shoreline Containment Wall Investigation
Cascade Pole Site

Log of Boring B-2

Figure
A-3

B-3

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Mobile B-61, 4" ID HSA Ground Elevation (ft): 15.4 (MLLW)	Water Level
0						GP	Crushed rock drill pad - Installed by Wilder 08/2000; removed 09/2000.	
5						GP	Quarry spalls/Riprap slope protection	
10	S-1A	b2	23			GM	Wood Debris and Brown to black, silty, sandy, GRAVEL (wet, medium dense) (UV response, sulfur odor, no sheen) (fill)	ATD
	S-1B	b2					Refusal at 12.5 feet - move west approximately 5 feet and resume drilling	
15	S-2	b2	15	W = 25 GS		SM	Gray, silty, gravelly, fine SAND with marine shells and wood (medium dense, wet) (no UV response, sulfur odor, no sheen) (fill)	
20	S-3	b2	0	W = 88 AL		MH	Gray to green SILT with sand and marine shells (very soft, wet) (no UV response, slight odor, slight sheen) (aquitard)	
				GT				
25	S-4A	c3						
	S-4B	c3		GS				
	S-5	b2	2	W = 52				
30	S-6	c3						
				GT				
35								
40								
45								

Boring Completed 08/29/00
Total Depth of Boring = 32.8 ft.

Point located at Local Coordinates:
North: 638186.9
East: 402136.7

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

21015.164 12/14/00 S:\MODELING\GINT\MPROJECTS\21015-16.GPJ SOIL BORING LOG

Landau Associates

Shoreline Containment Wall Investigation
Cascade Pole Site

Log of Boring B-3

Figure
A-4

B-4

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Mobile B-61, 4" ID HSA Ground Elevation (ft): 17.5 (MLLW)	Water Level
0						GM	Gray, silty, sandy GRAVEL with shells (dense, wet) (no UV response, no odor, no sheen) (fill)	
5	S-1	b2	50/ 6"					▽ ATD
	S-2	b2	13				wood debris	
						SP-SM	Gray, fine to medium SAND with silt (medium dense, wet) (no UV response, sulfur odor, slight sheen) (fill)	
10	S-3	b2	14	W = 20 GS			Grades gravelly	
	S-4	b2	3			GP-GM	Gray, sandy GRAVEL with silt and marine shells (very loose, wet) (slight UV response, no odor, no sheen) (fill)	
15	S-5a	b2	2			SM/ML	Gray, sandy SILT or silty fine to medium SAND with marine shells (very soft/loose, wet) (fill) (no UV response, no odor, no sheen)	
	S-5b			W = 78		MH		
	S-6	b2	1				Gray to green SILT with sand (very soft, wet) (no UV response, no odor, no sheen) (aquitard)	
20				GT				
	S-7	c3		AL GS GT W = 74				
25				GT				
30								
35								
40								
45								

Boring Completed 08/30/00
Total Depth of Boring = 26.8 ft.

Point located at Local Coordinates:
North: 638229.8
East: 401992.1

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

21015.164 12/14/00 S:\MODELING\GINT\WPROJECTS\21015-16.GPJ SOIL BORING LOG

Landau Associates

Shoreline Containment Wall Investigation
Cascade Pole Site

Log of Boring B-4

Figure
A-5

B-5

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Mobile B-61, 4" ID HSA Ground Elevation (ft): 16.8 (MLLW)	Water Level
0							No sampling (0 to 20 ft)	
5								▽ Estimated
10								
15								
20	S-1	b2	12			GP-GM	Gray, sandy GRAVEL with silt (medium dense, wet) (no UV response, no odor, no sheen) (fill)	
	S-2	b2	15	-200 = 6%				
25	S-3	b2	2	W = 46		MH	Gray SILT with marine shells (very soft to soft, wet) (slight UV response, slight odor, no sheen) (aquitard)	
	S-4	c3						
30	S-5	c3		GT AL GT W = 40				
				GT		SM/ML	Gray, very silty, fine to medium SAND with gravel and marine shells (medium dense, wet) (no UV response, no odor, no sheen) (aquitard)	
35	S-6	b2	11					
	S-7	b2	20	W = 21 GS		SP	Gray, gravelly, fine to medium SAND and trace silt (medium dense, wet) (no UV response, no odor, no sheen) (lower aquifer)	
40								
45								

Boring Completed 08/31/00
Total Depth of Boring = 37.5 ft.

Point located at Local Coordinates:
North: 638096.3
East: 402274.3

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

21015.164 12/14/00 S:\MODELING\GINT\WPROJECTS\21015-16.GPJ SOIL BORING LOG

Landau Associates

Shoreline Containment Wall Investigation
Cascade Pole Site

Log of Boring B-5

Figure
A-6

APPENDIX B

Laboratory Testing

APPENDIX B

LABORATORY TESTING

Physical laboratory tests were performed by Landau Associates and Rosa Environmental and Geotechnical Laboratory (Rosa). Natural moisture content, Atterberg limits, and grain size classification tests were conducted in Landau Associates' laboratory. Triaxial testing and supplemental grain size and Atterberg limits were conducted by Rosa. The Rosa report is included within this appendix.

Natural moisture content determinations of the samples were performed in general accordance with ASTM D 2216 test procedures. The results from the moisture content determinations are indicated on the boring logs.

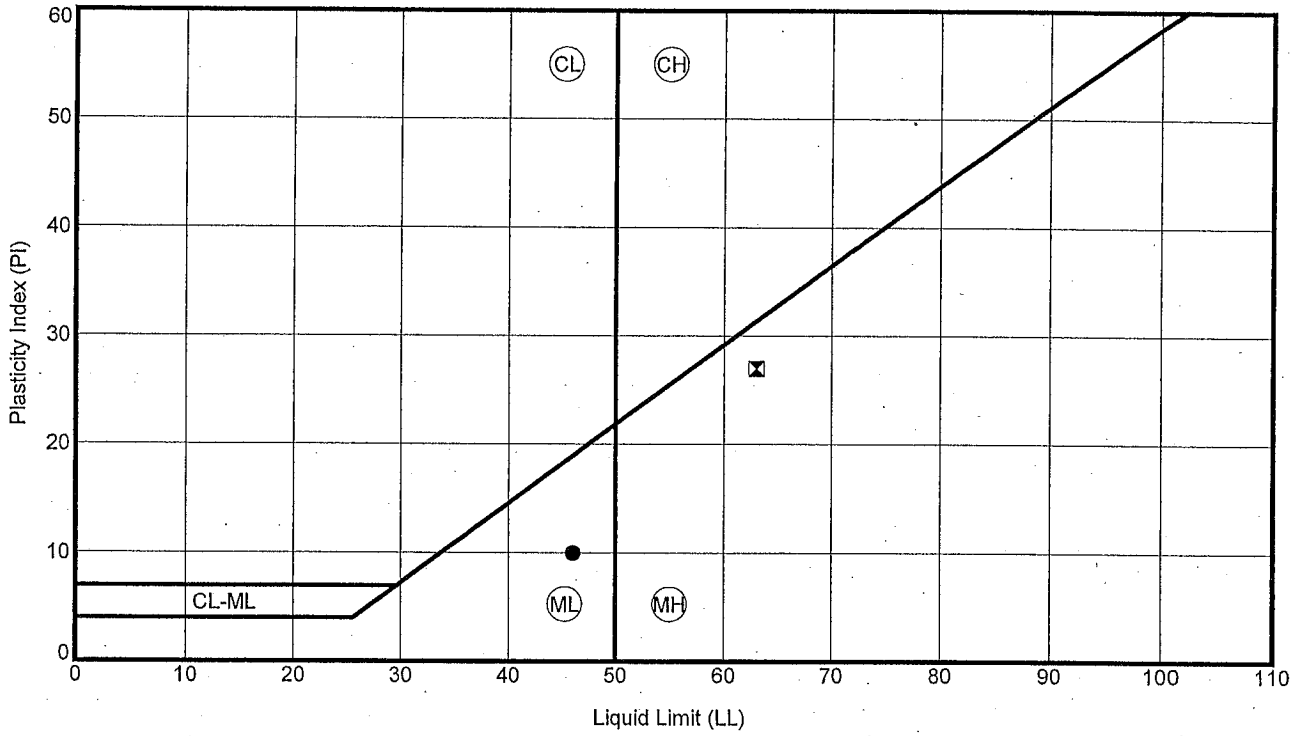
Atterberg limits testing was performed in general accordance with test procedures outlined in ASTM D 4318. The purpose of the test was to determine the liquid limit, plastic limit, and plasticity index of fine-grained material. Results for the Atterberg limits testing can be found on Figure B-1 and in Rosa's lab report.

Grain size analyses were conducted in general accordance with ASTM D 422 and ASTM D 1140, and are reflected in the classifications and descriptions provided on the boring logs. Results of the grain size analyses are also presented in the form of grain size distribution curves on Figures B-2 and B-3 and in Rosa's lab report.

Consolidated Undrained triaxial tests were performed on selected soil samples, to determine the undrained shear strength (S_U) and the undrained friction angle of the aquitard soils, in general accordance with ASTM D 4767. The raw data from this testing is presented in Rosa's lab report. A summary of the strength testing results is presented in the report text.

Consolidated Undrained (CU) triaxial shear tests were conducted on selected samples from borings B-5 (sample S-5) and B-4 (sample S-7). Sample B-5, S-5 was identified as a grey clayey silt with heavy shell fragments, which was considered to be typical of the aquitard soil found along the proposed shoreline wall alignment. Sample B-4, S-7 was selected as a testing control sample because it was a fairly uniform grey clayey silt, with very few shell fragments, and would indicate any testing anomalies caused by the heavy shell content of the other samples.

CU triaxial shear tests were performed on three separate portions of sample B-5, S-5 at confining pressures of 3, 7, and 15.5 psi. One portion of the control sample B-4, S-7 was tested at a confining pressure of 7 psi. The test confining pressures were selected based on estimates of the vertical effective stresses that will exist at the time of contaminated soil excavation in front of the shoreline containment wall.



ATTERBERG LIMIT TEST RESULTS

Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	B-2	8	24.0	46	36	10	47	Gray SILT with trace sand, marine shells, and gravel	ML
⊠	B-3	3	20.0	63	36	27	88	Gray to green SILT with sand and marine shells	MH

ASTM D 4318 Test Method

21015.164 12/14/00 S:\MODELING\GINTW\PROJECTS\21015-16.GPJ ATTERBERG LIMITS FIGURE

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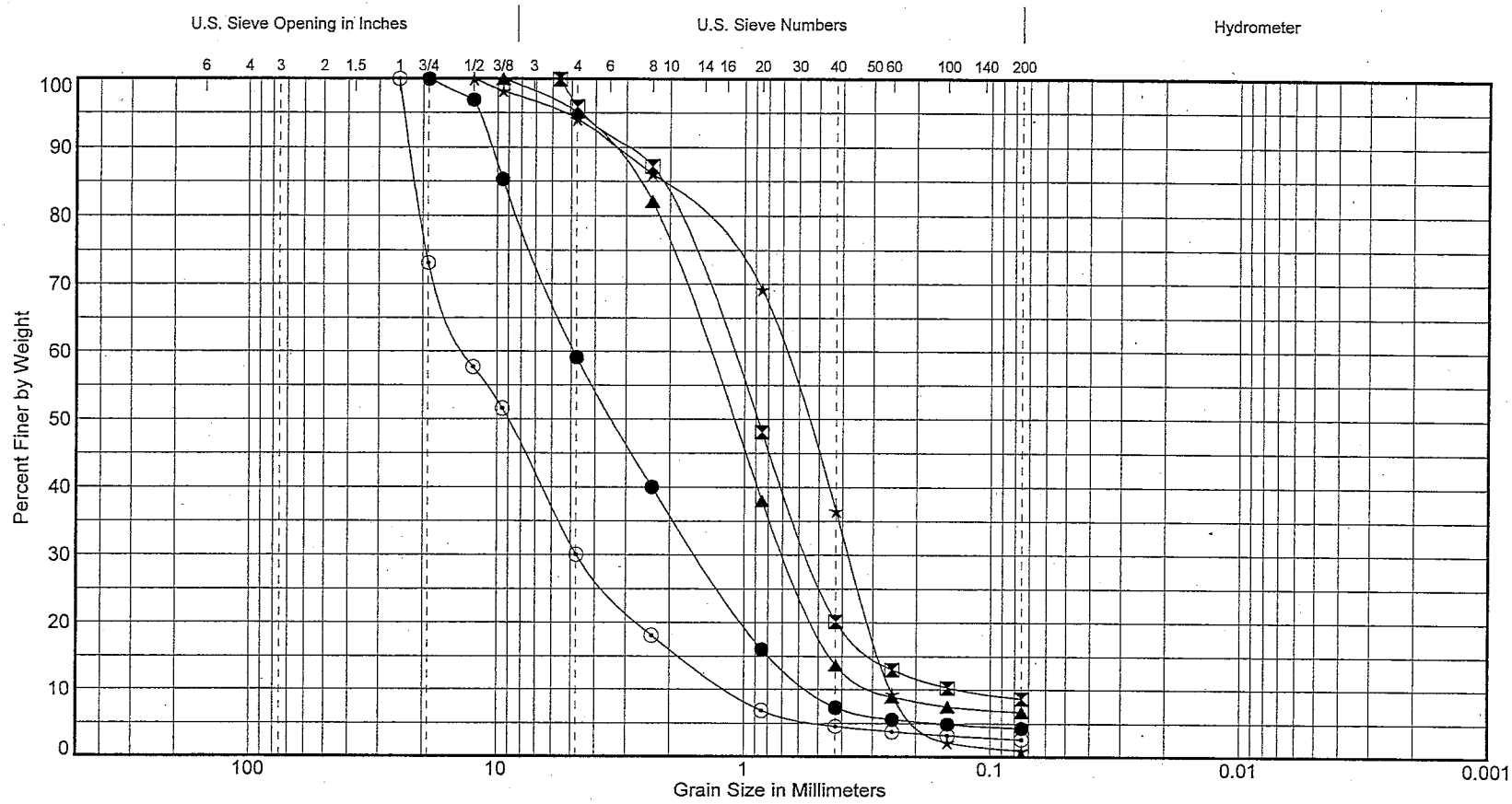
Shoreline Containment Wall Investigation Cascade Pole Site	Plasticity Chart	Figure B-1



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

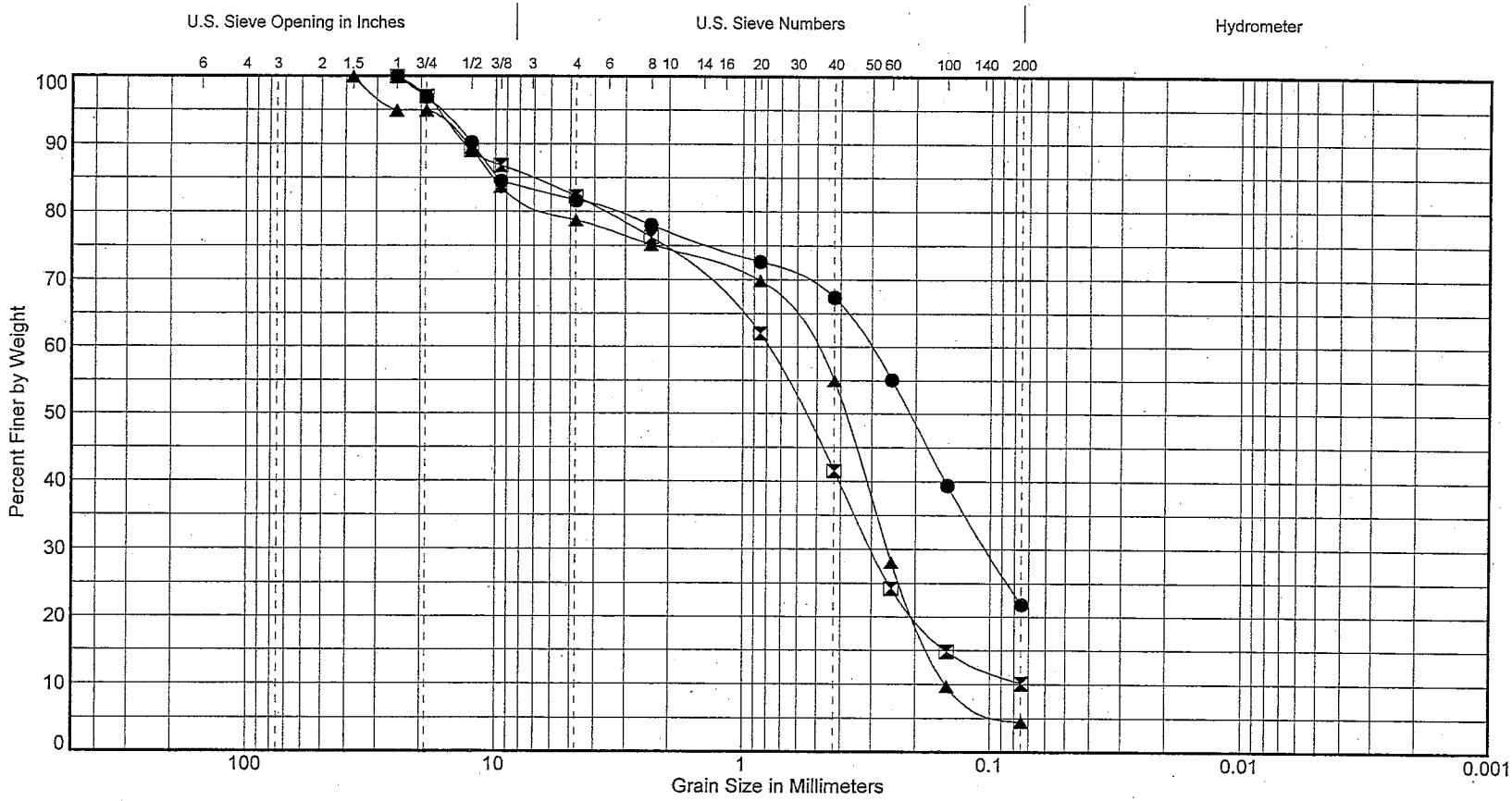
Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	B-1	4	17.5	14	Brown, gravelly, medium to coarse SAND with trace silt	SP
⊠	B-1	6	25.0	22	Gray, fine to coarse SAND with silt and trace gravel	SW-SM
▲	B-1	9	32.5	20	Gray, medium to coarse SAND with silt and trace gravel	SP-SM
★	B-1	12	40.0	16	Gray, fine to medium SAND with trace gravel	SP
⊙	B-2	4	14.0	7	Brown, sandy GRAVEL with trace silt	GW

Landau Associates

Shoreline Containment Wall Investigation
Cascade Pole Site

Grain Size Distribution

Figure B-2



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	B-3	2	15.0	25	Gray, silty, gravelly, fine SAND	SM
⊠	B-4	3	10.0	20	Gray, gravelly, fine to medium SAND with silt	SP-SM
▲	B-5	7	35.5	21	Gray, gravelly, fine to medium SAND with trace silt	SP

Landau Associates

Shoreline Containment Wall Investigation
Cascade Pole Site

Grain Size Distribution

Figure
B-3

REG Lab WMBE
Rosa Environmental & Geotechnical Laboratory, LLC

1001 SW Klickitat Way, Suite 107
Seattle, WA 98134
(206) 287-9122

October 22, 2000

Mr. Mark Ahlstrom
Landau Associates, Inc.
23107 100th Ave. West
P.O. Box 1029
Edmonds, WA 98020-9129

Regarding: Landau Associates Project No. 21015.164; REGL Project No. 1020-007

Dear Mr. Ahlstrom;

The enclosed data tables and plots contain the triaxial compression test results you requested. The report includes summary tables and plots for the consolidated, undrained triaxial shear test results, grain size analysis and Atterberg Limits, as well as a narrative describing the testing and results.

Please call me if you have any questions or comments on the data or its presentation.

Best Regards,
Rosa Environmental & Geotechnical Laboratory, LLC

Harold Benny
Quality Assurance Manager

REG Lab WMBE
Rosa Environmental & Geotechnical Laboratory, LLC

1001 SW Klickitat Way, Suite 107
Seattle, WA 98134
(206) 287-9122

Client: Landau Associates, Inc.	REGL Project No.: 1020-007
Client Project No.: 21015.164	Sample Batch No.: NA

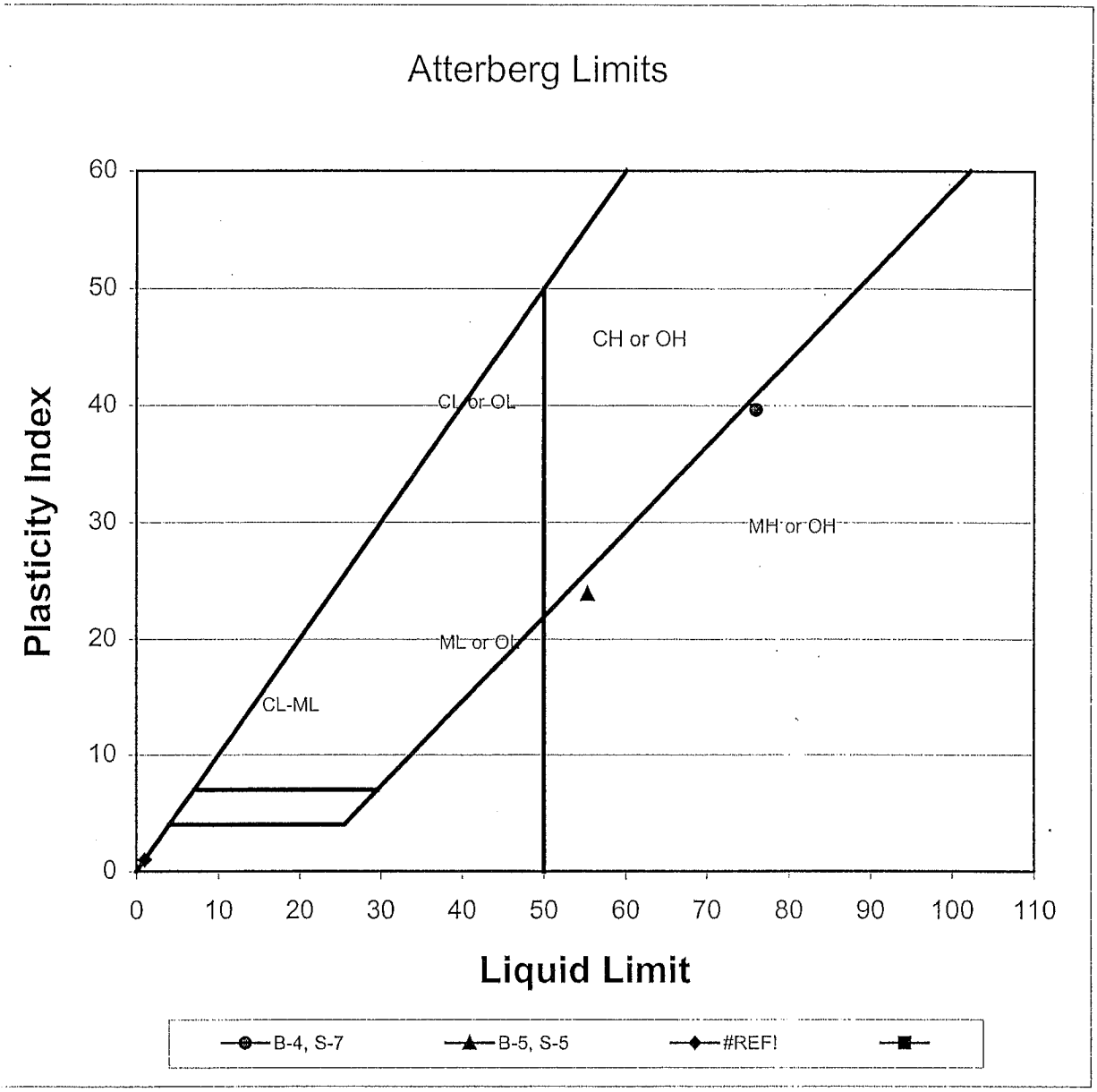
Case Narrative

1. Six Shelby tube samples were received for testing. Of these, four tubes were extruded for examination by Landau Associates. Samples for consolidated, undrained triaxial compression were selected. Two samples were also designated for grain size analysis and two for Atterberg Limits.
2. Sample B-5, S-5 was selected for CU tests at 3, 7, and 15.5 psi confining pressures, and Atterberg Limits. The sample was visually classified as gray, moist, clayey silt, with shell fragments throughout.
3. Sample B-4, S-7 was also selected for CU testing at 7 psi, along with Atterberg Limits and grain size analysis. The sample was visually classified as gray, moist, clayey silt.
4. Sample B-3, S-4B was selected for grain size analysis.
5. The triaxial testing was run according to ASTM D-4767. The CU sample was trimmed without difficulty. The sample was backpressure saturated until a B value of >0.95 was obtained. The specimen was then consolidated at the designated pressure. Timed readings were taken and plots of consolidation vs. square root of time were constructed to determine the point at which t50 occurred for calculation of the strain rate.
6. Following saturation and consolidation, the sample was allowed to sit overnight before beginning the shear portion of the analysis. The CU test was run at a strain rate of 0.0025 inches per min. Following the CU test, the sample was split for examination and the moisture content was determined. Both the oven dried and archived halves will be saved for 90 days before disposal.
7. The Atterberg Limits were determined according to ASTM D-4318. The results are shown on the attached plot.
8. The grain size distribution was determined according to ASTM D-422. The results are shown on the attached plot and summary tables.

Approved by: _____ Date: Oct. 22, 2000
Title: Laboratory Manager

ROSA ENVIRONMENTAL AND GEOTECHNICAL LABORATORY, LLC

Landau Associates, Inc.
Project: 21015.164



Sample Number	Depth	Plasticity Index	Liquid Limit	Plastic Limit	Classification
B-4, S-7	22-24.5	39.6	76.1	36.5	MH
B-5, S-5	30.5-32.5	23.9	55.3	31.4	MH

1020-007

Rosa Environmental Geotechnical Laboratory, LLC

Landau Associates, Inc.
21015.164

Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	1"	3/4"	1/2"	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (125)	#200 (75)	32	22	13	9	7	3.2	1.3
B-3 S4B 26-28.5'	100.0	100.0	100.0	100.0	100.0	99.7	99.3	98.7	96.5	92.9	88.0	75.5	71.1	57.8	51.1	44.4	35.5	27.8
B-4 S-7 22-24.5	100.0	100.0	100.0	100.0	100.0	100.0	99.7	99.4	98.7	94.7	76.3	52.4	45.2	39.7	34.3	32.5	23.5	16.3

Testing performed according to ASTM D421/D422

1020-007

ROSA ENVIRONMENTAL AND GEOTECHNICAL LABORATORY

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21015.164

Percent Retained in Each Size Fraction

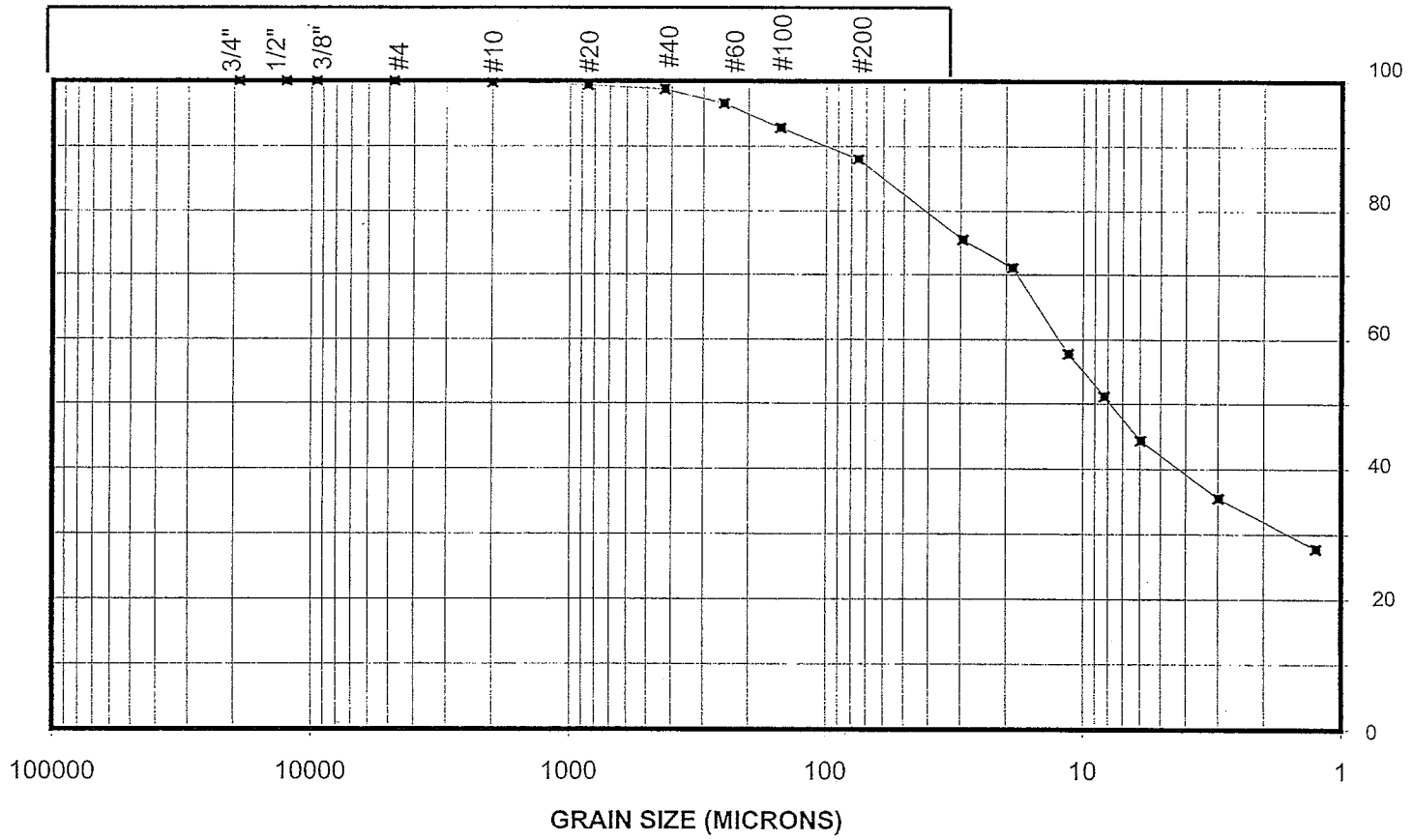
Sample No.	% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Total Sand	% Silt	% Clay
Size (microns)	> 4750	4750-2000	2000-425	425-75	4750-75	75-3	<3
B-3 S4B 26-28.5'	0.0	0.3	1.0	10.7	12.0	52.5	35.5
B-4 S-7 22-24.5	0.0	0.0	0.6	23.1	23.7	52.8	23.5

1020-007

ROSA ENVIRONMENTAL & GEOTECHNICAL LABORATORY

ASTM D-422 GRAIN SIZE DISTRIBUTION

Client: Landau Associates, Inc.
Sample No.: B-3, S-4B

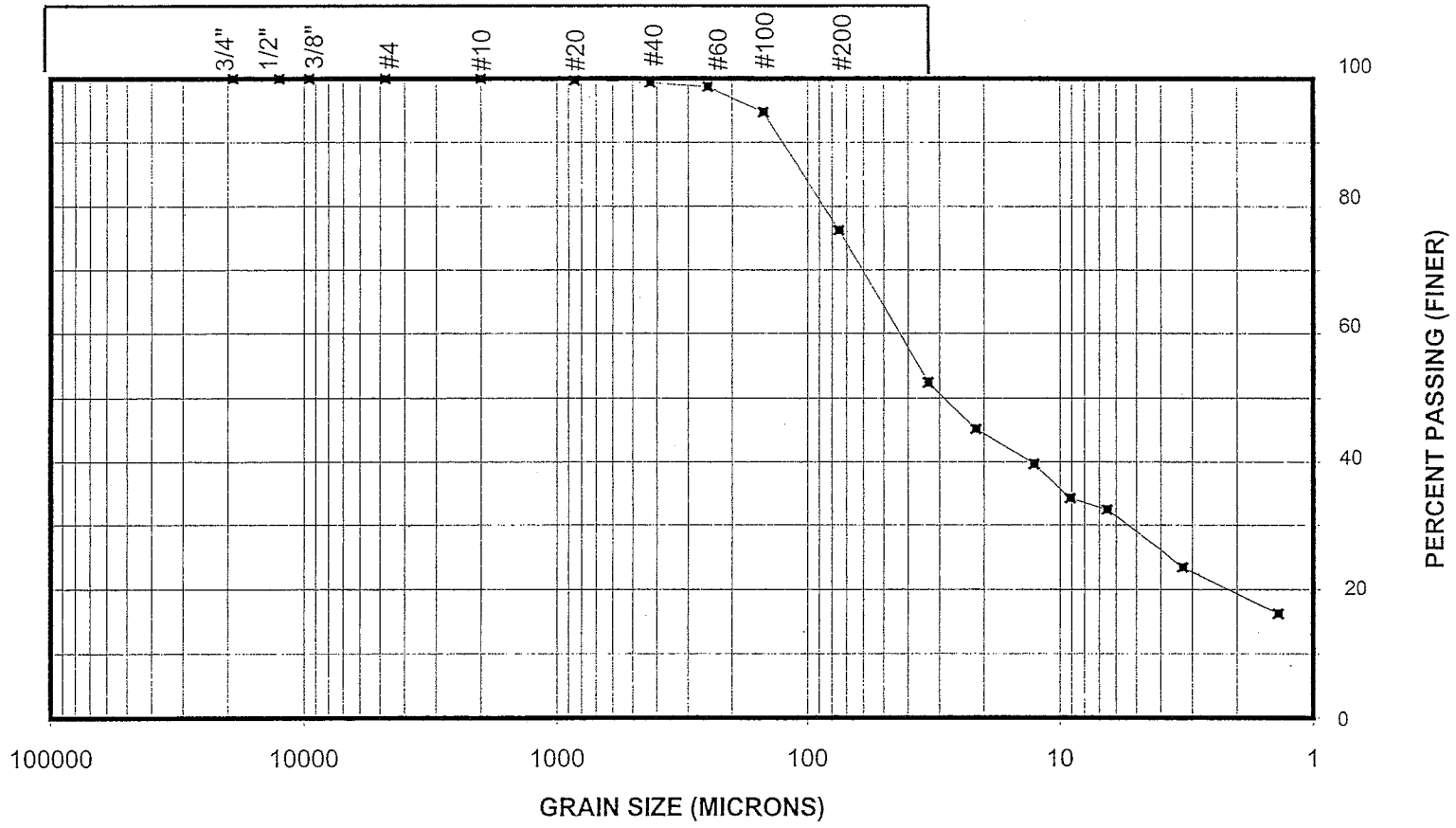


1020-007

ROSA ENVIRONMENTAL & GEOTECHNICAL LABORATORY

ASTM D-422 GRAIN SIZE DISTRIBUTION

Client: Landau Associates, Inc.
Sample No.: B-4, S-7



1020-007

Landau Associates, Inc.
Project: 21015.164

Project Number	1020-007	LVDT	Load Cell	Strain Ratio	Corrected Area	Deviator Stress	Corrected Stress	Pore Pressure	Δ U	Induced Pore Pressure	σ'3	σ'1	σ'1/σ'3	(σ1−σ3)/2	(σ'1+σ'3)/2
Units		.001"	lbs		ft^2	psf	psf	psi	psi	psf	psf	psf			
Sample #	B-5 S-5	0	0	0	0.0437	0	0	35.0	0.0	0	432	432	1	0	432
Depth	30.5-32.5	5	10	0.0008	0.0437	229	229	35.7	0.7	101	331	560	1.69	114	446
Cell pressure	38	10	16	0.0017	0.0437	366	365	35.9	0.9	130	302	668	2.21	183	485
Back Pressure	35	15	20	0.0025	0.0438	457	456	36.0	1.0	144	288	744	2.58	228	516
Strain Rate	0.0025	20	23	0.0033	0.0438	525	524	36.1	1.1	158	274	798	2.92	262	536
Initial Platten Height	0	25	26	0.0041	0.0438	593	592	36.2	1.2	173	259	851	3.28	296	555
Initial Load Cell Reading	0	50	36	0.0083	0.0440	818	816	36.0	1.0	144	288	1104	3.83	409	696
Initial Length	6.066	75	42	0.0124	0.0442	950	947	36.0	1.0	144	288	1235	4.29	475	762
Initial Area	0.0437	100	50	0.0166	0.0444	1126	1122	35.9	0.9	130	302	1425	4.71	563	864
Height after Saturation	6.046	125	55	0.0207	0.0446	1233	1229	35.7	0.7	101	331	1560	4.71	617	946
Height after Consolidation	6.026	154	59	0.0256	0.0448	1317	1311	35.7	0.7	101	331	1642	4.96	658	987
		189	63	0.0314	0.0451	1398	1391	35.7	0.7	101	331	1722	5.20	699	1027
		211	65	0.0350	0.0453	1436	1429	35.6	0.6	86	346	1775	5.13	718	1060
		225	66	0.0373	0.0454	1455	1447	35.6	0.6	86	346	1793	5.19	728	1069
		253	68	0.0420	0.0456	1492	1483	35.6	0.6	86	346	1829	5.29	746	1087
		281	70	0.0466	0.0458	1528	1519	35.5	0.5	72	360	1879	5.22	764	1119
		316	71	0.0524	0.0461	1541	1530	35.5	0.5	72	360	1890	5.25	770	1125
		325	72	0.0539	0.0462	1560	1549	35.4	0.4	58	374	1923	5.14	780	1149
		350	73	0.0581	0.0464	1575	1563	35.4	0.4	58	374	1937	5.17	787	1156
		375	74	0.0622	0.0466	1589	1576	35.4	0.4	58	374	1951	5.21	795	1163
		400	75	0.0664	0.0468	1604	1590	35.3	0.3	43	389	1979	5.09	802	1184
		450	76	0.0747	0.0472	1610	1595	35.3	0.3	43	389	1984	5.10	805	1186
		500	78	0.0830	0.0476	1638	1621	35.2	0.2	29	403	2025	5.02	819	1214
		550	80	0.0913	0.0481	1665	1647	35.2	0.2	29	403	2050	5.08	832	1227
		600	81	0.0996	0.0485	1670	1651	35.2	0.2	29	403	2054	5.09	835	1228
		650	82	0.1079	0.0489	1675	1654	35.2	0.2	29	403	2057	5.10	838	1230
		700	83	0.1162	0.0494	1680	1657	35.2	0.2	29	403	2061	5.11	840	1232
		750	84	0.1245	0.0499	1684	1660	35.1	0.1	14	418	2078	4.98	842	1248
		826	84	0.1371	0.0506	1660	1634	35.1	0.1	14	418	2052	4.91	830	1235
		900	85	0.1494	0.0513	1656	1628	35.1	0.1	14	418	2046	4.90	828	1232
		950	86	0.1577	0.0518	1659	1630	35.0	0.0	0	432	2062	4.77	829	1247
		1000	87	0.1660	0.0524	1662	1631	35.0	0.0	0	432	2063	4.78	831	1248
		1078	87	0.1789	0.053181	1636	1604	35.0	0.0	0	432	2036	4.71	818	1234

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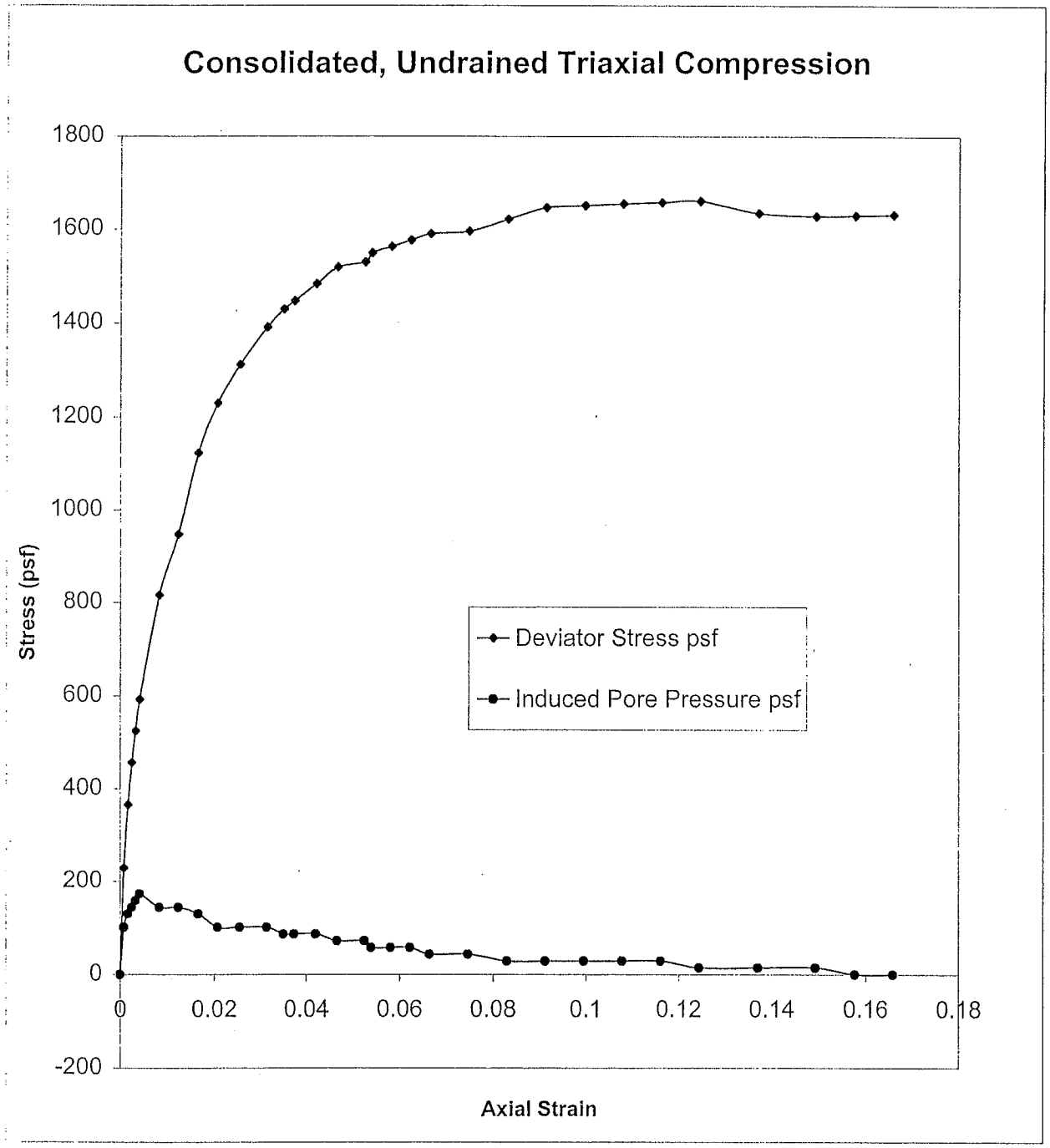
Project: 21015.164



Sample	Depth	Water Content (%)		Void Ratio		Saturation		Unit Weight (lbs/ft^3)		Pressure (psi)		
Number	feet	Initial	Final	Initial	Final	Initial	Final	Initial Wet	Initial Dry	Consol	Cell	Back
B-5 S-5	30.5-32.5	37.7	38.2	1.06	1.03	0.96	1.00	113	81	3	38	35

1020-007

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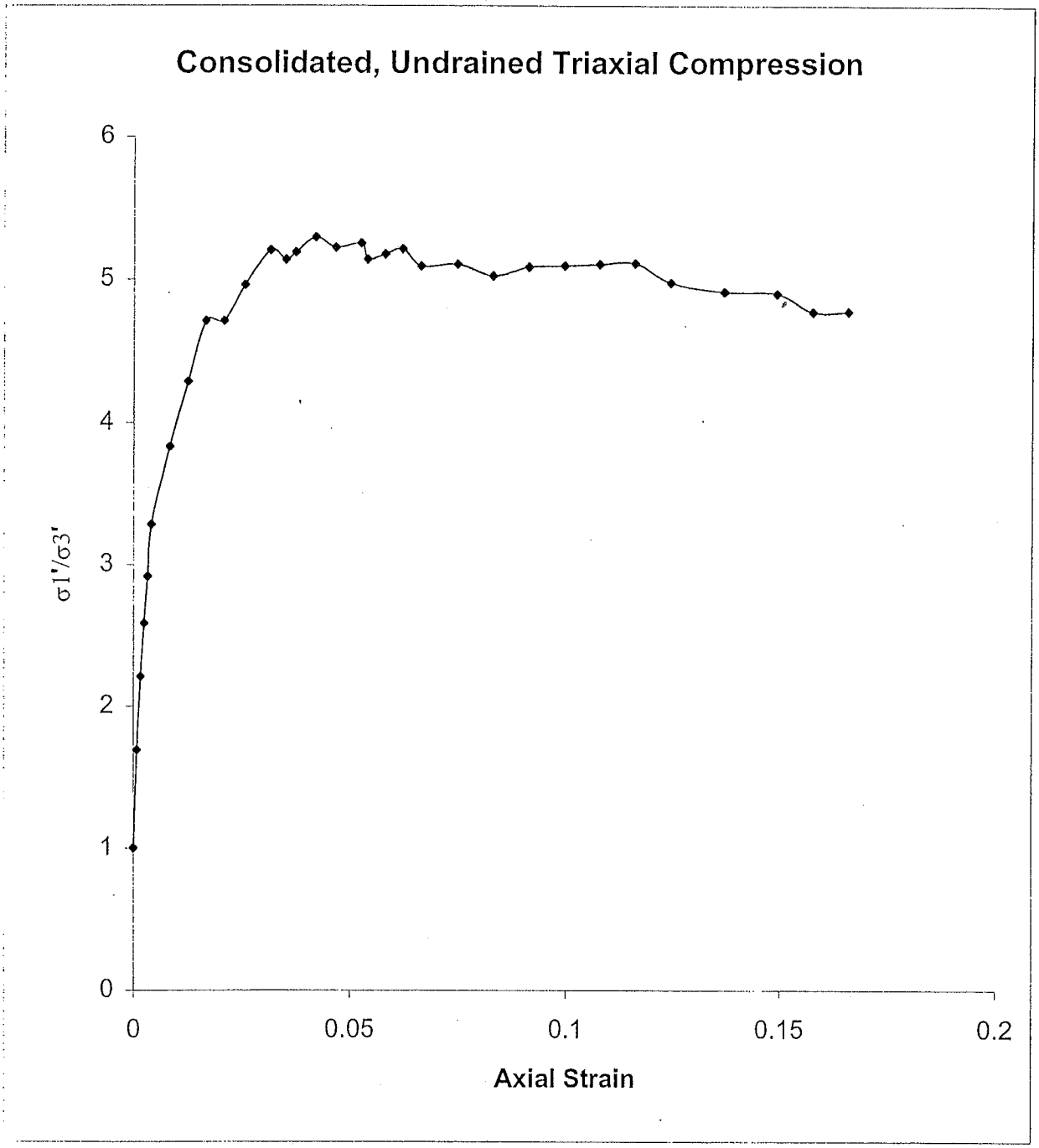
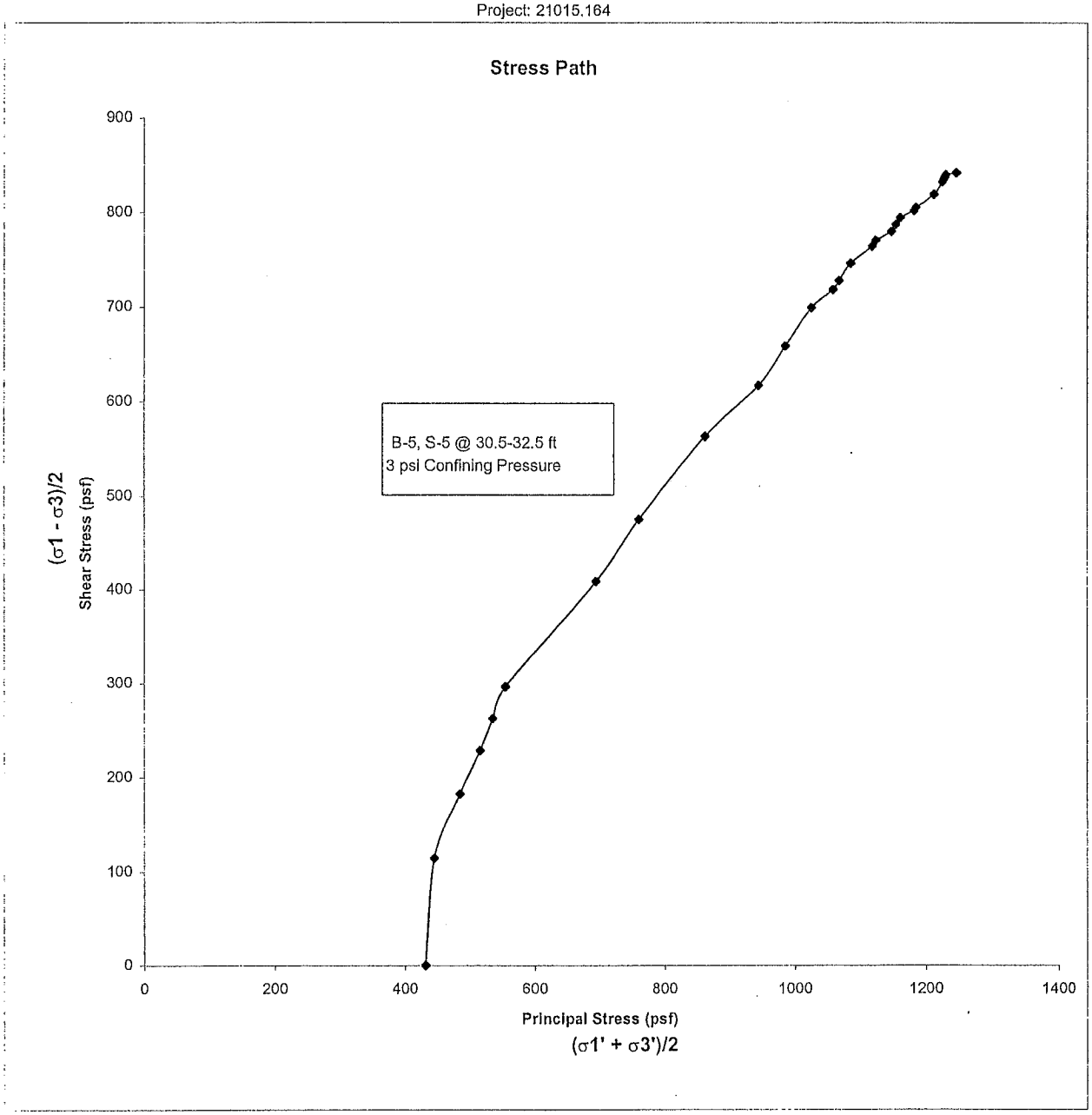
Project: 21015.164



Sample	Depth	Water Content (%)		Void Ratio		Saturation		Unit Weight (lbs/ft^3)		Pressure (psi)		
Number	Feet	Initial	Final	Initial	Final	Initial	Final	Initial Wet	Initial Dry	Consol	Cell	Back
B-5 S-5	30.5-32.5	37.7	38.2	1.06	1.03	0.96	1.00	112.6	81.5	3	38	35

1020-007

Landau Associates, Inc.
Project: 21015.164



1020-007

Landau Associates, Inc.
Project: 21015.164

Project Number	1020-007	LVDT	Load Cell	Strain Ratio	Corrected Area	Deviator Stress	Corrected Stress	Pore Pressure	Δ U	Induced Pore Pressure	σ'3	σ'1	σ'1/σ'3	(σ1−σ3)/2	(σ'1+σ'3)/2
Units		.001"	lbs		ft^2	psf	psf	psi	psi	psf	psf	psf			
Sample #	B-5 S-5	0	0	0	0.0433	0	0	30.0	0.0	0	1008	1008	1	0	1008
Depth	30.5-32.5	5	12	0.0009	0.0433	277	277	30.9	0.9	130	878	1155	1.32	139	1017
Cell pressure	37	10	22	0.0017	0.0433	508	507	31.6	1.6	230	778	1285	1.65	254	1031
Back Pressure	30	17	29	0.0029	0.0434	668	668	32.3	2.3	331	677	1345	1.99	334	1011
Strain Rate	0.0025	21	34	0.0036	0.0434	783	782	32.6	2.6	374	634	1416	2.23	392	1025
Initial Platten Height	0	27	37	0.0046	0.0435	851	850	32.9	2.9	418	590	1441	2.44	426	1016
Initial Load Cell Reading	0	50	49	0.0085	0.0436	1123	1121	33.6	3.6	518	490	1611	3.29	561	1050
Initial Length	5.896	75	57	0.0128	0.0438	1301	1298	34.1	4.1	590	418	1715	4.11	650	1067
Initial Area	0.0433	100	62	0.0171	0.0440	1409	1405	34.2	4.2	605	403	1808	4.48	704	1106
Height after Saturation	5.856	125	66	0.0214	0.0442	1493	1488	34.4	4.4	634	374	1863	4.98	746	1119
Height after Consolidation	5.853	150	69	0.0256	0.0444	1554	1548	34.5	4.5	648	360	1908	5.30	777	1134
		175	71	0.0299	0.0446	1592	1586	34.5	4.5	648	360	1946	5.40	796	1153
		200	73	0.0342	0.0448	1630	1622	34.5	4.5	648	360	1982	5.51	815	1171
		225	74	0.0384	0.0450	1645	1636	34.5	4.5	648	360	1996	5.55	822	1178
		253	75	0.0432	0.0452	1659	1649	34.5	4.5	648	360	2009	5.58	829	1185
		275	76	0.0470	0.0454	1674	1664	34.5	4.5	648	360	2024	5.62	837	1192
		300	77	0.0513	0.0456	1689	1678	34.4	4.4	634	374	2052	5.48	844	1213
		325	78	0.0555	0.0458	1703	1691	34.4	4.4	634	374	2066	5.52	851	1220
		350	79	0.0598	0.0460	1717	1704	34.4	4.4	634	374	2079	5.55	858	1227
		375	79	0.0641	0.0462	1709	1696	34.4	4.4	634	374	2070	5.53	855	1222
		400	80	0.0683	0.0464	1723	1709	34.3	4.3	619	389	2097	5.39	861	1243
		425	81	0.0726	0.0467	1736	1721	34.3	4.3	619	389	2110	5.43	868	1249
		460	81	0.0786	0.0470	1725	1709	34.3	4.3	619	389	2098	5.40	863	1243
		500	82	0.0854	0.0473	1733	1716	34.3	4.3	619	389	2105	5.41	867	1247
		550	83	0.0940	0.0478	1738	1719	34.2	4.2	605	403	2123	5.26	869	1263
		600	84	0.1025	0.0482	1743	1722	34.1	4.1	590	418	2140	5.12	871	1279
		680	85	0.1162	0.0490	1736	1714	33.7	3.7	533	475	2189	4.61	868	1332
		700	85	0.1196	0.0491	1730	1706	33.8	3.8	547	461	2167	4.70	865	1314
		750	86	0.1281	0.0496	1733	1708	33.8	3.8	547	461	2169	4.71	867	1315
		838	87	0.1432	0.0505	1723	1696	33.8	3.8	547	461	2157	4.68	862	1309
		850	87	0.1452	0.0506	1719	1691	33.8	3.8	547	461	2152	4.67	859	1306
		900	88	0.1538	0.0511	1721	1692	33.9	3.9	562	446	2139	4.79	861	1293
		950	88	0.1623	0.051646	1704	1674	33.9	3.9	562	446	2120	4.75	852	1283
		1015	89	0.1734	0.05234	1700	1669	33.9	3.9	562	446	2115	4.74	850	1281
		1050	89	0.1794	0.052721	1688	1655	33.9	3.9	562	446	2102	4.71	844	1274
		1100	90	0.1879	0.053276	1689	1655	33.9	3.9	562	446	2102	4.71	845	1274

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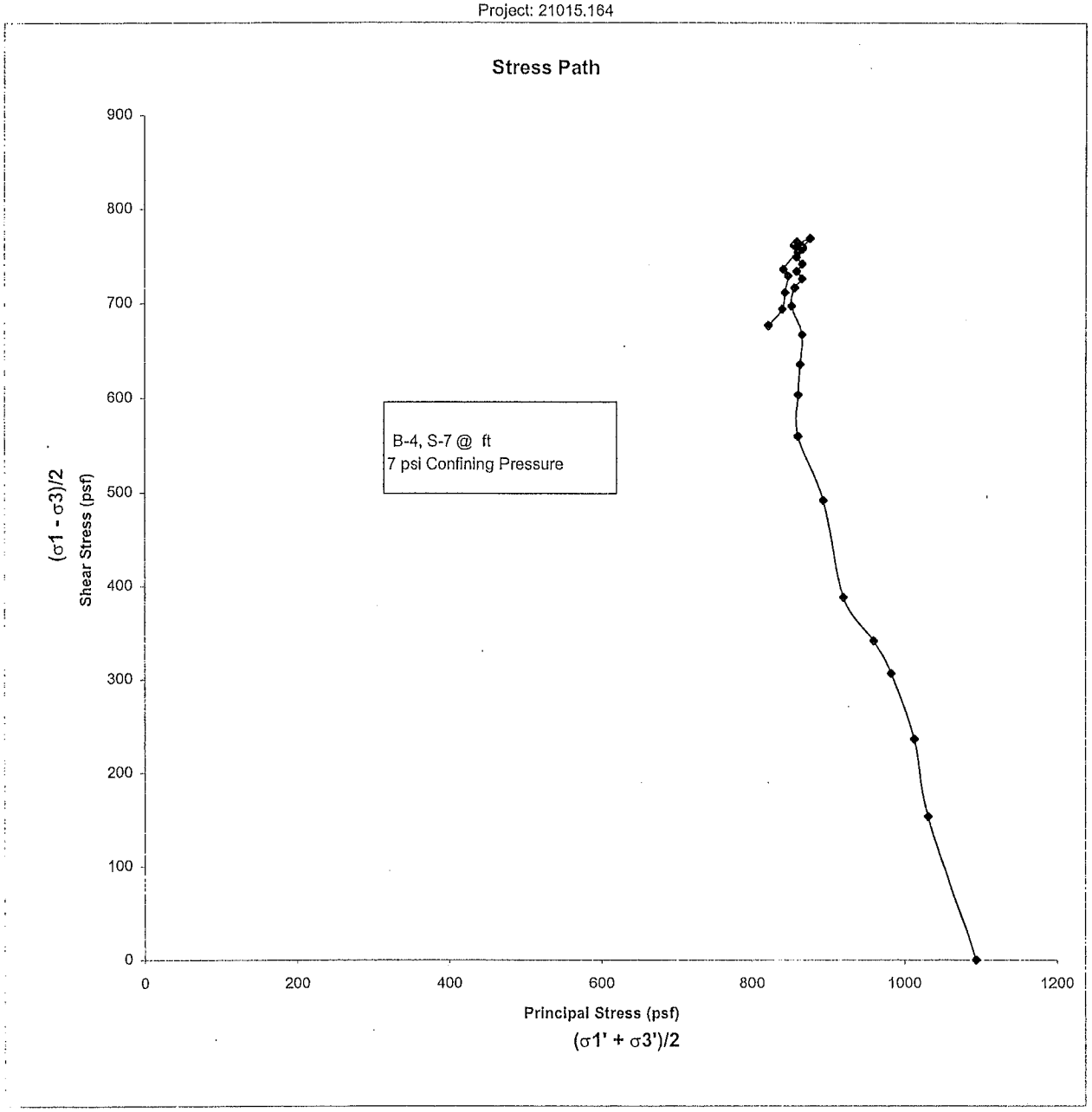

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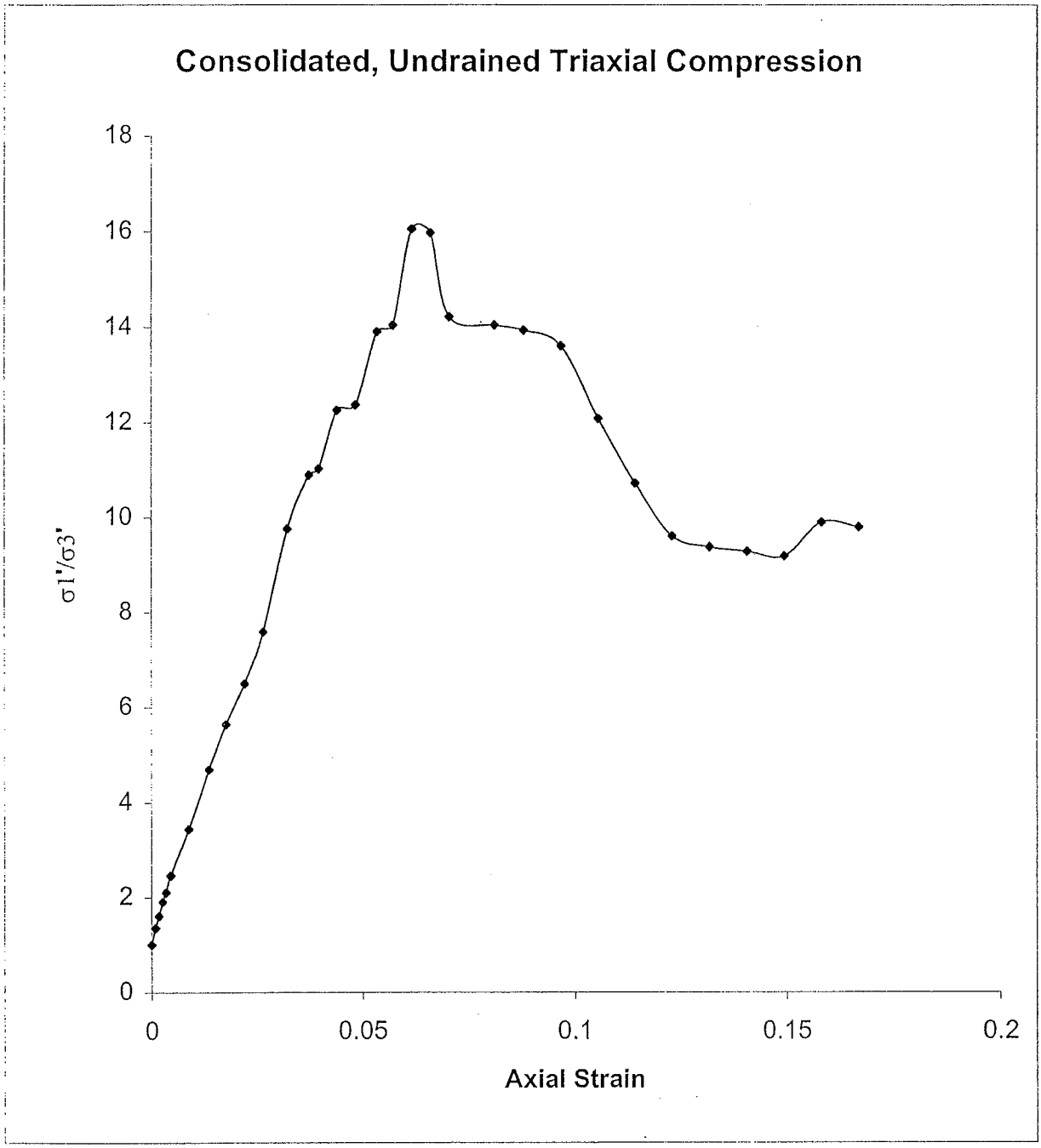

Sample	Depth	Water Content (%)		Void Ratio		Saturation		Unit Weight (lbs/ft^3)		Pressure (psi)		
Number	Feet	Initial	Final	Initial	Final	Initial	Final	Initial Wet	Initial Dry	Consol	Cell	Back
B-4 S-7	22-24.5	74.3	71.6	2.09	1.93	0.96	1.00	95.2	55.5	8	43	35

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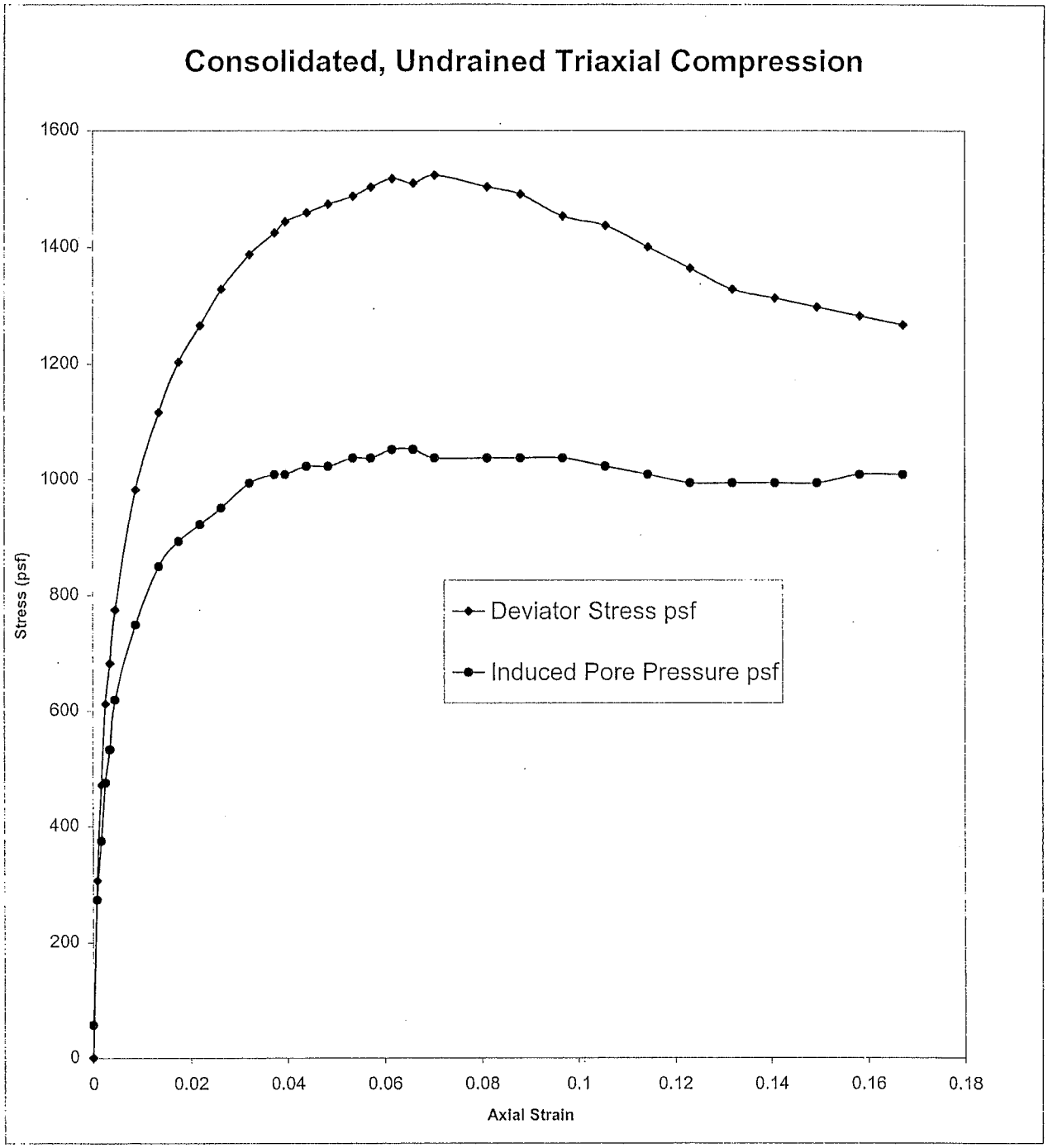

Sample	Depth	Water Content (%)		Void Ratio		Saturation		Unit Weight (lbs/ft^3)		Pressure (psi)		
Number	feet	Initial	Final	Initial	Final	Initial	Final	Initial Wet	Initial Dry	Consol	Cell	Back
B-4 S-7	22-24.5	74.3	71.6	2.09	1.93	0.96	1.00	95	55	8	43	35

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Project Number	1020-007	LVDT	Load Cell	Strain Ratio	Corrected Area	Deviator Stress	Corrected Stress	Pore Pressure	Δ U	Induced Pore Pressure	σ'3	σ'1	σ'1/σ'3	(σ1−σ3)/2	(σ'1+σ'3)/2
Units		.001"	lbs		ft^2	psf	psf	psi	psi	psf	psf	psf			
Sample #	B-4 S-7	0	0	0	0.0423	0	0	35.4	0.4	58	1094	1094	1	0	1094
Depth	22-24.5	5	13	0.0009	0.0424	307	307	36.9	1.9	274	878	1185	1.35	153	1032
Cell pressure	43	10	20	0.0018	0.0424	472	471	37.6	2.6	374	778	1249	1.61	236	1013
Back Pressure	35	15	26	0.0026	0.0424	613	612	38.3	3.3	475	677	1289	1.90	306	983
Strain Rate	0.0025	20	29	0.0035	0.0425	683	682	38.7	3.7	533	619	1301	2.10	341	960
Initial Platten Height	0	26	33	0.0046	0.0425	776	775	39.3	4.3	619	533	1308	2.45	388	920
Initial Load Cell Reading	0	50	42	0.0088	0.0427	983	981	40.2	5.2	749	403	1385	3.43	492	894
Initial Length	5.818	77	48	0.0136	0.0429	1118	1115	40.9	5.9	850	302	1418	4.69	559	860
Initial Area	0.0423	100	52	0.0176	0.0431	1207	1203	41.2	6.2	893	259	1462	5.64	603	861
Height after Saturation	5.789	125	55	0.0220	0.0433	1271	1266	41.4	6.4	922	230	1496	6.49	635	863
Height after Consolidation	5.682	150	58	0.0264	0.0435	1334	1328	41.6	6.6	950	202	1530	7.59	667	866
		183	61	0.0322	0.0437	1395	1387	41.9	6.9	994	158	1546	9.76	697	852
		212	63	0.0373	0.0440	1433	1425	42.0	7.0	1008	144	1569	10.89	716	856
		225	64	0.0396	0.0441	1452	1443	42.0	7.0	1008	144	1587	11.02	726	866
		250	65	0.0440	0.0443	1468	1458	42.1	7.1	1022	130	1588	12.25	734	859
		275	66	0.0484	0.0445	1484	1473	42.1	7.1	1022	130	1603	12.37	742	866
		304	67	0.0535	0.0447	1498	1487	42.2	7.2	1037	115	1602	13.90	749	858
		325	68	0.0572	0.0449	1514	1502	42.2	7.2	1037	115	1617	14.04	757	866
		350	69	0.0616	0.0451	1530	1516	42.3	7.3	1051	101	1617	16.04	765	859
		375	69	0.0660	0.0453	1522	1508	42.3	7.3	1051	101	1609	15.96	761	855
		400	70	0.0704	0.0455	1537	1522	42.2	7.2	1037	115	1637	14.21	769	876
		461	70	0.0811	0.0461	1519	1502	42.2	7.2	1037	115	1618	14.04	760	866
		500	70	0.0880	0.0464	1508	1490	42.2	7.2	1037	115	1605	13.93	754	860
		550	69	0.0968	0.0469	1472	1452	42.2	7.2	1037	115	1568	13.61	736	841
		600	69	0.1056	0.0473	1458	1436	42.1	7.1	1022	130	1566	12.08	729	848
		650	68	0.1144	0.0478	1423	1400	42.0	7.0	1008	144	1544	10.72	711	844
		700	67	0.1232	0.0483	1388	1363	41.9	6.9	994	158	1522	9.61	694	840
		750	66	0.1320	0.0488	1353	1327	41.9	6.9	994	158	1486	9.38	677	822
		800	66	0.1408	0.0493	1340	1312	41.9	6.9	994	158	1471	9.28	670	814
		850	66	0.1496	0.0498	1326	1297	41.9	6.9	994	158	1455	9.19	663	807
		900	66	0.1584	0.0503	1312	1282	42.0	7.0	1008	144	1426	9.90	656	785
		950	66	0.1672	0.0508	1298	1267	42.0	7.0	1008	144	1411	9.80	649	777
		1000	66	0.1760	0.051375	1285	1252	42.0	7.0	1008	144	1396	9.69	642	770
		1050	66	0.1848	0.051929	1271	1237	42.0	7.0	1008	144	1381	9.59	635	762
		1100	66	0.1936	0.052496	1257	1222	42.0	7.0	1008	144	1366	9.49	629	755

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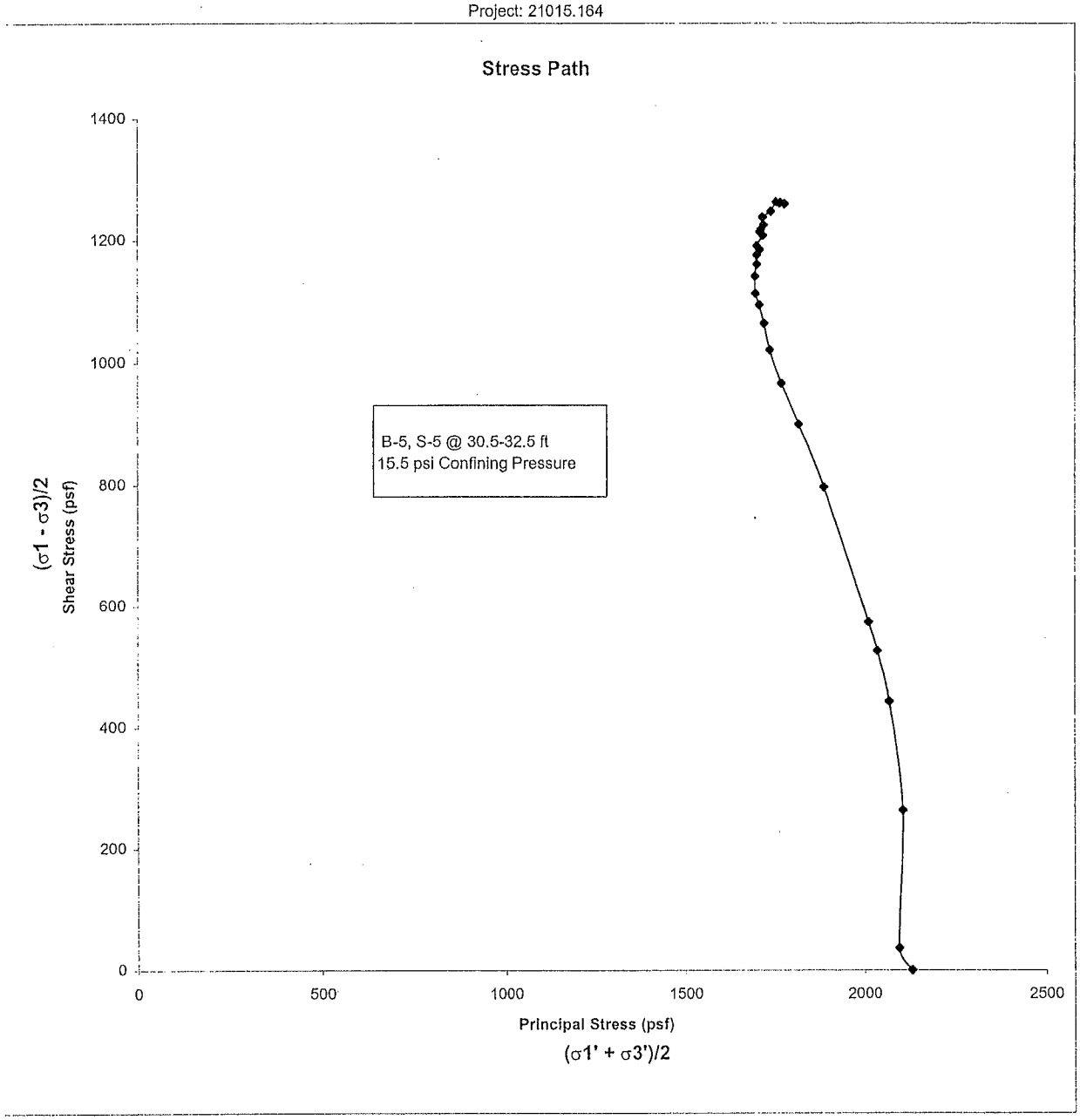

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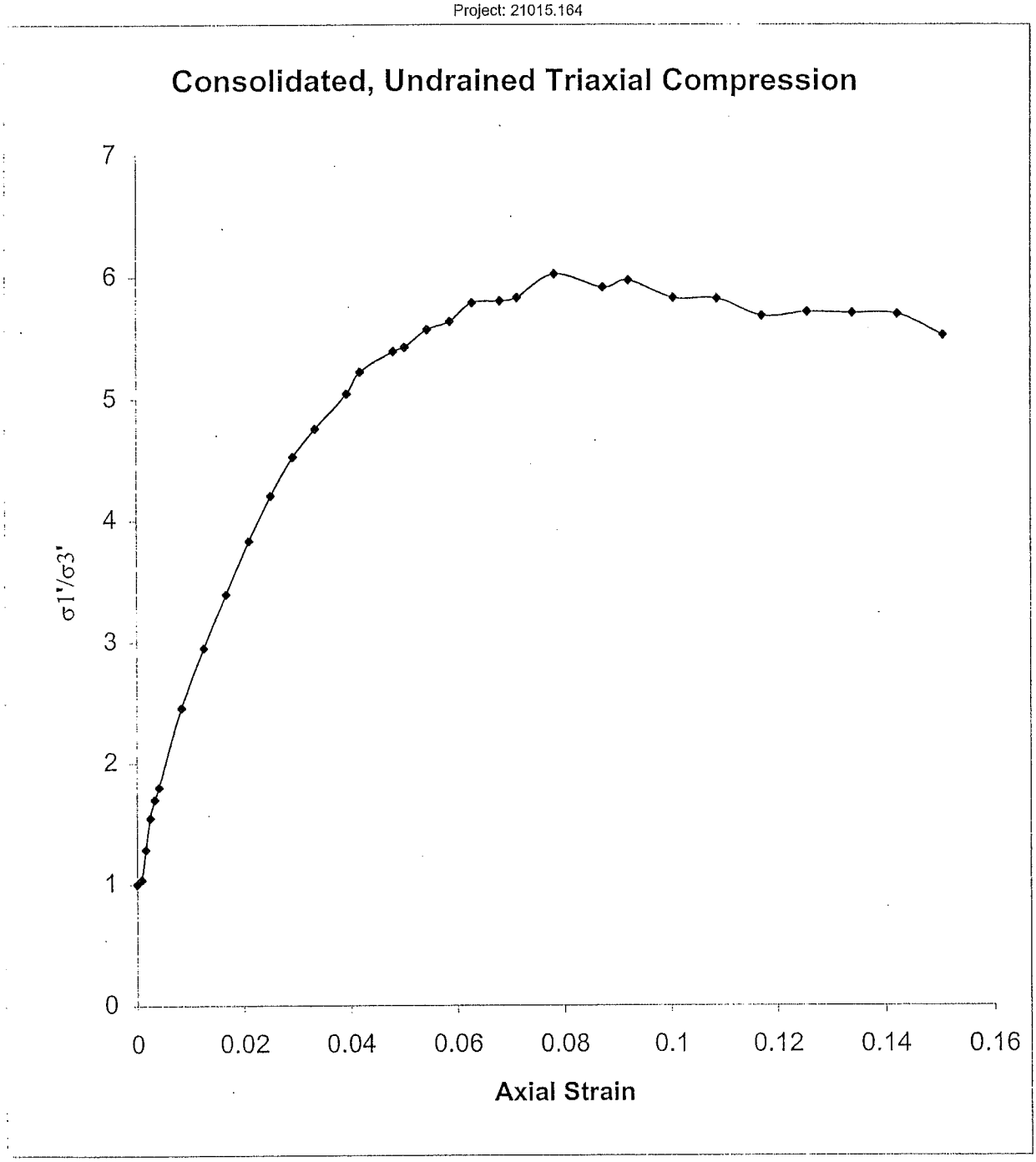

Sample	Depth	Water Content (%)		Void Ratio		Saturation		Unit Weight (lbs/ft^3)		Pressure (psi)		
Number	Feet	Initial	Final	Initial	Final	Initial	Final	Initial Wet	Initial Dry	Consol	Cell	Back
B-5 S-5	30.5-32.5	36.8	34.9	1.15	0.97	0.87	0.97	107.4	79.6	15.5	52.5	37

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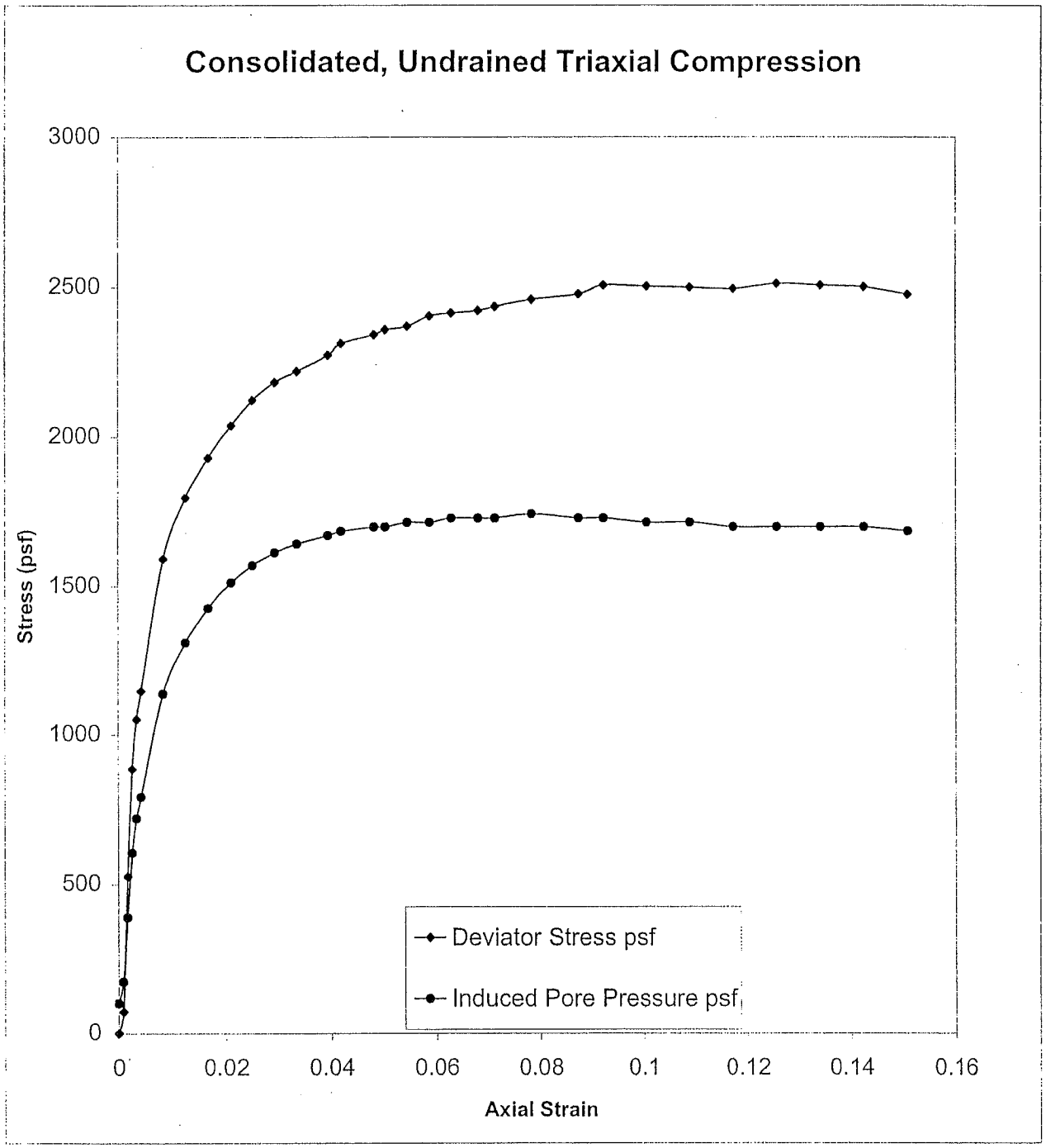

Sample	Depth	Water Content (%)		Void Ratio		Saturation		Unit Weight (lbs/ft^3)		Pressure (psi)		
Number	feet	Initial	Final	Initial	Final	Initial	Final	Initial Wet	Initial Dry	Consol	Cell	Back
B-5 S-5	30.5-32.5	36.8	34.9	1.15	0.97	0.87	0.97	107	80	15.5	52.5	37

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Project Number	1020-007	LVDT	Load Cell	Strain Ratio	Corrected Area	Deviator Stress	Corrected Stress	Pore Pressure	Δ U	Induced Pore Pressure	σ'3	σ'1	σ'1/σ'3	(σ1−σ3)/2	(σ'1+σ'3)/2
Units		.001"	lbs		ft^2	psf	psf	psi	psi	psf	psf	psf			
Sample #	B-5 S-5	0	0	0	0.0417	0	0	37.7	0.7	101	2131	2131	1	0	2131
Depth	30.5-32.5	5	3	0.0008	0.0417	72	72	38.2	1.2	173	2059	2131	1.03	36	2095
Cell pressure	52.5	10	22	0.0017	0.0418	527	526	39.7	2.7	389	1843	2369	1.29	263	2106
Back Pressure	37	15	37	0.0025	0.0418	885	884	41.2	4.2	605	1627	2512	1.54	443	2069
Strain Rate	0.0025	20	44	0.0034	0.0418	1052	1051	42.0	5.0	720	1512	2563	1.69	526	2037
Initial Platten Height	0	25	48	0.0042	0.0419	1146	1145	42.5	5.5	792	1440	2585	1.80	573	2013
Initial Load Cell Reading	0	50	67	0.0084	0.0421	1593	1591	44.9	7.9	1138	1094	2686	2.45	797	1890
Initial Length	6.082	75	76	0.0126	0.0422	1800	1797	46.1	9.1	1310	922	2718	2.95	900	1820
Initial Area	0.0417	100	82	0.0168	0.0424	1933	1930	46.9	9.9	1426	806	2736	3.39	967	1771
Height after Saturation	6.042	126	87	0.0211	0.0426	2042	2037	47.5	10.5	1512	720	2757	3.83	1021	1739
Height after Consolidation	5.966	150	91	0.0251	0.0428	2127	2122	47.9	10.9	1570	662	2784	4.20	1064	1723
		175	94	0.0293	0.0430	2188	2181	48.2	11.2	1613	619	2801	4.52	1094	1710
		200	96	0.0335	0.0431	2225	2217	48.4	11.4	1642	590	2808	4.76	1112	1699
		235	99	0.0394	0.0434	2280	2272	48.6	11.6	1670	562	2833	5.05	1140	1697
		250	101	0.0419	0.0435	2320	2311	48.7	11.7	1685	547	2858	5.22	1160	1703
		287	103	0.0481	0.0438	2351	2341	48.8	11.8	1699	533	2873	5.39	1176	1703
		300	104	0.0503	0.0439	2368	2357	48.8	11.8	1699	533	2890	5.42	1184	1712
		325	105	0.0545	0.0441	2381	2369	48.9	11.9	1714	518	2887	5.57	1190	1703
		350	107	0.0587	0.0443	2415	2403	48.9	11.9	1714	518	2921	5.63	1208	1720
		375	108	0.0629	0.0445	2427	2413	49.0	12.0	1728	504	2917	5.79	1214	1711
		406	109	0.0681	0.0447	2436	2421	49.0	12.0	1728	504	2925	5.80	1218	1715
		425	110	0.0712	0.0449	2450	2435	49.0	12.0	1728	504	2939	5.83	1225	1721
		467	112	0.0783	0.0452	2475	2459	49.1	12.1	1742	490	2948	6.02	1238	1719
		521	114	0.0873	0.0457	2495	2477	49.0	12.0	1728	504	2981	5.91	1247	1742
		550	116	0.0922	0.0459	2525	2506	49.0	12.0	1728	504	3010	5.97	1263	1757
		600	117	0.1006	0.0464	2523	2503	48.9	11.9	1714	518	3021	5.83	1262	1770
		650	118	0.1090	0.0468	2521	2499	48.9	11.9	1714	518	3017	5.82	1261	1768
		700	119	0.1173	0.0472	2519	2495	48.8	11.8	1699	533	3028	5.68	1259	1780
		750	121	0.1257	0.0477	2537	2511	48.8	11.8	1699	533	3044	5.71	1268	1789
		800	122	0.1341	0.0482	2533	2506	48.8	11.8	1699	533	3039	5.70	1267	1786
		850	123	0.1425	0.0486	2529	2501	48.8	11.8	1699	533	3034	5.69	1265	1783
		900	123	0.1509	0.0491	2505	2475	48.7	11.7	1685	547	3022	5.52	1252	1785
		964	124.5	0.1616	0.04974	2503	2472	48.7	11.7	1685	547	3019	5.52	1252	1783
		1003	125	0.1681	0.050131	2493	2461	48.6	11.6	1670	562	3023	5.38	1247	1792
		1082	126	0.1814	0.050941	2473	2439	48.6	11.6	1670	562	3001	5.34	1237	1781
		1112	127	0.1864	0.051256	2478	2443	48.5	11.5	1656	576	3019	5.24	1239	1797

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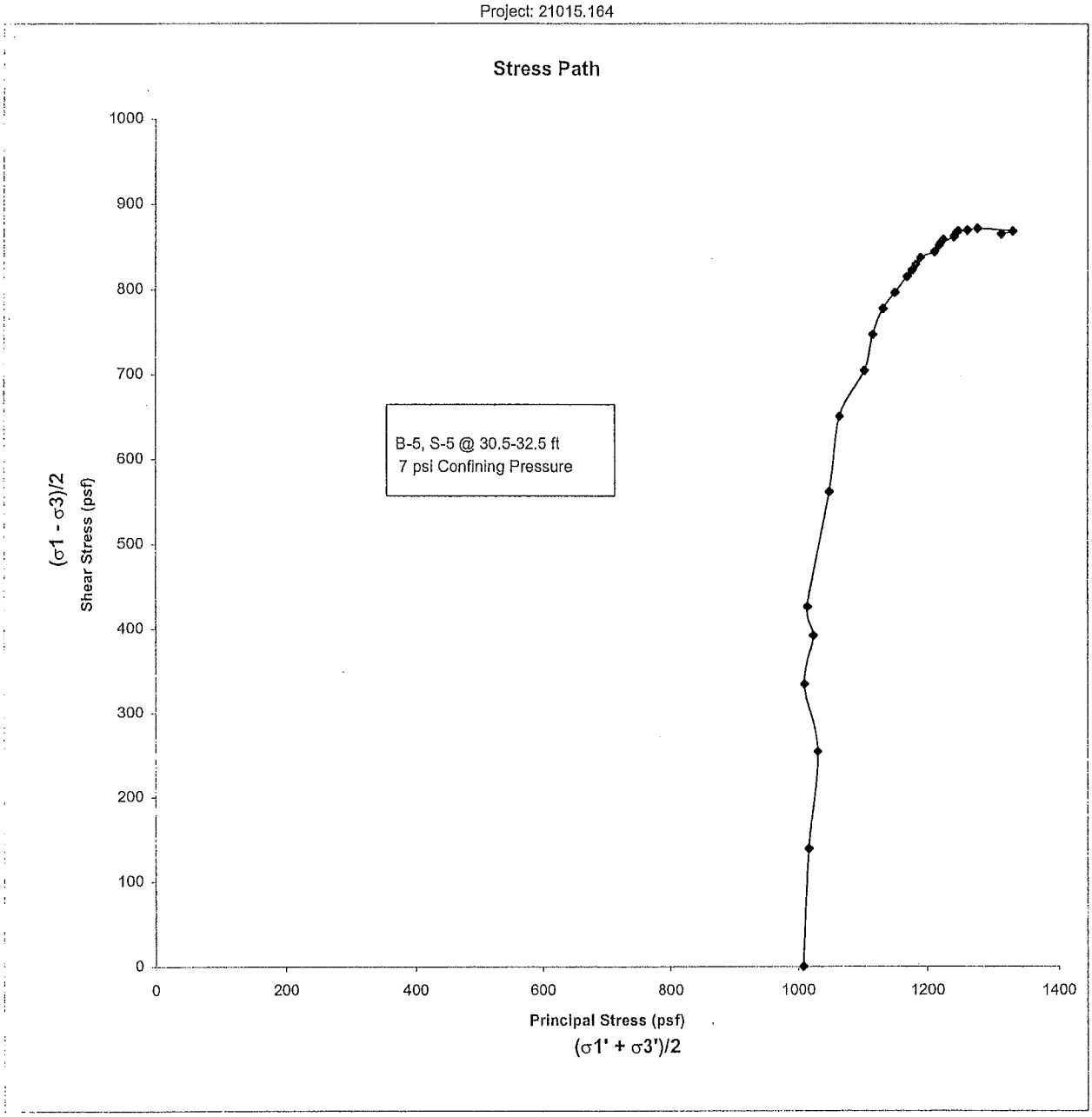

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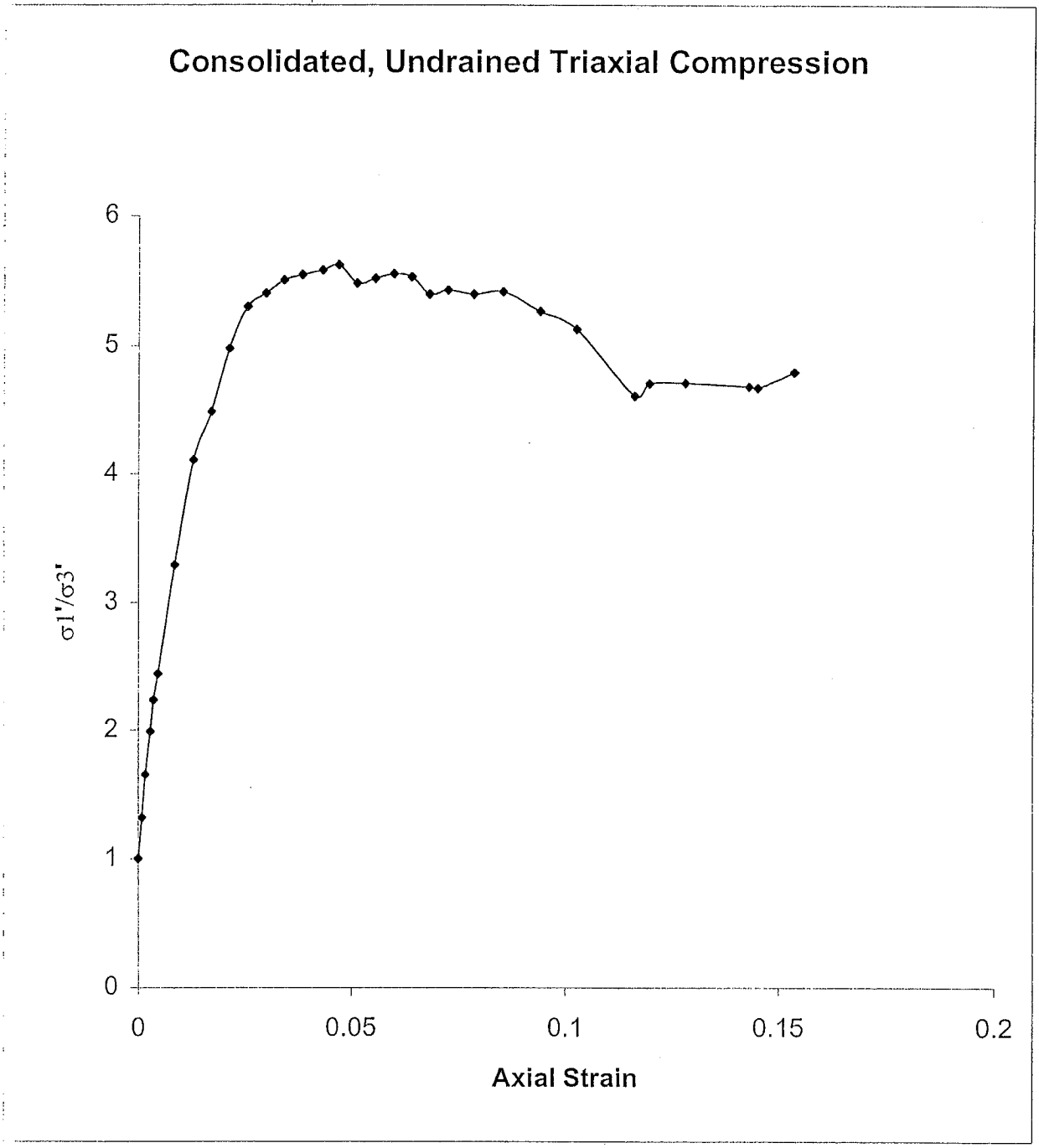

Sample	Depth	Water Content (%)		Void Ratio		Saturation		Unit Weight (lbs/ft^3)		Pressure (psi)		
Number	Feet	Initial	Final	Initial	Final	Initial	Final	Initial Wet	Initial Dry	Consol	Cell	Back
B-5 S-5	30.5-32.5	43.7	44.2	1.23	1.19	0.96	1.00	108.4	75.2	7	37	30

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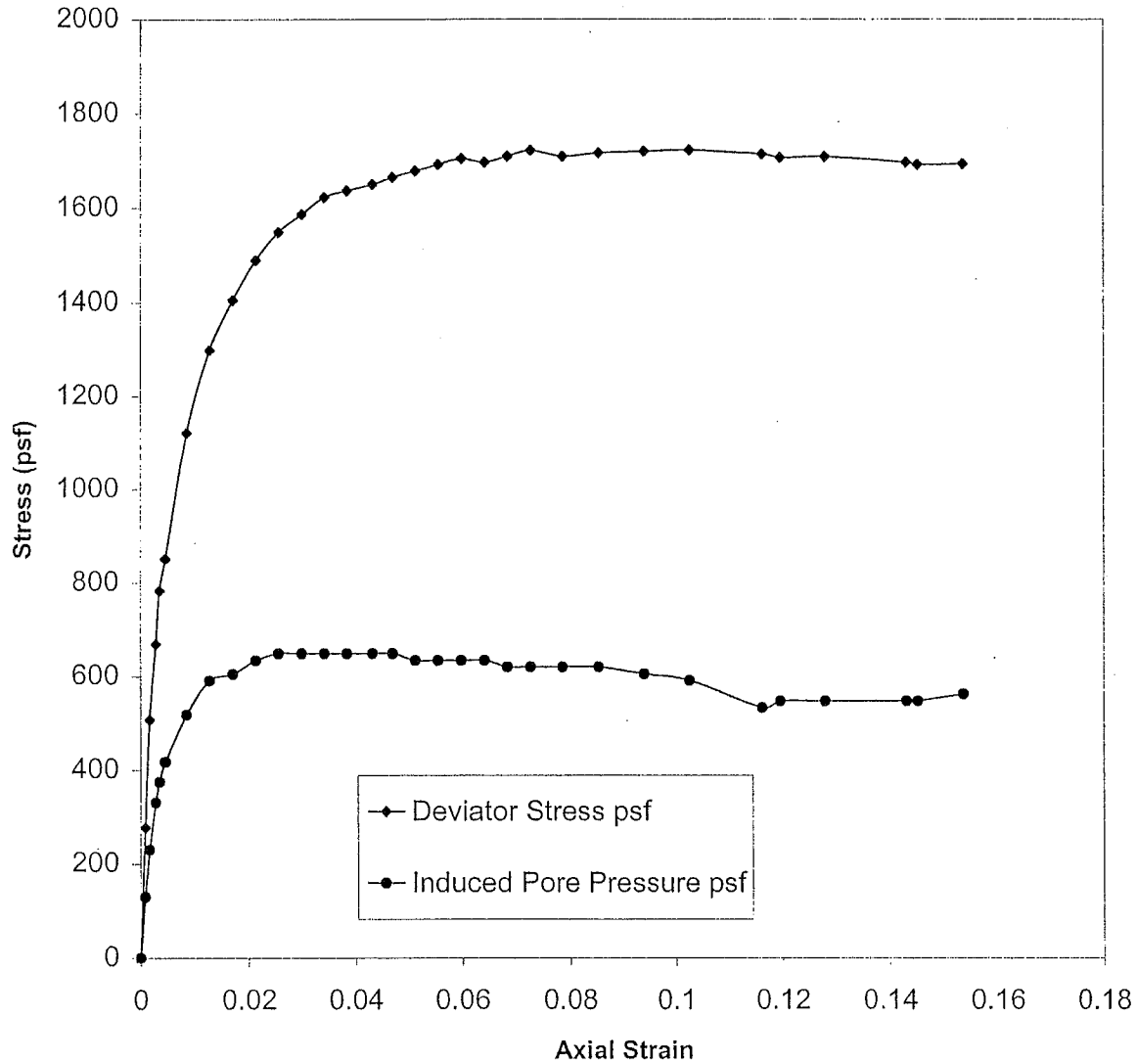
Consolidated, Undrained Triaxial Compression



Sample	Depth	Water Content (%)		Void Ratio		Saturation		Unit Weight (lbs/ft^3)		Pressure (psi)		
Number	feet	Initial	Final	Initial	Final	Initial	Final	Initial Wet	Initial Dry	Consol	Cell	Back
B-5 S-5	30.5-32.5	43.7	44.2	1.23	1.19	0.96	1.00	108	75	7	37	30

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