PBS
Engineering +
Environmental

June 2, 2015

Lewis County Public Works
Attn: Mr. Tim Fife, Assistant County Engineer
2025 NE Kresky Avenue
Chehalis, Washington 98532

Via E-mail: Tim.Fife@lewiscountywa.gov

Re: Geotechnical Engineering Services Report - Addendum No. 1
Roadway Realignment Project
Centralia Alpha Road
Lewis County, Washington
PBS Project No. 73137.000

INTRODUCTION AND BACKGROUND

This report presents the results of the PBS Engineering and Environmental Inc. (PBS) additional subsurface exploration and inclinometer monitoring for the proposed Centralia Alpha Road realignment project in Lewis County, Washington. The County is planning to widen the road in areas, change the road grades to improve line of sight for connector roads, and reconfigure slopes.

On February 12, 2015, PBS collected data from the inclinometer casing installed in boring B-1 (CAB-1) at Station 48+30 of Centralia Alpha Road. The results showed casing deflection at a depth of about 22 feet below the existing ground surface (bgs), which could indicate a failure zone extending beneath the roadway. Consequently, we recommended installing another inclinometer casing and instrumentation to measure groundwater depths approximately 60 feet south of boring B-1 (30 feet south of the road prism) roughly parallel with the assumed direction of slope movement (Figure 1, Site Plan).

In addition, we also recommended increasing the frequency of monitoring events to once a month through June 2015. Our original proposal assumed two visits, with one in February (completed) and one in June 2015. The new scope of services included three additional site visits (performed in March, April, and May).

This report presents the scope of services, subsurface observations, and inclinometer monitoring results for borings B-1 (CAB-1), B-3 (CAB-3), and the newly installed B-9 (CAB-9).

SCOPE OF SERVICES

The purpose of our services was to observe subsurface conditions and provide the results of the inclinometer readings collected through April 2015. PBS completed the following scope of services.

Task 1: Data Collection and Subsurface Explorations

A track-mounted drill rig was used to advance one boring (B-9) to a depth of approximately 41.5 feet below ground surface (bgs) approximately 30 feet south of the road prism and 60 feet south of boring B-1. The boring was logged, groundwater conditions noted, and representative soil samples collected by a member of the PBS geotechnical staff. In-situ standard penetration tests (SPT) were performed at regular 2½- to 5-foot intervals. An undisturbed sample was collected in a thin-wall Shelby tube at 20 feet bgs. Collected samples were returned to our laboratory for visual-manual classification and testing.

Inclinometer casing and a vibrating-wire transducer equipped with a datalogger were installed in the boring for future monitoring.

Task 2: Laboratory Testing

Samples returned to our laboratory were classified in accordance with the United Soil Classification System (UCSC) following ASTM D2488 Visual-Manual Procedure. Laboratory tests included natural water contents, Atterberg limits, and grain-size analyses.

Task 3: Present Results

This addendum report includes a Site Plan showing the pertinent boring locations, the boring logs for B-1 and B-9, description of the subsurface conditions, laboratory test results, and initial instrument monitoring readings for all inclinometer casings.

Task 4: Monitoring of Slope Inclinometer and VWP

Inclinometer and piezometer readings were taken at borings B-1, B-3, and B-9 in March and April 2015. The data were reduced and plotted for summary presentation in this report. Recommendations for additional actions or instrument modifications have been provided, as necessary.

SUBSURFACE EXPLORATIONS

On March 23, 2015, one boring (designated B-9) was drilled to 41.5 feet bgs using mud-rotary drilling techniques by Hard Core Drilling, Inc. of Dundee, Oregon (refer, Figure 1). A PBS engineer observed the general soil conditions that were then used to estimate geotechnical parameters for planning purposes.

Disturbed soil samples were taken in the borings at 2.5- to 5-foot intervals. Soil samples were obtained using a standard 2-inch outside diameter (OD), split-spoon sampler following procedures prescribed for the SPT. Using the SPT, the sampler is driven 18 inches into the soil using a 140-pound hammer dropped 30 inches. The number of blows required to drive the sampler the last 12 inches is defined as the standard penetration resistance (N-value). The N-value provides a measure of the relative density of granular soils, such as sands and gravels, and the consistency of cohesive soils, such as clays and plastic silts. The disturbed soil samples were examined by a PBS engineer in the field and then sealed in plastic bags for further examination and physical testing in our laboratory.

A relatively undisturbed sample was also taken from the boring at approximately 20 feet bgs. The sample was obtained in a 3-inch OD, thin-wall Shelby tube by hydraulically pushing the Shelby tube into undisturbed soil at the bottom of the borehole. The soil exposed at the end of the tube was examined and classified. After field classification, the ends of the tube were capped to preserve the natural moisture of the sample. The tube was returned to our laboratory for further examination and testing.

The logs for B-1, B-3, and B-9 show the various types of materials that were encountered in the borings and the depths where the materials and/or characteristics of these materials changed, although the changes may be gradual (refer, Figures A1, A2, and A3). Where material types and descriptions changed between samples, the contacts were interpreted. The types of samples taken during drilling and the sample identification numbers are shown to the right of the classification of materials on the boring logs. The N-values are shown further to the right. Measured groundwater levels and the dates of the readings are plotted in the column on the right.

The soil types are based on visual-manual classifications using ASTM D 2488-09a guidelines. Consistency, color, relative moisture, degree of plasticity, and other distinguishing characteristics of the soil samples were noted. The samples were reexamined in the PBS laboratory, various standard classification tests were conducted, and the field classifications were modified where necessary. The terminology used in the soil classifications and other modifiers are defined and presented on the attached Tables A-1 and A-2.

The logs for borings B-1 and B-9 summarizing the subsurface conditions encountered are presented on the attached Figures A1 and A3. PBS has summarized the subsurface units below the existing ground surface as follows:

Boring B-1

PAVEMENT SECTION:	Asphalt Concrete – 12 inches thick. Base Course – 6 inches thick.
FILL:	1.5 to 9 feet bgs: – Fill encountered in boring B-1 consisted of 2.5 feet of brown poorly graded SAND (SP) underlain by poorly graded GRAVEL (GP). The relative densities were very loose to medium dense, with N-values between 4 and 16 blows per foot.
LOGAN HILL FORMATION:	9 to 21.5 feet bgs – Logan Hill Formation was encountered in boring B-1 beneath the fill and consisted of light brown Fat CLAY (CH). The consistency was soft to medium stiff with high plasticity and N-values between 4 and 5 blows per foot.
WILKES FORMATION:	21.5 to 35.8 feet bgs – Wilkes Formation was encountered in the boring and extended to a depth of at least 35.8 feet bgs. The unit consisted of brown and gray Fat CLAY (CH). A 1-foot thick dense gray clayey SAND (SC) layer was encountered 21.5 feet bgs. The consistency of the clay was stiff to very hard with high plasticity and N-values between 14 and 50/3” blows per foot.

Boring B-9

LOGAN HILL FORMATION:	0 to 18 feet bgs – Logan Hill Formation was encountered in boring B-9. The unit generally consisted of light brown Elastic SILT (MH). The consistency was soft to stiff with high plasticity (PI=24) and N-values between 4 and 15 blows per foot.
WILKES FORMATION:	18 to 41.5 feet bgs – Wilkes Formation was encountered in the boring and extended to a depth of at least 41.5 feet bgs. The upper 4 feet consisted of gray Fat CLAY (CH) with gravel underlain by gray Fat CLAY (CH). The consistency was very stiff to hard with high plasticity (PI=30) and N-values between 17 and 35 blows per foot.

Groundwater

The depth to groundwater was measured 24 hours after drilling on March 24, 2015, at approximately 22 feet bgs. Please note that groundwater levels can fluctuate during the year depending on climate and other factors including precipitation and irrigation. Generally, the highest groundwater levels occur in late winter and early spring; and the lowest levels in late summer and early fall. We recommend that the contractor determine the actual groundwater levels at the time of construction to determine potential groundwater impacts.

LABORATORY

Soil samples obtained during our exploration were returned to the laboratory to assist in soil classification and to evaluate the material's general physical properties and engineering characteristics. Laboratory tests included natural moisture contents, Atterberg limits, and grain-size analysis. Laboratory test results are presented on the boring logs.

The applicable ASTM methods were used to perform the laboratory tests and included the following:

ASTM D 2488-09a – Visual Classification

The soils were classified in accordance with the Unified Soil Classification System with certain other terminology, such as the relative density or consistency of the soil deposits, in general accordance with engineering practice. In determining the soil type (that is, gravel, sand, silt, or clay) the term that best described the major portion of the sample was used. Modifying terminology to further describe the samples is defined on the attached Table A-1.

ASTM 2216 – Moisture Content

Natural moisture content determinations were made on samples of the fine-grained soils (that is, silts, clays, and silty sands). The natural moisture content is defined as the ratio of the weight of water to dry weight of soil, expressed as a percentage. The results of the moisture content determinations are presented on Figures A1 and A2.

ASTM D 4318 – Atterberg Limits

Atterberg limits were determined for select soil samples for classifying soils into various groups for correlation. The results of the Atterberg limits tests, which included liquid and plastic limits, are plotted on the attached Figure B1 and on the boring logs, Figures A1 and A2.

ASTM D 422 – Grain-Size Analysis

Grain Size Analyses (ASTM D422) were completed on soil samples to determine the portion of soil passing the No. 200 Sieve (that is, silt and clay) for classification purposes. The results of grain-size testing are presented on the boring logs, Figures A1 and A2.

INCLINOMETER MONITORING

Three slope inclinometers designated CAB-1, CAB-3, CAB-9 are being monitored along Centralia Alpha Road. The inclinometers consist of 2.75-inch diameter polyvinyl chloride casing with interior tracks to insert a monitoring probe down the casing. The inclinometer probe attaches to a datalogger and measures and records inclinometer casing deflection, presumably related to ground movement.

Slope Indicator^{TM} manufactures this probe and datalogger system and publishes an error calculation formula that reports the instrument accuracy based on the number of data points involved in calculating observed cumulative deflection. If there is no new discernible deflection in the inclinometer plots, or the deflection measured is less than the calculated error, the results are reported as a value less than the calculated error.

Inclinometer CAB-1. Inclinometer CAB-1, located near Station 48+30, recorded measurable deflection of 0.14 inches since the last monitoring event between depths of 20 feet and 24 feet bgs from October 2014 and February 2015. Subsequent readings in March and April 2015 did not show additional casing deflection. The cumulative casing displacements on the A- (downslope) and B-axes (perpendicular to A-axis) are presented in Figure C1.

Inclinometer CAB-3. Inclinometer CAB-3, located near Station 51+00, recorded deflection of less than the instrument accuracy of casing deflections of 0.002 inches since the last monitoring event. The cumulative casing displacements on the A- and B-axes are presented in Figure C2.

Inclinometer CAB-9. Inclinometer CAB-9, located approximately 60 feet south of CAB-1 near Station 48+30, recorded deflection of less than the instrument accuracy of casing deflections of 0.002 inches since the baseline monitoring event in March 2015. The cumulative casing displacements on the A- and B-axes are presented in Figure C3.

Vibrating Wire Transducer

Geokon Model 4500 vibrating wire piezometers were installed in CAB-3 and CAB-9 at depths of 38.8 and 38.5 feet bgs, respectively, and attached to Model LC-2 single channel dataloggers. The systems are programmed to collect readings at 1-hour intervals. The data are converted into groundwater depths using the manufacturer's instrument data sheets. Based on these readings, the groundwater depth has fluctuated between about 30 feet and 32 feet bgs in CAB-3 and between 22 and 24 feet bgs in CAB-9. Figure C4 in Attachment C presents the groundwater depths between October 15, 2014, and April 23, 2015.

CONCLUSIONS

The inclinometer casing measurements represent the cumulative deflections over the 6-month period following our geotechnical engineering investigation in CAB-1 and CAB-3 and a 2-month period following the installation in boring B-9. Cumulative displacement of 0.14 inches was measured in CAB-1, which equates to approximately ½ inch per year, between depths of 20 feet and 24 feet bgs in the prior 4 months. No additional casing deflection has been measured since February 2015. Measureable casing deflections were not observed in CAB-3 or CAB-9.

RECOMMENDATIONS

Based on the measured displacement in CAB-1, lack of recent rainfall, and the anticipated end to the rainy season, PBS recommends postponing the May and June 2015 monitoring events until December 2015 or after. Existing road damage indicates slope instability associated primarily with the 8 to 10 feet of fill material present along the northern edge of the road. The measured deflection in CAB-1between 20 feet and 24 feet bgs could correspond to a deeper-seated landslide zone. Construction grading as currently proposed may destabilize this area by removing toe support.

LIMITATIONS

This report has been prepared for the exclusive use of the addressee and their engineers for aiding in the design and construction of the proposed development and is not to be relied upon by other parties. It is not to be photographed, photocopied, or similarly reproduced, in total or in part, without express written consent of the Client and PBS. It is the addressee's responsibility to provide this report to the appropriate design professionals, building officials, and contractors to assure correct implementation of the recommendations.

Instrument monitoring and observations reported are for conditions observed at the time of our services and may not be the same at other times. As our client, please recognize that instrumentation monitoring is a technique employed to reduce risk. PBS cannot be responsible for interpretation of this report by others. Conditions at other locations and times may vary and data are limited to the accuracy of the instruments. Provision of instrumentation monitoring by PBS personnel is not insurance, nor does it guarantee against ground movement or facility impacts. Unless indicated in the report, the data obtained from each instrument represents on-going collection of data, not the final data for the instrument. In all cases, Lewis County shall retain sole responsibility for any and all damages related to the feature or features being monitored, regardless of when they may occur or are found.

CLOSING

We trust this instrument monitoring report meets your current needs. Please contact Mark Swank at 503.417.7738 if you have any questions or wish to discuss our observations, conclusions, and recommendations further.

Sincerely,
PBS Engineering and Environmental Inc.

State of Washington
Expires 4/21/2016
Engineering Geologist
2960
Licensed Geologist
Mark Swank

Mark Swank, LG, LEG
Senior Engineering Geologist

MS/RW/rg

FIGURES

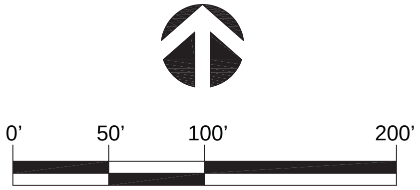
ATTACHMENTS

FIGURES

SOURCE: GOOGLE EARTH PRO JULY 2014 IMAGE

LEGEND

⊕ B-1	BORING NUMBER AND LOCATION



SCALE: 1” = 100’

PREPARED FOR: LEWIS COUNTY

PBS

PROJECT #
73137.000

DATE
NOV 2014

SITE PLAN

CENTRALIA ALPHA ROAD
CHEHALIS, WASHINGTON

FIGURE
1

ATTACHMENT A

Field Explorations

Soil Descriptions

Soils exist in mixtures with varying proportions of components. The predominant soil, i.e., greater than 50 percent based upon total dry weight, is the primary soil type and is capitalized in our log descriptions, e.g., SAND, GRAVEL, SILT or CLAY. Lesser percentages of other constituents in the soil mixture are indicated by use of modifier words in general accordance with the Visual-Manual Procedure (ASTM D2488-06). “General Accordance” means that certain local and common descriptive practices have been followed. In accordance with ASTM D2488-06, group symbols (such as GP or CH) are applied on that portion of the soil passing the 3-inch (75mm) sieve based upon visual examination. The following describes the use of soil names and modifying terms used to describe fine- and coarse-grained soils.

Fine - Grained Soils (More than 50% fines passing 0.075 mm, #200 sieve)
The primary soil type, i.e. SILT or CLAY is designated through visual – manual procedures to evaluate soil toughness, dilatency, dry strength, and plasticity. The following describes the terminology used to describe fine - grained soils, and varies from ASTM 2488 terminology in the use of some common terms.

Primary soil NAME, adjective and symbols			Plasticity Description	Plasticity Index (PI)
SILT ML & MH	**CLAY** CL & CH	**ORGANIC SILT & CLAY** OL & OH		
SILT		Organic SILT	Non-plastic	0 - 3
SILT		Organic SILT	Low plasticity	4 - 10
SILT / Elastic SILT	Lean CLAY	Organic clayey SILT	Medium Plasticity	10 – 20
Elastic SILT	Lean/Fat CLAY	Organic silty CLAY	High Plasticity	20 – 40
Elastic SILT	Fat CLAY	Organic CLAY	Very Plastic	>40

Modifying terms describing secondary constituents, estimated to 5 percent increments, are applied as follows:

Description	% Composition
With sand; with gravel (combined total greater than 15% but less than 30%, modifier is whichever is greater)	15% to 25%
Sandy; or gravelly (combined total greater than 30% but less than 50%, modifier is whichever is greater)	30% to 50%

Borderline Symbols, for example CH/MH, are used where soils are not distinctly in one category or where variable soil units contain more than one soil type. **Dual Symbols,** for example CL-ML, are used where two symbols are required in accordance with ASTM D2488.

Soil Consistency. Consistency terms are applied to fine-grained, plastic soils (i.e., PI ≥ 7). Descriptive terms are based on direct measure or correlation to the Standard Penetration Test N-value as determined by ASTM D1586-84, as follows. Note, SILT soils with low to non-plastic behavior (i.e. PI < 7) are classified using relative density.

Consistency Term	SPT N-value	Unconfined Compressive Strength tsf	kPa
Very soft	Less than 2	Less than 0.25	Less than 24
Soft	2 – 4	0.25 - 0.5	24 - 48
Medium stiff	5 – 8	0.5 - 1.0	48 – 96
Stiff	9 – 15	1.0 - 2.0	96 – 192
Very stiff	16 – 30	2.0 - 4.0	192 – 383
Hard	Over 30	Over 4.0	Over 383

Soil Descriptions

Coarse - Grained Soils (less than 50% fines)
Coarse-grained soil descriptions, i.e., SAND or GRAVEL, are based on that portion of materials passing a 3-inch (75mm) sieve. Coarse-grained soil group symbols are applied in accordance with ASTM D2488-06 based upon the degree of grading, or distribution of grain sizes of the soil. For example, well graded sand containing a wide range of grain sizes is designated SW; poorly graded gravel, GP, contains high percentages of only certain grain sizes. Terms applied to grain sizes follow.

Material	Particle Diameter	
	Inches	Millimeters
Sand (S)	0.003 - 0.19	0.075 - 4.8
Gravel (G)	0.19 - 3.0	4.8 - 75
	Additional Constituents	
Cobble	3.0 - 12	75 - 300
Boulder	12 - 120	300 - 3050

The primary soil type is capitalized, and the amount of fines in the soil are described as indicated by the following examples. Other soil mixtures will provide similar descriptive names.

Example: Coarse-Grained Soil Descriptions with Fines

5% to less than 15% fines (Dual Symbols)	15% to less than 50% fines
GRAVEL with silt, GW-GM	Silty GRAVEL: GM
SAND with clay, SP-SC	Silty SAND: SM

Additional descriptive terminology applied to coarse-grained soils follow.

Example: Coarse-Grained Soil Descriptions with Other Coarse-Grained Constituents

Coarse-Grained Soil Containing Secondary Constituents	
With sand or with gravel	> 15% sand or gravel
With cobbles; with boulders	Any amount of cobbles or boulders.

Cobble and boulder deposits may include a description of the matrix soils, as defined above.

Relative Density terms are applied to granular, non-plastic soils based on direct measure or correlation to the Standard Penetration Test N-value as determined by ASTM D1586-84.

Relative Density Term	SPT N-value
Very loose	0 - 4
Loose	5 - 10
Medium dense	11 - 30
Dense	31 - 50
Very dense	> 50

Rock Descriptions

Scale of Rock Strength

Description	Designation	Unconfined Compressive Strength, psi	Unconfined Compressive Strength, MPa	Field Identification
Extremely weak rock	R0	35 – 150	0.25 – 1	Indented by thumbnail.
Very weak rock	R1	150 – 725	1 – 5	Crumbles under firm blows with point of geology pick; can be peeled by a pocket knife.
Weak rock	R2	725 – 3,500	5 – 25	Can be peeled with a pocket knife; shallow indentation made by firm blow with point of geological hammer.
Medium weak rock	R3	3,500 – 7,000	25 – 50	Cannot by scraped or peeled with a pocket knife; specimen can be fractured with a single firm blow of geological hammer.
Strong rock	R4	7,000 – 15,000	50 – 100	Specimen requires more than one blow with a geological hammer to fracture it.
Very strong rock	R5	15,000 – 36,000	100 – 250	Specimen requires many blows of geological hammer to fracture it.
Extremely strong rock	R6	> 36,000	> 250	Specimen can only be chipped with geological hammer.

Descriptive Terminology for Fracture Density

(Excludes mechanical breaks)

Descriptive Term	Core Description
Unfractured	No fractures
Very Slightly	Core recovered mostly in lengths > 3 feet
Slightly	Core recovered mostly in lengths of 1 to 3 feet
Moderately	Core recovered mostly in lengths of 0.3 to 1 feet with most 0.6 feet
Intensely	Core lengths average from 0.1 to 0.3 feet with scattered fragment intervals
Very Intensely	Core recovered as chips and fragments with a few scattered short core lengths

Descriptive Terminology for Vesicularity

Descriptive Term	Percent voids by volume
Dense	< 1%
Slightly vesicular	1 – 10%
Moderately vesicular	10 – 30%
Highly vesicular	30 – 50%
Scoriaceous	> 50%

Correlation of RQD and Rock Quality

Rock Quality Descriptor	RQD Value
Very poor	0 – 25
Poor	25 - 50
Fair	50 - 75
Good	75 – 90

Table A-1
Terminology Used to Describe Soil and Rock

Rock Descriptions

Scale of Rock Weathering

Stage	Description	Quality Distinction
Fresh	Rock is fresh, crystals are bright, few joints may show slight staining as a result of ground water.	No discoloration
Very Slight	Rock is generally fresh, joints are stained, some joints may have thin clay coatings, crystals in broken face show bright.	Discoloration only on major discontinuity surfaces [1]
Slight	Rock is generally fresh, joints are stained and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some feldspar crystals are dull and discolored. Rocks ring under hammer if crystalline.	Discoloration on all discontinuity surfaces and on rock
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some are clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.	Decomposition and/or disintegration < 50% of rock [2]
Moderately Severe	All rock, except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick. Rock goes "clunk" when struck.	Decomposition and/or disintegration > 50%, but not complete
Severe	All rock, except quartz, discolored or stained. Rock "fabric" is clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of harder rock usually left, such as corestones in basalt.	
Very Severe	All rock, except quartz, discolored or stained. Rock "fabric" is discernible, but mass effectively reduced to "soil" with only fragments of harder rock remaining.	Decomposition and/or disintegration 100% with structure/fabric intact
Complete	Rock is reduced to "soil". Rock "fabric" is not discernible, or only in small scattered locations. Quartz may be present as dikes or stringers.	Decomposition and/or disintegration 100% with structure/fabric destroyed

NOTES:

[1] Discontinuities consist of any natural break (joint, fracture or fault) or plane of weakness (shear or gouge zone, bedding plane) in a rock mass

[2] Decomposition refers to chemical alteration of mineral grains; disintegration refers to mechanical breakdown

[3] Stage and description from ASCE Manual No. 56 (1976), quality distinction from Murray (1981)

Rock strength scale taken from Duncan C. Wyllie, "Foundations on Rock, Second Edition, 1999".

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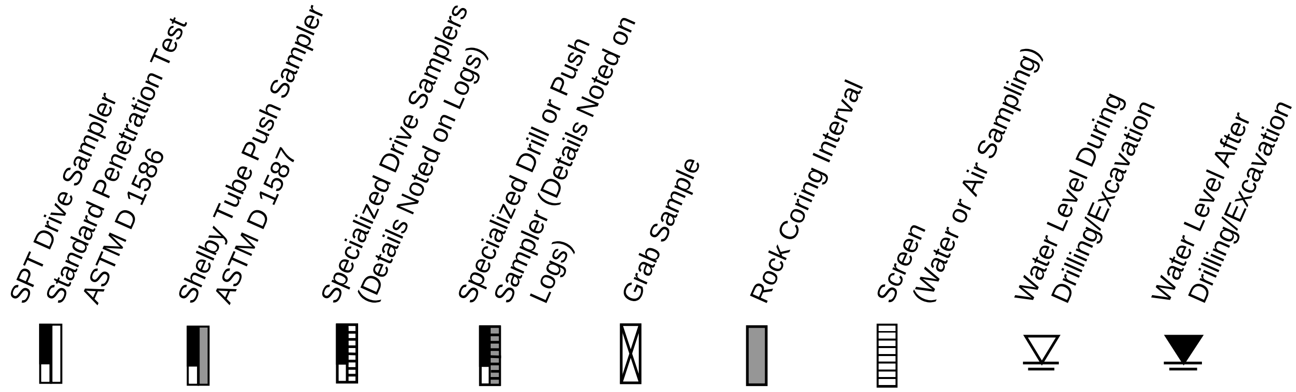
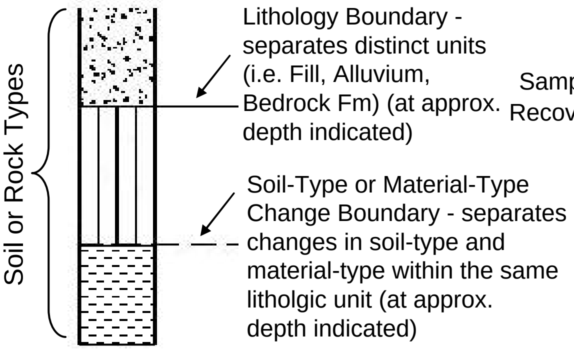
Table A-2
Key To Test Pit and Boring Log Symbols

SAMPLING DESCRIPTIONS[1]

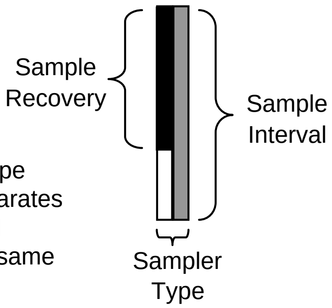


LOG GRAPHICS

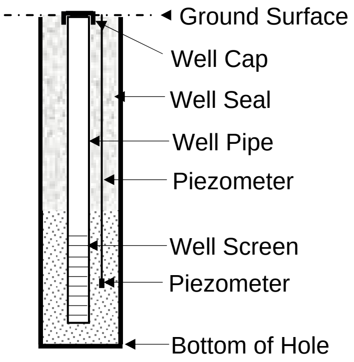
Soil and Rock



Sampling Symbols



Instrumentation Detail



Geotechnical Testing/Acronym Explanations

PP	Pocket Penetrometer	LL	Liquid Limit
DD	Dry Density	ATT	Atterberg Limits
DCP	Dynamic Cone Penetrometer	SIEV	Sieve Gradation
TOR	Torvane	CBR	California Bearing Ratio
CON	Consolidation	OC	Organic Content
DS	Direct Shear	RES	Resilient Modulus
P200	Percent Passing U.S. Standard No. 200 Sieve	VS	Vane Shear
UC	Unconfined Compressive Strength	HYD	Hydrometer Gradation
PL	Plasticity Limit	bgs	Below ground surface
PI	Plasticity Index	MSL	Mean Sea Level

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[1]Note: Details of soil and rock classification systems are available on request.

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4412 SW Corbett Avenue
Portland, Oregon 97239
Phone: 503.248.1939
Fax: 866.727.0140

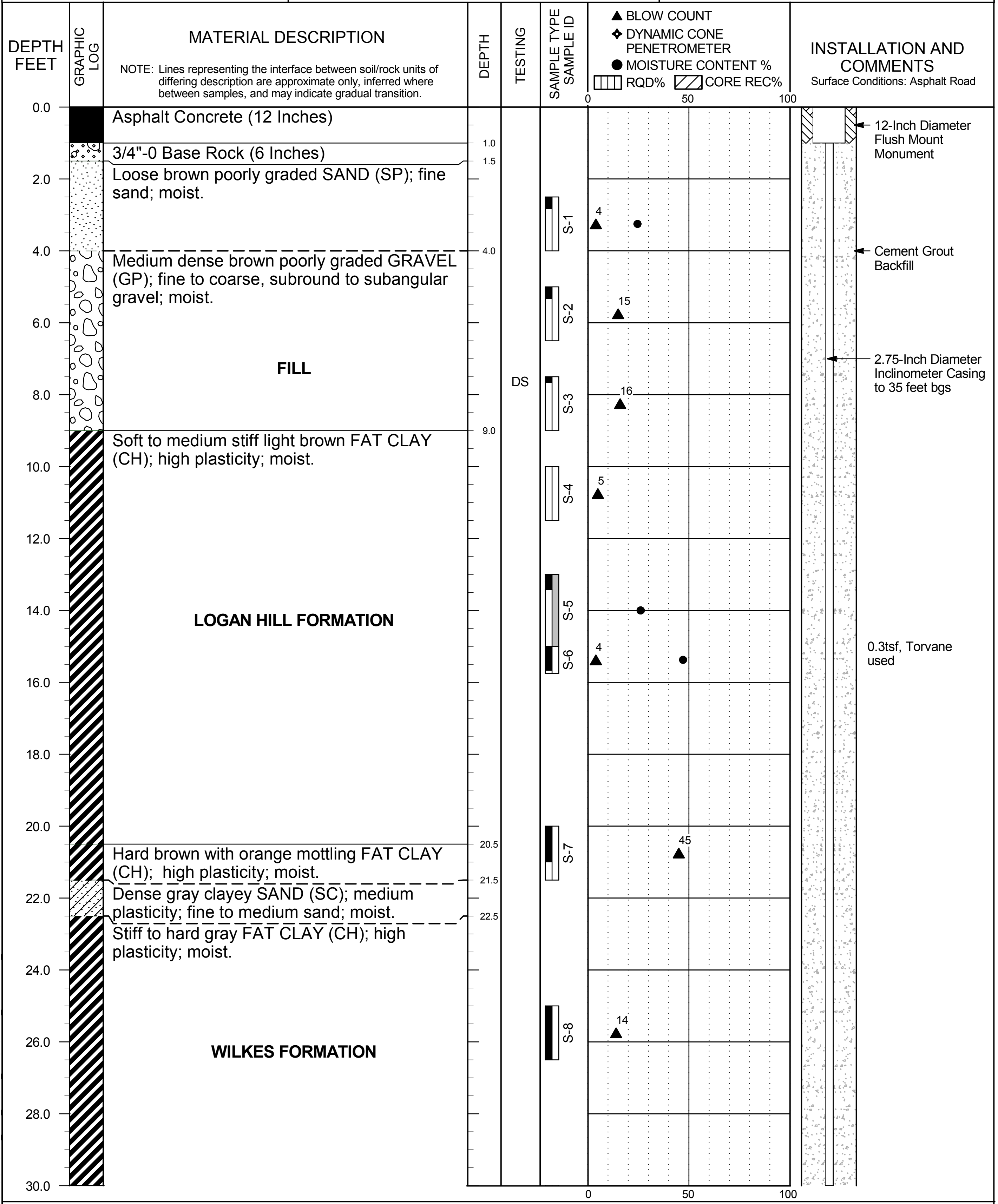
CENTRALIA ALPHA ROAD IMPROVEMENTS
LEWIS COUNTY, WA

PBS PROJECT NUMBER:
73137.000

BORING B-1

APPROX. BORING B-1 LOCATION:
STATION 49+00
(See Site Plan)

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.



Depth (ft)	Material Description
0.0–1.0	Asphalt Concrete (12 Inches)
1.0–1.5	3/4"-0 Base Rock (6 Inches)
1.5–4.0	Loose brown poorly graded SAND (SP); fine sand; moist.
4.0–9.0	Medium dense brown poorly graded GRAVEL (GP); fine to coarse, subround to subangular gravel; moist.
	FILL
9.0–20.5	Soft to medium stiff light brown FAT CLAY (CH); high plasticity; moist.
	LOGAN HILL FORMATION
20.5–21.5	Hard brown with orange mottling FAT CLAY (CH); high plasticity; moist.
21.5–22.5	Dense gray clayey SAND (SC); medium plasticity; fine to medium sand; moist.
22.5–	Stiff to hard gray FAT CLAY (CH); high plasticity; moist.
	WILKES FORMATION

12-Inch Diameter Flush Mount Monument

Cement Grout Backfill

2.75-Inch Diameter Inclinometer Casing to 35 feet bgs

0.3tsf, Torvane used

DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Rikli

BIT DIAMETER: 4 7/8-inch
HAMMER EFFICIENCY PERCENT: 82
LOGGING COMPLETED: 10/09/14

FIGURE A1

PBS Engineering + Environmental
4412 SW Corbett Avenue
Portland, Oregon 97239
Phone: 503.248.1939
Fax: 866.727.0140

CENTRALIA ALPHA ROAD IMPROVEMENTS
LEWIS COUNTY, WA

PBS PROJECT NUMBER:
73137.000

BORING B-1
(continued)

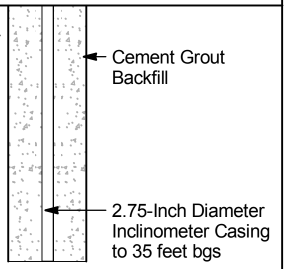
APPROX. BORING B-1 LOCATION:
STATION 49+00
(See Site Plan)

▲ BLOW COUNT
✦ DYNAMIC CONE PENETROMETER
● MOISTURE CONTENT %
▥ RQD%
▨ CORE REC%

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

INSTALLATION AND COMMENTS
Surface Conditions: Asphalt Road

DEPTH FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE TYPE SAMPLE ID	BLOW COUNT (0 – 50 – 100)
30.0	Stiff to hard gray FAT CLAY (CH); high plasticity; moist. **WILKES FORMATION**			S-9	44-50/5"
35.0				S-10	44-50/3"
35.8	Final depth 35.8 feet below ground surface; Inclinometer Casing installed	35.8			
36.0 – 60.0					



DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Rikli

BIT DIAMETER: 4 7/8-inch
HAMMER EFFICIENCY PERCENT: 82
LOGGING COMPLETED: 10/09/14

FIGURE A1

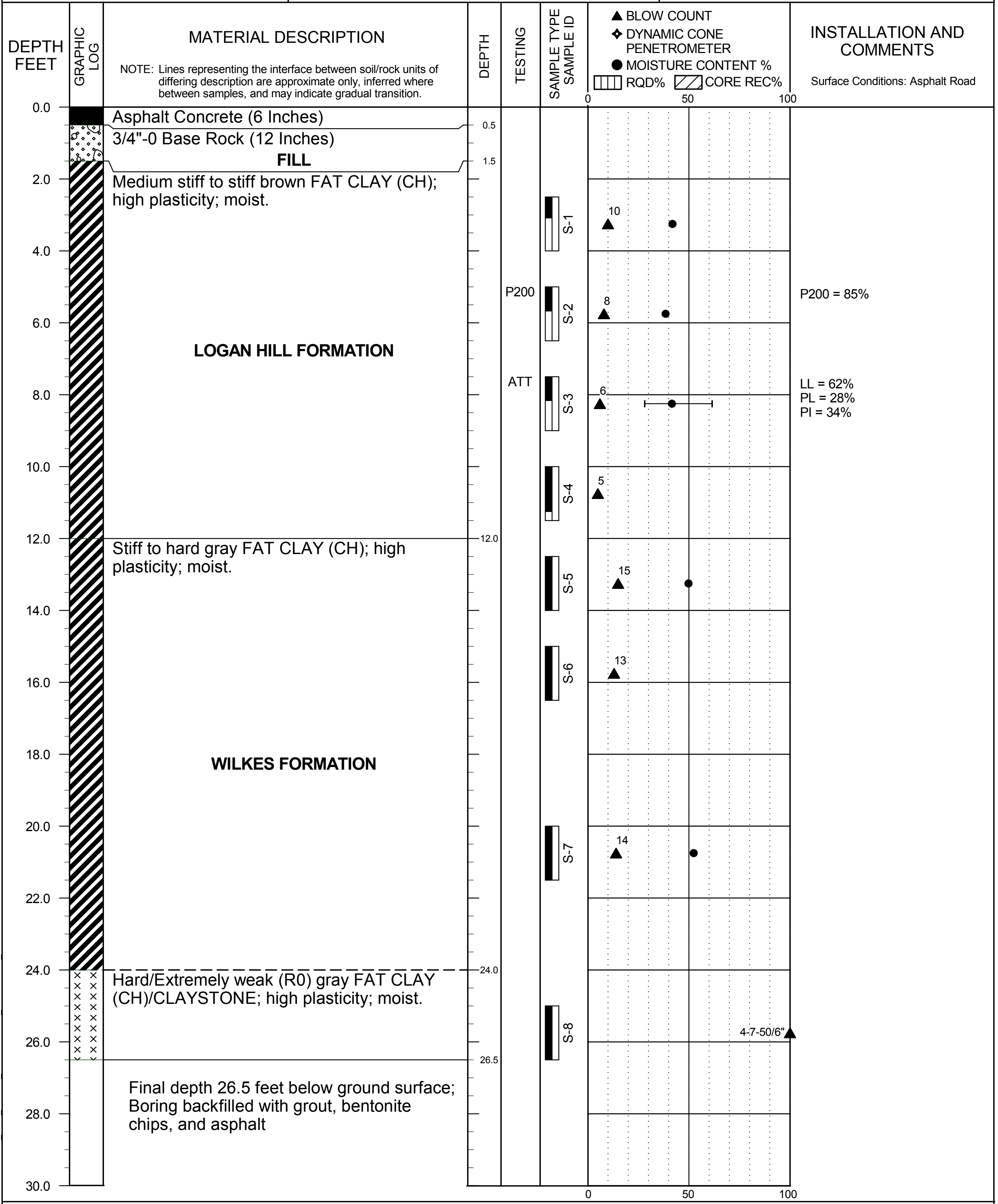
PBS Engineering + Environmental
4412 SW Corbett Avenue
Portland, Oregon 97239
Phone: 503.248.1939
Fax: 866.727.0140

CENTRALIA ALPHA ROAD IMPROVEMENTS
LEWIS COUNTY, WA

PBS PROJECT NUMBER:
73137.000

BORING B-2

APPROX. BORING B-2 LOCATION:
STATION 50+00
(See Site Plan)



NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

Surface Conditions: Asphalt Road

Asphalt Concrete (6 Inches)

3/4"-0 Base Rock (12 Inches)

FILL

Medium stiff to stiff brown FAT CLAY (CH); high plasticity; moist.

LOGAN HILL FORMATION

Stiff to hard gray FAT CLAY (CH); high plasticity; moist.

WILKES FORMATION

Hard/Extremely weak (R0) gray FAT CLAY (CH)/CLAYSTONE; high plasticity; moist.

Final depth 26.5 feet below ground surface; Boring backfilled with grout, bentonite chips, and asphalt

P200 = 85%

LL = 62%
PL = 28%
PI = 34%

DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Rikli

BIT DIAMETER: 4 7/8-inch
HAMMER EFFICIENCY PERCENT: 82
LOGGING COMPLETED: 10/10/14

FIGURE A2

PBS Engineering + Environmental

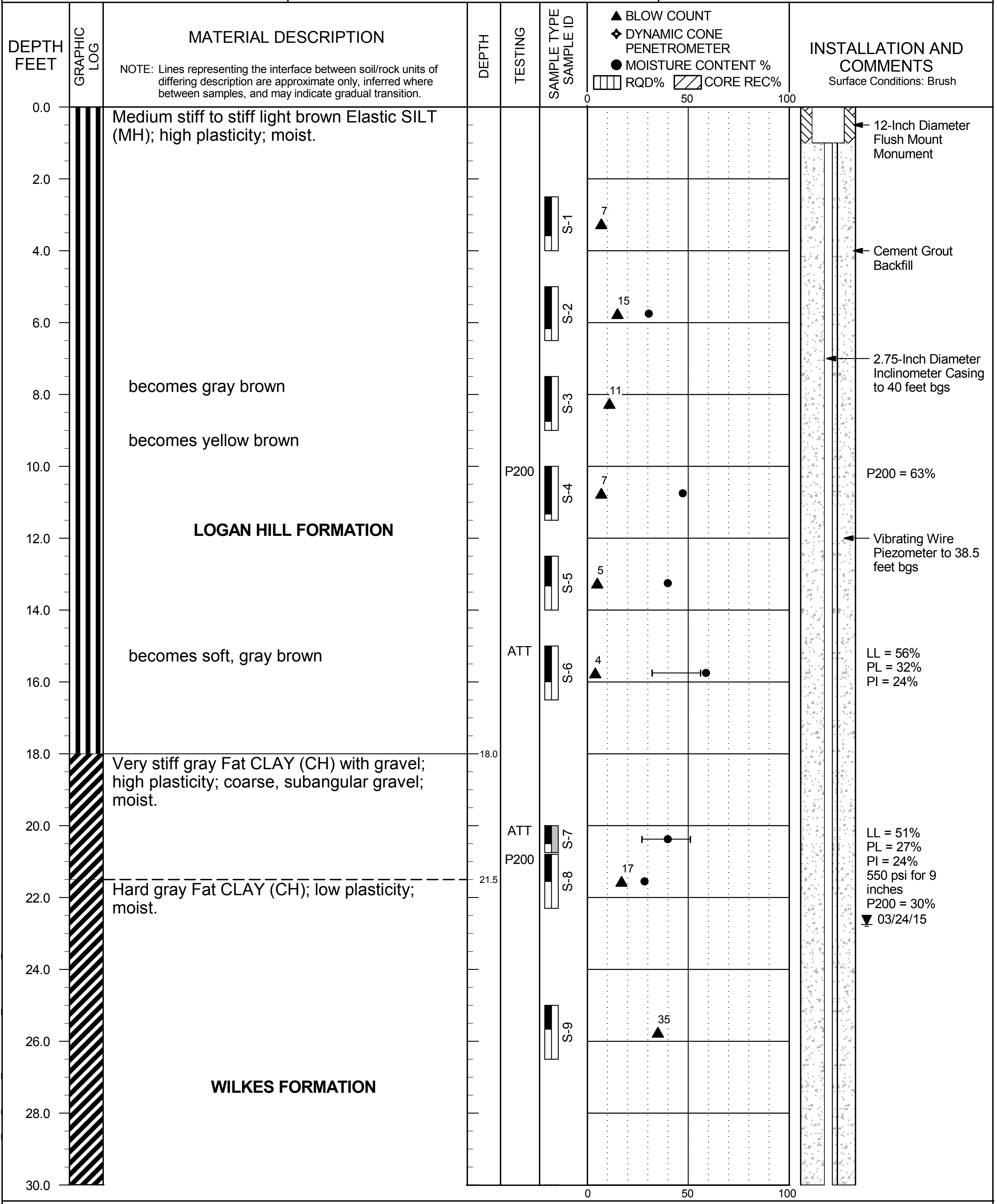
4412 SW Corbett Avenue
Portland, Oregon 97239
Phone: 503.248.1939
Fax: 866.727.0140

CENTRALIA ALPHA ROAD IMPROVEMENTS
LEWIS COUNTY, WA

BORING B-9

PBS PROJECT NUMBER:
73137.000

APPROX. BORING B-9 LOCATION:
(See Site Plan)



NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

Surface Conditions: Brush

Medium stiff to stiff light brown Elastic SILT (MH); high plasticity; moist.

becomes gray brown

becomes yellow brown

LOGAN HILL FORMATION

becomes soft, gray brown

Very stiff gray Fat CLAY (CH) with gravel; high plasticity; coarse, subangular gravel; moist.

Hard gray Fat CLAY (CH); low plasticity; moist.

WILKES FORMATION

12-Inch Diameter Flush Mount Monument

Cement Grout Backfill

2.75-Inch Diameter Inclinometer Casing to 40 feet bgs

P200 = 63%

Vibrating Wire Piezometer to 38.5 feet bgs

LL = 56%
PL = 32%
PI = 24%

LL = 51%
PL = 27%
PI = 24%
550 psi for 9 inches
P200 = 30%
▼ 03/24/15

DRILLING METHOD: Mud Rotary
DRILLED BY: Hardcore Drilling
LOGGED BY: T. Rikli

BIT DIAMETER: 4 7/8 inches
HAMMER EFFICIENCY PERCENT:
LOGGING COMPLETED: 3/23/15

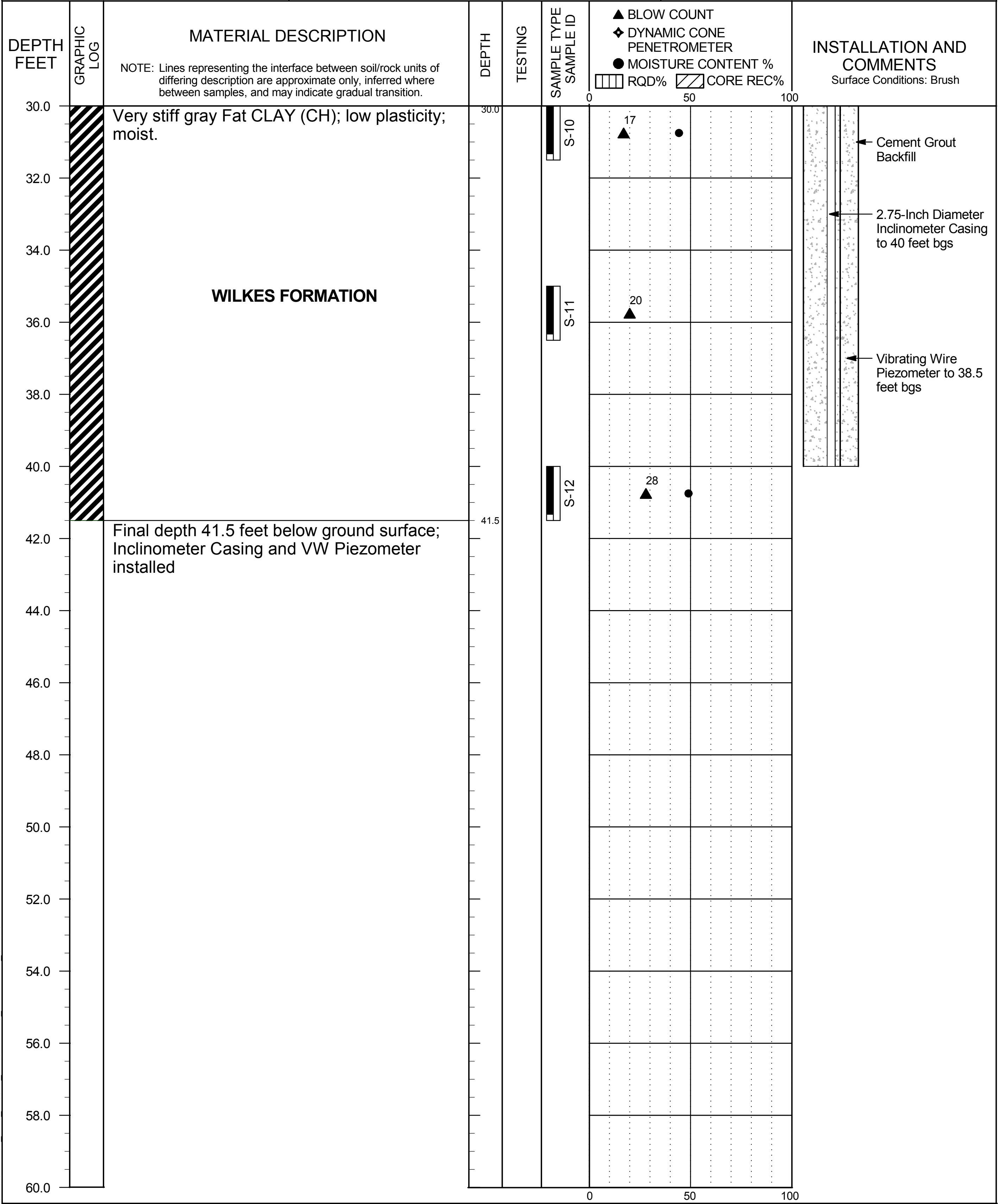
FIGURE A3

CENTRALIA ALPHA ROAD IMPROVEMENTS
LEWIS COUNTY, WA

PBS PROJECT NUMBER:
73137.000

BORING B-9
(continued)

APPROX. BORING B-9 LOCATION:
(See Site Plan)



NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

Very stiff gray Fat CLAY (CH); low plasticity; moist.

WILKES FORMATION

Final depth 41.5 feet below ground surface; Inclinometer Casing and VW Piezometer installed

DRILLING METHOD: Mud Rotary
DRILLED BY: Hardcore Drilling
LOGGED BY: T. Rikli

BIT DIAMETER: 4 7/8 inches
HAMMER EFFICIENCY PERCENT:
LOGGING COMPLETED: 3/23/15

FIGURE A3

ATTACHMENT B

Laboratory Results

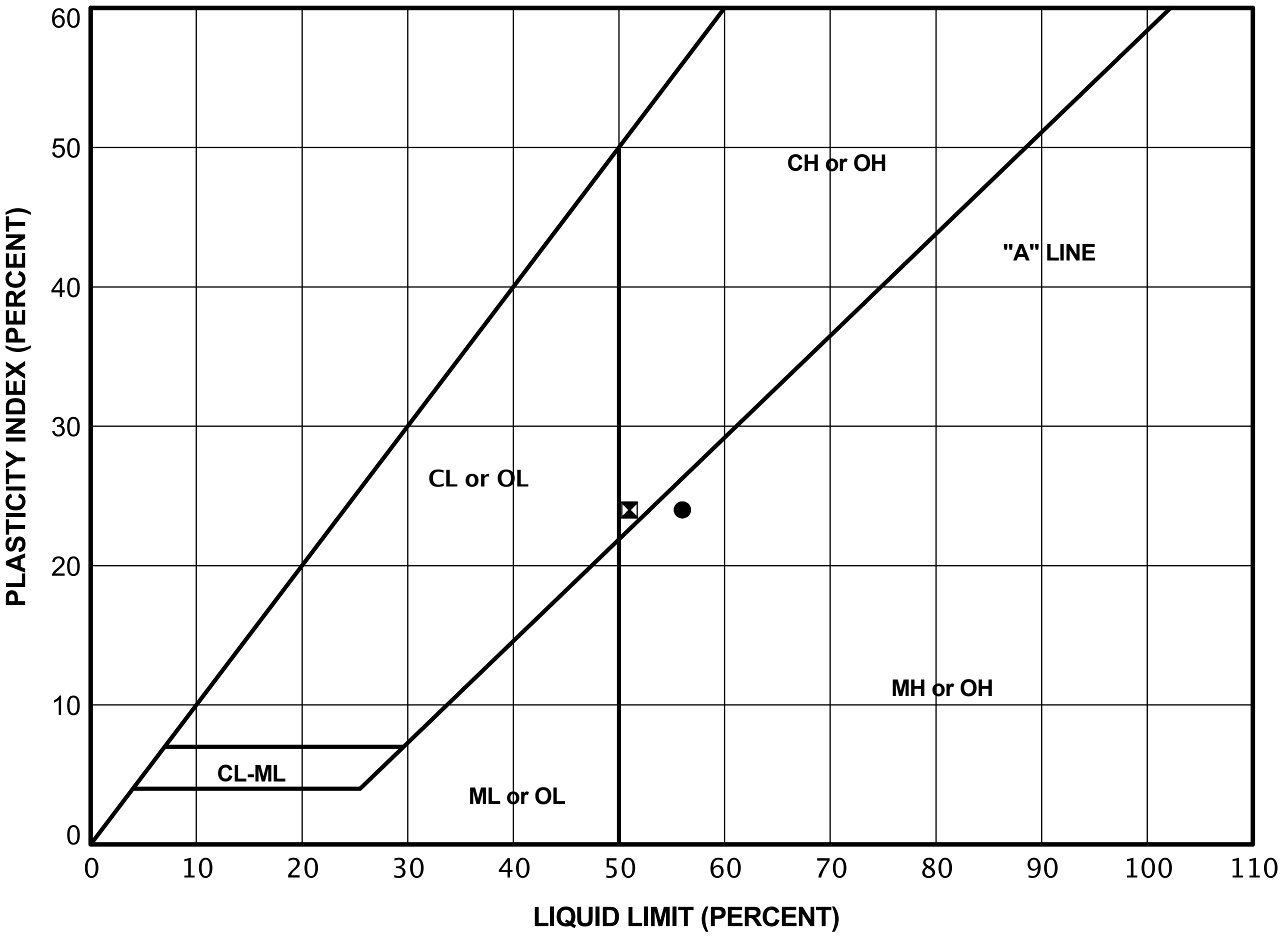
PBS Engineering + Environmental
4412 SW Corbett Avenue
Portland, Oregon 97239
Phone: 503.248.1939
Fax: 866.727.0140

ATTERBERG LIMITS TEST RESULTS

CENTRALIA ALPHA ROAD IMPROVEMENTS
LEWIS COUNTY, WA

PBS PROJECT NUMBER:
73137.000

TEST METHOD: ASTM D4318



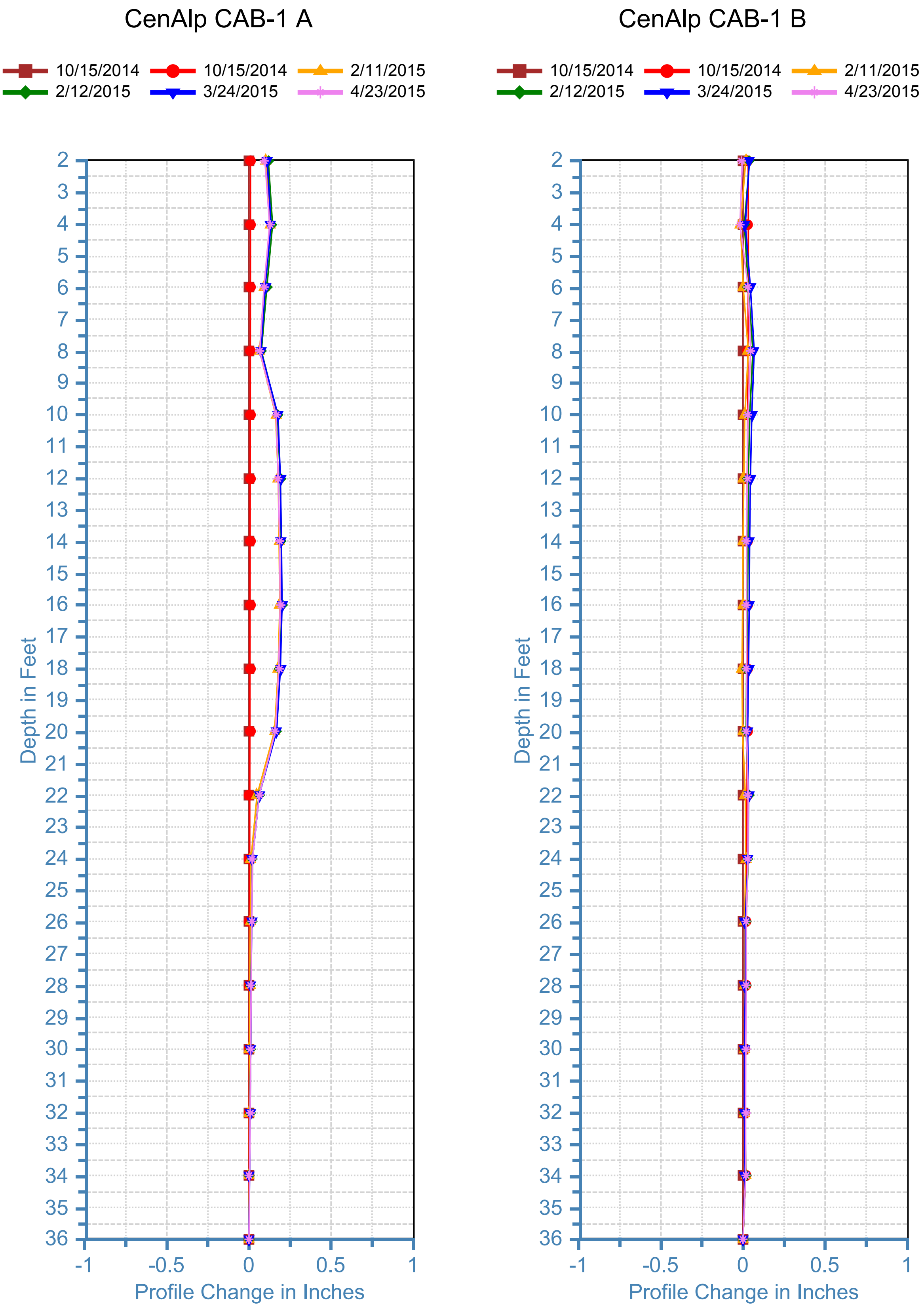
KEY	EXPLORATION NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	NATURAL MOISTURE CONTENT (PERCENT)	PERCENT PASSING NO. 40 SIEVE (PERCENT)	LIQUID LIMIT (PERCENT)	PLASTIC LIMIT (PERCENT)	PLASTICITY INDEX (PERCENT)
●	B-9	S-6	15.0	59	NA	56	32	24
☒	B-9	S-7	20.0	40	NA	51	27	24

_ATTERBERG LIMITS 73137_B1-8_110514_RD.GPJ PBS_DATATMPL_GEO.GDT PRINT DATE: 5/18/15:

FIGURE B1

ATTACHMENT C

Inclinometer and Piezometer Plots



CenAlp CAB-1 A

CenAlp CAB-1 B

FIGURE C1

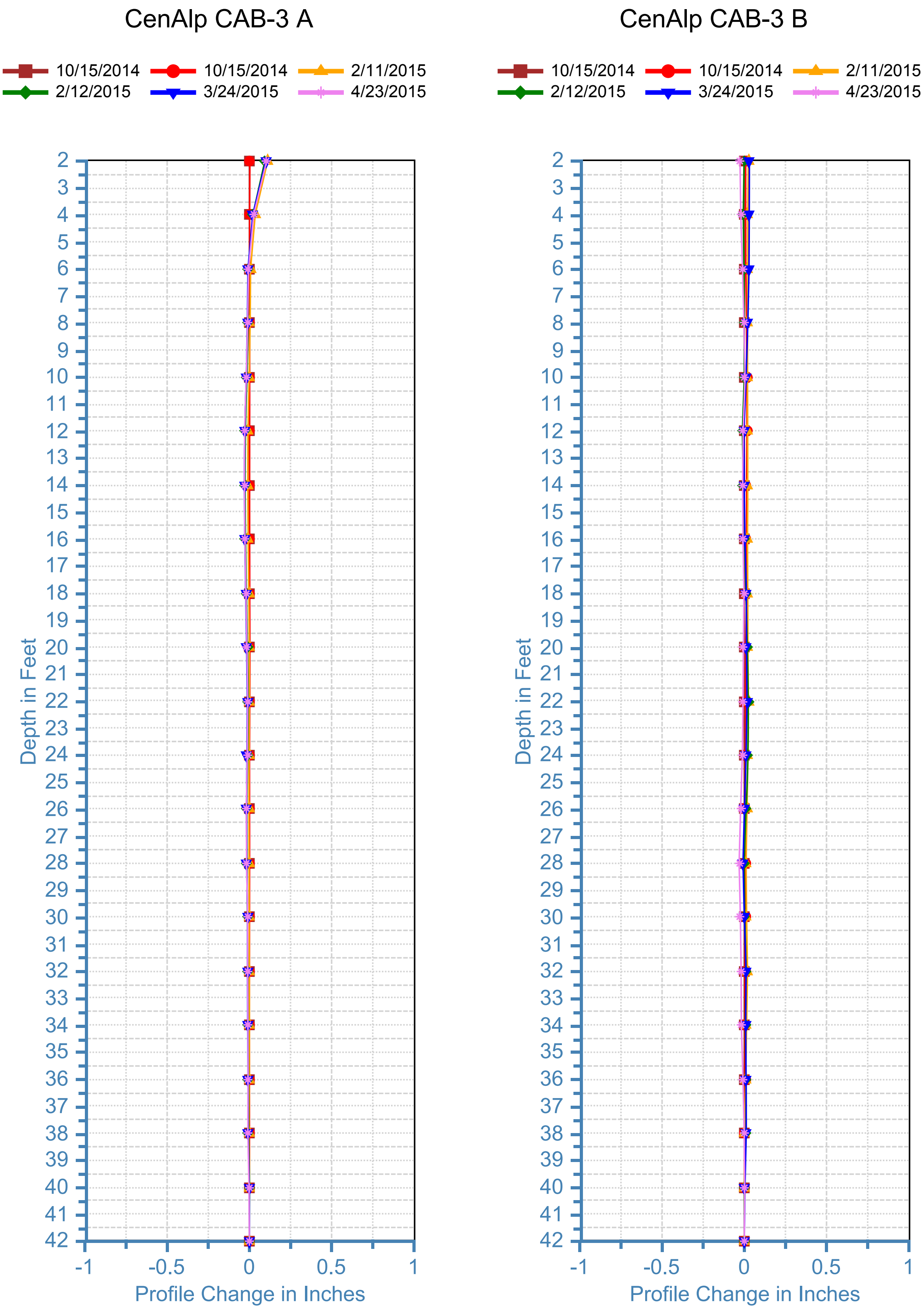
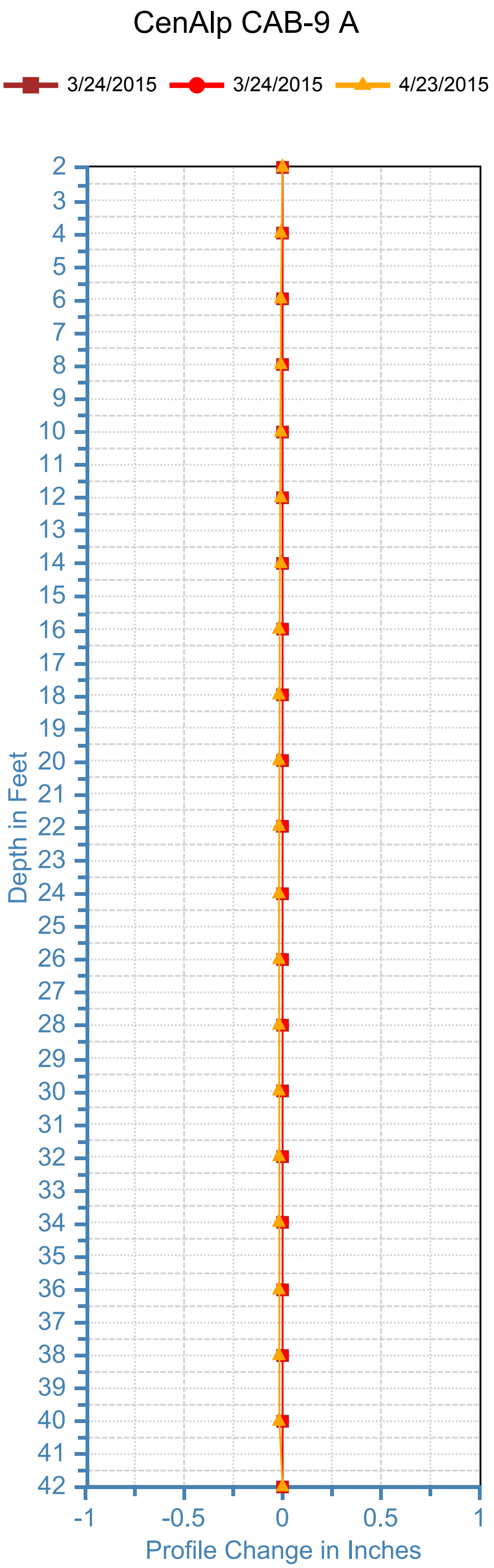
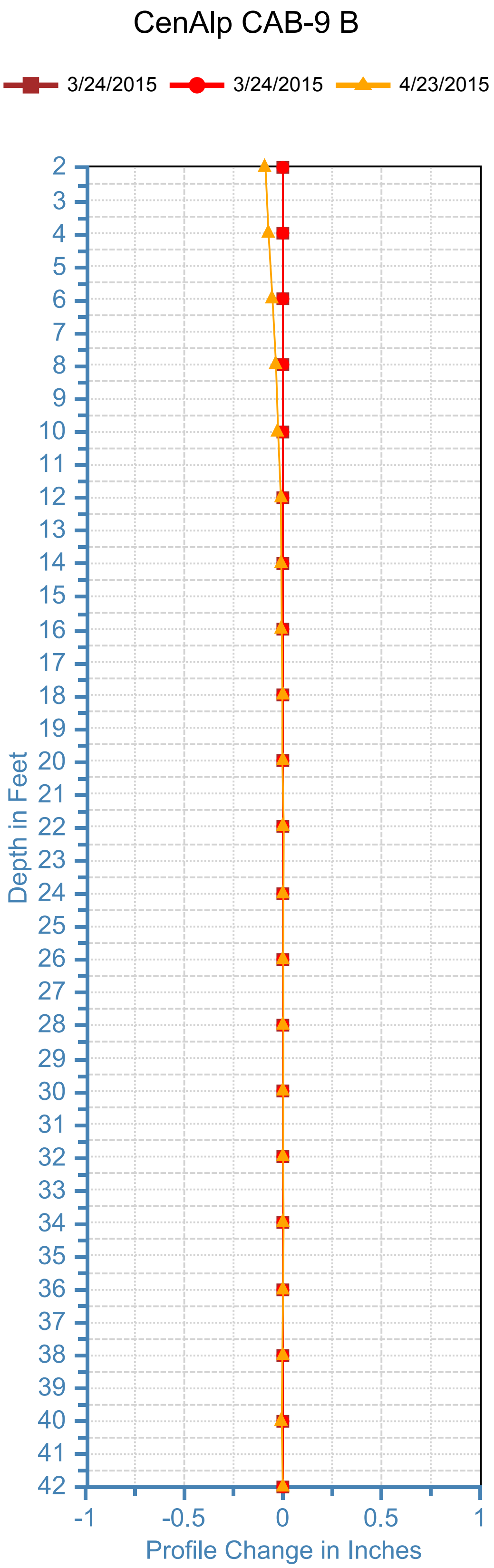

CenAlp CAB-3 A
10/15/2014
10/15/2014
2/11/2015
2/12/2015
3/24/2015
4/23/2015
Depth in Feet
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
-1
-0.5
0
0.5
1
Profile Change in Inches
CenAlp CAB-3 B
10/15/2014
10/15/2014
2/11/2015
2/12/2015
3/24/2015
4/23/2015
Depth in Feet
Profile Change in Inches

FIGURE C2


CenAlp CAB-9 A
3/24/2015
3/24/2015
4/23/2015
Depth in Feet
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
-1
-0.5
0
0.5
1
Profile Change in Inches


CenAlp CAB-9 B
3/24/2015
3/24/2015
4/23/2015
Depth in Feet
2
3
4
5
6
7
8
9
10
11
12
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30
31
32
33
34
35
36
37
38
39
40
41
42
-1
-0.5
0
0.5
1
Profile Change in Inches

FIGURE C3

Borings B-3 and B-9 Piezometer Readings

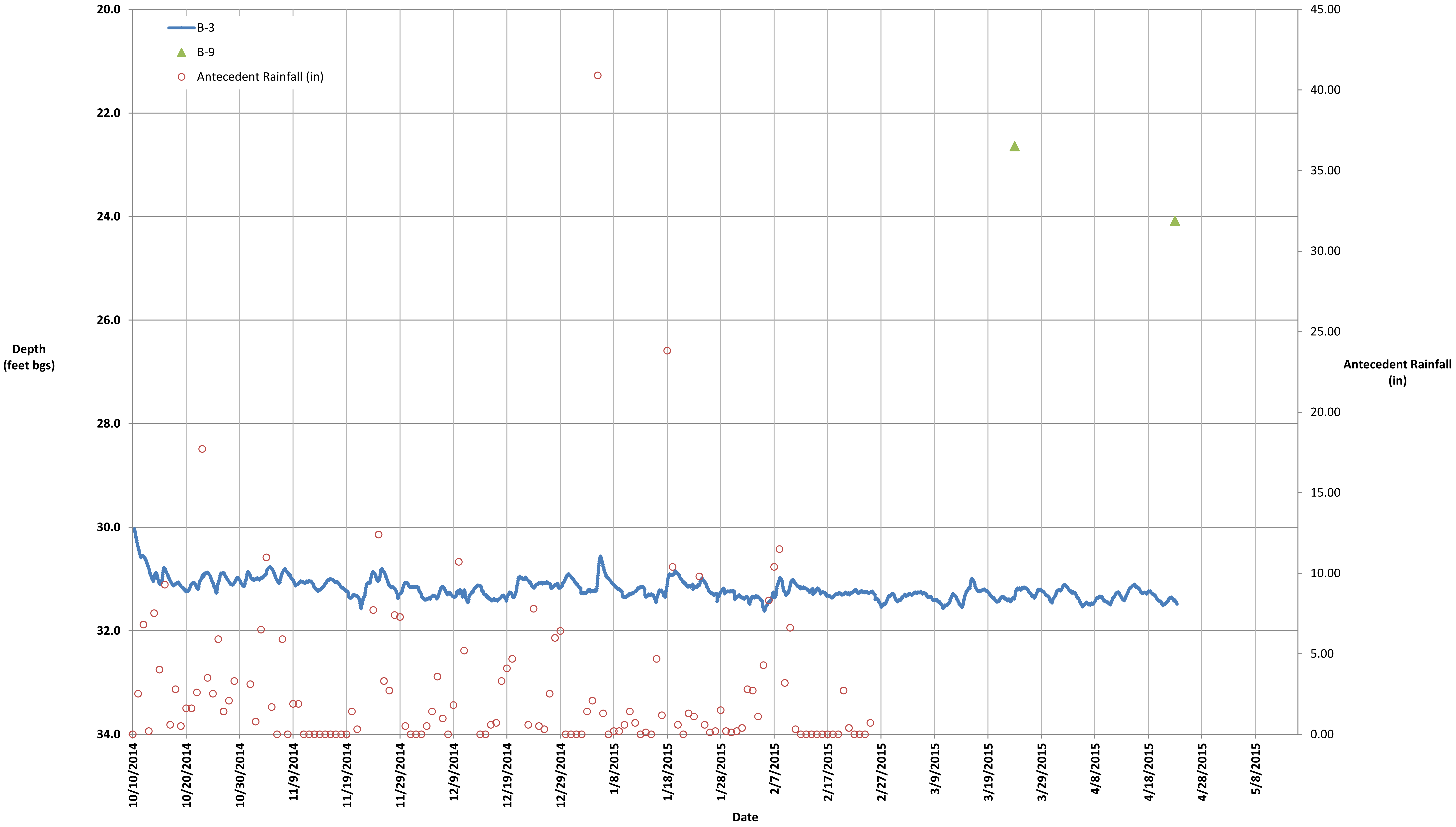

FIGURE C4