



May 6, 2026

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Iowa Department of Natural Resources  
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**RE: Follow-up Response to Comments - Construction/Reconstruction of wells MW-2CR and BMW-24-03**

Dear Brian:

Please see below for the list of verbal comments discussed during your call with Todd Kincaid on April 30, 2026.

**IDNR Comment: The nomenclature of the constructed interval of MW-2CR should be different than the area open to the stope. Water level measurements and chemistry data should be named accordingly.**

**Bowman Response:** *Noted, water level measurements and samples from the constructed, screened interval within MW-2CR will be stored and presented as MW-2CR-BS (Below Stope).*

**IDNR Comment: The nomenclature of the constructed interval of BMW-24-03 should be different than the area open to the stope. Water level elevation and chemistry data should be named accordingly.**

**Bowman Response:** *Noted, we have separated solid samples from water quality samples in our database. Water level measurements from within the stope have been stored and labeled as "BMW-24-03-S" (Stope) measurements from within the constructed, screened interval have been labeled "BMW-24-03" (Below the Stope). No water samples have been collected outside the constructed, screened interval within BMW-24-03.*

**IDNR Comment: How do you know the water within the stope is not originating from the upper groundwater bearing zone and impacting the water level measurement within the Stope?**

**Bowman Response:** *We can't be sure that this is not happening. Recognition of the potential contribution to the upper groundwater bearing zone is why we are installing the screened interval below the stope in BMW-24-03 and MW-2CR. We will rely on the relationship in the heads measured in the stope versus those measured in the screened interval below the stope to assess the potential impact. Note that we are emplacing approximately seven feet of grout between the bottom of the stope and the top of the screened interval in both wells to make sure that there is not a pathway between the stope and the screened interval.*

**IDNR Comment: Are you concerned with removing the constructed interval below the stope in BMW-24-03?**

**Bowman Response:** *We are not concerned about removing the constructed interval in BMW-24-03 because this was already done during the initial installation. During the initial construction effort, the drilling steel became stuck within the borehole of BMW-24-03 after we had attempted to construct the well. As a result, we had to over-drill and reconstruct the well. We intend to implement the same practice to complete this effort. This is standard practice in replacement of wells which have failed during or after construction. We do have contingency built into our scope so that we and the driller can stay on Site to resolve any problems we may encounter.*

**IDNR Comment: Are there concerns with displacing contaminated material from the stope deeper into the middle groundwater bearing zone?**

**Bowman Response:** *We are not concerned about displacing stope material into the underlying middle groundwater bearing zone because we will be using telescoping casings as part of the sonic drilling method. The procedure will entail:*

- *Progressing a four-inch diameter pilot hole down to a depth of five feet below the floor of the stope (this will be within the native rock but above the targeted screened interval).*
- *Progressing a six-inch diameter wider hole down to the same depth.*
- *Progressing an eight-inch outer diameter bit with eight-inch casing above it down to the same depth (five feet below the bottom of the stope). The eight-inch casing will extend to the land surface thus preventing any stope material from entering the inner part of the eight-inch borehole.*
- *Removal and decontamination of the four and six-inch bits.*

- *Progressing the four and six-inch diameter bits into the middle groundwater bearing zone five feet at a time. This time the six-inch diameter casing will be progressed from the surface down to the floor for each run.*

*When the six-inch diameter casing reaches the target depth, the six-inch casing will extend from that depth to the land surface and be inside of the eight-inch casing that extends from five feet below the bottom of the stope to the land surface. The two-inch diameter stainless steel well pipe will then be extended from the land surface to the target depth inside of the six-inch casing. The well will then be constructed by emplacing the sand and grout to the target depths.*

*As the well is constructed, the sand pack, and grout will be placed within the borehole, inside of the six-inch bit and casing. With every five feet of construction material placed, a five-foot interval of the six-inch bit and casing will be retracted from the borehole allowing the sand and grout to settle and expand out to the wall of the borehole against the native material. Once the construction reaches the bottom of the eight-inch casing, the six-inch casing will be removed entirely. The construction process will then continue within the eight-inch casing up to the floor of the stope. At that point the eight-inch casing will be removed entirely and the well will be completed.*

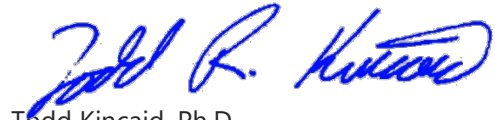
*The borehole will be continuously inspected with a downhole camera to assess the settling of the material into the progressively wider hole until the bottom of the stope is reached, more construction material will be added to correct any settling identified during inspection. This method will not allow for stope material to fall into the open borehole during well construction.*

**IDNR Comment: Are there concerns with the survey methodologies implemented at the site?**

**Bowman Response:** *The GPS survey method will be the same as that used during the 2024-2025 groundwater investigation program. The GPS method involves surveying the ground surface elevation using a ground control point where 300 measurements are collected at a vertical accuracy of 0.1 feet and a horizontal accuracy of 0.2 feet. The vertical offset to the measuring point is measured using an engineer's stick rule. On average, the difference in water level elevation between BMW-24-03 and BMW-24-04 is approximately two feet. Continental believes the survey method provides sufficient accuracy for our purposes.*

Feel free to reach out with any questions regarding this information.

Sincerely,



Todd Kincaid, Ph.D.

For –

Dylan Morlang  
Project Hydrogeologist

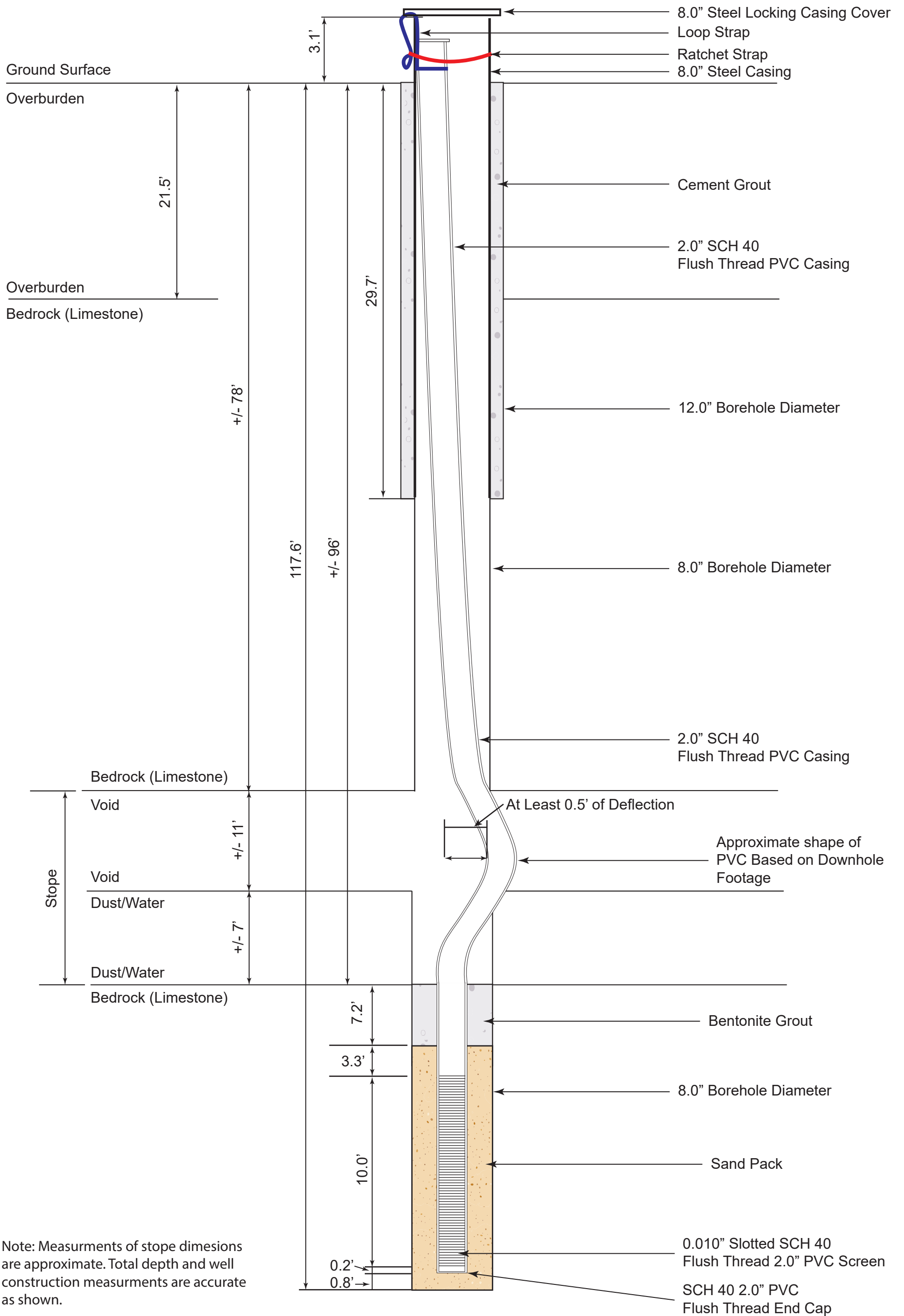
cc.

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Brittany Barrientos – Stinson, LLP.  
Sarah Lintecum – Stinson, LLP.  
Bill Hilger – Continental Cement Co.  
Todd Kincaid – GeoHydros, LLC.  
Mike Polacco – Bowman  
Jennifer Popp – Bowman


attch.

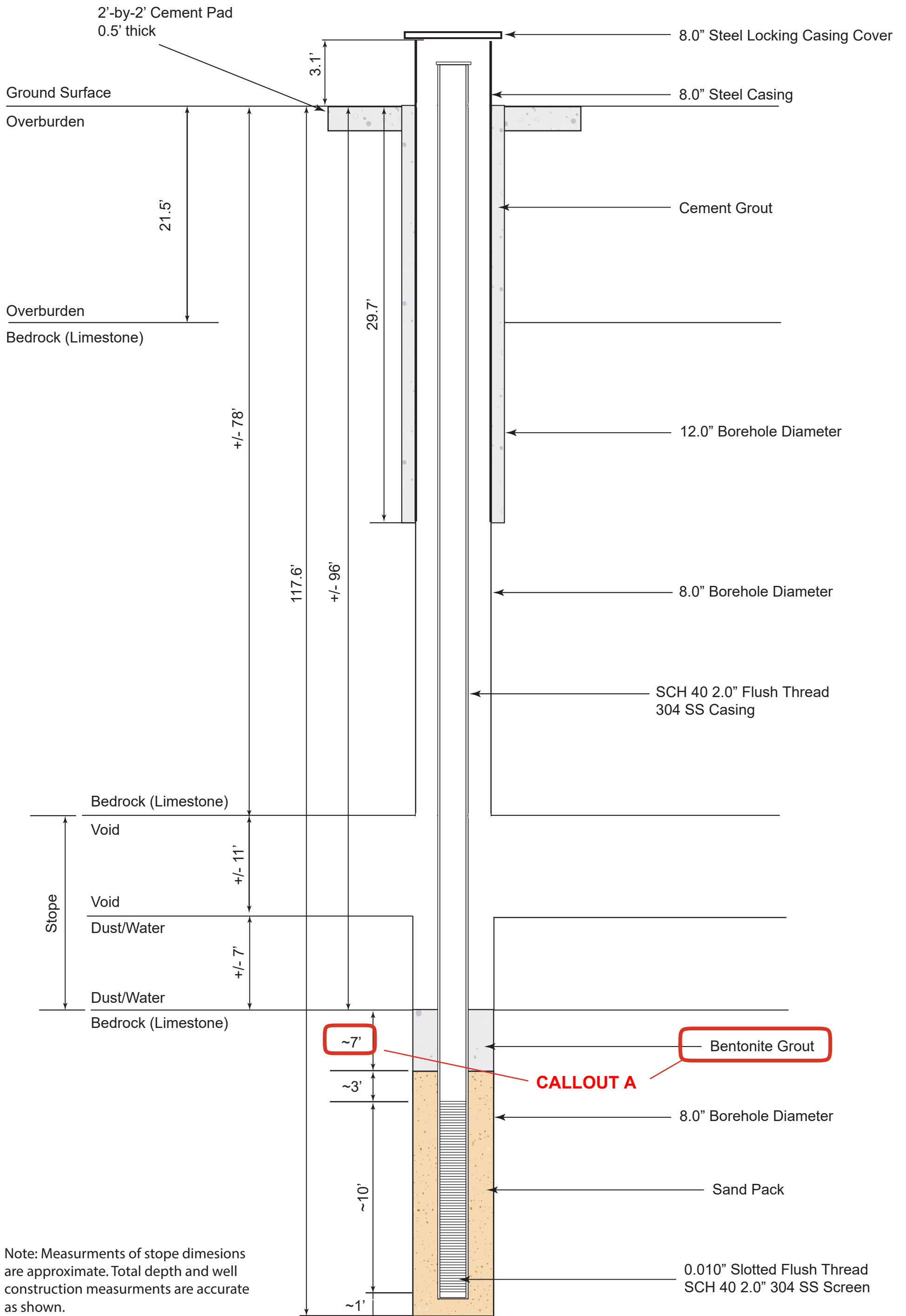
Proposed Well Construction Diagrams  
ASTM Standards for Logging Soils and Rock  
USEPA LSADPROC-300-R5  
SESDPROC-205-R3

Attachment 1  
Proposed Well Construction Diagrams




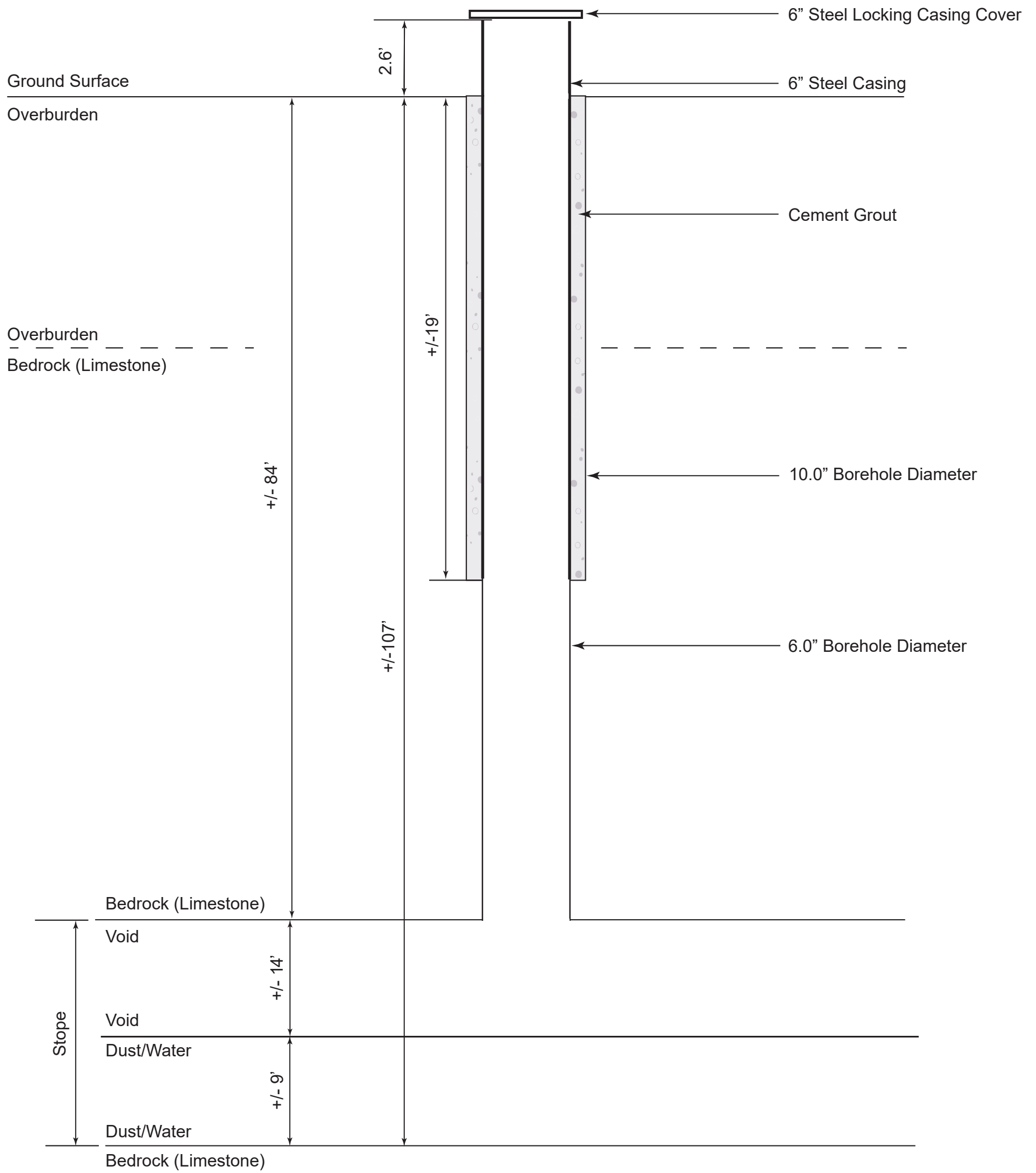
Note: Measurements of stope dimensions are approximate. Total depth and well construction measurements are accurate as shown.

DATE	REVISIONS RECORD/DESCRIPTION	THIS DRAWING IS NOT TO BE USED FOR ENGINEERING PURPOSES	DRAWN BY : DKM	Previous Monitoring Well BMW-24-03 - Schematic	
			DESIGN BY : DKM	CONTINENTAL CEMENT COMPANY, LLC	
			CHECK BY : RAH	BUFFALO	SCOTT COUNTY, IA
			PROJ. NO : 320197		
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Note: Measurements of stope dimensions are approximate. Total depth and well construction measurements are accurate as shown.

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**Current MW-2CR - Schematic**

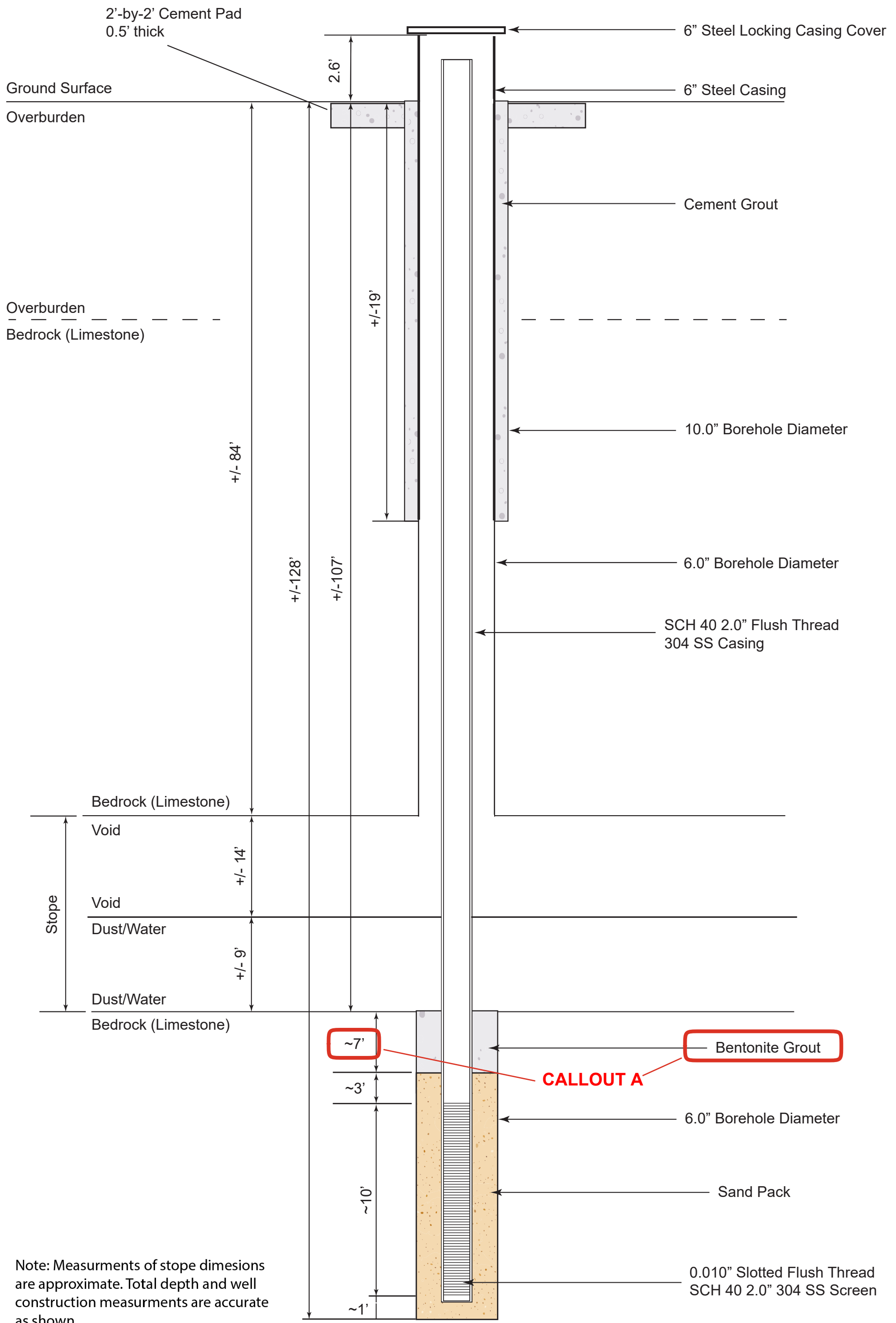
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Note: Measurements of stope dimensions are approximate. Total depth and well construction measurements are accurate as shown.

DATE	REVISIONS RECORD/DESCRIPTION	THIS DRAWING IS NOT TO BE USED FOR ENGINEERING PURPOSES	DRAWN BY : DKM	Proposed MW-2CR - Schematic	
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Attachment 2  
ASTM Standards for Logging Soils and Rock

# Soil and Rock Logging, Classification, and Presentation Manual

**2010 Edition**

State of California  
Department of Transportation  
Division of Engineering Services  
Geotechnical Services



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# Preface

Detailed soil and rock descriptions are an essential part of the information developed to support Caltrans' design and construction processes. Subsurface information for any given area is, and can be, generated and accumulated over a prolonged period of time by various geotechnical practitioners for different projects and purposes. It is imperative that geotechnical practitioners working on Caltrans projects use standardized terminology and procedures to maintain consistency in borehole logging and reporting practices. Geotechnical Services in the Division of Engineering Services has published this Manual to ensure the Department's investment in maintaining consistent logging practices.

This Manual, "*Soil and Rock Logging, Classification, and Presentation Manual*", addresses the following:

- Serves as a comprehensive reference for Departmental staff, consultants, and contractors
- Provides standardized soil *description* and *identification* procedures utilizing field data
- Provides standardized soil *classification* procedures utilizing laboratory data
- Provides standardized rock *description* and *identification* procedures utilizing field and laboratory data
- Serves as a basis for Departmental products and tools, such as:
  - Boring Log presentation formats,
  - Log of Test Borings (LOTB) legend sheets,
  - Descriptive terminology presented in geotechnical reports, and
  - Geotechnical Data Management System

The information presented in this Manual is based predominantly on American Society for Testing and Materials (ASTM) standards and other publications. These references provide standardized methods for identifying, describing, or classifying soil and rock; however, they do not provide adequate descriptive terminology and criteria for identifying soil and rock for engineering purposes. Consequently, this manual extends, and in some cases modifies these standards to include additional descriptive terms and criteria.

In addition to soil and rock identification, description, or classification, this Manual contains instructions that present Departmental standards for borehole and sample identification, minimum material requirements for various laboratory tests, and boring log presentation formats.

Geotechnical Services staff and any other organization providing geotechnical reports or records of geotechnical investigations for the Department must use the procedures presented in this Manual.



Dolores Valls  
Deputy Division Chief, Geotechnical Services

# Acknowledgements

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# Section 1: Introduction

## 1.1 Intent of the Manual

This Manual defines the Department’s practices and procedures for soil and rock description, identification, classification, and for preparation of boring logs.

Standardized terminology and consistent presentation procedures for projects statewide benefit the Department’s staff, engineering consultants, bidders, and contractors. Geotechnical Services staff as well as any other organization providing geotechnical reports or records of geotechnical investigations to the Department must follow the procedures presented in this Manual.

The following terms are used throughout this Manual to convey the Department’s policy:

**Figure 1-1**  
**Policy Terminology**

Term	Definition
Must, Required	<i>Mandatory Standard.</i> The associated provisions shall be used. There is no acceptable alternative.
Should	<i>Advisory Standard.</i> The associated provisions are preferred practices.
May, Optional	<i>Permissive Standard.</i> Use or application of the associated provisions is left to the discretion of the Geoprofessional.

## 1.2 Limitations

Although this manual may be used to train new employees, this is not its primary intent.

This manual does not replace education or experience and must be used with professional judgment. Not all aspects of this manual may be applicable in all circumstances and thus it should be applied with consideration of a project’s many unique aspects.

This manual does not purport to address all of the safety problems, if any, associated with its use. It is

the responsibility of the user of this standard to establish, or adhere to, appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. The reader must follow at a minimum, the *Caltrans Code of Safe Drilling Practices*.

## 1.3 Exceptions

Exceptions to the procedures set forth in this Manual (and Errata Sheet) require prior approval per the memorandum titled *Exception Process for Geotechnical Services Policies and Procedures*, dated December 7, 2009.

## 1.4 Quality Assurance

Prior to issuing a Log of Test Borings staff must complete the quality control and assurance (QC/QA) process as required per the memorandum titled *Quality Control/Quality Assurance Documentation on LOTB Sheets* dated July 1, 2007.

## 1.5 Revisions to the Manual

Staff may propose changes to the Manual by posting their comments on the Geotechnical Services Discussion Board found on the Caltrans intranet. Those who are not employed directly by Caltrans must submit their comments to the Committee Chairperson, who is identified on the Geotechnical Services webpage. Approved revisions will be issued via the Errata Sheet.

## 1.6 Organization of the Manual

The Manual is divided into five sections:

### Section 1

- Explains the intent and organization of the Manual and the processes for requesting exceptions and proposing changes to it
- Presents an overview of the logging process and acceptable presentation formats

### Section 2

- Presents the Department's field description and identification procedures for soil and rock, without laboratory testing
- Explains procedures for handling and labeling soil and rock samples
- Requires a quality check of borehole logs and soil and rock samples

### Section 3

- Describes the Department's classification procedures for soil and rock samples using laboratory tests

### Section 4

- Presents the process for developing and presenting geotechnical information on a *Log of Test Borings (LOTB)* or a *Boring Record (BR)*

### Section 5

- Specifies presentation content and formats for the *Log of Test Borings (LOTB)* and *Boring Record (BR)*

## 1.7 Overview of the Logging Process and Presentation Formats

The Department presents subsurface information using:

- Log of Test Borings (LOTB), and/or
- Boring Record (BR)

An LOTB is typically associated with a structure and is attached to Project Plans. A BR is typically associated with an earthwork project and is attached to a Geotechnical Report.

The process of creating boring logs, i.e., Log of Test Borings (LOTB) and Boring Record (BR) can be summarized in four steps (*See Figure 1-2*):

- Field sampling and descriptions (*Section 2*)
- Quality check of field descriptions and samples (*Section 2*)
- Refinement of descriptions, and classification of soil, based on laboratory test results, if performed (*Section 3*)
- Preparation of the boring log(s) (*Sections 4 and 5*)

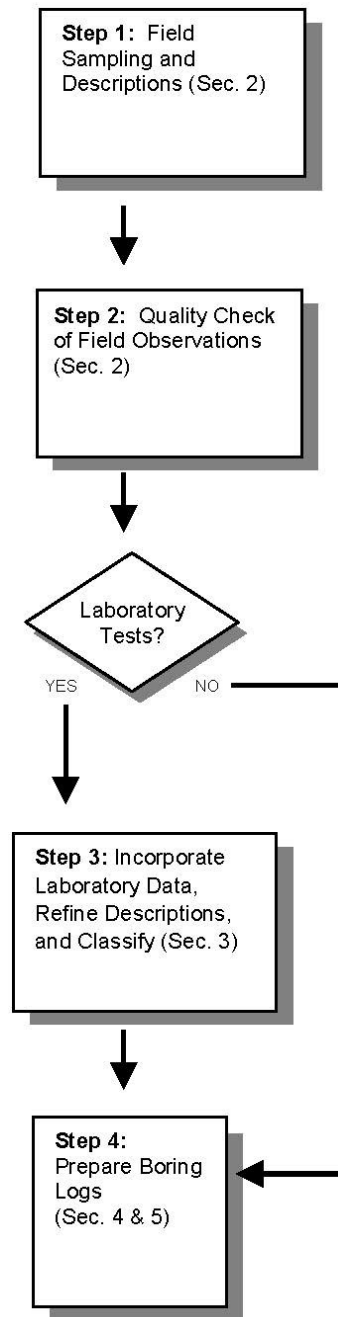
Prior to the field investigation, the geoprofessional should have a general understanding of the local soil and geologic information, and know the parameters and the basic descriptors required for the planned analyses. The need for specific laboratory tests, such as strength, consolidation, or permeability may govern the type of drilling and sampling used.

A combination of field observations and laboratory test results may be needed to describe or classify the soil or rock samples, and generate appropriate layer descriptions for the LOTB or BR (*Sections 2 and 3*). In most cases, however, field identifications and descriptions are adequate for project design, bidding and construction.

If the results of laboratory tests differ from the field description of the sample, and, in the opinion of the geoprofessional, the test results represent the actual conditions of the soil or rock, the classification and/or description resulting from the laboratory tests must be used on the LOTB or BR, and in the geotechnical report. Disclosure of the tests on the LOTB and/or the BR may indicate the sample or layer description was modified based on laboratory test results. (See Sections 4 and 5)

Throughout this manual the terms *identification* and *classification* are used in context to differentiate the basis for assigning a soil's Group Name and Group Symbol. A soil's *classification* is only determined on the basis of laboratory test results (described in Section 3), whereas, its *identification* is determined by visual/manual methods (described in Section 2).

**Figure 1-2  
Logging and Presentation Process**



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# Section 2: Field Procedures for Soil and Rock Logging, Description, and Identification

## 2.1 Introduction

This section presents the procedures for logging, describing, and identifying soil and rock samples in the field based on visual and manual procedures.

The information presented in this section is predominantly based on:

- American Society for Testing and Materials (ASTM) D 2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, and
- The *Engineering Geology Field Manual* published by the Bureau of Reclamation.

This Manual extends, and in some cases modifies, the ASTM standard to include additional descriptive terms and criteria. It is not our intent to replace the ASTM standards but to build on them, and make them better understood.

The identifications and descriptions in the field logs may be corrected, calibrated, or verified later based on laboratory test results (as described in Section 3) in order to develop the final boring logs.

In addition to soil and rock identification and description, this section contains instructions for hole and sample identification, and minimum material requirements for various laboratory tests.

## 2.2 Terms and Definitions

The following terms and definitions may be used to describe soil and rock description components.

**Figure 2-1  
Distribution Terms**

Descriptor	Definition	Examples
Scattered	Occurring at widely spaced and usually irregular intervals	Scattered thin shale interbeds
Sporadic	Occurring singly or widely apart	Sporadic boulders
Locally	Occurring at random locations	Moderately hard, locally very hard
Rhythmically	Occurring at regular, predictable locations	Rhythmically bedded sandstone and shale

**Figure 2-2**  
**Relational Terms**

Descriptor	Definition	Examples
to	Intermediate, having properties in between two adjacent descriptors, (borderline)	Moderately hard to moderately soft
and	Having roughly equal amounts of two or more descriptors	Fine and coarse sand  Rounded and angular
From/to	Having properties of three or more descriptors, including all descriptors in range	From rounded to angular
Grading from/to or Increasing/Decreasing from/to	Denoting a gradual change with depth, may range over several descriptors	Grading from moderately weathered to fresh
Varies from/to or “-“ (used with numerical ranges)	Denotes non-uniform variation, does not include all descriptors in range	Varies from soft to hard  4-6” Cobbles
Chaotic	No discernable pattern	Chaotic interbeds of silt, sand and clay
Predominantly	Having more than any other constituent	Predominantly Cobbles

Caution should be used to correctly apply the above terms as not all terms can be used with all descriptors. For example, a weathering description of “slightly weathered to fresh” is not acceptable because the term fresh indicates absence of any discoloration and oxidation. As such, the rock is either fresh or it isn’t. Similarly, describing a soil’s moisture to be “dry to moist” is incorrect because the soil either contains moisture (moist) or it doesn’t (dry).

### 2.3 General Project and Hole Information

An important aspect of fieldwork is properly identifying the location of the project site, drilling tools and methods used, and the personnel involved in the fieldwork. Figure 2-3 presents the information to be recorded for every hole. This information may not necessarily be reported on the LOTB or BR.

**Figure 2-3  
Information Required for Field Log**

Item	Description
1	<b>Date(s) of work</b>
2	<b>Hole Identification</b>
3	<p><b>Project and Site Information:</b></p> <ul style="list-style-type: none"> <li>• Project Name</li> <li>• Structure/Bridge Name and Number (if available)</li> <li>• Project Number (Charge District - Expenditure Authorization, 8-digits)</li> <li>• District</li> <li>• County</li> <li>• Route</li> <li>• Postmile, range and prefix</li> </ul>
4	<p><b>Borehole Location and Elevation:</b></p> <ul style="list-style-type: none"> <li>• Location: <ul style="list-style-type: none"> <li>○ Station and offset (required if available)</li> <li>○ Latitude and longitude, horizontal datum (optional)</li> <li>○ Northing and Easting, local coordinate reference system (optional)</li> </ul> <p><i>Note:</i> In the absence of accurate coordinate data, a suitable and verifiable field description may be temporarily used. (e.g. postmile and centerline offset, distance to fixed object or benchmark, etc.)</p> </li> <li>• Elevation, vertical datum, benchmark location and description</li> <li>• Survey method(s) used, approximate accuracy (e.g. less than a foot)</li> </ul>
5	<p><b>Personnel:</b></p> <ul style="list-style-type: none"> <li>• Logger/Geoprofessional</li> <li>• Drillers</li> </ul>
6	<p><b>Drilling and Sampling Equipment (verify with Driller):</b></p> <ul style="list-style-type: none"> <li>• Drilling (manufacturer and model, and Caltrans equipment identification number)</li> <li>• Drilling method (mud rotary, air rotary, solid auger, hollow stem auger. etc.)</li> <li>• Drill rod description (type, diameter)</li> <li>• Drill bit description</li> <li>• Casing (type, diameter) and installation depth</li> <li>• SPT Hammer Type: Safety/Automatic Hammer, etc. <ul style="list-style-type: none"> <li>○ Lifting mechanism (for safety hammer)</li> <li>○ Hammer Energy Ratio (ERI)</li> </ul> </li> <li>• Type of sampler(s) and size(s) <ul style="list-style-type: none"> <li>○ Undisturbed Shelby tube</li> <li>○ Undisturbed Piston</li> <li>○ Split spoon (e.g. SPT, Cal Mod, etc.)</li> <li>○ Core (both rock and soil)</li> <li>○ Disturbed (include auger cuttings)</li> <li>○ Other</li> </ul> </li> </ul>
7	<p><b>Groundwater:</b></p> <ul style="list-style-type: none"> <li>• Method (observed while drilling, measured in hole, etc.)</li> <li>• Date, time, and elevation of each reading</li> </ul>
8	<p><b>Hole Completion:</b></p> <ul style="list-style-type: none"> <li>• Reason for termination (e.g., drilled to depth, refusal, early termination of traffic control, etc.)</li> <li>• Backfill Method (e.g., grout, soil cuttings, dry bentonite chips, piezometers installed, slope inclinometer installed, TDR, instrumentation, etc.)</li> </ul>

## 2.4 Assignment of Hole Identification

Identify holes using the following convention:

$$H - YY - NNN$$

Where:

*H*: Hole Type Code (Figure 2-4)

*YY*: 2-digit year

*NNN*: 3-digit number (001-999)

The *YY-NNN* component of the hole identification is unique and matched to a Caltrans project expenditure authorization number (EA), site, structure, or bridge number. If two drilling methods are used, such as auger boring followed by rotary drilled boring, the predominant tool governs the selection of Hole Type Code (H).

**Figure 2-4 (after ASTM D 6453)  
Hole Type Code and Description**

Hole Type Code	Description
A	Auger boring (hollow or solid stem, bucket)
R	Rotary drilled boring (conventional)
RC	Rotary core (self-cased wire-line, continuously-sampled)
RW	Rotary core (self-cased wire-line, not continuously sampled)
P	Rotary percussion boring (Air)
HD	Hand driven (1-inch soil tube)
HA	Hand auger
D	Driven (dynamic cone penetrometer)
CPT	Cone Penetration Test
O	Other (note on LOTB)

## 2.5 Soil Description and Identification Procedures

This section presents the method for identification and description of soil after ASTM D 2488 and USBR (2001). The detail of description provided for a particular soil should be dictated by the complexity and objectives of the project. Optional descriptors, if presented, should be critical to the design and/or construction needs of the project.

It is recognized that the uncertainty in visual soil description may be greater than 5% for any given soil constituent. Proportional or percentage descriptions varying by up to 10% for individual constituents may be considered to be descriptions of the same material.

### 2.5.1 Soil Description and Identification

When describing and identifying soil, record the data in accordance with Figure 2-5, and present the information on the LOTB or BR in the sequence shown. Items marked “required” must be used, when applicable, to describe the soil sample. For example, percent cobbles and/or boulders is required only if cobbles and/or boulders are encountered. Do not report negative information (e.g. no boulders or cobbles).

Use semicolons between required descriptors, commas within a descriptive component for optional descriptors, and a period at the end of each descriptive sequence.

Report each soil component identified by sequence 7 in order of decreasing proportion (not particle size). Report particle size range and (optionally) angularity and shape, separated by commas. Separate soil components with semicolons. For example,

*...moist; some SAND, coarse, subangular; little GRAVEL, fine, angular; ...*

-or-

*...moist; some coarse, subangular SAND; little fine, angular GRAVEL; ...*

**Figure 2-5**  
**Identification and Description Sequence**

Sequence	Identification Components	Refer to Section		Required	Optional
		Field	Lab		
1	Group Name	2.5.2	3.2.2	●	(no bullet)
2	Group Symbol	2.5.2	3.2.2	(no bullet)	(no bullet)
(empty cell)	<b>Description Components</b>	(empty cell)	(empty cell)	(empty cell)	(empty cell)
3	Consistency of Cohesive Soil	2.5.3	3.2.3	●	(no bullet)
4	Apparent Density of Cohesionless Soil	2.5.4	(empty cell)	●	(no bullet)
5	Color	2.5.5	(empty cell)	(no bullet)	(no bullet)
6	Moisture	2.5.6	(empty cell)	●	(no bullet)
7	Percent or Proportion of Soil	2.5.7	3.2.4	●	(no bullet)
7	Particle Size	2.5.8	2.5.8	●	(no bullet)
7	Particle Angularity	2.5.9	(empty cell)	(no bullet)	○
7	Particle Shape	2.5.10	(empty cell)	(no bullet)	○
8	Plasticity (for fine-grained soil)	2.5.11	3.2.5	(no bullet)	○
9	Dry Strength (for fine-grained soil)	2.5.12	(empty cell)	(no bullet)	○
10	Dilatency (for fine-grained soil)	2.5.13	(empty cell)	(no bullet)	○
11	Toughness (for fine-grained soil)	2.5.14	(empty cell)	(no bullet)	○
12	Structure	2.5.15	(empty cell)	(no bullet)	(no bullet)
13	Cementation	2.5.16	(empty cell)	●	(no bullet)
14	Percent of Cobbles and Boulders	2.5.17	(empty cell)	●	(no bullet)
14	Description of Cobbles and Boulders	2.5.18	(empty cell)	●	(no bullet)
15	Consistency Field Test Result	2.5.3	(empty cell)	●	(no bullet)
16	Additional Comments	2.5.19	(empty cell)	(no bullet)	○

The following examples illustrate the application of the descriptive sequence based on field procedures.

1. Example of a complete descriptive sequence for a sample using required and optional components:

*Well-graded SAND with GRAVEL (SW); medium dense; brown and light gray; wet; 75% SAND, from coarse to fine, rounded; 20% GRAVEL, coarse, subrounded to rounded, flat and elongated; 5% fines; weak cementation.*

Example of a complete descriptive sequence for the same soil sample using only required components:

*Well-graded SAND with GRAVEL (SW); medium dense; brown and light gray; wet; mostly SAND, from coarse to fine; little coarse GRAVEL; trace fines; weak cementation.*

Example of the complete descriptive sequence for the same soil sample that omits the percent or proportion of the primary soil constituent and omits the particle size range, which may be done when the percentage or proportion and particle size range of the primary soil constituent are clearly inferred:

*Well-graded SAND with GRAVEL (SW); medium dense; brown and light gray; wet; little coarse GRAVEL; trace fines; weak cementation.*

2. Example of a complete descriptive sequence that omits the percent or proportion of the primary and secondary soil constituents, which may be done when the percentage or proportion of the primary and secondary soil constituents can be clearly inferred:

*SANDY lean CLAY (CL); stiff; brown and light gray; wet; fine SAND; PP=1.5 tsf.*

Corresponds to the following complete description:

*SANDY lean CLAY (CL); stiff; brown and light gray; wet; mostly fines; some fine SAND; medium plasticity; PP=1.5 tsf.*

### 2.5.1.1 Description of Pavement Structural Sections

Do not use the descriptive sequence (Figure 2-5) to describe pavement sections. Report each material and its thickness, e.g.,

- ASPHALT CONCRETE (12")
- CONCRETE (24" bridge footing)
- AGGREGATE BASE (30")

### 2.5.1.2 Description of Interbedded Soil

State the predominant soil group name and symbol followed by the bedding thickness (Figure 2-30) of the components and the group name and symbol of the secondary layers. Follow this with the complete individual descriptions of the layers, e.g., for a sample consisting of moderate beds of sand interbedded with thin beds of silt:

*Poorly-graded SAND (SP) moderately bedded with thin interbeds of SILT (ML). SAND (SP); dense; brown; moist; fine SAND. SILT (ML); dense; brown; moist; nonplastic.*

### 2.5.1.3 Description of Fills

State the word "FILL" parenthetically after the soil descriptive sequence.

For complex fills (e.g. thinly-layered, chaotic, highly variable soil), state the predominant soil group name and symbol followed by the layer thickness (Figure 2-30) of the components and the group name and symbol of the secondary layers. This is followed by the complete individual descriptions of the layers, e.g.

*Poorly-graded SAND (SP); thickly interlayered with thin layers of SILT (ML) and GRAVEL (GP); SAND (SP); dense; brown; moist; fine SAND; SILT (ML); dense; brown; moist; nonplastic; GRAVEL (GP); medium dense; gray; moist; coarse; (FILL).*

## 2.5.2 Group Name and Group Symbol

Identify a soil by assigning a group name and group symbol using the figures in the section for fine- or coarse-grained soil (Figure 2-6 or 2-8).

The ASTM procedure for identifying and describing fine-grained and coarse-grained soil is only applicable to material passing the 3-inch sieve. The percentage(s) of cobbles and/or boulders (if encountered) must be reported per Section 2.5.17.

**Borderline Symbol** – Because ASTM D 2488 is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to assign it a single group symbol. To indicate that the soil may fall into one of two groups, use a borderline symbol, which is two symbols separated by a slash, e.g., SC/CL or CL/CH.

A borderline symbol must be used when:

- The percentage of fines is estimated to be between 45 and 55%. One symbol must be for a coarse-grained soil with fines; the other for a fine-grained soil, e.g., GM/ML or CL/SC.
- The percentage of sand and the percentage of gravel are estimated to be about the same, e.g., GP/SP, SC/GC, GM/SM.

- The soil could be well- or poorly-graded, e.g., GW/GP, SW/SP.
- The dominant fine-grained component of the soil could be either silt or clay, e.g., CL/ML, CH/MH, SC/SM.

The group name for a soil with a borderline symbol must be the group name for the first symbol, except for:

- CL/CH lean to fat CLAY,
- ML/CL CLAYEY SILT, and
- CL/ML SILTY CLAY

Borderline symbols should not be used indiscriminately. Use of a single group symbol is preferable.

**Dual Symbol** – A dual symbol is two symbols separated by a hyphen, e.g., GP-GM, SW-SC, CL-ML. They are used to indicate that the soil has about 10% fines.

### 2.5.2.1 Fine-Grained Soil

Fines are particles that pass through a Number 200 sieve. A soil is considered to be fine-grained if it contains 50% or more fines. Assign a Group Name and Symbol to fine-grained soil according to Figure 2-6.

**Figure 2-6**  
**Identification of Fine-Grained Soil (after ASTM D 2488)**

Group Symbol	Coarse Fraction	Coarse Fraction	Sand or Gravel	Group Name
CL	<30% plus No.200	<15% plus No.200		Lean CLAY
		15-25% plus No.200	% sand $\geq$ % gravel	Lean CLAY with SAND
			% sand < % gravel	Lean CLAY with GRAVEL
	$\geq$ 30% plus No.200	% sand $\geq$ % gravel	< 15% gravel	SANDY lean CLAY
			$\geq$ 15% gravel	SANDY lean CLAY with GRAVEL
		% sand < % gravel	< 15% sand	GRAVELLY lean CLAY
		$\geq$ 15% sand	GRAVELLY lean CLAY with SAND	
ML	<30% plus No.200	<15% plus No.200		SILT
		15-25% plus No.200	% sand $\geq$ % gravel	SILT with SAND
			% sand < % gravel	SILT with GRAVEL
	$\geq$ 30% plus No.200	% sand $\geq$ % gravel	< 15% gravel	SANDY SILT
			$\geq$ 15% gravel	SANDY SILT with GRAVEL
		% sand < % gravel	< 15% sand	GRAVELLY SILT
		$\geq$ 15% sand	GRAVELLY SILT with SAND	
CH	<30% plus No.200	<15% plus No.200		Fat CLAY
		15-25% plus No.200	% sand $\geq$ % gravel	Fat CLAY with SAND
			% sand < % gravel	Fat CLAY with GRAVEL
	$\geq$ 30% plus No.200	% sand $\geq$ % gravel	< 15% gravel	SANDY fat CLAY
			$\geq$ 15% gravel	SANDY fat CLAY with GRAVEL
		% sand < % gravel	< 15% sand	GRAVELLY fat CLAY
		$\geq$ 15% sand	GRAVELLY fat CLAY with SAND	
MH	<30% plus No.200	<15% plus No.200		Elastic SILT
		15-25% plus No.200	% sand $\geq$ % gravel	Elastic SILT with SAND
			% sand < % gravel	Elastic SILT with GRAVEL
	$\geq$ 30% plus No.200	% sand $\geq$ % gravel	< 15% gravel	SANDY elastic SILT
			$\geq$ 15% gravel	SANDY elastic SILT with GRAVEL
		% sand < % gravel	< 15% sand	GRAVELLY elastic SILT
		$\geq$ 15% sand	GRAVELLY elastic SILT with SAND	
OL/ OH	<30% plus No.200	<15% plus No.200		ORGANIC SOIL
		15-25% plus No.200	% sand $\geq$ % gravel	ORGANIC SOIL with SAND
			% sand < % gravel	ORGANIC SOIL with GRAVEL
	$\geq$ 30% plus No.200	% sand $\geq$ % gravel	< 15% gravel	SANDY ORGANIC SOIL
			$\geq$ 15% gravel	SANDY ORGANIC SOIL with GRAVEL
		% sand < % gravel	< 15% sand	GRAVELLY ORGANIC SOIL
		$\geq$ 15% sand	GRAVELLY ORGANIC SOIL with SAND	

**Clay and Silt** – Identify the soil as Lean CLAY (CL), Fat CLAY (CH), SILT (ML), or Elastic SILT (MH), using the criteria in Figure 2-7.

**Figure 2-7**  
**Identification of Clayey and Silty Soil**

Group Symbol	Dry Strength	Dilatancy	Toughness	Plasticity
ML	None to low	Slow to rapid	Low or thread cannot be formed	Low to nonplastic
CL	Medium to high	None to slow	Medium	Medium
MH	Low to medium	None to slow	Low to medium	Low to medium
CH	High to very high	None	High	High

**Organic Soil** – Identify the soil as organic, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soil is usually dark brown or black and may have an organic odor. Often, organic soil will change color, for example, black to brown, when exposed to the air. Some organic soil will lighten in color significantly when air-dried. Organic soil normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

**Identification of Peat** – Peat is an organic soil composed primarily of vegetation in various stages of decomposition. It has a fibrous to amorphous texture, usually dark brown or black, and an organic odor. Identify Peat with the Group Name and Symbol, PEAT (PT). There are no standardized criteria for describing peat, thus the descriptive sequence in Figure 2-5 need not be followed. The description presented should be determined based on the needs of the project.

### 2.5.2.2 Coarse-Grained Soil

A coarse-grained soil contains fewer than 50% fines. A coarse-grained soil is identified as gravel if the percentage of gravel is greater than the percentage of sand, or as sand if the percentage of gravel is equal to or less than the percentage of sand. A well-graded sand or gravel has roughly equal amounts of all particle sizes. A poorly-graded sand or gravel is missing one or more particle sizes.

Assign a Group Name and Symbol to coarse-grained soil according to Figure 2-8.

**Figure 2-8**  
**Identification of Coarse-Grained Soil (from ASTM D-2488)**

	Fines	Grade	Type of Fines	Group Symbol	Sand/Gravel	Group Name
Gravel	≤ 5%	Well		GW	< 15% sand	Well-graded GRAVEL
					≥ 15% sand	Well-graded GRAVEL with SAND
		Poorly		GP	< 15% sand	Poorly-graded GRAVEL
					≥ 15% sand	Poorly-graded GRAVEL with SAND
	10%	Well	ML or MH	GW-GM	< 15% sand	Well-graded GRAVEL with SILT
					≥ 15% sand	Well-graded GRAVEL with SILT and SAND
			CL or CH	GW-GC	< 15% sand	Well-graded GRAVEL with CLAY
					≥ 15% sand	Well-graded GRAVEL with CLAY and SAND
		Poorly	ML or MH	GP-GM	< 15% sand	Poorly-graded GRAVEL with SILT
					≥ 15% sand	Poorly-graded GRAVEL with SILT and SAND
			CL or CH	GP-GC	< 15% sand	Poorly-graded GRAVEL with CLAY
					≥ 15% sand	Poorly-graded GRAVEL with CLAY and SAND
	≥ 15%		ML or MH	GM	< 15% sand	SILTY GRAVEL
					≥ 15% sand	SILTY GRAVEL with SAND
		CL or CH	GC	< 15% sand	CLAYEY GRAVEL	
				≥ 15% sand	CLAYEY GRAVEL with SAND	
Sand	≤ 5%	Well		SW	< 15% gravel	Well-graded SAND
					≥ 15% gravel	Well-graded SAND with GRAVEL
		Poorly		SP	< 15% gravel	Poorly-graded SAND
					≥ 15% gravel	Poorly-graded SAND with GRAVEL
	10%	Well	ML or MH	SW-SM	< 15% gravel	Well-graded SAND with SILT
					≥ 15% gravel	Well-graded SAND with SILT and GRAVEL
			CL or CH	SW-SC	< 15% gravel	Well-graded SAND with CLAY
					≥ 15% gravel	Well-graded SAND with CLAY and GRAVEL
		Poorly	ML or MH	SP-SM	< 15% gravel	Poorly-graded SAND with SILT
					≥ 15% gravel	Poorly-graded SAND with SILT and GRAVEL
			CL or CH	SP-SC	< 15% gravel	Poorly-graded SAND with CLAY
					≥ 15% gravel	Poorly-graded SAND with CLAY and GRAVEL
	≥ 15%		ML or MH	SM	< 15% gravel	SILTY SAND
					≥ 15% gravel	SILTY SAND with GRAVEL
		CL or CH	SC	< 15% gravel	CLAYEY SAND	
				≥ 15% gravel	CLAYEY SAND with GRAVEL	

### 2.5.3 Consistency of Cohesive Soil

Cohesive soil derives its strength from cohesion (tendency of particles to stick together) rather than friction between particles. Clay (CL and CH) and elastic silt (MH) are cohesive; silt (ML) may or may not be cohesive. The required field procedure for the determination of consistency of cohesive soil is to perform tests with a pocket penetrometer or torvane on relatively undisturbed samples, or to perform down-hole vane shear tests. (See Appendix A for details on the test procedures.) The test result(s) are added to the descriptive sequence using the syntax “PP = measurement”, “TV = measurement”, or “VS = measurement” where the measurement is in units of tsf.

Use the terms and criteria in Figure 2-9 to describe the consistency of predominantly cohesive soil.

**Figure 2-9**  
**Consistency of Cohesive Soil (after AASHTO 1988 and Bureau of Reclamation 2001)**

Description	Pocket Penetrometer Measurement, PP, (tsf)	Torvane Measurement, TV, (tsf)	Vane Shear Measurement, VS, (tsf)
Very Soft	PP < 0.25	TV < 0.12	VS < 0.12
Soft	0.25 ≤ PP < 0.5	0.12 ≤ TV < 0.25	0.12 ≤ VS < 0.25
Medium Stiff	0.5 ≤ PP < 1	0.25 ≤ TV < 0.5	0.25 ≤ VS < 0.5
Stiff	1 ≤ PP < 2	0.5 ≤ TV < 1	0.5 ≤ VS < 1
Very Stiff	2 ≤ PP < 4	1 ≤ TV < 2	1 ≤ VS < 2
Hard	4 ≤ PP	2 ≤ TV	2 ≤ VS

## 2.5.4 Apparent Density of Cohesionless Soil

Describe the apparent density of predominantly cohesionless soil (Figure 2-10).

**Figure 2-10 (after AASHTO, 1988)**  
**Apparent Density of Cohesionless Soil**

Description	SPT $N_{60}$ (blows/ft)
Very Loose	$N_{60} < 5$
Loose	$5 \leq N_{60} < 10$
Medium Dense	$10 \leq N_{60} < 30$
Dense	$30 \leq N_{60} < 50$
Very dense	$50 \leq N_{60}$

The apparent density of a coarse-grained (predominantly cohesionless) soil is based on a corrected Standard Penetration Test (SPT)  $N_{60}$  value (described in Appendix A) as follows:

$$N_{60} = N_{measured} * (ER_i / 60)$$

where,

$$ER_i = \text{Hammer energy ratio (\%)}$$

Example:  $N_{measured} = 8, ER_i = 90\%$

$$N_{60} = 8 * (90/60) = 12$$

The soil is *medium dense*

## 2.5.5 Color

Use the *Munsell Soil Color Charts* to describe the color of a soil sample at its natural moisture content at the time of sampling. Describe the predominant colors or range of colors if there is substantial color variation using the terms in Figures 2-1, 2-2 and/or 2-11 as appropriate. For example:

*Variegated brown and light yellowish brown*

For additional information, see ASTM D 1535, *Standard Practice for Specifying Color by the Munsell System*.

**Figure 2-11**  
**Color Terms**

Description	Definition	Examples
Variegated	Having streaks, marks, or patches of a different color or colors; varicolored	Variegated green, gray and black
Mottled	Having spots or blotches different colors	Mottled green, gray and black
Multicolored	Lots of colors (state predominant colors)	Multicolored, green, gray and black

## 2.5.6 Moisture

Describe the moisture condition (Figure 2-12).

**Figure 2-12 (after ASTM 2488)  
Moisture**

Description	Criteria
Dry	No discernable moisture
Moist	Moisture present, but no free water
Wet	Visible free water

Soil determined to be "moist" may be alternatively qualitatively described as "slightly moist" or "very moist" if needed.

## 2.5.7 Percent or Proportion of Soil

Report the percentage or proportion of gravel, sand, and fines, by weight of the total sample (excluding the cobbles and boulders), either by using a proportional descriptor (Figure 2-13) or as a weight percentage (not a range), estimated to the nearest 5 %, of the total sample (excluding the cobbles and boulders). Report the percents or proportions in order of decreasing abundance. Percentages must add up to 100%. Visual descriptors may be omitted if the proportions can be clearly inferred from the group name and soil description. Refer to Section 2.5.17 for reporting percent of cobbles and/or boulders.

**Figure 2-13 (after ASTM 2488)  
Percent or Proportion of Soil, Pp**

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	$5 \leq Pp \leq 10\%$
Little	$15 \leq Pp \leq 25\%$
Some	$30 \leq Pp \leq 45\%$
Mostly	$50 \leq Pp \leq 100\%$

## 2.5.8 Particle Size

Describe the size of particles (Figure 2-14).

**Figure 2-14 (from ASTM D 2488)  
Particle Size, Ps**

Description	Sieve Size	Approximate Particle Size (in)
Boulder	Greater than 12 in.	$12 < Ps$
Cobble	3 to 12 in.	$3 < Ps \leq 12$
Coarse Gravel	3/4 to 3 in.	$3/4 < Ps \leq 3$
Fine Gravel	No. 4 to 3/4 in.	$1/5 < Ps \leq 3/4$
Coarse Sand	No. 10 to No. 4	$1/16 < Ps \leq 1/5$
Medium Sand	No. 40 to No. 10	$1/64 < Ps \leq 1/16$
Fine Sand	No. 200 to No. 40	$1/300 < Ps \leq 1/64$
Silt and Clay	Passing No. 200	$Ps \leq 1/300$

## 2.5.9 Particle Angularity

Describe the angularity of the sand (coarse grains only), gravel, cobbles, and boulders (Figure 2-15).

**Figure 2-15 (after ASTM 2488)  
Particle Angularity**

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description, but have rounded edges
Subrounded	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

### 2.5.10 Particle Shape

Describe the shape of the gravel, cobbles, and boulders *if* they meet any of the criteria in Figure 2-16.

**Figure 2-16 (after ASTM 2488)**  
**Particle Shape**

Description	Criteria
Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and Elongated	Particles meet criteria for both flat and elongated

### 2.5.11 Plasticity (for Fine-Grained Soil)

Describe plasticity (Figure 2-17).

**Figure 2-17 (after ASTM 2488)**  
**Plasticity**

Description	Criteria
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

### 2.5.12 Dry Strength (for Fine-Grained Soil)

Determine dry strength (Figure 2-18). *(See Appendix A for field test procedures.)*

**Figure 2-18 (after ASTM 2488)**  
**Dry Strength**

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

### 2.5.13 Dilatancy (for Fine-Grained Soil)

Determine dilatancy (Figure 2-19). *(See Appendix A for field test procedures.)*

**Figure 2-19 (after ASTM 2488)**  
**Dilatancy**

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

### 2.5.14 Toughness (for Fine-Grained Soil)

Determine toughness (Figure 2-20). (See Appendix A for field test procedures.)

**Figure 2-20 (after ASTM 2488)**  
**Toughness**

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

### 2.5.15 Structure

Describe the structure of intact soil (Figure 2-21).

**Figure 2-21 (after ASTM 2488)**  
**Structure**

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least ¼ in. thick; note thickness.
Laminated	Alternating layers of varying material or color with the layers less than ¼ in. thick; note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout.

### 2.5.16 Cementation

Describe the cementation of intact coarse-grained soil (Figure 2-22).

**Figure 2-22 (after ASTM 2488)**  
**Cementation**

Description	Criteria
Weak	Crumbles or breaks with handling or light finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

### 2.5.17 Percent of Cobbles and Boulders

Particles greater than 3 inches in diameter are identified and described as “COBBLES,” or “BOULDERS,” or “COBBLES and BOULDERS” as defined in Section 2.5.8. Cobbles and boulders must be reported by volume percentage (to the nearest 5%). Do not use the proportional descriptors defined in Figure 2-13.

Estimation of the volume of cobbles and/or boulders is based upon recovered intersected or observed lengths and/or drill rig behavior.

A subset of rock descriptors (Section 2.5.18) must be used to describe cobbles and boulders. Isolated boulders may be treated as individual units and described as such.

For example, it is estimated that 30% by volume of the material is cobbles, describe the sample as:

*Well-graded SAND with GRAVEL and COBBLES (SW); medium dense; brown and light gray; wet; 75% from coarse to fine rounded SAND; 20% coarse subrounded to rounded, flat and elongated GRAVEL; 5% fines; weak cementation; 30% SANDSTONE COBBLES, 4-6 inches, hard.*

-or-

*Well-graded SAND with GRAVEL and COBBLES (SW); medium dense; brown and light gray; wet; little coarse subrounded to rounded, flat and elongated GRAVEL; trace fines; weak cementation; 30% SANDSTONE COBBLES, 4-6”, hard.*

Note, the percentages of constituents in the first example do not add up to 100% as cobbles are estimated by total volume, but gravel, sand, and fines, are estimated by weight of the total sample excluding the cobbles and boulders, per Section 2.5.7.

If the predominant constituent of the layer is estimated to be cobbles and/or boulders, the group name must be “COBBLES” or “BOULDERS” or “COBBLES and BOULDERS” with the interstitial or matrix soil description following. There is no Group Symbol for cobbles and/or boulders. Note this is a departure from the descriptive sequence in Section 2.5.1 as Sequence 14 is reported after Sequence 1. For example, it is estimated that 60% by volume of the material is cobbles, describe the layer as:

*COBBLES; 60%; SANDSTONE; hard; 8-10 inches; with interstitial well-graded SAND with GRAVEL (SW); brown and light gray; wet; rounded SAND; little coarse, subrounded to rounded, flat and elongated GRAVEL; trace fines; weak cementation.*

Or if there are 45% cobbles in a SW matrix:

*COBBLES; 45%; SANDSTONE; hard; 8-10 inches; in a matrix of well-graded SAND with GRAVEL (SW); medium dense; brown and light gray; wet; rounded SAND; little coarse, subrounded to rounded, flat and elongated GRAVEL; trace fines; weak cementation.*

## 2.5.18 Description of Cobbles and Boulders

The description of cobbles and boulders must include, at minimum, the following information:

- Rock Type or Rock Name
- Rock hardness
- The intersected length(s)

An *intersected length* is the measured or observed length of cobble or boulder during drilling. This is not necessarily the maximum size of the cobble or boulder, e.g., a 10-inch intersected length may be identified as a boulder.

### 2.5.19 Additional Comments

Additional constituents and soil characteristics not included in the previous categories may be noted and described. Comments may include:

- Amount of roots or root holes
- Amount of mica, gypsum, etc.
- Amount of voids
- Surface coatings on coarse-grained particles
- Oxide staining
- Odor
- Cementing agents (e.g. calcium carbonate – see Appendix A.7)
- Geologic formation name or soil survey unit name, presented as the last term in the sequence capitalized in parenthesis, e.g. (BAY MUD), (FRANCISCAN FORMATION)

References for terms or procedures, not covered by this manual, presented under *Additional Comments*, must be presented in the “Notes” section on the LOTB sheet or Boring Record.

### 2.5.20 Other Drilling Observations

Other observations (not included in the descriptive sequence) that may be presented on the LOTB or BR as notes or remarks include:

- Caving or sloughing of borehole or trench sides
- Difficulty in drilling or excavating, etc.
- Ground water inflow, elevation(s), and estimated rate(s)
- Loss of drill fluid circulation
- Changes in drilling methods not clearly shown on the boring log

## 2.6 Rock Identification and Description Procedures

The procedures presented in this section are based on a hybrid of the International Society of Rock Mechanics (ISRM) (1981) standards and the Bureau of Reclamation (2001) standards.

Although not included in the descriptive sequence, Core Recovery (REC) and Rock Quality Designation (RQD) must be recorded and presented on the boring logs. Core Recovery and RQD must be reported for all rock coring operations as described in Appendices A.9 and A.10.

### 2.6.1 Rock Identification and Descriptive Sequence

Describe rock using Figure 2-23. The detail of description provided for a particular rock type should be dictated by the complexity and objectives of the project. Optional descriptors, if presented, must be relevant to the design and/or construction needs of the project.

**Figure 2-23**  
**Rock Identification and Descriptive Sequence**

Sequence	Identification Components	Refer to Section		Required	Optional
		Field	Lab		
1	Rock Type	2.6.2		●	
2	Rock Name	2.6.2		●	
	<b>Description Components</b>				
3	Rock Grain Size (Coarse-grained sedimentary rock)	2.6.4		●	
	Crystal Size (Igneous and Metamorphic rock)	2.6.4			○
4	Bedding Spacing	2.6.5		●	
5	Color	2.6.6		●	
6	Weathering Descriptors for Intact Rock	2.6.7		●	
7	Rock Hardness	2.6.8		●	
8	Fracture Density	2.6.9		●	
9	Fracture Condition	2.6.10			○
10	Rate of Slaking (Jar Slake Test)	2.6.11			○
11	Relative Strength of Intact Rock		3.3.1		○
12	Additional Comments	2.5.12			○

### 2.6.1.1 Description of Interbedded Rock

Describe interbedded rock as follows:

State the rock type and the predominant rock name followed by the bedding thicknesses (Figure 2-30) of the components and the rock name of the secondary layers. This is followed by the complete individual descriptions of the layers e.g, for a sample consisting of moderate beds of sandstone interbedded with thin beds of siltstone:

*SEDIMENTARY ROCK (SANDSTONE) moderately bedded with thin interbeds of SILTSTONE. SANDSTONE; fine grained; gray; fresh; hard; slightly fractured; SILTSTONE; gray; slightly weathered; moderately hard; moderately fractured.*

### 2.6.1.2 Description for Intensely Weathered to Decomposed or Decomposed Rock

Intensely weathered to decomposed or decomposed rock that is friable and can be reduced to gravel size or smaller by normal hand pressure must be identified and described as rock as completely as possible, followed by the soil identification or classification, and description in parentheses (per Section 2.5). For example:

*IGNEOUS ROCK (DIORITE); yellowish brown; intensely weathered to decomposed; very soft; unfractured; (Lean CLAY with SAND (CL)); medium stiff; moist; little coarse SAND; PP=1 tsf).*

Or when a rock is decomposed, hardness and fracturing usually do not apply:

*IGNEOUS ROCK (DIORITE); yellowish brown; decomposed; (Lean CLAY with SAND (CL)); medium stiff; moist; little coarse SAND; PP=0.6 tsf).*

Note, color is not repeated in the descriptive sequence for soil.

### 2.6.1.3 Description of Poorly Indurated Rock

Poorly indurated formational materials such as siltstone, claystone, weakly cemented sandstone etc.

which display both rock-like and soil-like properties, regardless of the degree of weathering, must be described as rock as completely as possible followed by the soil identification or classification and description in parentheses. Add "POORLY INDURATED" to the Rock Name, e.g.,

*SEDIMENTARY ROCK (POORLY INDURATED SANDSTONE); medium grained; variably light gray and light yellowish brown; fresh; very soft; unfractured; (Poorly-graded SAND (SP)); very dense; moist; medium sand; strong cementation).*

### 2.6.2 Rock Identification

Rock is identified by a combination of Rock Type (Igneous, Metamorphic or Sedimentary) followed by the Rock Name. Rock Name may be a generalized Family Name (e.g., Granite, Sandstone) or a more specific name (e.g., Granodiorite, Arkose) if the identification is made by a qualified geoprofessional, e.g.,

*IGNEOUS ROCK (GRANITE)*

-or-

*IGNEOUS ROCK (GRANODIORITE)*

Note that a specific rock name is usually not relevant for geotechnical work, the family name is generally sufficient and may often be found in published geologic maps. Figures 2-24, 2-25 and 2-26 present rocks commonly found in California. The lists of rock names presented in this section are not intended to be comprehensive.

#### 2.6.2.1 Igneous Rock

Igneous rock is identified by a combination of three characteristics: chemical composition, texture, and method of emplacement.

Chemical Composition: Igneous rocks may be Felsic, characterized by light color and high silica and alkali metal content; Intermediate; or Mafic/Ultramafic, characterized by dark color and high iron and magnesium content.

Texture: Igneous rock may be coarse-grained (phaneritic) where individual minerals are identifiable with the naked eye, or fine-grained

(aphanitic) where individual minerals are not identifiable with the naked eye.

Method of Emplacement: Igneous rock may be formed deep underground (intrusive or plutonic rocks), typically coarse grained, or at or near the surface (extrusive or volcanic rock), typically fine-grained.

Volcanic rock may be further subdivided into lava flows, where molten rock flows over the landscape and solidifies into rock, and pyroclastic deposits which are formed from explosive eruptions where lava and rock particles are thrown into the air. Volcanic rocks may also be characterized by the method of emplacement and texture (Figure 2-24).

### 2.6.2.2 Sedimentary Rock

Sedimentary rock is formed by the process of induration or lithification whereby sediments compact under pressure and gradually become rock. Lithification includes all the processes which convert unconsolidated sediments into sedimentary rock.

Sedimentary rock may be well indurated or lithified as solid rock, or poorly indurated or poorly lithified and display soil-like characteristics. Poorly indurated rock should be distinguished from weathered rock as described in Section 2.6.1.3. Refer to Figure 2-25.

### 2.6.2.3 Metamorphic Rock

Metamorphic rock is igneous, sedimentary or other metamorphic rock that has been changed by heat and/or pressure. Metamorphism may be either regional metamorphism, due to widespread burial and heat, or contact metamorphism, due to heat from a nearby igneous intrusion.

The original rock character may or may not be discernable after metamorphism. If it is still

discernable, the rock name may be the parent rock type or name with the prefix “meta”, e.g., Metavolcanic, Metasedimentary, Metasandstone, Metaandesite.

Regionally metamorphosed rock types are distinguished by mineralogy and texture. These vary according to the degree of metamorphism, or metamorphic grade. Foliation is an alignment of mineral grains or compositional banding. It varies from slaty cleavage due to the parallel growth of mica crystals, to a gneissic texture where minerals group in bands, which resemble bedding. Foliation is usually most common in rock derived from fine-grained sedimentary rock. Refer to Figure 2-26.

### 2.6.3 Rock Description

Rock description includes the Rock Type followed by the Rock Name (either specific, or family name, with modifiers such as scoria, ash fall etc) in parentheses followed by the required descriptors.

Examples:

*IGNEOUS ROCK (BASALT); very thickly bedded; black; fresh; hard; slightly fractured.*

*IGNEOUS ROCK (RHYOLITE ASH FLOW); thickly bedded; white; slightly weathered; soft; slightly fractured.*

*METAMORPHIC ROCK (METASANDSTONE); thickly bedded; white, locally yellowish brown; slightly weathered; moderately soft; slightly fractured.*

-or more specifically-

*METAMORPHIC ROCK (QUARTZITE); thickly bedded; white, locally yellowish brown; slightly weathered; moderately soft; slightly fractured.*

**Figure 2-24  
Igneous Rock**

Rock Type	Categorization		Rock Name		Typical Characteristics
			Family Name	Specific Name (examples)	
<b>Igneous</b>	<b>Felsic</b>	Coarse-grained	<b>Granite</b>	Granite, Tonalite, Granodiorite, Quartz Monzonite	Light Colored; composed primarily of quartz and feldspar (plagioclase and orthoclase) with minor ferromagnesian minerals. Emplaced as large intrusive plutonic bodies.
		Fine-grained	<b>Rhyolite</b>	Rhyolite, Quartz Latite, Trachyte	As above, except emplaced as volcanic ash flows, ash falls, local flows and domes.
	<b>Intermediate</b>	Coarse-grained	<b>Diorite</b>	Diorite, Monzonite	Medium gray or medium green (intermediate colored); composed primarily of plagioclase feldspars with ~30-50% ferromagnesian minerals (absent or minor quartz). Emplaced as small to large intrusive plutonic bodies.
		Fine-grained	<b>Andesite</b>	Andesite, Latite, Dacite	As above, except emplaced as volcanic flows, mud flows and breccias.
	<b>Mafic/ Ultramafic</b>	Coarse-grained	<b>Gabbro</b>	Gabbro, Peridotite, Norite, Dunite	Dark gray or black (dark colored); composed primarily of ferromagnesian minerals with minor plagioclase feldspar. Typically emplaced in California as accretionary memtamorphosed bodies (e.g ophiolite complexes).
		Fine-grained	<b>Basalt</b>	Basalt, Picrite	As above, except emplaced as local to widespread volcanic lava flows and cinder cones.
<b>Volcanic Rock Name Modifiers</b>					
<b>Lava flow</b>	Typical of basalt.				
<b>Ash flow</b>	Typical of rhyolite - An airborne deposit formed from lava and rock fragments, which flow through the air down the flanks of a volcano.				
<b>Ash fall</b>	An airborne deposit formed from small rock fragments erupted to high altitudes, which then rain down.				
<b>Mudflow</b>	Typical of andesite. May be a primary feature where erupting lava is mixed with snow or water and flows downhill, or may be a secondary feature where an existing volcanic deposit fails in a landslide.				
<b>Breccia</b>	Flowing rock hardens, breaks up and is incorporated back into the flow.				
<b>Agglomerate</b>	Volcanic rock formed primarily of volcanic bombs. Volcanic bombs are globs of lava thrown through the air and may gravel-sized or as large as a small car.				
<b>Obsidian</b>	Volcanic rock consisting almost entirely of glass.				
<b>Pumice</b>	Solidified lava froth – resembles a sponge with about 90% porosity, floats on water.				
<b>Scoria</b>	Like pumice, but with larger vesicles (rounded voids) and thicker vesicle walls. Sinks in water.				

**Figure 2-25**  
**Sedimentary Rock**

Rock Type	Categorization*		Rock Name	Characteristics
<b>Sedimentary</b>	<b>Clastic Rocks</b>	<b>Course-grained</b>	<b>Conglomerate</b>	Rock composed of rounded clasts of gravel, cobbles, and/or boulders with interstitial finer-grained material.
				A conglomerate composed of angular clasts.
				Rock composed mostly of sand-sized particles.
			<b>Graywacke</b>	Sandstone characterized by well graded, usually angular, sand and gravel in a fine-grained matrix.
		<b>Fine-grained</b>	<b>Mudstone</b>	Poorly indurated, generally structureless rock composed of clay. Generally slakes in water.
			<b>Claystone</b>	Well indurated, generally structureless rock composed of clay.
			<b>Shale</b>	Well indurated mudstones or claystones which are fissile, or break along planes generally parallel to bedding planes.
			<b>Siltstone</b>	Rock composed mostly of silt-sized particles. May be structureless or display bedding. Usually not fissile unless there is significant clay content.
	<b>Evaporates</b>			Evaporites are generally identified by their primary mineral constituent, e.g., Gypsum, Borates, Halite (rock salt), Carbonate etc.
	<b>Precipitates</b>	<b>Organic</b>	<b>Limestone</b>	Well indurated rock composed of calcium carbonate or calcium-magnesium carbonate (dolomite) with or without shells or shell fragments.
			<b>Chalk</b>	Poorly indurated limestone.
			<b>Diatomite</b>	Poorly indurated rock comprised of diatom shells.
		<b>Inorganic</b>	<b>Chert</b>	Generally microcrystalline silica.

\*Sedimentary rocks may be divided into three categories:

**Clastic:** Formed from particles of preexisting rocks transported and deposited primarily in water.

**Evaporate:** Formed by the precipitation of minerals due to the complete evaporation of relatively small bodies of surface water; generally identified by their primary mineral constituent.

**Precipitate:** Formed by the precipitation of minerals, generally in oceans.

**Figure 2-26  
Metamorphic Rock**

Rock Type	Categorization	Family Name	Characteristics
<b>Metamorphic</b>	<b>Foliated</b>	<small>Metamorphic, Foliated, Slate</small> <b>Slate</b>	Usually fine-grained with well developed slaty cleavage (tendency to break along well defined planes).
		<small>Metamorphic, Foliated, Phyllite</small> <b>Phyllite</b>	Coarser grained than slate with phyllitic texture, similar to slaty cleavage, but planes may be less well defined or wavy.
		<small>Metamorphic, Foliated, Schist</small> <b>Schist</b>	Coarse-grained, significant alignment of minerals, some slaty cleavage.
		<small>Metamorphic, Foliated, Gneiss</small> <b>Gneiss</b>	Coarse-grained, foliation entirely due to alignment and banding of minerals.
	<b>Non-foliated or poorly foliated</b>	<small>Metamorphic, Non-foliated or poorly foliated, Granulite</small> <b>Granulite</b>	Higher degree of metamorphism than gneiss, resemble coarse-grained igneous rocks.
		<small>Metamorphic, Non-foliated or poorly foliated, Amphibolite</small> <b>Amphibolite</b>	Nearly monomineralic coarse-grained rock composed of amphibole.
		<small>Metamorphic, Non-foliated or poorly foliated, Hornfels</small> <b>Hornfels</b>	Generally fine-grained contact-metamorphosed rock.
		<small>Metamorphic, Non-foliated or poorly foliated, Skarn</small> <b>Skarn</b>	Usually coarse-grained contact metamorphic rock where significant metasomatism has occurred.

### 2.6.4 Rock Grain-size descriptors

Describe the grain or clast size in accordance with Figures 2-27, 2-28 and 2-29.

**Figure 2-27  
Grain-Size for Crystalline Igneous and Metamorphic Rock**

Description	Average Crystal Size, S (in)
Very Coarse Grained or Pegmatitic	$3/8 \leq S$
Coarse-grained	$3/16 < S \leq 3/8$
Medium-grained	$1/32 < S \leq 3/16$
Fine-grained	$1/250 < S \leq 1/32$
Aphanitic	$S \leq 1/250$

**Figure 2-28**  
**Grain-Size (Clastic Rock)**

USCS Description	Lithified Product
Boulder	Boulder Conglomerate
Cobble	Cobble Conglomerate
Coarse Gravel	Coarse Gravel Conglomerate
Fine Gravel	Fine Gravel Conglomerate
Coarse Sand	Coarse Sandstone
Medium Sand	Medium Sandstone
Fine Sand	Fine Sandstone
Silt	Siltstone, Shale
Clay	Claystone, Shale

**Figure 2-29**  
**Grain-Size (Pyroclastic Igneous Rock)**

Fragment	Lithified Product	Size, S (in)
Block (Angular)	Volcanic Breccia	2.5 < S
Bomb (Rounded)	Agglomerate	
Lapilli	Lapilli Tuff	1/20 < S ≤ 2.5
Coarse Ash	Coarse Ash Tuff	1/400 < S ≤ 1/20
Fine Ash	Fine Ash Tuff	S ≤ 1/400

## 2.6.5 Bedding Spacing Descriptors

Describe the bedding thickness or spacing of sedimentary or bedded volcanic rock (Figure 2-30).

**Figure 2-30 (after USBR 2001)**  
**Bedding Spacing**

Description	Thickness/Spacing, Sb
Massive	10 ft. < Sb
Very Thickly Bedded	3 ft. < Sb ≤ 10 ft.
Thickly Bedded	1 ft. < Sb ≤ 3 ft.
Moderately Bedded	4 in. < Sb ≤ 1 ft.
Thinly Bedded	1 in. < Sb ≤ 4 in.
Very Thinly Bedded	1/4 in. < Sb ≤ 1 in.
Laminated	Sb ≤ 1/4 in.

## 2.6.6 Rock Colors

Use the color name from the *Munsell Soil Color Charts*, which is based on the National Bureau of Standards/Inter Society Color Council system, to describe the rock at the time of sampling. If the sample contains layers or patches of varying colors, describe the predominant colors observed.

For additional information, see ASTM D 1535, *Standard Practice for Specifying Color by the Munsell System*.

## 2.6.7 Weathering Descriptors for Intact Rock

Describe the rock weathering (Figure 2-31).

**Figure 2-31 (after USBR 2001)  
Weathering for Intact Rock**

Description	Diagnostic Features					General Characteristics
	Chemical Weathering-Discoloration and/or Oxidation		Mechanical Weathering-Grain Boundary Conditions (Disaggregation) Primarily for Granitics and Some Coarse-Grained Sediments	Texture and Leaching		
	Body of Rock	Fracture Surfaces		Texture	Leaching	
Fresh	No discoloration, not oxidized.	No discoloration or oxidation.	No separation, intact (tight).	No change.	No leaching.	Hammer rings when crystalline rocks are struck.
Slightly Weathered	Discoloration or oxidation is limited to surface of, or short distance from, fractures; some feldspar crystals are dull.	Minor to complete discoloration or oxidation of most surfaces.	No visible separation, intact (tight).	Preserved.	Minor leaching of some soluble minerals.	Hammer rings when crystalline rocks are struck. Body of rock not weakened.
Moderately Weathered	Discoloration or oxidation extends from fractures usually throughout; Fe-Mg minerals are "rusty," feldspar crystals are "cloudy".	All fracture surfaces are discolored or oxidized.	Partial separation of boundaries visible.	Generally preserved.	Soluble minerals may be mostly leached.	Hammer does not ring when rock is struck. Body of rock is slightly weakened.
Intensely Weathered	Discoloration or oxidation throughout; all feldspars and Fe-Mg minerals are altered to clay to some extent; or chemical alteration produces in situ disaggregation, see grain boundary conditions.	All fracture surfaces are discolored or oxidized, surfaces friable.	Partial separation, rock is friable; in semiarid conditions granitics are disaggregated.	Texture altered by chemical disintegration (hydration, argillation).	Leaching of soluble minerals may be complete.	Dull sound when struck with hammer, usually can be broken with moderate to heavy manual pressure or by light hammer blow without reference to planes of weakness such as incipient or hairline fractures, or veinlets. Rock is significantly weakened.
Decomposed	Discolored or oxidized throughout, but resistant minerals such as quartz may be unaltered; all feldspars and Fe-Mg minerals are completely altered to clay.	n/a	Complete separation of grain boundaries (disaggregated).	Resembles a soil, partial or complete remnant rock structure may be preserved; leaching of soluble minerals usually complete. <small>Resembles a soil, partial or complete remnant rock structure may be preserved, leaching of soluble minerals usually complete.</small>	Resembles a soil, partial or complete remnant rock structure may be preserved, leaching of soluble minerals usually complete. <small>Resembles a soil, partial or complete remnant rock structure may be preserved, leaching of soluble minerals usually complete.</small>	Can be granulated by hand. Resistant minerals such as quartz may be present as "stringers" or "dikes."

## 2.6.8 Rock Hardness

Describe the hardness of intact rock core (Figure 2-32).

**Figure 2-32 (after USBR 2001)**  
**Rock Hardness**

Description	Criteria
Extremely Hard	Cannot be scratched with a pocketknife or sharp pick. Can only be chipped with repeated heavy hammer blows.
Very Hard	Cannot be scratched with a pocketknife or sharp pick. Breaks with repeated heavy hammer blows.
Hard	Can be scratched with a pocketknife or sharp pick with difficulty (heavy pressure). Breaks with heavy hammer blows.
Moderately Hard	Can be scratched with a pocketknife or sharp pick with light or moderate pressure. Breaks with moderate hammer blows.
Moderately Soft	Can be grooved 1/16 in. deep with a pocketknife or sharp pick with moderate or heavy pressure. Breaks with light hammer blow or heavy manual pressure.
Soft	Can be grooved or gouged easily with a pocketknife or sharp pick with light pressure, can be scratched with fingernail. Breaks with light to moderate manual pressure.
Very Soft	Can be readily indented, grooved or gouged with fingernail, or carved with a pocketknife. Breaks with light manual pressure.

## 2.6.9 Fracture Density

Fractures are defined in Section 2.6.10. The fracture density is based on the fracture spacing observed in recovered core, excluding mechanical breaks, measured along the core axis. Note that fracture density and RQD should correlate. Describe the fracture density (Figure 2-33).

**Figure 2-33 (after USBR 2001)**  
**Fracture Density**

Description	Observed Fracture Density
Unfractured	No fractures.
Very Slightly Fractured	Core lengths greater than 3 ft.
Slightly Fractured	Core lengths mostly from 1 to 3 ft.
Moderately Fractured	Core lengths mostly 4 in. to 1 ft.
Intensely Fractured	Core lengths mostly from 1 to 4 in.
Very Intensely Fractured	Mostly chips and fragments.

## 2.6.10 Fracture Condition

*Fracture* is a term used to describe any break in geologic material, including shears and shear zones. Use a single description, or range of descriptors, to describe the fractures over the length of the core. Descriptors must be presented in the following order.

1. Fracture Group Identification
2. Dip Magnitude
3. Spacing
4. Width
5. Infilling
6. Composition of Infilling
7. Weathering or Alteration
8. Hardness
9. Healing
10. Roughness

e.g.,

*SEDIMENTARY ROCK (GRAYWACKE); fine-grained; massive; gray; moderately weathered; hard; moderately fractured; (F1, 45 deg, 2-3' spacing, moderately wide, thin filling of clay, soft, slightly rough) (F2, 28 deg, 1' apparent spacing, open, very thin filling of calcite, hard, moderately healed, smooth).*

### 2.6.10.1 Fracture Group Identification

Uniquely identify each fracture group in the descriptive sequence using the terms F1, F2...Fx for fracture groups.

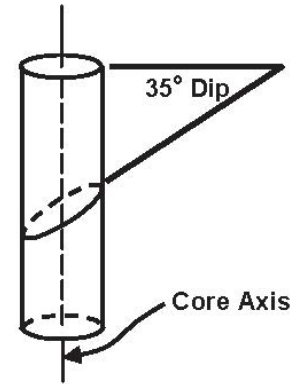
### 2.6.10.2 Fracture Dip Magnitude

Report fracture dip magnitude. (Figure 2-34)

**Figure 2-34**  
**Fracture Dip Magnitude**

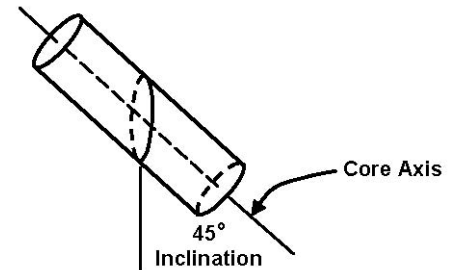
**Vertical Hole:**

True dip (but not strike unless from oriented core) is reported.



**Angle Hole:**

True dip is usually not known; angle is measured from core axis and is called inclination.

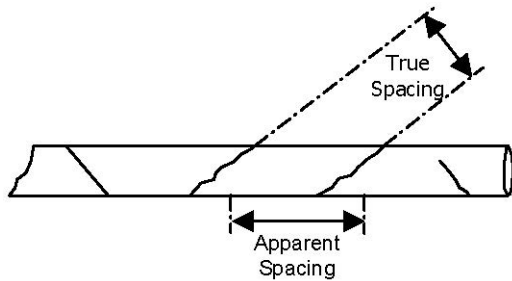


### 2.6.10.3 Fracture Spacing

Fracture spacing is the distance measured between similar oriented fractures. Fracture spacing may either be presented as a single distance or as a range of distances measured for a fracture group. Spacing is measured as shown in Figure 2-35.

Apparent spacing, if measured, must be described as such.

**Figure 2-35**  
**True and Apparent Fracture Spacing**



### 2.6.10.4 Fracture Width

Measure the fracture width normal to the fracture surfaces (Figure 2-36).

**Figure 2-36**  
**Fracture Width (after USBR 2001)**

Description	Fracture Width, FW (in)
Tight	No visible separation
Slightly Open	$FW < 1/32$
Moderately Open	$1/32 \leq FW < 1/8$
Open	$1/8 \leq FW < 3/8$
Moderately Wide	$3/8 \leq FW < 1$
Wide	$1 \leq FW$

### 2.6.10.5 Fracture Infilling

Describe the thickness of coatings or fillings (Figure 2-37).

**Figure 2-37 (after USBR 2001)**  
**Filling or Coating Thickness**

Description	Fracture Filling, FF
Clean	No film coating
Very Thin	$FF < 1/32$ in.
Moderately Thin	$1/32$ in. $\leq$ $FF < 1/8$ in.
Thin	$1/8$ in. $\leq$ $FF < 3/8$ in.
Moderately Thick	$3/8$ in. $\leq$ $FF < 1$ in.
Thick	$1$ in. $\leq$ $FF$

### 2.6.10.6 Composition of Infilling

Fractures may be filled with minerals or soil. Identify and describe the fracture fillings to convey properties that may be significant to the project design.

### 2.6.10.7 Weathering or Alteration

Describe the weathering or alteration of fracture infilling (excluding soil materials) using the weathering descriptors for intact rock (Figure 2-31)

### 2.6.10.8 Hardness

Describe the hardness of the infill material using either the hardness descriptors for rock (Figure 2-32) or estimate the consistency or apparent density descriptor for soil.

### 2.6.10.9 Healing

Describe the fracture healing (Figure 2-38).

**Figure 2-38**  
**Fracture Healing (after USBR 2001)**

Description	Healing
Totally Healed	Fracture is completely healed or recemented to a degree at least as hard as surrounding rock.
Moderately Healed	Greater than 50 percent of fracture is healed or recemented.
Partly Healed	Less than 50 percent of fractured material, filling, or fracture surface is healed or recemented.
Not Healed	Fracture surface filling is not healed or recemented.

### 2.6.10.10 Roughness

Describe the fracture surface roughness (small scale asperities) (Figure 2-39).

**Figure 2-39**  
**Fracture Roughness (after USBR 2001)**

Description	Roughness
Stepped	Near-normal steps and ridges occur on the fracture surface.
Rough	Large, angular asperities can be seen.
Moderately Rough	Asperities are clearly visible and fracture surface feels abrasive.
Slightly Rough	Small asperities on the fracture surface are visible and can be felt.
Smooth	No asperities, smooth to the touch.

### 2.6.11 Rate of Slaking

Slaking is the crumbling and disintegration of some rocks when exposed to air or moisture. Slaking may be partial (rock breaks up into smaller particles), or complete (rock is completely disintegrated to clay, silt, and sand).

Rocks that are prone to slaking include shale, siltstone, claystone, weakly welded tuff, and highly weathered crystalline igneous and metamorphic rocks. See Appendix A for test procedures. Describe rate of slaking (Figure 2-40).

**Figure 2-40**  
**Rate of Slaking (from Air Force Manual)**

Jar Slake Index, $I_J$	Observed Behavior
1	Degrades to a pile of small particles or fragments.
2	Breaks rapidly and forms many fragments.
3	Breaks slowly and forms few fragments.
4	Breaks rapidly and develops several fractures.
5	Breaks slowly and develops few fractures.
6	No change to condition of the rock fragment.

### 2.6.12 Additional Comments

Note additional relevant rock characteristics not included in the previous categories.

References for terms or procedures, not covered by this manual, presented under *Additional Comments*, must be presented in the “Notes” section on the LOTB sheet or Boring Record.

### 2.6.13 Other Drilling Observations

Other observations (not included in the descriptive sequence) that may be presented on the LOTB or BR as notes or remarks include:

- Time for core run
- Difficulty in drilling or excavating, etc.
- Ground water inflow, elevation(s), and estimated rate(s)
- Loss of drill fluid circulation

## 2.7 Sample Preparation and Identification for Laboratory Testing and Storage

Geoprofessionals who drill, identify, sample, preserve, and transport soil samples play an important role in ensuring the quality of the laboratory test results. When performing field investigations, the geoprofessional must be familiar with the following ASTM standards:

- ASTM D 1586, “Test Method for Penetration Test and Split-Barrel Sampling of Soils”
- ASTM D 1587, “Practice for Thin-Walled Tube Sampling of Soils”
- ASTM D 3550, “Practice for Ring-Lined Barrel Sampling of Soils”
- ASTM D 4220, “Standard Practices for Preserving and Transporting Soil Samples”

The following information explains the procedures and information required to prepare soil and rock samples to the Caltrans Geotechnical Laboratory, an AASHTO Materials Reference Laboratory (AMRL) accredited facility located in Sacramento.

### 2.7.1 Sample Preparation and Identification for Laboratory Testing and Storage

All samples must be named according to the following convention:

$$\text{Hole ID} - \text{SNN} - T$$

Where,

*Hole ID*: Refer to Section 2.4

*S*: The Sample Type Code (Figure 2-41)

*NN*: 2-digit sample number (01–99), numbered from the top down.

*T*: 1-digit tube number, starting with the bottom tube numbered as 1.

For example:

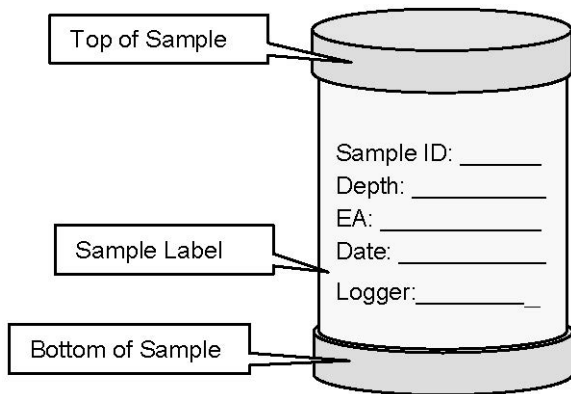
$$A - 10 - 005 - U02 - 3$$

**Figure 2-41**  
**Sample Type Codes (after ASTM D 6453)**

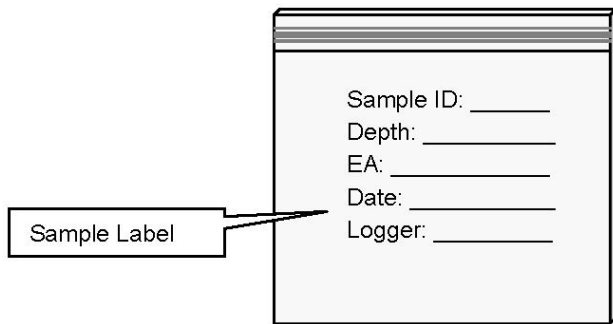
Code	Description
U	Undisturbed Shelby tube
P	Undisturbed Piston
S	Split spoon (includes SPT and Cal Mod Samplers)
B	Bulk
C	Core (both rock and soil)
D	Disturbed (include auger cuttings)
O	Other

Label brass and Shelby tubes and bagged samples (Figures 2-42 and 2-43).

**Figure 2-42**  
**Brass and Shelby Tube Label**



**Figure 2-43**  
**Bagged Sample Label**



## 2.7.2 Identification of Large Soil Samples

In addition to the labeling requirements explained above, some soil samples must also be labeled with a Sample Identification Card (Caltrans Form TL-101), including:

- Samples weighing more than 5 lbs.
- Samples to be tested by the Materials Engineering and Testing Services (METS), test names are followed by “\*\*” in Figure 2-44.

Place Form TL-101 inside a sealed plastic bag then put it inside the large plastic or canvas sample bag.

**Figure 2-44**  
**Minimum Material Requirements for Various Test Methods**

Test Method(s)	Test Name	Material Required	Typical Sample Size/Type	TL-101 Required
AASHTO T 265 ASTM D 2216	Moisture Content	0.5 lb	1/2 Tube	No
ASTM D 4767	Unit Weight	1 lb	1 Tube	No
AASHTO T 100	Specific Gravity	0.5 lb	1/2 Tube	No
ASTM D 422	Particle-Size Analysis	1 lb	1 Tube	No
AASHTO T 89 AASHTO T 90	Liquid Limit Plastic Limit, Plasticity Index	1 lb	1 Tube	No
ASTM D 2435	Consolidation Undisturbed (2.0" Diameter)	-	1 Tube	No
	(2.5" Diameter)	-	1 Tube	No
	Remolded (2.0" Diameter)	80 lb	2 Full Canvas Bags	Yes
ASTM D 4546	Swell Potential Undisturbed (2.0" Diameter)	-	1 Tube	No
	(2.5" Diameter)	-	1 Tube	No
	Remolded (2.0" Diameter)	80 lb	2 Full Canvas Bags	Yes
ASTM D 5333	Collapse Potential Undisturbed (2.0" Diameter)	-	1 Tube	No
	(2.5" Diameter)	-	1 Tube	No
	Remolded (2.0" Diameter)	80 lb	2 Full Canvas Bags	Yes
ASTM D 3080	Direct Shear Undisturbed	-	1 Tube	No
	Remolded	80 lb	2 Full Canvas Bags	Yes
CTM 216	Relative Compaction (Compaction Curve Only)	80 lb	2 Full Canvas Bags	Yes
CTM 220	Permeability Undisturbed Falling Head	-	1 Tube	No
	Remolded Falling Head	80 lb	2 Full Canvas Bags	Yes
	Constant Head	80 lb	2 Full Canvas Bags	Yes

Test Method(s)	Test Name	Material Required	Typical Sample Size/Type	TL-101 Required
ASTM D 2166 ASTM D 2938	Unconfined Compression	-	1 Tube or Core	No
ASTM D 4767	Triaxial CU (3 points) Undisturbed (2.0" Diameter)	-	3 Tubes - in series	No
	(2.5" Diameter)	-	3 Tubes - in series	No
ASTM D 2850	Remolded (2.8" Diameter)	80 lb	2 Full Canvas Bags	Yes
	Triaxial UU (1 point) Undisturbed (2.0" Diameter)	-	1 Tube	No
	(2.5" Diameter)	-	1 Tube	No
	Remolded (2.8" Diameter)	80 lb	2 Full Canvas Bags	Yes
ASTM D 427	Shrinkage Limit	1 lb	1 Tube	No
ASTM D 5731	Point Load	-	Rock Core	No
ASTM D 4829	Expansion Index	40 lb	1 Full Canvas Bag	Yes
CTM 217 AASHTO T 176	Sand Equivalent**	10 lb	1/4 Full Canvas Bag	Yes
CTM 301 AASHTO T 190	R-Value**	80 lb	2 Full Canvas Bags	Yes
CTM 643 CTM 417 CTM 422	Corrosion** Sulfates** Chlorides**	10 lb	1/4 Full Canvas Bag	Yes
EPA 9081	Organic Content** PH**	10 lb	1/4 Full Canvas Bag	Yes
	Cation Exchange**			

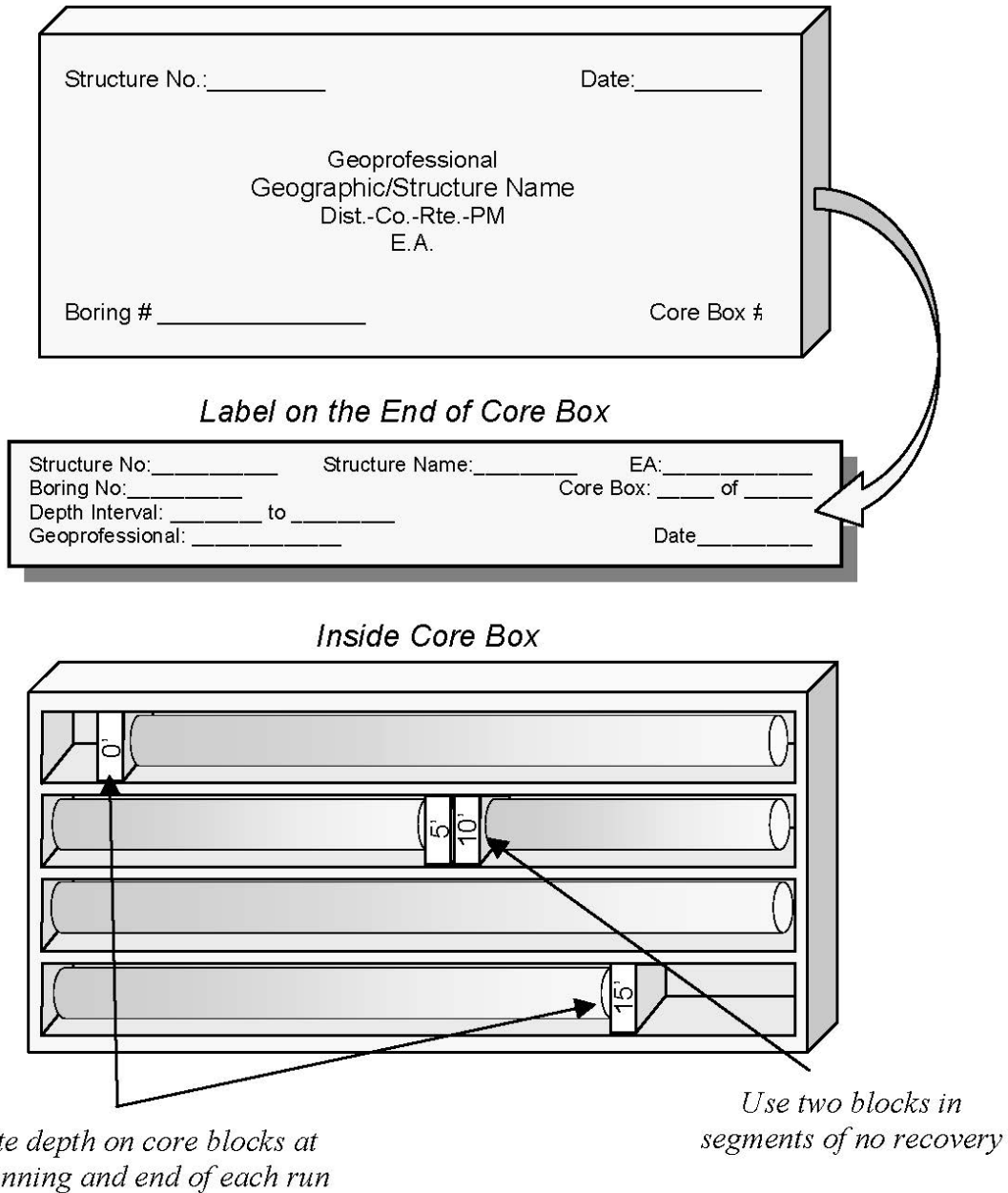
*Notes:*

- \*\* Tests performed by Materials Engineering and Testing Services (METS)
- A 12" by 24" canvas bag completely filled contains approximately 40 lb of material.
- A 2" by 4" tube contains approximately 1 lb. of material.
- Minimum material weights shown for remolded samples include sufficient material for the development of a moisture density curve.
- Triaxial samples from Shelby tubes require a minimum sample length equal to three times the sample diameter.

### 2.7.3 Core Box Layout

Label core boxes as shown in Figure 2-45.

**Figure 2-45**  
**Core Box Layout and Label**



## **2.8 Quality Check of Field Observations and Samples**

The geoprofessional must conduct a quality check of his/her field notes and observations in the office. Sample descriptions and identifications must be reviewed and revised as necessary to ensure that they are in compliance with this manual. Sample descriptors that are subject to change due to time or environment, such as moisture or RQD, must not be revised.

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## Section 3: Procedures for Soil and Rock Description and/or Classification Using Laboratory Test Results

### 3.1 Introduction

Section 2 presents the procedures for describing and identifying soil and rock samples in the field using visual and manual methods and basic field-testing tools. Most of these field procedures are sufficient to identify and describe the soil and rock in qualitative terms, and are appropriate for reporting in final boring logs, as described in Sections 4 and 5. In many cases field-generated descriptors can be correlated to engineering parameters for use in geotechnical designs. In some cases, however, the geoprofessional may want to more quantitatively and definitively characterize a particular sample using laboratory test results.

This section addresses how to apply specific laboratory test results to revise and supplement the original field observations, identifications, and descriptions. The information presented in this Section is based largely on the American Society for Testing and Materials (ASTM) D 2487, *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*.

### 3.2 Revising Soil Descriptions and Assigning Soil Classification Using Laboratory Test Results

Six components in the identification and descriptive sequence for soil (Section 2.5.1) may be revised with laboratory test results. They are:

- Group Name
- Group Symbol
- Consistency
- Percent or Proportion of Soil
- Particle Size Range
- Plasticity

The *Group Name* and *Group Symbol* are determined in the field using visual and manual procedures based on ASTM D 2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. The field method requires the user to make judgments on a number of observations (e.g., percent of constituents by weight, whether a soil is well or poorly-graded, and whether the soil is a clay or silt or some combination thereof).

Laboratory particle-size analysis, liquid limit, and plasticity index provide a quantitative basis for *classification* of the soil. Furthermore, the laboratory procedure employs a much more comprehensive listing of possible Group Names, as compared to field methods.

Consistency is determined in the field using one or more of three methods (vane shear test, Torvane, or Pocket Penetrometer), with varying levels of accuracy and repeatability. Laboratory triaxial, direct shear, and unconfined compression tests provide less subjective undrained shear strength values that can be correlated to specific consistency descriptors.

Percent gravel, sand, and fines, and the range of particle sizes are estimated in the field using visual methods (e.g. jar test, visual approximation, etc.). The laboratory particle-size analysis test provides a quantitative distribution of particle sizes in proportion to the total sample weight.

### **3.2.1 Soil Classification and Description Descriptive Sequence**

Use the descriptive sequence in Figure 2-5 when classifying and describing soil. Items indicated by a check mark in the “Required” column must be used to completely describe all the components of the soil. To incorporate laboratory test data in the classification and descriptive sequence, refer to the sections in this Manual noted in Figure 2-5 (*See “Lab” column*).

### **3.2.2 Group Name and Group Symbol**

This section presents a procedure for classifying soil for engineering purposes based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index. This method is based on the ASTM version of the Unified Soil Classification System (USCS).

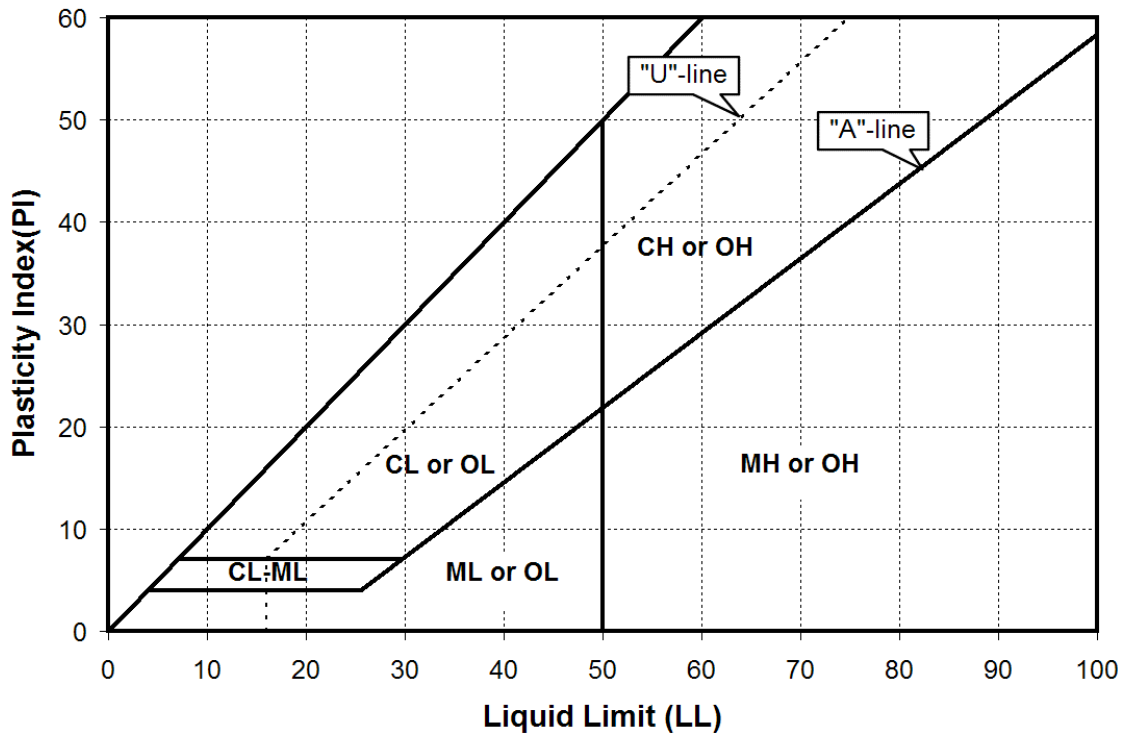
The ASTM procedure for classifying and describing fine-grained and coarse-grained soil is only applicable to material passing the 3-inch sieve. If the sample includes cobbles and/or boulders, they must be reported per Section 2.5.17.

### **3.2.2.1 Procedure for Classification of Fine-Grained Soil**

If 50% or more by dry weight of the test specimen passes the No. 200 sieve, the soil is fine-grained, and is classified using the liquid limit and plasticity index (Figures 3-1 and 3-2).

- In cases where the liquid limit exceeds 100, or the plasticity index exceeds 60, the plasticity chart may be expanded by maintaining the same scale on both axes and extending all relevant lines.
- If the geoprofessional suspects there is sufficient organic matter to influence the soil classification, additional testing must be requested from the Geotechnical Laboratory.

**Figure 3-1**  
**Classification of Fine-Grained Soil**



**Figure 3-2**  
**Classification of Fine-Grained Soil**

Liquid Limit	Organic	Plasticity Index	Group Symbol	Fines	Courseness	Group Name	
LL < 50	Inorganic	PI > 7 and plots on or above "A"-line	CL	< 30% plus No. 200	< 15% plus No. 200	Lean CLAY	
					15-30% plus No. 200	% sand ≥ % gravel	Lean CLAY with SAND
						% sand < % gravel	Lean CLAY with GRAVEL
				≥ 30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY lean CLAY
					% sand < % gravel	≥ 15% gravel	SANDY lean CLAY with GRAVEL
						< 15% gravel	GRAVELLY lean CLAY
		4 < PI < 7 and plots on or above "A"-line	CL-ML	< 30% plus No. 200	< 15% plus No. 200	SILTY CLAY	
					15-30% plus No. 200	% sand ≥ % gravel	SILTY CLAY with SAND
						% sand < % gravel	SILTY CLAY with GRAVEL
				≥ 30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY SILTY CLAY
					% sand < % gravel	≥ 15% gravel	SANDY SILTY CLAY with GRAVEL
						< 15% gravel	GRAVELLY SILTY CLAY
	PI < 4 or plots below "A"-line	ML	< 30% plus No. 200	< 15% plus No. 200	SILT		
				15-30% plus No. 200	% sand ≥ % gravel	SILT with SAND	
					% sand < % gravel	SILT with GRAVEL	
			≥ 30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY SILT	
				% sand < % gravel	≥ 15% gravel	SANDY SILT with GRAVEL	
					< 15% gravel	GRAVELLY SILT	
	Organic	PI ≥ 4 and plots on or above "A"-line	OL	< 30% plus No. 200	< 15% plus No. 200	ORGANIC CLAY	
					15-30% plus No. 200	% sand ≥ % gravel	ORGANIC CLAY with SAND
						% sand < % gravel	ORGANIC CLAY with GRAVEL
				≥ 30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY ORGANIC CLAY
					% sand < % gravel	≥ 15% gravel	SANDY ORGANIC CLAY with GRAVEL
						< 15% gravel	GRAVELLY ORGANIC CLAY
PI < 4 or plots below "A"-line		OL	< 30% plus No. 200	< 15% plus No. 200	ORGANIC SILT		
				15-30% plus No. 200	% sand ≥ % gravel	ORGANIC SILT with SAND	
					% sand < % gravel	ORGANIC SILT with GRAVEL	
			≥ 30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY ORGANIC SILT	
				% sand < % gravel	≥ 15% gravel	SANDY ORGANIC SILT with GRAVEL	
					< 15% gravel	GRAVELLY ORGANIC SILT	
% sand < % gravel	≥ 15% gravel	GRAVELLY ORGANIC SILT with SAND					

Figure 3-2, continued

Liquid Limit	Organic	Plasticity Index	Group Symbol	Fines	Coarseness	Group Name	
- LL > 50	Inorganic	Plots on or above "A"-line	CH	<30% plus No. 200	<15% plus No. 200	Fat CLAY	
					15-30% plus No. 200	% sand $\geq$ % gravel	Fat CLAY with SAND
				$\geq$ 30% plus No. 200	% sand < % gravel	Fat CLAY with GRAVEL	
					% sand $\geq$ % gravel	< 15% gravel	SANDY fat CLAY
					% sand < % gravel	$\geq$ 15% gravel	SANDY fat CLAY with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY fat CLAY
		Plots below "A"-line	MH	<30% plus No. 200	<15% plus No. 200	Elastic SILT	
					15-30% plus No. 200	% sand $\geq$ % gravel	Elastic SILT with SAND
				$\geq$ 30% plus No. 200	% sand < % gravel	Elastic SILT with GRAVEL	
					% sand $\geq$ % gravel	< 15% gravel	SANDY elastic SILT
					% sand < % gravel	$\geq$ 15% gravel	SANDY elastic SILT with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY elastic SILT
	Organic	Plots on or above "A"-line	OH	<30% plus No. 200	<15% plus No. 200	ORGANIC CLAY	
					15-30% plus No. 200	% sand > % gravel	ORGANIC CLAY with SAND
				$\geq$ 30% plus No. 200	% sand < % gravel	ORGANIC CLAY with GRAVEL	
					% sand $\geq$ % gravel	< 15% gravel	SANDY ORGANIC CLAY
					% sand < % gravel	$\geq$ 15% gravel	SANDY ORGANIC CLAY with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY ORGANIC CLAY
		Plots below "A"-line	OH	<30% plus No. 200	<15% plus No. 200	ORGANIC SILT	
					15-30% plus No. 200	% sand $\geq$ % gravel	ORGANIC SILT with SAND
				$\geq$ 30% plus No. 200	% sand < % gravel	ORGANIC SILT with GRAVEL	
					% sand $\geq$ % gravel	< 15% gravel	SANDY ORGANIC SILT
					% sand < % gravel	$\geq$ 15% gravel	SANDY ORGANIC SILT with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY ORGANIC SILT
% sand < % gravel	$\geq$ 15% sand	GRAVELLY ORGANIC SILT with SAND					

### 3.2.2.2 Procedure for Classification of Coarse-Grained Soil

If more than 50% by dry weight is retained on the No. 200 sieve, the soil is coarse-grained. Coarse-grained soil is classified using the following procedure:

- The soil is gravel if more than 50% of the coarse fraction (plus No. 200 sieve) is retained on the No. 4 sieve.
- The soil is sand if 50% or more of the coarse fraction (plus No. 200 sieve) passes through the No. 4 sieve.
- Soil is classified as either well-graded or poorly-graded based on the coefficients of uniformity ( $C_u$ ) and curvature ( $C_c$ ), determined as follows:

If 12% or less of the test specimen passes through the No. 200 sieve, plot the cumulative particle-size distribution and compute the coefficient of uniformity,  $C_u$ , and coefficient of curvature,  $C_c$ , as given in Equations 1 and 2.

$$\text{Equation 1} \quad C_u = \frac{D_{60}}{D_{10}}$$

$$\text{Equation 2} \quad C_c = \frac{(D_{30})^2}{(D_{10} \times D_{60})}$$

Where  $D_{10}$ ,  $D_{30}$ , and  $D_{60}$  are the particle-size diameters corresponding to 10, 30, and 60 percentiles on the cumulative particle-size distribution curve. It may be necessary to extrapolate the curve to obtain the  $D_{10}$  diameter.

Use the above results to determine the classification according to Figure 3-3.

**Figure 3-3**  
**Classification of Coarse-Grained Soil**

	Fines	Grade <small>Sand or Gravel, Fines, Grade</small>	Type of Fines	Group Symbol	Sand/ Gravel	Group Name
Gravel	≤ 5%	Cu ≥ 4 and 1 ≤ Cc ≤ 3	[placeholder]	GW	< 15% sand	Well-graded GRAVEL
			[placeholder]	GW	≥ 15% sand	Well-graded GRAVEL with SAND
	5-12%	Cu ≥ 4 and 1 ≤ Cc ≤ 3	ML or MH	GW-GM	< 15% sand	Well-graded GRAVEL with SILT
			ML or MH	GW-GM	≥ 15% sand	Well-graded GRAVEL with SILT and SAND
		CL, CH or CL-ML	GW-GC	< 15% sand	Well-graded GRAVEL with CLAY (or SILTY CLAY)	
			GW-GC	≥ 15% sand	Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)	
		Cu < 4 and/or 1 > Cc > 3	ML or MH	GP-GM	< 15% sand	Poorly-graded GRAVEL with SILT
			ML or MH	GP-GM	≥ 15% sand	Poorly-graded GRAVEL with SILT and SAND
	CL, CH or CL-ML	GP-GC	< 15% sand	Poorly-graded GRAVEL with CLAY (or SILTY CLAY)		
		GP-GC	≥ 15% sand	Poorly-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
	> 12%	ML or MH	GM	GM	< 15% sand	SILTY GRAVEL
			GM	GM	≥ 15% sand	SILTY GRAVEL with SAND
CL or CH		GC	GC	< 15% sand	CLAYEY GRAVEL	
		GC	GC	≥ 15% sand	CLAYEY GRAVEL with SAND	
CL-ML		GC-GM	< 15% sand	SILTY, CLAYEY GRAVEL		
		GC-GM	≥ 15% sand	SILTY, CLAYEY GRAVEL with SAND		
Sand	≤ 5%	Cu ≥ 6 and 1 ≤ Cc ≤ 3	[placeholder]	SW	< 15% gravel	Well-graded SAND
		[placeholder]	SW	≥ 15% gravel	Well-graded SAND with GRAVEL	
	5-12%	Cu ≥ 6 and 1 ≤ Cc ≤ 3	ML or MH	SW-SM	< 15% gravel	Well-graded SAND with SILT
			ML or MH	SW-SM	≥ 15% gravel	Well-graded SAND with SILT and GRAVEL
		CL, CH or CL-ML	SW-SC	< 15% gravel	Well-graded SAND with CLAY	
			SW-SC	≥ 15% gravel	Well-graded SAND with CLAY and GRAVEL	
		Cu < 6 and/or 1 > Cc > 3	ML or MH	SP-SM	< 15% gravel	Poorly-graded SAND with SILT
			ML or MH	SP-SM	≥ 15% gravel	Poorly-graded SAND with SILT and GRAVEL
	CL, CH or CL-ML	SP-SC	< 15% gravel	Poorly-graded SAND with CLAY		
		SP-SC	≥ 15% gravel	Poorly-graded SAND with CLAY and GRAVEL		
	> 12%	ML or MH	SM	SM	< 15% gravel	SILTY SAND
			SM	SM	≥ 15% gravel	SILTY SAND with GRAVEL
		CL or CH	SC	SC	< 15% gravel	CLAYEY SAND
			SC	SC	≥ 15% gravel	CLAYEY SAND with GRAVEL
		CL-ML	SC-SM	< 15% gravel	SILTY, CLAYEY SAND	
			SC-SM	≥ 15% gravel	SILTY, CLAYEY SAND with GRAVEL	

### 3.2.3 Consistency of Cohesive Soil

Cohesive soil consistency descriptors must conform to Figure 3-5, generally after Das (1983) and Bureau of Reclamation standards (2001). Note that the terms to be used have been modified from those contained in both references.

Laboratory tests used to determine consistency of cohesive soil are triaxial or unconfined compression tests.

**Figure 3-5  
Consistency**

Description	Shear Strength, $S_s$ (tsf)
Very Soft	$S_s < 0.12$
Soft	$0.12 \leq S_s < 0.25$
Medium Stiff	$0.25 \leq S_s < 0.5$
Stiff	$0.5 \leq S_s < 1$
Very Stiff	$1 \leq S_s < 2$
Hard	$2 \leq S_s$

### 3.2.4 Percent or Proportion of Soil

Laboratory percentages of gravel, sand, and fines must either be reported using qualitative proportional descriptors (e.g. some SAND) or

parenthetical percentages following the qualitative descriptor (e.g. some SAND (37%))

*SANDY SILT (ML); dense; gray; moist; some fine SAND; nonplastic.*

Indicating the sample contains “some SAND” (30-45%) per Figure 2-13.

-or-

*SANDY SILT (ML); dense; gray; moist; some fine SAND (37%); nonplastic.*

Indicating the sample contains “some SAND” (30-45%), and the lab test indicates 37% SAND.

### 3.2.5 Plasticity (for Fine-Grained Soil)

Do not include field determination of plasticity in the descriptive sequence when Group Name and Group Symbol are based on liquid limit and plasticity index.

## 3.3 Strength of Intact Rock

The strength of intact rock is typically determined by unconfined compression laboratory testing. The test result is added to the descriptive sequence using the syntax “UC = strength”, where the strength is in units of psi.

# Section 4: Presentation of Subsurface Information

## 4.1 Introduction

The process of creating boring logs, i.e., Log of Test Borings (LOTB) and Boring Records (BR) can be summarized in four steps:

- Field sampling and descriptions (*Section 2*)
- Quality check of field descriptions (*Section 2*)
- Refinement of descriptions, and classification of soil, based on laboratory test results, if performed (*Section 3*)
- Preparation of the boring logs (*Sections 4 and 5*)

This section presents the *Layer Presentation Method* and provides details and guidance for incorporating laboratory test data and preparing boring logs. Figure 4-1 illustrates the process from obtaining subsurface information to the creation of boring logs.

## 4.2 Factual vs. Interpretive Subsurface Data

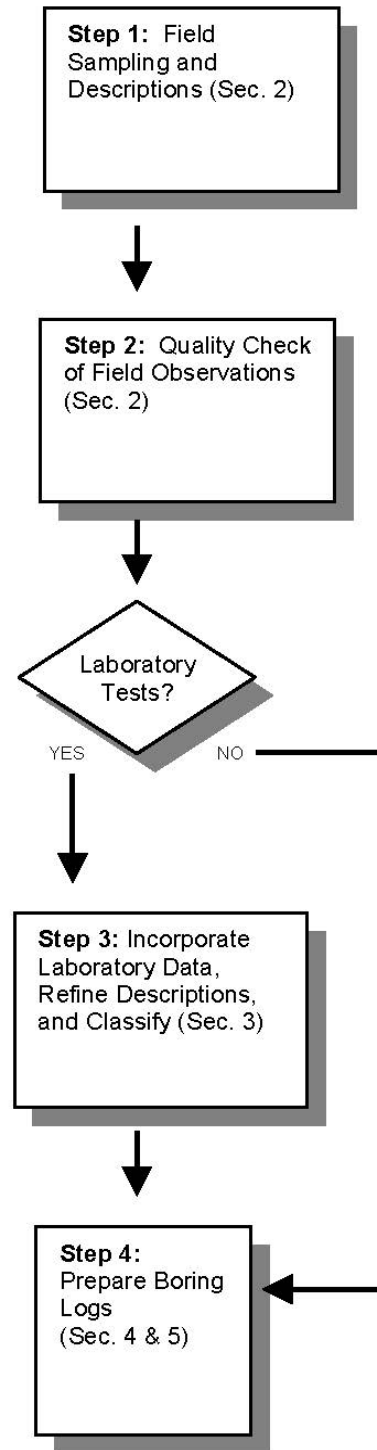
FHWA guidelines state: “factual subsurface data which are pertinent to the project subsurface conditions should be presented in an easily understood fashion on the contract documents.” However, the description of subsurface conditions always requires some degree of professional interpretation.

Some examples:

- Field description and identification procedures, according to ASTM D 2488, require estimation and interpretation.
- Sampling may occur at discrete intervals, yet layer boundaries may fall between sampling locations. The boundaries may be identified based on visual observations of cuttings and/or drill rig behavior during drilling. There may be uncertainty as to the depth at which a material change occurs.

- Continuity of material types between discrete sampling locations is sometimes difficult to confirm.

Figure 4-1



### 4.3 Layer Presentation Method

The Layer Presentation Method defines a layer as the limits of soil with one group symbol or the limits of rock with a single rock type. The layer presentation simplifies the boring log by:

- Eliminating presentation of duplicate descriptors.
- Presenting changes where they occur.
- Improving clarity to prospective bidders, contractors, and construction personnel.

#### 4.3.1 Rules and Considerations

The following rules and considerations apply to the layer presentation method:

- The layer presentation must be made in such a way that the individual sample descriptions can be generally reconstructed.
- The descriptive sequence used to describe a sample of soil or rock must describe that sample in its entirety, and may describe all or part of a layer depending on the subsequent changes reported, if any.
- A change must be reported at the elevation where it is measured or inferred, which is not necessarily at a sample location, and the new description applies from that elevation to the bottom of the layer unless another change is reported. Leader lines (on LOTB) are used as appropriate to locate a descriptive change.
- A descriptor applies at the adjacent elevation unless a leader line (on LOTB) is used.
- A change in a soil's Group Symbol or a Rock Type must result in a new layer.
- A change in a soil's Group Name or Rock Name may result in a new layer.
- The first descriptive sequence in a layer must apply to the first sample and from the top of the layer and until a change is reported
- Laboratory and field test results apply only to the sample at the location of the laboratory test symbol or field test result. Individual descriptors, whether based on field observations or laboratory results, apply from

the locations presented and until a change is reported.

- When performed, representative laboratory test results must be used to determine the applicable descriptors within the descriptive sequence (i.e. Group Name and Symbol, consistency, and gradation properties).
- Descriptors within a layer with the same field descriptions should be corrected based on the laboratory test(s) of one or more representative samples. For example, if three consecutive samples were field identified to contain "some silt", and a representative laboratory test reported "little silt", then the other two descriptors should be corrected to say "little silt".
- Descriptive sequences may be restated as appropriate to provide clarity after multiple changes have been presented.

#### 4.3.2 Special Cases

- Parenthetical soil descriptions required per Section 2 for intensely weathered to decomposed or decomposed rock or poorly indurated rock are valid only until the rock becomes intensely or less weathered, or well indurated.
- For interbedded soil or rock, use the graphic for the predominant material.

### 4.4 Incorporating Laboratory Data, Refining Descriptions, and Classifying Soil

Use the most reliable data available to describe soil and rock. The data could be field-generated, or a combination of field- and laboratory-generated. If laboratory tests are performed, and in the opinion of the geoprofessional, the results represent the actual conditions of the soil or rock, the test results must control the identification, description, or classification of the soil or rock. Presence of a laboratory test symbol next to the LOTB stick (Section 5.2.5.2) indicates that a laboratory test was performed and that the related description is based on the laboratory test result. Conversely, if

laboratory tests are not shown as being performed, the descriptions presented on the LOTB are based solely on the visual practices described in this Manual.

The percent and/or proportion of constituents must be presented in one of two ways as illustrated in the following example.

Three consecutive samples were identified as SANDY SILT. Laboratory testing of the first sample indicate 37% sand.

*SANDY SILT (ML); dense; gray; moist; some fine SAND; nonplastic.*

Indicating the entire layer contains some SAND (30-45%).

-or-

*SANDY SILT (ML); dense; gray; moist; some fine SAND (37%); nonplastic.*

Indicating the entire layer contains some SAND (30-45%), but that the lab test indicates 37% SAND at the test location.

### 4.4.3 Example

The processes for developing boring logs have been presented in detail throughout this Manual. In general, field sample descriptions are corrected and calibrated based on laboratory results, layer boundaries are determined by grouping samples within the same Group Symbol or Rock Type, sample descriptions are consolidated into a single layer description, and, finally, description changes are noted with depth within layers.

The following example:

- Demonstrates how a geoprofessional develops a layer presentation, based on field descriptions and laboratory test results (Figure 4-2)
- Presents the LOTB for the layer presentation (Figure 4-3), and
- Presents how to interpret the LOTB and layer presentation (Figure 4-4)

Note the following in Figure 4-2:

- At the depth of 28 – 29 ft., required descriptors for rock hardness and fracture density are not presented as the sample was collected via a SPT.
- Group Name and Group Symbol for the clay layer are based upon ASTM D 2487 Laboratory test results for the samples at depths 18.5-20 ft and 23.5-25 ft.
- At the depth of 23.5 – 25 ft., the pocket penetrometer (PP) test result is not consistent with medium stiff consistency descriptor as the consistency descriptor is based on a laboratory triaxial (UU) test result. In this case, the PP result is still presented on the boring log.

**Figure 4-2**

Depth (ft.)	Sample	Field Testing	Field Description and Identification	Lab Testing	Lab Corrected Description and Identification or Classification	Final Layer Presentation
3.5-5	R-09-001-S01	SPT N = 4 N <sub>60</sub> = 6	Well-graded SAND with GRAVEL and COBBLES (SW); loose; yellowish brown; moist; little coarse and fine GRAVEL; trace fines; 10% IGNEOUS COBBLES, hard, 6-10", subrounded; (FILL).		Well-graded SAND with GRAVEL and COBBLES (SW); loose; yellowish brown; moist; little coarse and fine GRAVEL; trace fines; 10% IGNEOUS COBBLES, hard, 6-10", subrounded; (FILL).	Well-graded SAND with GRAVEL and COBBLES (SW); loose; yellowish brown; moist; little coarse and fine GRAVEL; trace fines; 10% IGNEOUS COBBLES, hard, 5-10 inches, subrounded; (FILL).
8.5-10	R-09-001-S02	SPT N = 8 N <sub>60</sub> =12	Well-graded SAND with GRAVEL and COBBLES (SW); medium dense; yellowish brown; moist; little coarse and fine GRAVEL; trace fines; 10% IGNEOUS COBBLES, hard, 5-10", subrounded; (FILL).	PA	Well-graded SAND with GRAVEL and COBBLES (SW); medium dense; yellowish brown; moist; sand (79%); little coarse and fine GRAVEL (17%); trace fines (4%); 10% IGNEOUS COBBLES, hard, 5-10", subrounded; (FILL).	Medium dense
13.5-15	R-09-001-U03	PP=0.35	SANDY lean CLAY (CL); soft; dark bluish gray; moist; medium SAND; trace shell fragments; PP=0.35; (BAY MUD).		SANDY lean CLAY (CL); soft; dark bluish gray; moist; medium SAND; trace shell fragments; PP=0.35; (BAY MUD).	SANDY lean CLAY (CL); soft; dark bluish gray; moist; medium SAND; trace shell fragments; PP=0.35 tsf; (BAY MUD).
18.5-20	R-09-001-U04	PP=0.4	SANDY lean CLAY (CL); soft; dark bluish gray; moist; medium SAND; PP=0.4; (BAY MUD).	PA, PI UU=0.45 tsf	SANDY lean CLAY (CL); soft; dark bluish gray; moist; fines (62%); medium SAND (38%); PP=0.4; (BAY MUD).	No shell fragments; PP=0.4 tsf.
23.5-25	R-09-001-U05	PP=0.45	SANDY lean CLAY (CL); soft; dark gray; moist; medium SAND; PP=0.45; (BAY MUD).	PA, PI UU=0.55 tsf	SANDY lean CLAY (CL); medium stiff; dark gray; moist; fines (66%); medium SAND (34%); PP=0.45; (BAY MUD).	Medium stiff; dark gray; PP=0.45 tsf.
28-29	R-09-001-S06	SPT N = 60/6 N <sub>60</sub> =90/6	SEDIMENTARY ROCK (SHALE); dark bluish gray with orange mottling; intensely weathered.		SEDIMENTARY ROCK (SHALE); dark bluish gray with orange mottling; intensely weathered.	SEDIMENTARY ROCK (SHALE); dark bluish gray with orange mottling; intensely weathered.
29-34	R-09-001-C07	REC=90% RQD=60%	SEDIMENTARY ROCK (SHALE); dark bluish gray; slightly weathered; moderately soft; moderately fractured.	UC=3600 psi	SEDIMENTARY ROCK (SHALE); dark bluish gray; slightly weathered; moderately soft; moderately fractured.	Dark bluish gray; moderately to slightly weathered; moderately soft; moderately fractured; UC=3600 psi.
34-39	R-09-001-C08	REC=100% RQD=90%	SEDIMENTARY ROCK (SHALE); dark bluish gray; fresh; moderately soft; slightly fractured.	UC=4100 psi	SEDIMENTARY ROCK (SHALE); dark bluish gray; fresh; moderately soft; slightly fractured.	Slightly fractured; UC=4100 psi.

The LOTB for the layer presentation developed in Figure 4-2 would appear as follows:

**Figure 4-3**  
**LOTB Example**

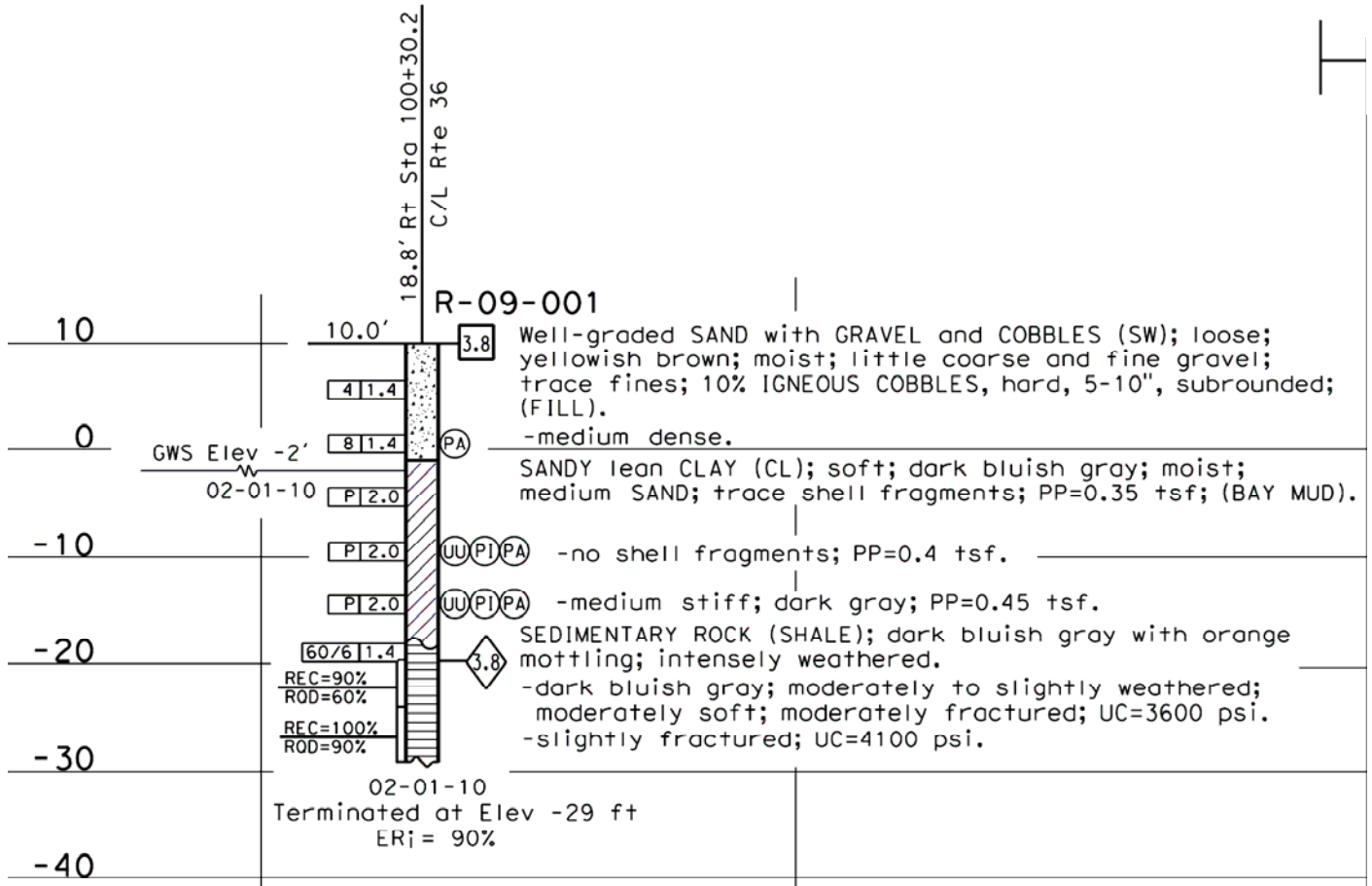


Figure 4-4 presents how to interpret the clay layer (elevation –1 ft to –18 ft) on the LOTB in Figure 4-3. Per the rules presented in Section 4.3.1, the uppermost soil description, located at the first sample location, represents the material from the top of the layer to the bottom of the layer unless modified by a subsequent descriptor. The arrows above and below each descriptor represent the range to which the descriptor applies, i.e., by definition the group symbol (CL) applies to the entire layer as indicated by the arrows.

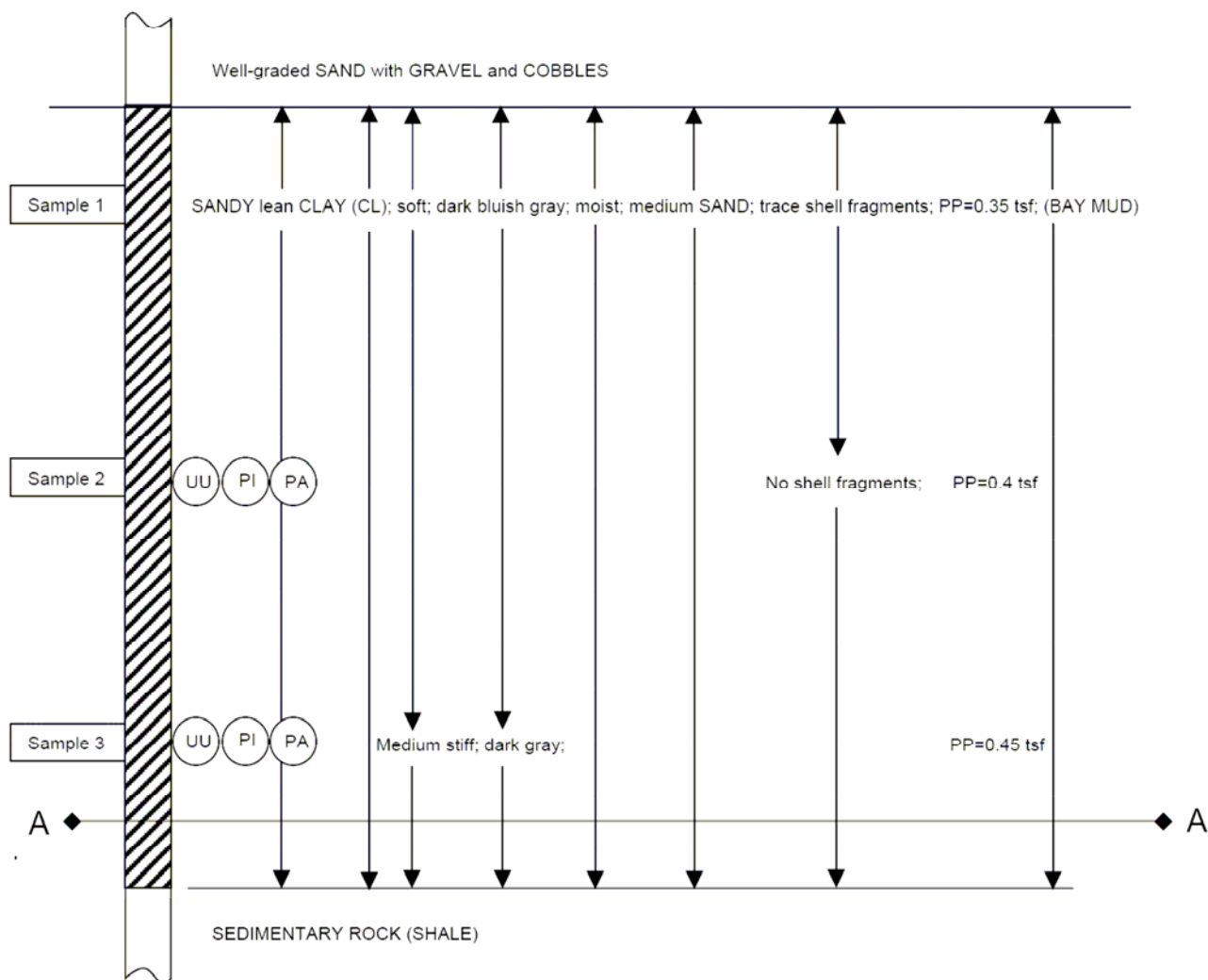
The soil description can be reconstructed at any location by drawing a horizontal line and identifying the appropriate descriptors by the intersected arrows. For example, the descriptive sequence between sample 3 and the rock layer (section A-A) is reconstructed as follows:

SANDY lean CLAY (CL); medium stiff; dark gray; moist; medium SAND; (BAY MUD).

Note the following:

- The pocket penetrometer test results apply only at the sample location
- “Trace shell fragments” would not appear in any descriptive sequence below Sample 2

**Figure 4-4**  
**Layer Interpretation**



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## **Section 5: Boring Log and Legend Presentation Formats**

### **5.1 Introduction**

The Department uses the following formats to present subsurface information:

- Log of Test Borings (LOTB), and/or
- Boring Record (BR).

An LOTB is typically associated with a structure facility and is part of the Project Plans. A BR is typically associated with an earthwork facility and is attached to a Geotechnical Report. If a subsurface exploration was performed, there will be at least one type of log presentation.

### **5.2 Log of Test Borings**

**Figure 5-1  
Example of LOTB**

DIST	COUNTY	ROUTE	TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
01	HUM	101			

Tom Whitman  
CERTIFIED ENGINEERING GEOLOGIST

06-21-11

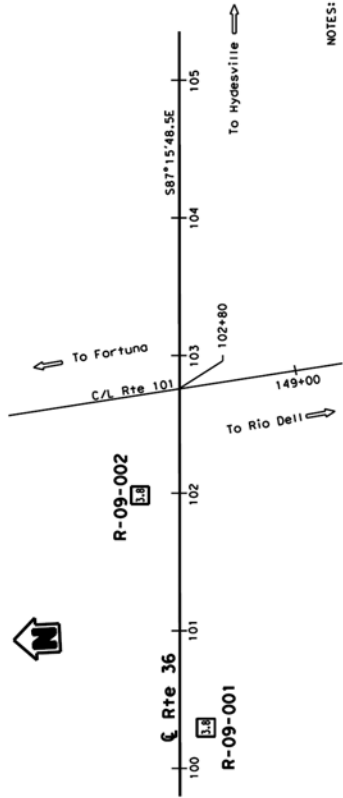
PLANS APPROVAL DATE

Tom Whitman  
DESIGNED BY

06-21-11  
DATE

THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS  
SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR  
COMPLETENESS OF ANY INFORMATION CONTAINED  
HEREIN OR FOR ANY ERRORS OR OMISSIONS THEREIN.

This LOTB sheet was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (2010).

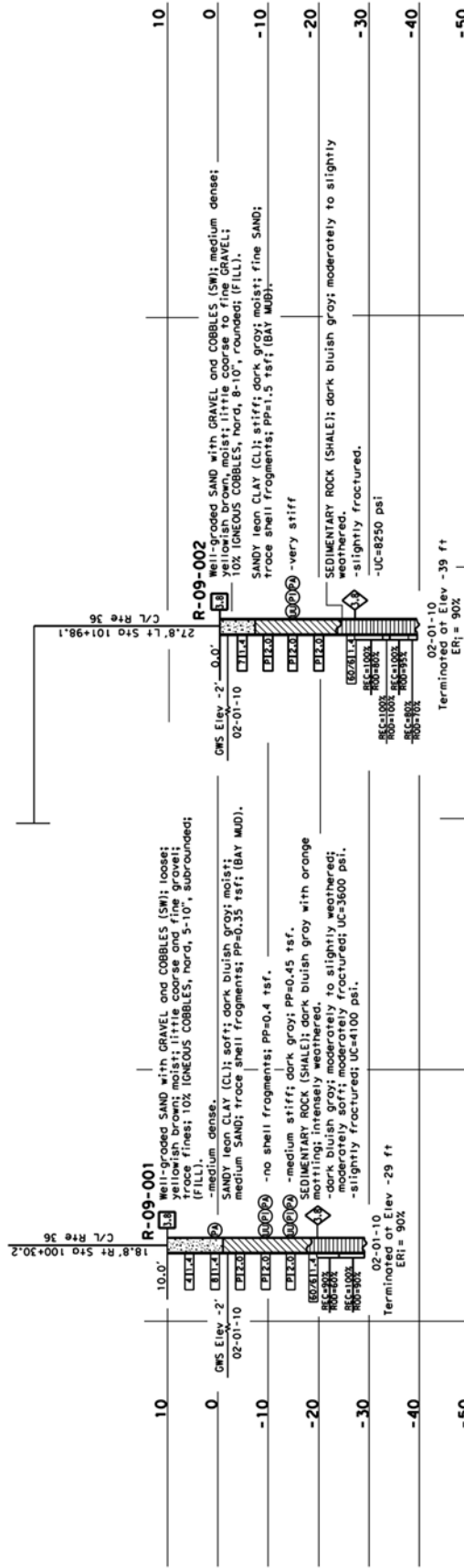


**BENCH MARK**

BM PRVY 38 Elev. 12.3'  
Found PK No.1 on NW curb, return  
left of Station 101+30 CL Rte 36  
NAV088

**NOTES:**

1. Sporadic boulders present at the ground surface up to 20' diameter.



**PROFILE**  
HOR. 1"=20'  
VER. 1"=10'

<b>ENGINEERING SERVICES</b>		<b>STATE OF CALIFORNIA</b>		<b>DIVISION OF ENGINEERING SERVICES</b>		<b>PROJECT NO.</b>	
FUNCTIONAL SUPERVISOR		CALIFORNIA		STRUCTURE DESIGN		06-0833	
NAME: Tim Polczynski		DEPARTMENT OF TRANSPORTATION		DESIGN BRANCH		10.5/11.2	
DESIGNED BY: JOHN BOHANN		FIELD INVESTIGATION BY: Tom Whitman		C.U. NO. 523		DATE OF FIELD LOG: 06-21-11	
CHECKED BY: JOHN BOHANN		DATE OF LOG: 06-21-11		C.U. NO. 523		DATE OF LOG: 06-21-11	
DATE OF LOG: 06-21-11		DATE OF LOG: 06-21-11		DATE OF LOG: 06-21-11		DATE OF LOG: 06-21-11	

## 5.2.1 Contents and Characteristics of the LOTB

The Log of Test Borings (LOTB) sheet is part of the project plans and:

- Presents the boring logs on an elevation scale.
- Presents a plan view showing the location of each boring relative to an alignment and/or existing or planned facility or structure.
- Presents the type(s) of drilling method(s) used to perform the investigation, the type(s) of sampling performed, and how the sampler was advanced.
- Presents the location and description, both graphical and written, of the types of soil and rock encountered within the borehole.
- Presents the types of field and laboratory testing performed.
- Present field and laboratory test data.
- Is optimized for printing on full-size plan sheets (24" x 36") and typically reproduced on 11" x 17" sized paper.
- Allows presentation of more than one boring log per plan sheet.
- Is accompanied by LOTB legend sheets.

## 5.2.2 Notes on the LOTB

Each LOTB sheet must contain a note section for presentation of relevant factual data and one of the following two notes:

If the procedures of this manual were followed without exception, then the note must read:

*“This LOTB sheet was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (Date)”*

If an exception to the procedures of this manual has been approved and implemented, then the note must be modified to read:

*“This LOTB sheet was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (Date)”*

*except as noted on the soil or rock legend or below”*

Optional notes may include:

- Changes in drilling equipment
- Site observations
- Other drilling observations

Do not repeat the procedures or requirements set forth in this manual in the notes section.

## 5.2.3 LOTB Sheet Formatting

LOTB sheets must be prepared in accordance with this manual and the Caltrans *Plans Preparation Manual*. The LOTB sheet border must present the following:

### 5.2.3.1 Signature Block (Upper Right Corner)

- a) The State of California Registered Civil Engineer, Geotechnical Engineer, Certified Engineering Geologist, or Professional Geologist seal with the signature, date, license number, and registration certificate expiration date of the geoprofessional in responsible charge of the LOTB sheet;
- b) Caltrans District, County, and Route;
- c) Name and address of consultant firm in responsible charge of the LOTB sheet (if applicable);
- d) Name and address of the lead local agency (if applicable); and
- e) A disclaimer stating "The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet."

(The Office Engineer will provide the Post Miles Total Project, Sheet Number, Total Sheets, and Plans Approval Date.)

### 5.2.3.2 Title Block (Bottom, from left to right)

- a) Titles "ENGINEERING SERVICES" and "GEOTECHNICAL SERVICES" for plans produced by or for Geotechnical Services. For consultant-prepared LOTB sheets, show the name of the Design Oversight (i.e., OSFP/OSCM Senior Liaison) Engineer and sign-off date.
- b) "FUNCTIONAL SUPERVISOR": The name of the person in charge of the functional unit responsible for providing oversight of the registered geoprofessional who developed the LOTB sheet.
- c) "DRAWN BY": The name of the person who prepared (drafted) the LOTB sheet
- d) "CHECKED BY": The name of the person who performed the quality control check of the LOTB sheet
- e) "FIELD INVESTIGATION BY": The name(s) of the field investigator(s);
- f) A note stating "STATE OF CALIFORNIA, DEPARTMENT OF TRANSPORTATION" with a scale below the sub-block and a label on the left side stating "ORIGINAL SCALE IN INCHES FOR REDUCED PLANS." For consultant-prepared LOTB sheets, the note must state "PREPARED FOR THE STATE OF CALIFORNIA, DEPARTMENT OF TRANSPORTATION."
- g) A note stating "DIVISION OF ENGINEERING SERVICES STRUCTURE DESIGN." For consultant-prepared LOTB sheets, instead of this note, show the name of the Project Engineer;
- h) The Caltrans Contract Expenditure Authorization (CU and EA) numbers;
- i) The State-assigned Bridge (or Structure) Number, Postmile, and the State-assigned Bridge (or Structure) Name;
- j) The initial drawn by, and subsequent revision dates; and
- k) A label stating "LOG OF TEST BORINGS \_ OF \_" (if applicable).

(The Office Engineer will provide the Sheet Number and Total Sheets Number.)

### 5.2.3.3 Plan View

- a) The Plan View must be shown at the top of the first LOTB sheet. When the site is sufficiently large or complex, the first LOTB sheet should be used entirely for the Plan View.
- b) Multiple LOTB sheets must be numbered with reference to the stationing of the control line (i.e., showing sheet No. 1 with the lowest stationing and the last sheet with the highest stationing).
- c) A distinct Plan View of the project site that is independent of the Profile View must be shown on the LOTB.
- d) Show the location, description, and elevation of the benchmark used for determining the top of boring elevations at the top left side of the Plan View under the heading "BENCHMARK". Identify the vertical datum (National Geodetic Vertical Datum, U.S. Geological Survey, U.S. Coast & Geodetic Survey, District, etc.) used to determine the benchmark elevations.
- e) Show the scale directly below the Plan View label.
- f) Show a North arrow.
- g) Lines or control lines shown in the Plan View must be consistent with those shown on the General Plan sheet.
- h) Show stationing and names for control lines. Stationing must increase from left to right. Show a minimum of two stations on all lines.
- i) Show control line intersection stationing and bearings.
- j) Show names and directions of nearest cities.
- k) Show names and directions of stream flows when applicable.
- l) Plot boring locations with symbols as shown in the legend to identify drilling methods (e.g., auger hole, rotary hole, cone

penetration). The Hole Identification must be presented with each symbol.

#### 5.2.3.4 Profile View

- a) Show the control line, increasing from left to right, horizontally across the bottom of the Profile View.
- b) Show the elevations and grid lines on both the left and right margins. Numerical values must be in multiples of 10 (e.g. 20, 10, 0, -10, -20).
- c) Show the Hole Identification, top of hole elevation, stationing, and offset at the top of each boring log.
- d) Show types and diameters of drill tools.
- e) Show the completion date of boring (m/d/y) at the bottom of each boring log.
- f) Show "Terminated at EL. XX" to indicate the bottom of boring elevation.
- g) Show the SPT hammer energy ratio, "Hammer Energy Ratio (ER<sub>i</sub>) = XX%," at the bottom of each boring.
- h) Provide groundwater information for each boring. If groundwater was measured, show the date(s) and elevation(s) of groundwater measurement(s). If groundwater was not encountered, state "*Groundwater was not encountered in boring(s) #####*". If groundwater was encountered but not measured, state "*Groundwater was encountered in boring(s) #####, but elevation was not measured.*"
- i) Show results from field penetration tests at relevant elevations along the boring log.
- j) Show types of field and laboratory tests with symbols as indicated in the legend, at relevant elevations along the right side of the boring log.
- k) Show the Profile scales (horizontal and vertical) under the heading "PROFILE".

#### 5.2.4 As-Built LOTB Sheet Formatting

As-Built LOTB sheet(s) must be prepared according to the following standards.

##### 5.2.4.1 Obtaining and Reproducing the As-Built LOTB Sheet

- a) Reproducible copies of As-Built LOTB sheets may be obtained from the Microfilm Services Units in the Caltrans District Offices. If the As-Built LOTB sheets provided to Local Agencies or consultants by the Caltrans District Offices are not legible, a full sized copy should be requested from Geotechnical Services.
- b) As-Built LOTB sheets must be size "D" (24" by 36"). The As-Built LOTB title block must be sized to fit and placed over any open space (preferably toward the top) on the As-Built LOTB sheet.
- c) Information on the As-Built LOTB sheet must be clear and legible. In order to improve the legibility of the information, it may be necessary to darken the line work and the notations.

##### 5.2.4.2 Typical Modifications to As-Built LOTB Sheets

If As-Built LOTB sheets are shown in metric units, the offset and stationing location of each boring must be converted to imperial units and presented in a table. The table must show the station and offset in relation to the new English line. The General Plan will show the current English control line.

##### 5.2.4.3 The As-Built LOTB Title Block must include the following information for the current project

- a) A note stating "GEOTECHNICAL SERVICES -- DIVISION OF ENGINEERING SERVICES" (if applicable).

- b) Caltrans District, County, Route, Post Miles - Total Project, State-assigned Bridge (or Structure) Number and Name, and Expenditure Authorization (CU and EA) numbers. The Office Engineer will provide the Sheet Number and Total Sheets Number.
- c) The State of California Registered Civil Engineer, Geotechnical Engineer, Certified Engineering Geologist, or Professional Geologist seal with the signature, date, license number, and registration certificate expiration date of the geoprofessional in responsible charge of the LOTB sheet
- d) A note stating, "As-Built Log of Test Borings sheet is considered an informational document only. As such, the State of California registration seal with signature, license number and registration certificate expiration date confirm that this is a true and accurate copy of the original document. It does not attest to the accuracy or validity of the information contained in the original document. This drawing is available and presented only for the convenience of any bidder, contractor or other interested party." (Figure 5-2).
- e) Identification of the original vertical datum and any conversion to the current project datum, i.e.,

*Datum Conversion: NAVD88 = NGVD29 + 3.2 ft*

- f) A sub-box stating "LOG OF TEST BORINGS \_ OF \_" (if applicable).
- g) A note stating "A COPY OF THIS LOG OF TEST BORINGS IS AVAILABLE AT OFFICE OF STRUCTURE MAINTENANCE AND INVESTIGATIONS, SACRAMENTO, CALIFORNIA" (if applicable).

### 5.2.5 The LOTB Legend Sheets

The soil and rock legend sheets are standard forms that provide convenient simplified references for the *required* soil and rock description, identification, and/or classification components presented in this Manual. References for *optional* descriptors do not appear on the legend sheets. To correctly interpret the LOTB, the reader must be familiar with this Manual.

There are three legend sheets, two predominantly for soil and the other for rock (Figures 5-3, 5-4 and 5-5).

The legend sheets define the format for the graphical presentation of a boring log and differentiate between the various borehole and sounding types. The legend sheets also present the symbols used to identify laboratory tests.


*As-Built Vertical Datum: NGVD29*

**Figure 5-2  
As-Built LOTB Title Block**








GEOTECHNICAL SERVICES – DIVISION OF ENGINEERING SERVICES					
As-Built Log of Test Borings sheet is considered an informational document only. As such, the State of California registration seal with signature, license number and registration certificate expiration date confirm that is this a true and accurate copy of the original document. It does not attest to the accuracy or validity of the information contained in the original document. This drawing is available and presented only for the convenience of any bidder, contractor or other interested party.					
DIST.	COUNTY	ROUTE	POST MILES – TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
11	SD	15	10.00-15.00	249	250
REGISTERED ENGINEER – CIVIL _____ DATE _____					
MAIN STREET OVERCROSSING					
LOG OF TEST BORINGS 5 OF 6					
As-Built Vertical Datum:			Datum Conversion:		
NOTE: A COPY OF THIS LOG OF TEST BORINGS IS AVAILABLE AT OFFICE OF STRUCTURE MAINTENANCE AND INVESTIGATIONS, SACRAMENTO, CALIFORNIA				CU: 11 EA: 432563	BRIDGE NO. 57-3456

Figure 5-3

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (2010)

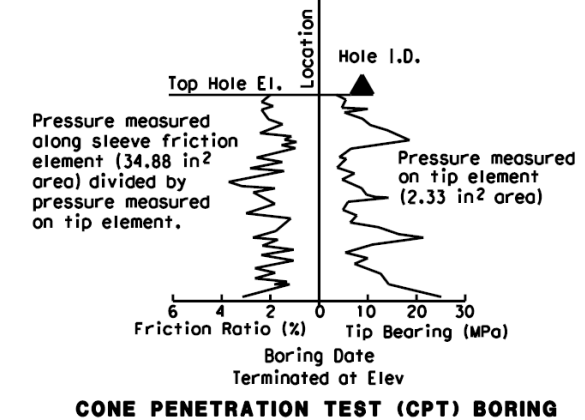
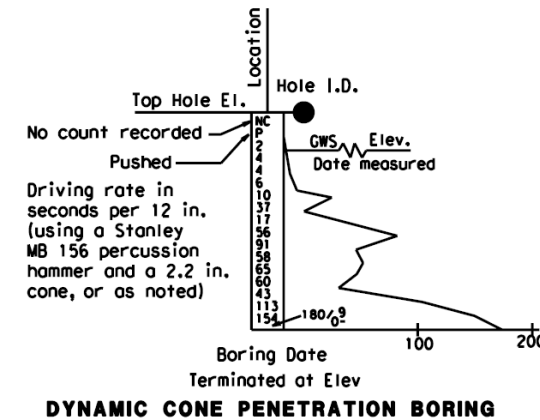
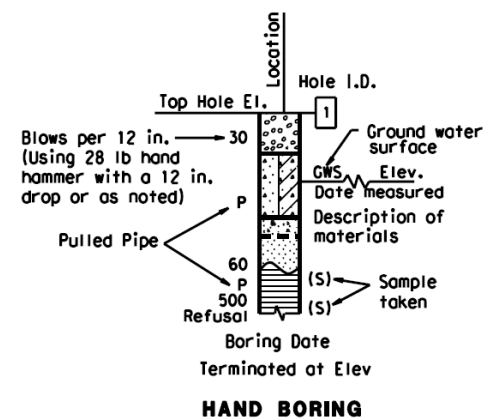
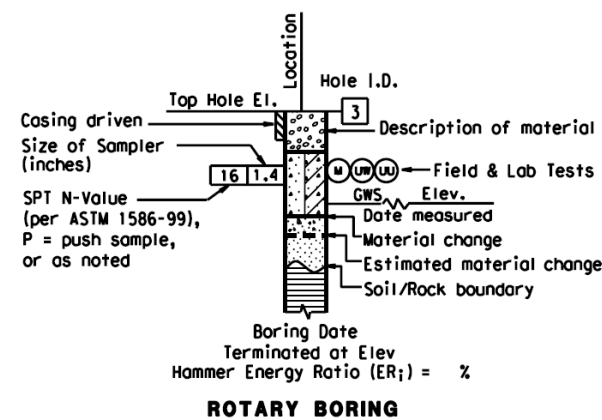
DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO	TOTAL SHEETS
REGISTERED CIVIL ENGINEER			DATE		
PLANS APPROVAL DATE					
<small>The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.</small>					

CEMENTATION	
Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION		
Symbol	Hole Type	Description
	A	Auger Boring (hollow or solid stem bucket)
	R	Rotary drilled boring (conventional)
	RW	Rotary drilled with self-casing wire-line
	RC	Rotary core with continuously-sampled, self-casing wire-line
	P	Rotary percussion boring (air)
	R	Rotary drilled diamond core
	HD	Hand driven (1-inch soil tube)
	HA	Hand Auger
	D	Dynamic Cone Penetration Boring
	CPT	Cone Penetration Test (ASTM D 5778)
	O	Other (note on LOTB)

**Note: Size in inches.**

CONSISTENCY OF COHESIVE SOILS				
Description	Shear Strength (tsf)	Pocket Penetrometer Measurement, PP, (tsf)	Torvane Measurement, TV, (tsf)	Vane Shear Measurement, VS, (tsf)
Very Soft	Less than 0.12	Less than 0.25	Less than 0.12	Less than 0.12
Soft	0.12 - 0.25	0.25 - 0.5	0.12 - 0.25	0.12 - 0.25
Medium Stiff	0.25 - 0.5	0.5 - 1	0.25 - 0.5	0.25 - 0.5
Stiff	0.5 - 1	1 - 2	0.5 - 1	0.5 - 1
Very Stiff	1 - 2	2 - 4	1 - 2	1 - 2
Hard	Greater than 2	Greater than 4	Greater than 2	Greater than 2



<b>ENGINEERING SERVICES</b>		<b>GEOTECHNICAL SERVICES</b>		<b>STATE OF CALIFORNIA</b>		<b>DIVISION OF ENGINEERING SERVICES</b>		<b>BRIDGE NO.</b>		<b>Project or Structure Name</b>	
FUNCTIONAL SUPERVISOR:		DRAWN BY:		DEPARTMENT OF TRANSPORTATION		STRUCTURE DESIGN		POST MILE		<b>LOG OF TEST BORINGS</b>	
CHECKED BY:		FIELD INVESTIGATION BY:		CU		EA		DISREGARD PRINTS BEARING EARLIER REVISION DATES		REVISION DATES	
OS LOTB SOIL LEGEND		ORIGINAL SCALE IN INCHES FOR REDUCED PLANS		0 1 2 3						SHEET OF	

Figure 5-4

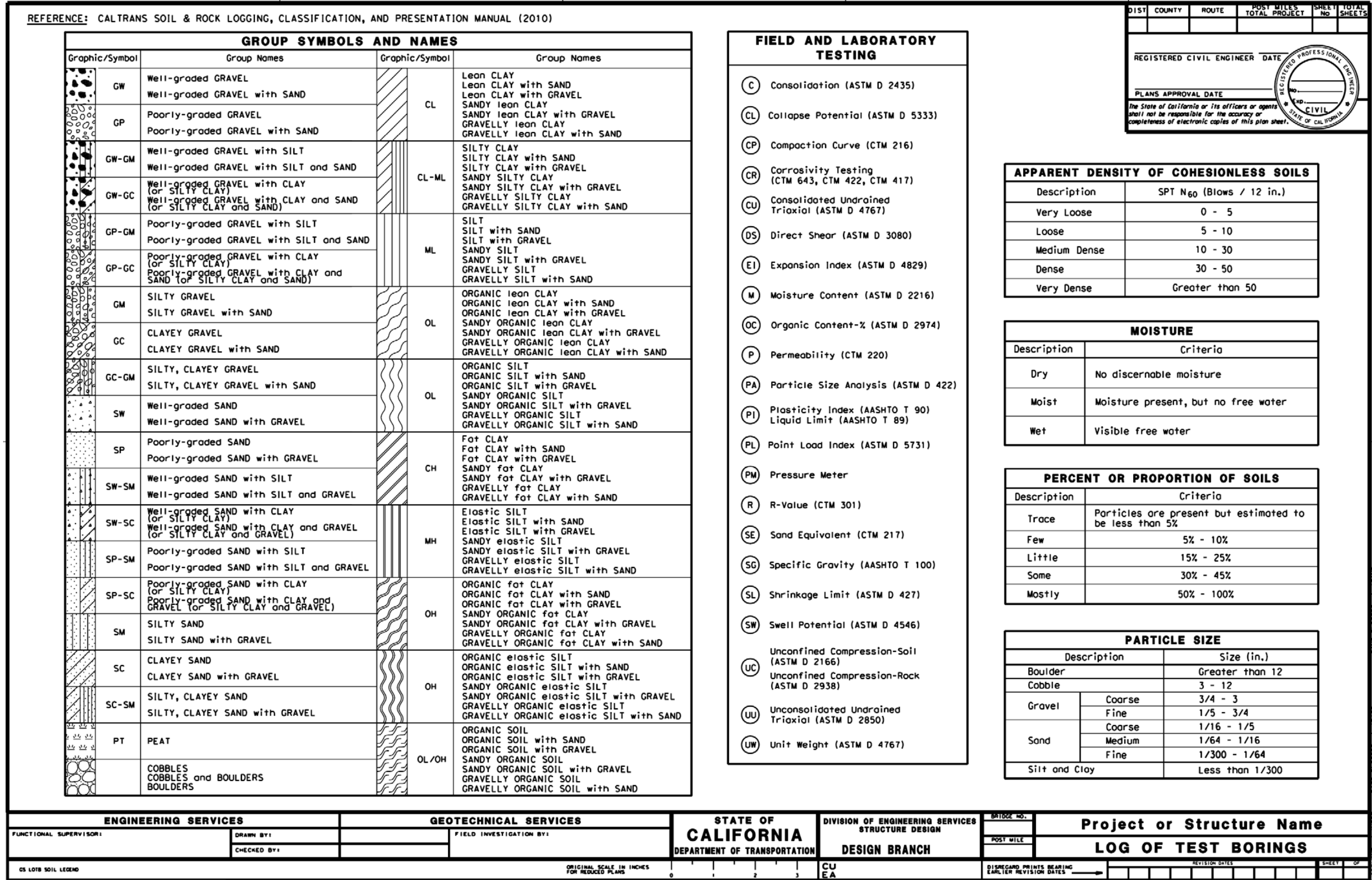
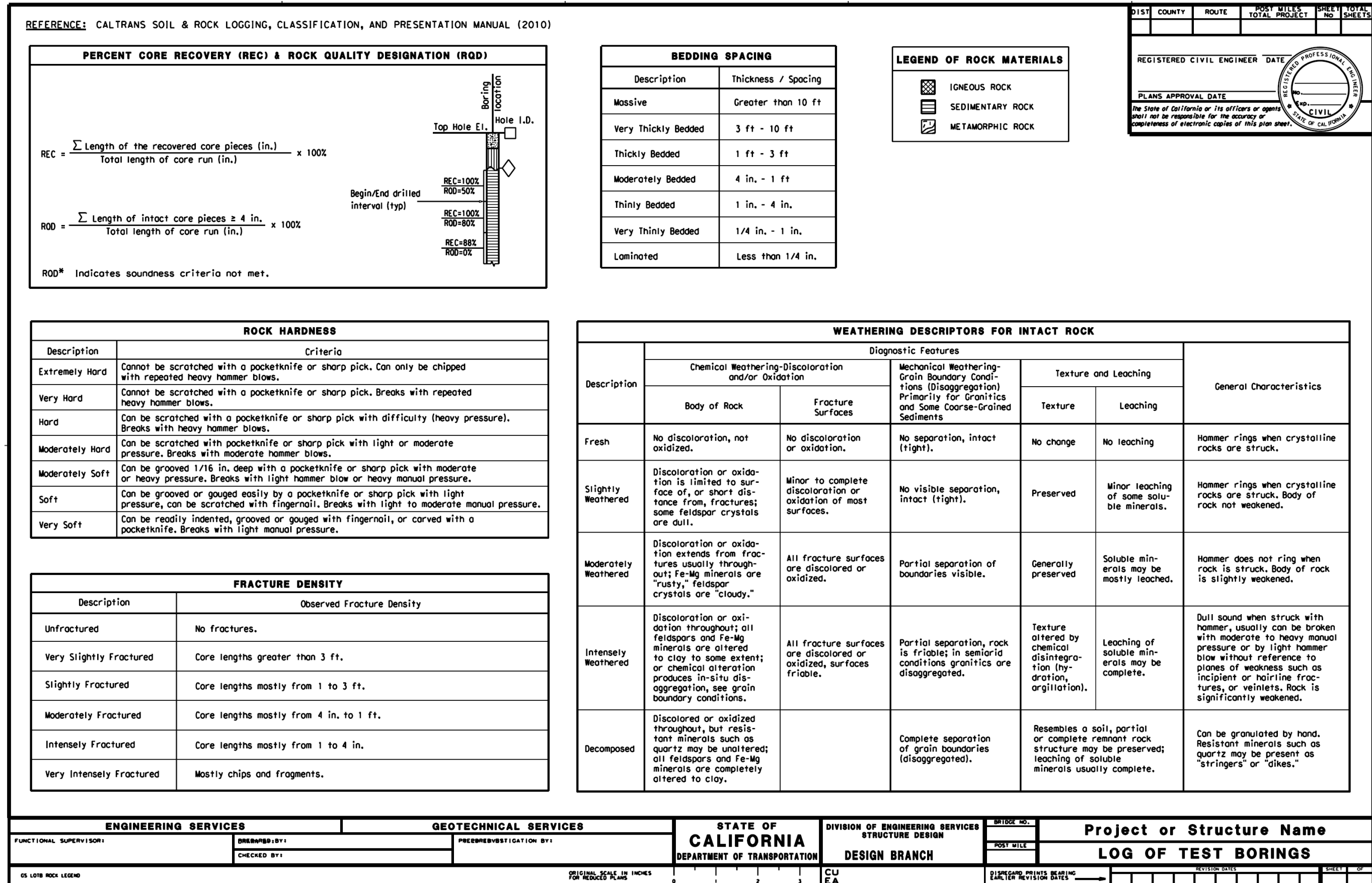


Figure 5-5



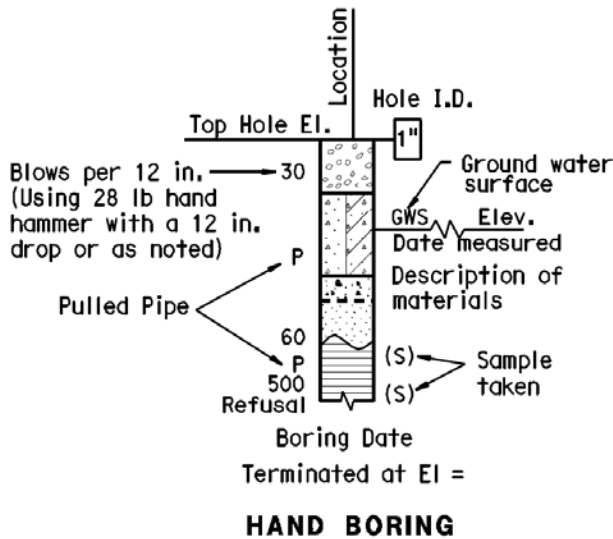
(This page intentionally left blank)

Four general hole-type formats are graphically presented as follows:

### 5.2.5.1 Hand Boring

Hand Driven (HD) (1-inch soil tube) and Hand Auger (HA) borings must be presented per Figure 5-6.

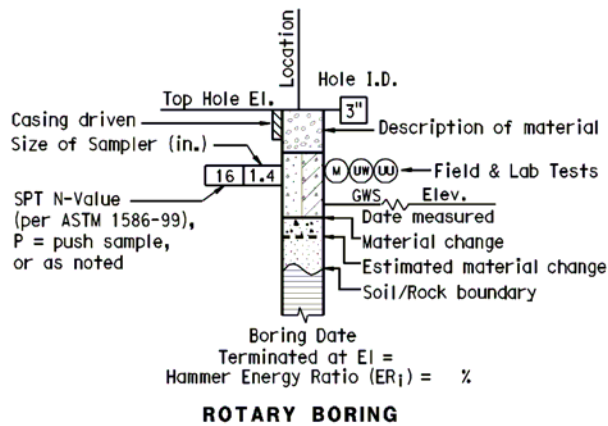
Figure 5-6



### 5.2.5.2 Rotary Boring

Rotary Drilled Boring or Diamond Core (R), Rotary Percussion Boring (Air) (P), Auger Boring (A), must be presented per Figure 5-7.

Figure 5-7



Changes in material with depth must be shown using the following terms and symbols (Figure 5-8):

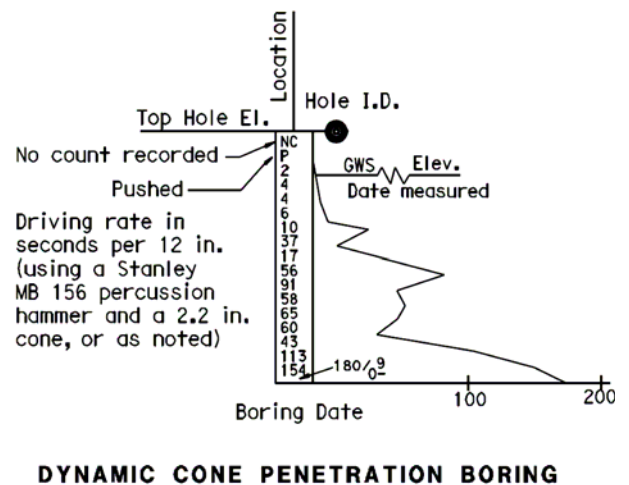
Figure 5-8  
Definitions for changes in material

Term	Definition	Symbol
Material Change	Change in material is observed in the sample or core, and the location of change can be accurately measured.	—————
Estimated Material Change	Change in material cannot be accurately located because either the change is gradational or because of limitations in the drilling/sampling methods used.	- - - - -
Soil/Rock Boundary	Material changes from soil characteristics to rock characteristics	~~~~~ - - - - -

### 5.2.5.3 Dynamic Cone Penetration Boring

The Dynamic Cone Penetration Boring (D) must be presented per Figure 5-9.

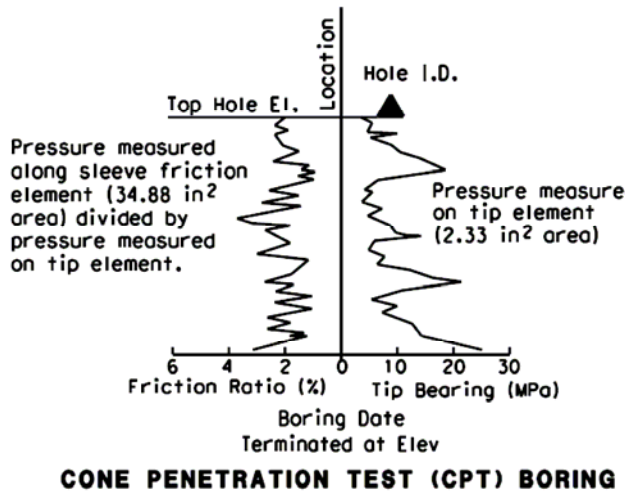
Figure 5-9



### 5.2.5.4 Cone Penetration Test (CPT) Boring

A Cone Penetration Test (CPT) boring must be presented using the following format:

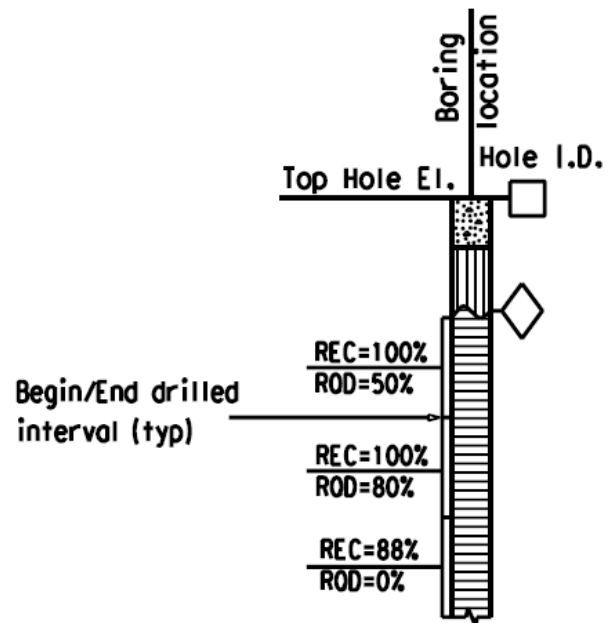
Figure 5-10



### 5.2.5.5 Rock Coring

Rock coring logs must be presented using the following format:

Figure 5-11



### 5.2.5.6 Hole Type Symbols

Hole type is identified within the hole identification numbering convention (see Section 2.3) and symbolized on the LOTB as follows:

Figure 5-12

BOREHOLE IDENTIFICATION		
Symbol	Hole Type	Description
	A	Auger Boring (hollow or solid stem bucket)
	R	Rotary drilled boring (conventional)
	RW	Rotary drilled with self-casing wire-line
	RC	Rotary core with continuously-sampled, self-casing wire-line
	P	Rotary percussion boring (air)
	R	Rotary drilled diamond core
	HD	Hand driven (1-inch soil tube)
	HA	Hand Auger
	D	Dynamic Cone Penetration Boring
	CPT	Cone Penetration Test (ASTM D 5778)
	O	Other (note on LOTB)

**Note: Size in inches.**

### 5.2.5.7 Graphical Representation of Material Types

Soil Group Name and Group Symbol and Rock Type are shown on the LOTB as follows:

Figure 5-13

GROUP SYMBOLS AND NAMES			
Graphic / Symbol	Group Names	Graphic / Symbol	Group Names
	GW		CL
	Well-graded GRAVEL Well-graded GRAVEL with SAND		
	GP		CL-ML
	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
	GW-GM		ML
	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND		
	GW-GC		OL
	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
	GP-GM		OL
	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND		
	GP-GC		CH
	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
	GM		MH
	SILTY GRAVEL SILTY GRAVEL with SAND		
	GC		OH
	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
	GC-GM		OH
	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND		
	SW		OL/OH
	Well-graded SAND Well-graded SAND with GRAVEL		
	SP		
	Poorly graded SAND Poorly graded SAND with GRAVEL		
	SW-SM		
	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
	SW-SC		
	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)		
	SP-SM		
	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
	SP-SC		
	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)		
	SM		
	SILTY SAND SILTY SAND with GRAVEL		
	SC		
	CLAYEY SAND CLAYEY SAND with GRAVEL		
	SC-SM		
	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
	PT		

ROCK GRAPHIC SYMBOLS	
	IGNEOUS ROCK
	SEDIMENTARY ROCK
	METAMORPHIC ROCK

## 5.3 Boring Records

Figure 5-14

LOGGED BY <b>Tom Whitman</b>		BEGIN DATE <b>2-1-10</b>	COMPLETION DATE <b>2-1-10</b>	BOREHOLE LOCATION (Lat/Long or North/East and Datum) <b>34° 0' 24.62" / -117° 7' 62.55" WGS 84</b>				HOLE ID <b>R-09-001</b>							
DRILLING CONTRACTOR <b>Caltrans</b>				BOREHOLE LOCATION (Offset, Station, Line) <b>18.8' Rt Sta 100+30.2 C/L Rte 36</b>				SURFACE ELEVATION <b>10.0 ft NAVD 88</b>							
DRILLING METHOD <b>Rotary Wash</b>				DRILL RIG <b>CS 2000 (track)</b>				BOREHOLE DIAMETER <b>3.8 in.</b>							
SAMPLER TYPE(S) AND SIZE(S) (ID) <b>SPT (1.4"), CalMod (2"), HQ core</b>				SPT HAMMER TYPE <b>Automatic</b>				HAMMER EFFICIENCY, ERI <b>90%</b>							
BOREHOLE BACKFILL AND COMPLETION <b>Neat cement grout backfill</b>				GROUNDWATER DURING DRILLING READINGS <b>12.0 ft</b>		AFTER DRILLING (DATE) <b>12.0 ft on 2-1-10</b>		TOTAL DEPTH OF BORING <b>39.0 ft</b>							
ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
0	0		Well-graded SAND with GRAVEL and COBBLES (SW); loose; yellowish brown; moist; little coarse and fine GRAVEL; trace fines; 10% IGNEOUS COBBLES, hard, 5-10", subrounded; (FILL).												
1	1														
2	2														
3	3														
4	4				S01	2	4								
5	5					2									
6	6					2									
7	7														
8	8														
9	9		medium dense.		S02	4	8			5	105			PA	
10	10					4									
11	11					4									
12	12		SANDY lean CLAY (CL); soft; dark bluish gray, moist; medium SAND; trace shell fragments; PP=0.35; (BAY MUD).												
13	13														
14	14				U03					22	100	PP=0.35			
15	15														
16	16														
17	17														
18	18														
19	19		no shell fragments.		U04					20	100	PP=0.4 UU=0.45			PA, PI
20	20														
21	21														
22	22														
23	23														
24	24		medium stiff, dark gray.		U05					20	101	PP=0.45 UU=0.55			PA, PI
25	25														

(continued)


	Department of Transportation Division of Engineering Services Geotechnical Services Office of Geotechnical Design - West				REPORT TITLE <b>BORING RECORD</b>			HOLE ID <b>R-09-001</b>	
	DIST. <b>01</b>	COUNTY <b>HUM</b>	ROUTE <b>101</b>	POSTMILE <b>10.5/11.2</b>	PROJECT OR BRIDGE NAME <b>Rte 36/101 Interchange</b>		EA <b>04-123321</b>		
	BRIDGE NUMBER <b>04-0873</b>		PREPARED BY <b>Tom Whitman</b>		DATE <b>2-1-10</b>		SHEET <b>1 of 2</b>		

Figure 5-14 (continued)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
25	25		SANDY LEAN CLAY (CL) <i>(continued)</i> .												
-16.00	26														
	27														
-18.00	28		SEDIMENTARY ROCK (SHALE); dark bluish gray with orange mottling; intensely weathered.		S06	10									
	29					60/6"									
-20.00	30		Dark bluish gray; moderately to slightly weathered; medium strong; moderately soft; moderately fractured; UC=3600.		C07			90	60						
	31														
-22.00	32														
	33														
-24.00	34		Slightly fractured; UC=4100		C08			100	90						
	35														
-26.00	36														
	37														
-28.00	38														
	39		Bottom of borehole at 39.0 ft. Boring terminated at planned depth.												
-30.00	40														
	41		This Boring Record was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (2010)												
-32.00	42														
	43														
-34.00	44														
	45														
-36.00	46														
	47														
-38.00	48														
	49														
-40.00	50														
	51														
-42.00	52														
	53														
-44.00	54														
	55														


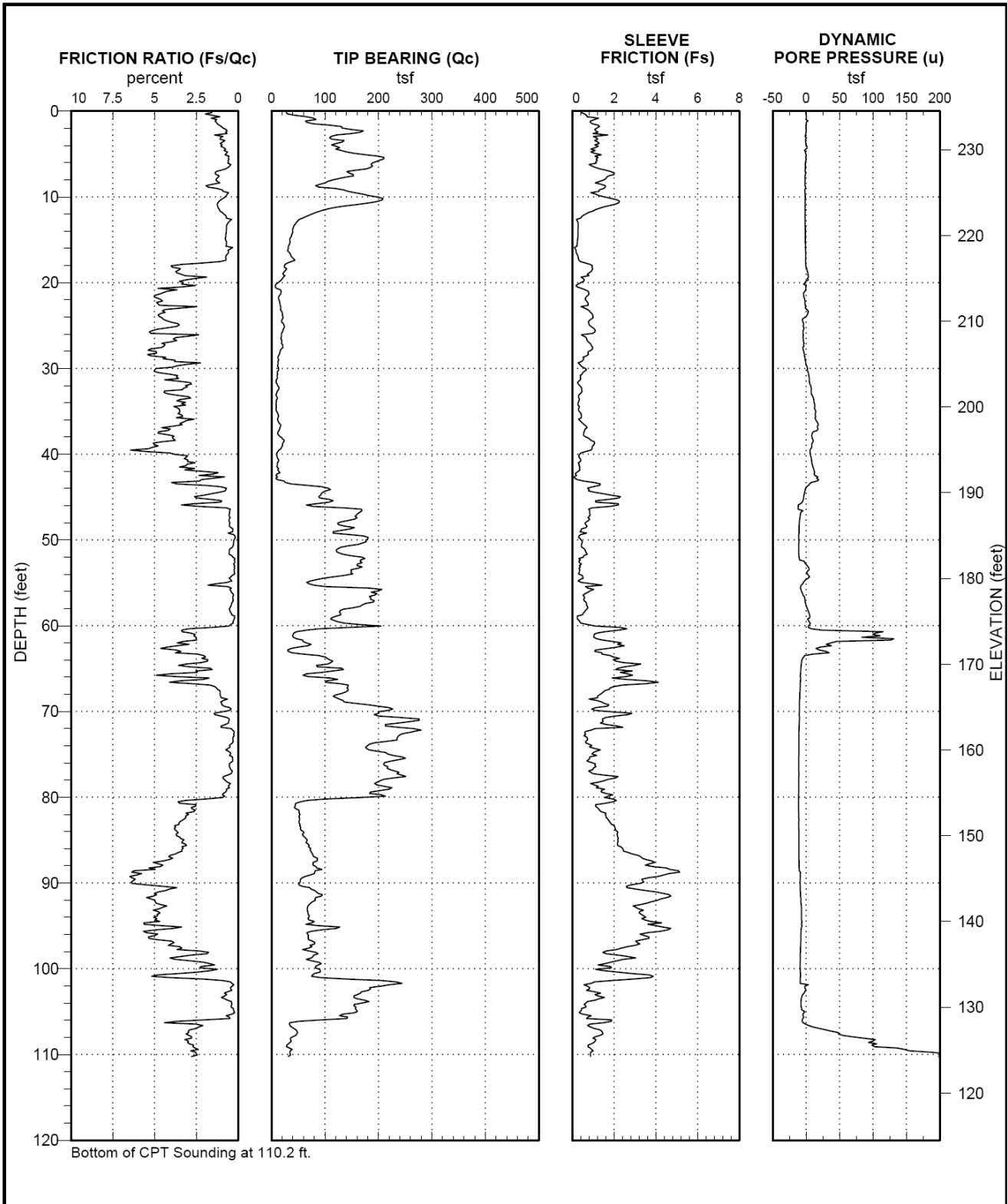
	Department of Transportation Division of Engineering Services Geotechnical Services Office of Geotechnical Design - West				REPORT TITLE <b>BORING RECORD</b>				HOLE ID <b>R-09-001</b>	
	DIST. <b>01</b>	COUNTY <b>HUM</b>	ROUTE <b>101</b>	POSTMILE <b>10.5/11.2</b>	PROJECT OR BRIDGE NAME <b>Rte 36/101 Interchange</b>		EA <b>04-123321</b>			
	BRIDGE NUMBER <b>04-0873</b>		PREPARED BY <b>Tom Whitman</b>		DATE <b>2-1-10</b>		SHEET <b>2 of 2</b>			

Figure 5-15



Department of Transportation  
 Division of Engineering Services  
 Geotechnical Services  
 Office of Geotechnical Design - West

REPORT TITLE <b>BORING RECORD</b>				HOLE ID <b>CPT-09-003</b>	
DIST. <b>01</b>	COUNTY <b>HUM</b>	ROUTE <b>101</b>	POSTMILE <b>10.5/11.2</b>	EA <b>04-123321</b>	
PROJECT OR BRIDGE NAME <b>Rte 36/101 Interchange</b>					
BRIDGE NUMBER <b>04-0873</b>		PREPARED BY <b>Tom Whitman</b>		DATE <b>2-1-10</b>	SHEET <b>1 of 1</b>

### 5.3.1 Content and Characteristics of the BR

A Boring Record (BR) is presented as an attachment to a geotechnical report and:

- Presents a single borehole record or CPT sounding.
- Presents the borings to an elevation scale.
- Presents the type of drilling method used to perform the investigation, the type of sampling performed, and how the sampler was advanced.
- Presents the location and description, both graphical and written, of the types of soil and rock encountered within the borehole.
- Accommodates the presentation of select field and laboratory test results.
- Is optimized for printing on 8.5" x 11" sheets
- Is accompanied by BR Legend Sheets.

### 5.3.2 Notes on the BR

If the procedures of this manual were followed without exception, then the following note must appear on the first page of the BR:

*“This Boring Record was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (Date)”*

If an exception to the procedures of this manual has been approved and implemented, then the note must be modified to read:

*“This Boring Record was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (Date) except as noted on the soil or rock legend or below”*

Optional notes are left to the discretion of the geoprofessional and, if are specific to an elevation or depth, should be presented at the appropriate location in the “Remarks” column. These notes may include:

- Changes in drilling equipment

- Other drilling observations

Notes that are more general, such as a site observation, should be placed within the body of the geotechnical report.

### 5.3.3 Boring Record Format

The BR must be formatted in general conformance with Figures 5-14 and 5-15. The format and information presented in the header and footer sections should match the Figures.

The following information must be presented in the body:

- Elevation
- Material Graphic
- Description
- Sample Location
- Sample Number
- Blows per foot (if performed)
- Drilling Method

### 5.3.4 The Boring Record Legend Sheets

The soil and rock legend sheets are standard forms that provide convenient references for the *required* soil and rock description, identification, and/or classification components presented in this Manual. References for selected *optional* descriptors do not appear on the legend sheets; however, they are explained in this Manual. To correctly interpret the BR, the reader must be familiar with this Manual.

There are three legend sheets: two predominantly for soil and the other for rock, as shown in Figures 5-16, 5-17 and 5-18.

The legend sheets define the format for the graphical presentation of a boring log and differentiate among the various borehole and sounding types. The legend sheets also present the symbols used to identify laboratory tests.

Figure 5-16

GROUP SYMBOLS AND NAMES			
Graphic / Symbol	Group Names	Graphic / Symbol	Group Names
	GW Well-graded GRAVEL Well-graded GRAVEL with SAND		CL Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
	GP Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
	GW-GM Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND		CL-ML SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
	GW-GC Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
	GP-GM Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND		ML SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
	GP-GC Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
	GM SILTY GRAVEL SILTY GRAVEL with SAND		OL ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
	GC CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
	GC-GM SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND		OL ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
	SW Well-graded SAND Well-graded SAND with GRAVEL		
	SP Poorly graded SAND Poorly graded SAND with GRAVEL		CH Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
	SW-SM Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
	SW-SC Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)		MH Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
	SP-SM Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
	SP-SC Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)		OH ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
	SM SILTY SAND SILTY SAND with GRAVEL		
	SC CLAYEY SAND CLAYEY SAND with GRAVEL		OH ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY elastic ELASTIC SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
	SC-SM SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
	PT PEAT		OL/OH ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING	
<b>C</b>	Consolidation (ASTM D 2435)
<b>CL</b>	Collapse Potential (ASTM D 5333)
<b>CP</b>	Compaction Curve (CTM 216)
<b>CR</b>	Corrosion, Sulfates, Chlorides (CTM 643; CTM 417, CTM 422)
<b>CU</b>	Consolidated Undrained Triaxial (ASTM D 4767)
<b>DS</b>	Direct Shear (ASTM D 3080)
<b>EI</b>	Expansion Index (ASTM D 4829)
<b>M</b>	Moisture Content (ASTM D 2216)
<b>OC</b>	Organic Content (ASTM D 2974)
<b>P</b>	Permeability (CTM 220)
<b>PA</b>	Particle Size Analysis (ASTM D 422)
<b>PI</b>	Liquid Limit, Plastic Limit, Plasticity Index (AASHTO T 89, AASHTO T 90)
<b>PL</b>	Point Load Index (ASTM D 5731)
<b>PM</b>	Pressure Meter
<b>R</b>	R-Value (CTM 301)
<b>SE</b>	Sand Equivalent (CTM 217)
<b>SG</b>	Specific Gravity (AASHTO T 100)
<b>SL</b>	Shrinkage Limit (ASTM D 427)
<b>SW</b>	Swell Potential (ASTM D 4546)
<b>UC</b>	Unconfined Compression - Soil (ASTM D 2166) Unconfined Compression - Rock (ASTM D 2938)
<b>UU</b>	Unconsolidated Undrained Triaxial (ASTM D 2850)
<b>UW</b>	Unit Weight (ASTM D 4767)

SAMPLER GRAPHIC SYMBOLS	
	Standard Penetration Test (SPT)
	Standard California Sampler
	Modified California Sampler
	Shelby Tube
	Piston Sampler
	NX Rock Core
	HQ Rock Core
	Bulk Sample
	Other (see remarks)

DRILLING METHOD SYMBOLS			
	Auger Drilling		Rotary Drilling
	Dynamic Cone or Hand Driven		Diamond Core

WATER LEVEL SYMBOLS	
	First Water Level Reading (during drilling)
	Static Water Level Reading (short-term)
	Static Water Level Reading (long-term)

**REFERENCE** Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010).

	Department of Transportation	REPORT TITLE				
	Division of Engineering Services	<b>BORING RECORD LEGEND</b>				
	Geotechnical Services	DIST. <b>01</b>	COUNTY <b>HUM</b>	ROUTE <b>101</b>	POSTMILE <b>10.5/11.2</b>	EA <b>04-123321</b>
	Office of Geotechnical Design - West	PROJECT OR BRIDGE NAME <b>Rte 36/101 Interchange</b>				
		BRIDGE NUMBER <b>04-0873</b>	PREPARED BY <b>Tom Whitman</b>	DATE <b>2-1-10</b>	SHEET <b>1 of 3</b>	

Figure 5-17

CONSISTENCY OF COHESIVE SOILS				
Description	Shear Strength (tsf)	Pocket Penetrometer, PP Measurement (tsf)	Torvane, TV, Measurement (tsf)	Vane Shear, VS, Measurement (tsf)
Very Soft	Less than 0.12	Less than 0.25	Less than 0.12	Less than 0.12
Soft	0.12 - 0.25	0.25 - 0.5	0.12 - 0.25	0.12 - 0.25
Medium Stiff	0.25 - 0.5	0.5 - 1	0.25 - 0.5	0.25 - 0.5
Stiff	0.5 - 1	1 - 2	0.5 - 1	0.5 - 1
Very Stiff	1 - 2	2 - 4	1 - 2	1 - 2
Hard	Greater than 2	Greater than 4	Greater than 2	Greater than 2

APPARENT DENSITY OF COHESIONLESS SOILS	
Description	SPT N <sub>60</sub> (blows / 12 inches)
Very Loose	0 - 5
Loose	5 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	Greater than 50

MOISTURE	
Description	Criteria
Dry	No discernable moisture
Moist	Moisture present, but no free water
Wet	Visible free water

PERCENT OR PROPORTION OF SOILS	
Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 - 10%
Little	15 - 25%
Some	30 - 45%
Mostly	50 - 100%

PARTICLE SIZE		
Description	Size (in)	
Boulder	Greater than 12	
Cobble	3 - 12	
Gravel	Coarse	3/4 - 3
	Fine	1/5 - 3/4
Sand	Coarse	1/16 - 1/5
	Medium	1/64 - 1/16
	Fine	1/300 - 1/64
Silt and Clay	Less than 1/300	

CEMENTATION	
Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

**REFERENCE** Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010).





	Department of Transportation	REPORT TITLE				
	Division of Engineering Services	<b>BORING RECORD LEGEND</b>				
	Geotechnical Services	DIST.	COUNTY	ROUTE	POSTMILE	EA
	Office of Geotechnical Design - West	01	HUM	101	10.5/11.2	04-123321
		PROJECT OR BRIDGE NAME				
	<b>Rte 36/101 Interchange</b>					
	BRIDGE NUMBER	PREPARED BY	DATE	SHEET		
	04-0873	Tom Whitman	2-1-10	2 of 3		

Figure 5-18

LEGEND OF ROCK MATERIALS		BEDDING SPACING			
	IGNEOUS ROCK	Description		Thickness/Spacing	
	SEDIMENTARY ROCK	Massive	Greater than 10 ft		
	METAMORPHIC ROCK	Very Thickly Bedded	3 ft - 10 ft		
		Thickly Bedded	1 ft - 3 ft		
		Moderately Bedded	4 in - 1 ft		
		Thinly Bedded	1 in - 4 in		
		Very Thinly Bedded	1/4 in - 1 in		
		Laminated	Less than 1/4 in		

WEATHERING DESCRIPTORS FOR INTACT ROCK						
Description	Diagnostic Features					General Characteristics
	Chemical Weathering-Discoloration-Oxidation		Mechanical Weathering and Grain Boundary Conditions	Texture and Leaching		
	Body of Rock	Fracture Surfaces		Texture	Leaching	
Fresh	No discoloration, not oxidized	No discoloration or oxidation	No separation, intact (tight)	No change	No leaching	Hammer rings when crystalline rocks are struck.
Slightly Weathered	Discoloration or oxidation is limited to surface of, or short distance from, fractures; some feldspar crystals are dull	Minor to complete discoloration or oxidation of most surfaces	No visible separation, intact (tight)	Preserved	Minor leaching of some soluble minerals	Hammer rings when crystalline rocks are struck. Body of rock not weakened.
Moderately Weathered	Discoloration or oxidation extends from fractures usually throughout; Fe-Mg minerals are "rusty"; feldspar crystals are "cloudy"	All fracture surfaces are discolored or oxidized	Partial separation of boundaries visible	Generally preserved	Soluble minerals may be mostly leached	Hammer does not ring when rock is struck. Body of rock is slightly weakened.
Intensely Weathered	Discoloration or oxidation throughout; all feldspars and Fe-Mg minerals are altered to clay to some extent; or chemical alteration produces in situ disaggregation, grain boundary conditions	All fracture surfaces are discolored or oxidized; surfaces friable	Partial separation, rock is friable; in semi-arid conditions, granitics are disaggregated	Texture altered by chemical disintegration (hydration, argillation)	Leaching of soluble minerals may be complete	Dull sound when struck with hammer; usually can be broken with moderate to heavy manual pressure or by light hammer blow without reference to planes of weakness such as incipient or hairline fractures or veinlets. Rock is significantly weakened.
Decomposed	Discolored or oxidized throughout, but resistant minerals such as quartz may be unaltered; all feldspars and Fe-Mg minerals are completely altered to clay		Complete separation of grain boundaries (disaggregated)	Resembles a soil; partial or complete remnant rock structure may be preserved; leaching of soluble minerals usually complete		Can be granulated by hand. Resistant minerals such as quartz may be present as "stringers" or "dikes".

PERCENT CORE RECOVERY (REC)
$\frac{\sum \text{Length of the recovered core pieces (in.)}}{\text{Total length of core run (in.)}} \times 100$

ROCK QUALITY DESIGNATION (RQD)
$\frac{\sum \text{Length of intact core pieces} \geq 4 \text{ in.}}{\text{Total length of core run (in.)}} \times 100$
RQD* indicates soundness criteria not met.

ROCK HARDNESS	
Description	Criteria
Extremely Hard	Cannot be scratched with a pocketknife or sharp pick. Can only be chipped with repeated heavy hammer blows
Very Hard	Cannot be scratched with a pocketknife or sharp pick. Breaks with repeated heavy hammer blows.
Hard	Can be scratched with a pocketknife or sharp pick with difficulty (heavy pressure). Breaks with heavy hammer blows.
Moderately Hard	Can be scratched with a pocketknife or sharp pick with light or moderate pressure. Breaks with moderate hammer blows
Moderately Soft	Can be grooved 1/16 in. deep with a pocketknife or sharp pick with moderate or heavy pressure. Breaks with light hammer blow or heavy manual pressure.
Soft	Can be grooved or gouged easily with a pocketknife or sharp pick with light pressure, can be scratched with fingernail. Breaks with light to moderate manual pressure.
Very Soft	Can be readily indented, grooved or gouged with fingernail, or carved with a pocketknife. Breaks with light manual pressure.


  

FRACTURE DENSITY	
Description	Observed Fracture Density
Unfractured	No fractures
Very Slightly Fractured	Core lengths greater than 3 ft.
Slightly Fractured	Core lengths mostly from 1 to 3 ft.
Moderately Fractured	Core lengths mostly 4 in. to 1 ft.
Intensely Fractured	Core lengths mostly from 1 to 4 in.
Very Intensely Fractured	Mostly chips and fragments.

**REFERENCE** Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010).

	Department of Transportation		REPORT TITLE				
	Division of Engineering Services		<b>BORING RECORD LEGEND</b>				
	Geotechnical Services		DIST. <b>01</b>	COUNTY <b>HUM</b>	ROUTE <b>101</b>	POSTMILE <b>10.5/11.2</b>	EA <b>04-123321</b>
	Office of Geotechnical Design - West		PROJECT OR BRIDGE NAME				
			<b>Rte 36/101 Interchange</b>				
		BRIDGE NUMBER <b>04-0873</b>	PREPARED BY <b>Tom Whitman</b>		DATE <b>2-1-10</b>	SHEET <b>3 of 3</b>	

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Select portions of the following references were used in developing this manual. The listed references are intended to acknowledge author and documents used in this manual. Listed references do not indicate alternate methods for logging or reporting subsurface information.

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\*The revision dates of all test methods referenced in this Manual are those dates current on the publishing date of this manual.

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# Appendix A: Field Test Procedures

## A.1 Pocket Penetrometer

The Pocket Penetrometer test is conducted using the following general instructions:

- To begin test, remove protective cap, push ring against body so that low side reads 0.
- Slowly insert piston until engraved mark is level with soil.
- Observe the reading in TSF (KG/SQ CM) using low side of ring, (side closest to the piston end): record reading and repeat.
- For weak soil, use 1" adapter foot, multiply reading by 0.0625.

## A.2 Torvane

The Torvane test is conducted using the following general instructions:

- To start test, push indicator counter clockwise to zero stop.
- Select reasonably flat surface at least 1 inch in diameter.
- Using midsize vane, one division equals 1 TSF (1KG/SQ CM).
- One division using small and large vane equals respectively 2.5 and 0.2 TSF (KG/SQ CM).
- Press pocket vane shear tester into soil to depth of blade; maintain constant vertical pressure while turning knob clockwise at rate to develop failure within 5 to 10 seconds.
- After failure develops, release remaining spring tension slowly. Pointer will indicate maximum shear value until manually reset.

## A.3 Dry Strength Test

Select enough material to mold into a ball about 1 inch diameter. Mold it until it has the consistency of putty, adding water if necessary. From the molded material, make at least three test specimen

balls about 1/2 inch in diameter. Allow the test specimens to dry in air, sun, or by artificial means, as long as the temperature does not exceed 140°F. If the test specimen contains natural dry lumps, those that are about 1/2 inch in diameter may be used in place of the molded balls. Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accordance with the criteria in the table in Section 2.4.14. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

## A.4 Dilatancy

Select enough material to mold into a ball about 1/2 inch diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency. Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in the table in Section 2.4.15. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

## A.5 Toughness

After the dilatancy test, shape the test specimen into an elongated pat and roll by hand on a smooth surface or between the palms into a thread about 1/8 inch diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 inch; this occurs when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the

lump crumbles. Note the toughness of the material during kneading. Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in the table in Section 2.4.16.

## A.6 Jar Slake Index Test

The Slake Durability Test (ASTM D 4644) is the most rigorous test of slaking, however the Jar Slake Test is a simple, but less sensitive method used in the field or in the office to screen specimens for the Slake Durability test. A water filled jar and a watch are required. The steps are as follows:

- Immerse a fragment in enough water to cover it by ½ inch. It is best if the rock is oven dried. It has been reported that moist material is relatively insensitive to degradation in this test when compared with dry material.
- After immersion, observe the sample continuously for 10 minutes and carefully during the first 30 minutes. When a reaction occurs, it is often during the first 30 minutes. A final observation is made after 24 hours.

The condition of the piece is categorized (complete breakdown, partial breakdown, no change), as shown in the table in Section 2.5.14

## A.7 Calcium Carbonate

Report the presence of calcium carbonate based on the sample reaction with dilute hydrochloric acid, and describe the reaction per Fig A.7-1.

**Figure A.7-1 (from ASTM 2488)**  
**Descriptors for calcium carbonate reaction**

Description	Criteria
None	No visible reaction.
Weak	Some reaction, with bubbles forming slowly.
Strong	Violent reaction, with bubbles forming immediately.

## A.8 Standard Penetration Test

The Standard Penetration Test (SPT) must be conducted according to the following two test methods:

- ASTM D 1586, Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils
- ASTM D 6066, Standard Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential

Blow counts (N) must be reported on the LOTB and BR as observed in the field without corrections.

Where,

N The sum of the hammer blows required to drive the sampler in the test interval from 0.5 to 1.5 ft below the cleanout depth.

Hammer efficiency must be shown on the LOTB and BR to allow the reader to determine  $N_{60}$ .

Where,

$ER_i$  Hammer energy ratio

$N_{60}$  Penetration resistance adjusted to a 60% drill rod energy ratio per ASTM D 6066:

$$N_{60} = N_{\text{measured}} \times (ER_i / 60)$$

The following are examples of how to report various SPT measurements:

- Blow counts for each of the 6-inch increments must be recorded in the field, but not necessarily reported on the LOTB and BR. The 2<sup>nd</sup> and 3<sup>rd</sup> driving intervals must be summed and reported.

For example:

1<sup>st</sup> 6 in. interval: 10 blows

2<sup>nd</sup> 6 in. interval: 15 blows

3<sup>rd</sup> 6 in. interval: 18 blows

N reported as “33”

- For partial increments, the depth of penetration must be reported to the nearest 1 inch, in addition to the number of blows.

For example:

1<sup>st</sup> 6 in. interval: 20 blows  
 2<sup>nd</sup> 6 in. interval: 40 blows  
 3<sup>rd</sup> 6 in. interval: 60 blows for 2 inches,  
 then refusal  
 N reported as “100/8-REF”

-or-

1st 6 in. interval: 20 blows  
 2<sup>nd</sup> 6 in. interval: 40 blows  
 3<sup>rd</sup> 6 in. interval: 50 blows for 2 inches  
 N reported as “90/8”

Refusal is defined as 10 blows with no discernable sampler advancement.

- If the seating interval (1<sup>st</sup> 6 in. interval) is not achieved, note refusal.

For example:

1st 6 in. interval: 50 blows for 2 inches,  
 then refusal

N reported as “REF”

- If the sampler sinks under its own weight without any hammer blows, then N is reported as “0”
- If a substantial change in material is encountered over the course of driving the sampler, the 2<sup>nd</sup> and 3<sup>rd</sup> driving intervals can be reported separately.

For example:

1st 6 in. interval: 10 blows  
 2nd 6 in. interval: 20 blows  
 3rd 6 in. interval: 60 blows for 3 inches,  
 N reported as “20/6, 60/3”

## A.9 Core Recovery (REC)

The core recovery value (REC), with few exceptions, provides an indication of the success of the coring operation in recovering the cored rock. Portions of the cored rock mass may not be recovered because the fluid used in the drilling operations washes away portions of the rock mass during the coring operation or the rotation of the core barrel traps and grinds away portions of the rock mass. Diminished core recovery can also be attributed to voids within the rock mass. Core recovery is expressed as a percentage.

$$REC = \frac{\Sigma (\text{Length of the recovered core pieces, inches})(100\%)}{\text{Total length of the core run, inches}}$$

## A.10 Rock Quality Designation (RQD)

Rock Quality Designation is a measure of the fracturing in a rock mass as observed in a core specimen. A high value of RQD indicates few or widely spaced fractures. RQD is valid for core diameters from 1.4 to 3.35 inches. The RQD criteria are generally based on ASTM D 6032.

$$RQD = \frac{\Sigma (\text{Length of intact core pieces} \geq 4 \text{ inches})(100\%)}{\text{Total length of the core run, inches}}$$

The RQD denotes the percentage of sound intact rock retrieved from a borehole. All pieces of sound intact rock core equal to or greater than 4 inches long, including intensely weathered core that cannot be hand broken, are summed and divided by the total length of the core run. An intact core is any segment of core between two open, natural discontinuities.

For weaker or more intensely weathered rock that do not appear sound, RQD, if reported, must be determined and shown with an asterisk, e.g., RQD\*=15%.

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Attachment 3

USEPA LSADPROC-300-R5

<b>Region 4</b> <b>U.S. Environmental Protection Agency</b> <b>Laboratory Services &amp; Applied Science Division</b> <b>Athens, Georgia</b>	
<b>Operating Procedure</b>	
Title: Soil Sampling	ID: LSASDPROC-300-R5
Issuing Authority: Field Services Branch Supervisor	
Effective Date: April 22, 2023	Review Due Date: June 10, 2024
Method Reference: N/A	SOP Author: Kevin Simmons

### **Purpose**

This document describes general and specific procedures, methods and considerations to be used and observed when collecting soil samples for field screening or laboratory analysis.

### **Scope/Application**

The procedures contained in this document are to be used by field personnel when collecting and handling soil samples in the field. On the occasion that LSASD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain a soil sample, the variant procedure will be documented in the field logbook and subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

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# 1 General Information

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## 1.1 Documentation/Verification

This procedure was prepared by persons deemed technically competent by LSASD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the LSASD local area network (LAN). The QAC is responsible for ensuring the most recent version of the procedure is placed on the LAN, and for maintaining records of review conducted prior to its issuance.

## 1.2 General Precautions

### 1.2.1 Safety

Proper safety precautions must be observed when collecting soil samples. Refer to the LSASD Safety and Occupational Health Manual and any pertinent site-specific Health and Safety Plans (HASP) and Job Hazard Assessments for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. The reader should address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

### 1.2.2 Procedural Precautions

The following precautions should be considered when collecting soil samples:

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done in a bound logbook.

- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader in the project files. (Air bills are generated online via UPS Campusship program and package tracking is done online). Receipts are not always received at time of shipping.
- Sampling in landscaped areas: Cuttings should be placed on plastic sheeting and returned to the borehole upon completion of the sample collection. Any 'turf plug' generated during the sampling process should be returned to the borehole.
- Sampling in non-landscaped areas: Return any unused sample material back to the auger, drill or push hole from which the sample was collected.

## **2 Special Sampling Considerations**

---

### **2.1 Special Precautions for Trace Contaminant Soil Sampling**

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different sample is collected and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers with samples suspected of containing high concentrations of contaminants shall be handled and stored separately.
- All background samples shall be segregated from obvious high-concentration or waste samples. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area. Samples of waste or highly-contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other member(s) collect the samples.
- Samplers must use new, verified/certified-clean disposable or non-disposable equipment cleaned according to procedures contained in the LSASD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205), for collection of samples for trace metals or organic compound analyses.

## 2.2 Sample Homogenization

1. If sub-sampling of the primary sample is to be performed in the laboratory, transfer the entire primary sample directly into an appropriate, labeled sample container(s). Proceed to step 4.
2. If sub-sampling the primary sample in the field or compositing multiple primary samples in the field, place the sample into a glass or stainless steel homogenization container and mix thoroughly. Each aliquot of a composite sample should be of the same approximate volume.
3. All soil samples must be thoroughly mixed to ensure that the sample is as representative as possible of the sample media. ***Samples for VOC analysis are not homogenized.*** The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:
  - The material in the sample pan should be divided into quarters and each quarter should be mixed individually.
  - Two quarters should then be mixed to form halves.
  - The two halves should be mixed to form a homogenous matrix.

This procedure should be repeated several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning the material over.

4. Place the sample into an appropriate, labeled container(s) by using the alternate shoveling method and secure the cap(s) tightly. The alternate shoveling method involves placing a spoonful of soil in each container in sequence and repeating until the containers are full or the sample volume has been exhausted. Threads on the container and lid should be cleaned to ensure a tight seal when closed.

## 2.3 Dressing Soil Surfaces

Any time a vertical or near vertical surface is sampled, such as achieved when shovels or similar devices are used for subsurface sampling, the surface should be dressed (scraped) to remove smeared soil. This is necessary to minimize the effects of contaminant migration interferences due to smearing of material from other levels.

## 2.4 Quality Control

If possible, a control sample should be collected from an area not affected by the possible contaminants of concern and submitted with the other samples. This control sample should be collected as close to the sampled area as possible and from the same soil type. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by sampling tools. LSASD Operating Procedure for Field Sampling Quality Control (SESDPROC-011) contains other procedures that may be applicable to soil sampling investigations.

## 2.5 Records

Field notes, recorded in a bound field logbook, as well as chain-of-custody documentation will be generated as described in the LSASD Operating Procedure for Logbooks (SESDPROC-010) and the LSASD Operating Procedure for Sample and Evidence Management (SESDPROC-005).

# 3 Samples Collected for Volatile Organic Compounds (VOC) or for Per- and Polyfluoroalkyl Substances (PFAS) Analyses

---

## 3.1 Soil Samples Collected for Volatile Organic Compounds (VOC) Analysis

The procedures outlined here are summarized from *Test Methods for Evaluating SolidWaste, Physical/Chemical Methods SW-846, Method 5035*. If samples are to be analyzed for VOCs, they should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with an auger bucket, the sample for VOC analysis should be collected directly from the auger bucket (preferred) or from minimally disturbed material immediately after an auger bucket is emptied into the pan. The sample shall be containerized by filling an En Core® Sampler or other Method 5035 compatible container. ***Samples for VOC analysis are not homogenized.*** Preservatives may be required for some samples with certain variations of Method 5035. Consult the method or the principal analytical chemist to determine if preservatives are necessary.

## 3.2 Soil Sampling for VOCs (Method 5035)

The following sampling protocol is recommended for site investigators assessing the extent of VOCs in soils at a project site. Because of the large number of options

available, careful coordination between field and laboratory personnel is needed. The specific sampling containers and sampling tools required will depend upon the detection levels and intended data use. Once this information has been established, selection of the appropriate sampling procedure and preservation method best applicable to the investigation can be made.

### **3.2.1 Equipment**

Soil for VOC analyses may be retrieved using any of the LSASD soil sampling methods described in Sections 4 through 8 of this procedure. Once the soil has been obtained, the En Core® Sampler, syringes, stainless steel spatula, standard 2- oz. soil VOC container, or pre-prepared 40 mL vials may be used/required for sub-sampling. The specific sample containers and the sampling tools required will depend upon the data quality objectives established for the site or sampling investigation. The various sub-sampling methods are described below.

### **3.2.2 Sampling Methodology - Low Concentrations (<200 µg/kg)**

When the total VOC concentration in the soil is expected to be less than 200 µg/kg, the samples may be collected directly with the En Core® Sampler or syringe. If using the syringes, the sample must be placed in the sample container (40 mL pre-prepared vial) immediately to reduce volatilization losses. The 40 mL vials should contain 10 mL of organic-free water for an un-preserved sample or approximately 10 mL of organic-free water and a preservative. It is recommended that the 40 mL vials be prepared and weighed by the laboratory (commercial sources are available which supply preserved and tared vials). When sampling directly with the En Core® Sampler, the vial must be immediately capped and locked.

A soil sample for VOC analysis may also be collected with conventional sampling equipment. A sample collected in this fashion must either be placed in the final sample container (En Core® Sampler or 40 mL pre-prepared vial) immediately or the sample may be immediately placed into an intermediate sample container with no head space. If an intermediate container (usually 2-oz. soil jar) is used, the sample must be transferred to the final sample container (En Core® Sampler or 40 mL pre-prepared vial) as soon as possible, not to exceed 30 minutes.

NOTE:After collection of the sample into either the En Core® Sampler or other container, the sample must immediately be stored in an ice chest and cooled.

Soil samples may be prepared for shipping and analysis as follows:

*En Core® Sampler* - the sample shall be capped, locked, and secured in the original foil bag. All foil bags containing En Core® samplers are then placed in a plastic bag and sealed with custody tape, if required.

*Syringe* - Add about 3.7 cc (approximately 5 grams) of sample material to 40-mL pre-prepared containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag. Note: When using the syringes, it is important that no air is allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample.

*Stainless Steel Laboratory Spatulas* - Add between 4.5 and 5.5 grams (approximate) of sample material to 40 mL containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag.

### **3.2.3 Sampling Methodology - High Concentrations (>200 µg/kg)**

Based upon the data quality objectives and the detection level requirements, this high-level method may also be used. Specifically, the sample may be packed into a single 2-oz. glass container with a screw cap and septum seal. The sample container must be filled quickly and completely to eliminate head space. Soils\sediments containing high total VOC concentrations may also be collected as described in Section 3.2.2, Sampling Methodology - Low Concentrations, and preserved using 10 mL methanol.

### **3.2.4 Special Techniques and Considerations for Method 5035**

#### Effervescence

If low concentration samples effervesce (rapidly form bubbles) from contact with the acid preservative, then either a test for effervescence must be performed prior to sampling, or the investigators must be prepared to collect each sample both preserved or un-preserved, as needed, or all samples must be collected unpreserved.

To check for effervescence, collect a test sample and add to a pre-preserved vial. If preservation (acidification) of the sample results in effervescence then preservation by acidification is not acceptable, and the sample must be collected un-preserved.

If effervescence occurs and only pre-preserved sample vials are available, the preservative solution may be placed into an appropriate hazardous waste container and the vials triple rinsed with organic free water. An appropriate amount of organic free water, equal to the amount of preservative solution, should be placed

into the vial. The sample may then be collected as an un-preserved sample. Note: the amount of organic free water placed into the vials will have to be accurately measured.

### Sample Size

While this method is an improvement over earlier ones, field investigators must be aware of an inherent limitation. Because of the extremely small sample size and the lack of sample mixing, sample representativeness for VOCs may be reduced compared to samples with larger volumes collected for other constituents. The sampling design and objectives of the investigation should take this into consideration.

### Holding Times

Sample holding times are specified in the Laboratory Services Branch *Laboratory Operations and Quality Assurance Manual* (ASBLOQAM), Most Recent Version. Field investigators should note that the holding time for an un-preserved VOC soil/sediment sample on ice is 48 hours. Arrangements should be made to ship the soil/sediment VOC samples to the laboratory by overnight delivery the day they are collected so the laboratory may preserve and/or analyze the sample within 48 hours of collection.

### Percent Solids

Samplers must ensure that the laboratory has sufficient material to determine percent solids in the VOC soil/sediment sample to correct the analytical results to dry weight. If other analyses requiring percent solids determination are being performed upon the sample, these results may be used. If not, a separate sample (minimum of 2 oz.) for percent solids determination will be required. The sample collected for percent solids may also be used by the laboratory to check for preservative compatibility.

### Safety

Methanol is a toxic and flammable liquid. Therefore, methanol must be handled with all required safety precautions related to toxic and flammable liquids. Inhalation of methanol vapors must be avoided. Vials should be opened and closed quickly during the sample preservation procedure. Methanol must be handled in a ventilated area. Use protective gloves when handling the methanol vials. Store methanol away from sources of ignition such as extreme heat or open flames. The vials of methanol should be stored in a cooler with ice at all times.

## Shipping

Methanol and sodium bisulfate are considered dangerous goods, therefore shipment of samples preserved with these materials by common carrier is regulated by the U.S. Department of Transportation and the International Air Transport Association (IATA). The rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the current edition of the IATA Dangerous Goods Regulations must be followed when shipping methanol and sodium bisulfate. Consult the above documents or the carrier for additional information. Shipment of the quantities of methanol and sodium bisulfate used for sample preservation falls under the exemption for small quantities.

The summary table on the following page lists the options available for compliance with SW846 Method 5035. The advantages and disadvantages are noted for each option. LASSD's goal is to minimize the use of hazardous material (methanol and sodium bisulfate) and minimize the generation of hazardous waste during sample collection.

**Table 1: Method 5035 Summary**

OPTION	PROCEDURE	ADVANTAGES	DISADVANTAGES
1	Collect two 40 mL vials with $\approx$ 5 grams of sample, and one 2 oz. glass jar w/septum lid for screening, % moisture and preservative compatibility.	Screening conducted by lab.	Presently a 48-hour holding time for unpreserved samples. Sample containers must be tared.
2	Collect three En Core® samplers, and one 2 oz. glass jar w/septum lid for screening, % solids.	Lab conducts all preservation/preparation procedures.	Presently a 48- hour holding time for preparation of samples.
3	Collect two 40 mL vials with 5 grams of sample and preserve w/methanol or sodium bisulfate, and one 2-oz. glass jar w/septum lid for screening, % solids .	High level VOC samples may be composited. Longer holding time.	Hazardous materials used in the field. Sample containers must be tared.
4	Collect one 2-oz. glass jar w/septum lid for analysis, % solids (high level VOC only).	Lab conducts all preservation/preparation procedures.	May have significant VOC loss.

### 3.3 Soil Samples for Per- and Polyfluoroalkyl Substances (PFAS) Analysis

Sources of PFAS contamination in soils can include direct discharges, direct applications of some PFAS products such as aqueous film-forming foams (AFFF), air deposition from manufacturing stack emissions, landfill leachate, and land applications of biosolids or effluents. The distribution of PFAS in soils is multifaceted and will be dependent on site-specific conditions and soils as well as the individual properties of the PFAS such as chain length and functional group. Heavy PFAS contamination of subsurface soils can serve as long-term sources for both groundwater and surface water contamination. For more information about conducting site investigations for PFAS, please see the Interstate Technology and Regulatory Council's (ITRC's) April 2020 Fact Sheets: *Site Characterization Considerations, Sampling Precautions, and Laboratory Analytical Methods for Per- and Polyfluoroalkyl Substances (PFAS)*, and *Environmental Fate and Transport for Per- and Polyfluoroalkyl Substances*.

#### 3.3.1 Sampling Equipment

Guidance documents recommend sampling equipment be made of stainless-steel, high-density polyethylene (HDPE), polypropylene, and/or silicone. Standard soil sampling equipment such as stainless-steel spoons, hand augers, and direct push samplers with liners that are PFAS-free can be used to collect samples for PFAS analyses. Direct contact sampling equipment that will be used to collect samples for PFAS analyses should be decontaminated following the procedures in the *Field Equipment Cleaning and Decontamination at the FEC*, LSASDPROC-206.

#### 3.3.2 PFAS Soil Sample Mixing and Homogenization Considerations

Because studies have shown the loss of PFAS due to adsorption to surfaces, samples should be minimally handled and directly placed into the sample container when possible. Sample preparation procedures should be specified in the Sampling and Analysis Plan (SAP). If compositing, mixing or homogenization of the sample is desired, it should preferably be done at the laboratory so that a representative subsample will be analyzed. In cases where the homogenization is conducted in the field, extra grab samples should accompany the mixed or composited samples to determine the variability and impacts on PFAS concentrations of the mixed samples.

#### 3.3.3 Trace Level Sampling Technique for PFAS

To prevent PFAS contamination, **extreme care** is required when handling containers, samples and equipment that will be used to collect samples for PFAS analyses. **New gloves** need to be worn when decontaminating and handling sample containers and equipment. When worn gloves become compromised by potential PFAS containing materials, they need to be changed for new gloves. Nitrile gloves are recommended for PFAS sampling investigations. Also, sample containers should be kept covered in original packaging or in Whirl-Paks® until ready for use due to potential PFAS

contamination from air deposition of vapors, aerosols, and particulates.

This trace level sampling technique is used to minimize PFAS contamination of the samples. This process will require two field personnel for PFAS sample collection. When the field investigators are prepared to fill the sample container(s), a designated sampler will don new gloves while a second designee, also with new gloves, will assist by opening sample container packaging/Whirl-Pak®. The designated sampler removes the sample container(s) from the packaging but keeps them closed. Only after the second designee is ready to fill the sample container does the designated sampler remove the cap and hold it in their hand until the appropriate sample volume is obtained. After capping the sample container(s), return them to their Whirl-Pak®. The designated sampler who holds the sample container(s) should not touch anything else during the sample collection process. This is important because of the wide use of PFAS in commercial products such as clothing, field gear, personnel protective equipment, sunscreen, insect repellants, and personal hygiene products. Additionally, the designated sampler should avoid touching the sample media and the inside of the sample container. The second designee will operate sampling equipment and assist with sample container packaging and labeling. Sampling equipment known or suspected to contain PFAS should be avoided during sampling activities.

### **3.3.4 Quality Control Samples and Standard Operating Procedures**

For soil samples undergoing PFAS analyses, it extremely important that quality control samples be collected as part of the investigation to account for the PFAS contribution of the sample containers, decontamination solutions, gloves, decontaminated equipment and plastic used to store equipment. Equipment rinse and material blanks are needed for PFAS sampling investigations to assess the direct contact sampling equipment impact on the sampling results. It is also helpful to take field quality control samples such as field blanks, duplicates, and trip blanks to evaluate the soil sampling and sample handling activities of the investigation. Laboratory sources of water used for equipment decontamination and blank sample collection should be produced as PFAS-free or assessed for background concentrations of PFAS.

Along with a good quality assurance program, standard operating procedures (SOPs) and detailed SAPs are required for PFAS investigations to provide consistency between samplers and investigations.

## **4 Manual Soil Sampling Methods**

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### **4.1 General**

These methods are used primarily to collect surface and shallow subsurface soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. The most common interval is 0 to 6 inches; however, the data quality objectives of the investigation may dictate another interval, such as 0 to 3 inches for risk assessment purposes. The shallow subsurface interval may be considered to extend from approximately 12 inches below ground surface to a site-specific depth at which sample collection using manual collection methods becomes impractical.

If a thick, matted root zone, gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials.

When compositing, make sure that each composite location (aliquot) consist of equal volumes, i.e., same number of equal spoonfuls.

### **4.2 Spoons**

Stainless steel spoons may be used for surface soil sampling to depths of approximately 6 inches below ground surface where conditions are generally soft and non-indurated, and there is no problematic vegetative layer to penetrate.

#### **4.2.1 Special Considerations When Using Spoons**

When using stainless steel spoons, consideration must be given to the procedure used to collect the volatile organic compound sample. If the soil being sampled is cohesive and holds its in situ texture in the spoon, the En Core® Sampler or syringe used to collect the sub-sample for Method 5035 should be plugged directly from the spoon. If, however, the soil is not cohesive and crumbles when removed from the ground surface for sampling, consideration should be given to plugging the sample for Method 5035 directly from the ground surface at a depth appropriate for the investigation Data Quality Objectives.

### **4.3 Hand Augers**

Hand augers may be used to advance boreholes and collect soil samples in the surface and shallow subsurface intervals. Typically, 3-inch stainless steel auger buckets with cutting

heads are used. The bucket is advanced by simultaneously pushing and turning using an attached handle with extensions (if needed).

#### **4.3.1 Surface Soil Sampling**

When conducting surface soil sampling with hand augers, the auger buckets may be used with a handle alone or with a handle and extensions. The bucket is advanced to the appropriate depth and the contents are transferred to the homogenization container for processing. Observe precautions for volatile organic compound and PFAS sample collection found in Section 3.

#### **4.3.2 Subsurface Soil Sampling**

Hand augers are the most common equipment used to collect shallow subsurface soil samples. Auger holes are advanced one bucket at a time until the sample depth is achieved. When the sample depth is reached, the bucket used to advance the hole is removed and a clean bucket is attached. The clean auger bucket is then placed in the hole and filled with soil to make up the sample and removed.

The practical depth of investigation using a hand auger depends upon the soil properties and depth of investigation. In sand, augering is usually easily performed, but the depth of collection is limited to the depth at which the sand begins to flow or collapse. Hand augers may also be of limited use in tight clays or cemented sands. In these soil types, the greater the depth attempted, the more difficult it is to recover a sample due to increased friction and torquing of the hand auger extensions. At some point these problems become so severe that power equipment must be used.

#### **4.3.3 Special Considerations for Soil Sampling with the Hand Auger**

- Because of the tendency for the auger bucket to scrape material from the sides of the auger hole while being extracted, the top several inches of soil in the auger bucket should be discarded prior to placing the bucket contents in the homogenization container for processing.
- Observe precautions for volatile organic compound (VOC) and PFAS sample collection found in Section 3. Collect the VOC sample directly from the auger bucket, if possible.
- Power augers, such as the Little Beaver® and drill rigs may be used to advance boreholes to depths for subsurface soil sampling with the hand auger. They may not be used for sample collection. When power augers are used to advance a borehole to depth for sampling, care must be taken that exhaust fumes, gasoline and/or oil do not contaminate the borehole or area in the immediate vicinity of sampling.
- When moving to a new sampling location, the entire hand auger assembly must be replaced with a properly decontaminated hand auger assembly.

## **5 Direct Push Soil Sampling Methods**

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### **5.1 General**

These methods are used primarily to collect shallow and deep subsurface soil samples. Three samplers are available for use within the Division's direct push tooling inventory. All of the sampling tools involve the collection and retrieval of the soil sample within a thin-walled liner. The following sections describe each of the specific sampling methods that can be accomplished using direct push techniques, along with details specific to each method. While LSASD currently uses the sample tooling described, tooling of similar design and materials is acceptable.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

### **5.2 Large Bore® Soil Sampler**

The Large Bore® (LB) sampler is a solid barrel direct push sampler equipped with a piston-rod point assembly used primarily for collection of depth-discrete subsurface soil samples. The sample barrel is approximately 30-inches (762 mm) long and has a 1.5-inch (38 mm) outside diameter. The LB® sampler is capable of recovering a discrete sample core 22 inches x 1.0 inch (559 mm x 25 mm) contained inside a removable liner. The resultant sample volume is a maximum of 283 mL.

After the LB® sample barrel is equipped with the cutting shoe and liner, the piston-rod point assembly is inserted, along with the drive head and piston stop assembly. The assembled sampler is driven to the desired sampling depth, at which time the piston stop pin is removed, freeing the push point. The LB® sampler is then pushed into the soil a distance equal to the length of the LB® sample barrel. The probe rod string, with the LB® sampler attached, is then removed from the subsurface. After retrieval, the LB® sampler is then removed from the probe rod string. The drive head is then removed to allow removal of the liner and soil sample.

### **5.3 Macro-Core® Soil Sampler**

The Macro-Core® (MC) sampler is a solid barrel direct push sampler equipped with a piston-rod point assembly used primarily for collection of either continuous or depth-discrete subsurface soil samples. Although other lengths are available, the standard MC® sampler has an assembled length of approximately 52 inches (1321 mm) with an outside

diameter of 2.2 inches (56 mm). The MC® sampler is capable of recovering a discrete sample core 45 inches x 1.5 inches (1143 mm x 38 mm) contained inside a removable liner. The resultant sample volume is a maximum of 1300 mL. The MC® sampler may be used in either an open-tube or closed-point configuration. Although the MC® sampler can be used as an open-barrel sampler, in LSASD usage, the piston point is always used to prevent the collection of slough from the borehole sides.

#### **5.4 Dual Tube Soil Sampling System**

The Dual Tube 21 soil sampling system is a direct push system for collecting continuous core samples of unconsolidated materials from within a sealed outer casing of 2.125-inch (54 mm) OD probe rod. The samples are collected within a liner that is threaded onto the leading end of a string of 1.0-inch diameter probe rod. Collected samples have a volume of up to 800 mL in the form of a 1.125-inch x 48-inch (29 mm x 1219 mm) core. Use of this method allows for collection of continuous core inside a cased hole, minimizing or preventing cross-contamination between different intervals during sample collection. The outer casing is advanced, one core length at a time, with only the inner probe rod and core being removed and replaced between samples. If the sampling zone of interest begins at some depth below ground surface, a solid drive tip must be used to drive the dual tube assembly and core to its initial sample depth.

#### **5.5 Special Considerations When Using Direct Push Sampling Methods**

- *Liner Use and Material Selection* – Direct Push Soil Samples are collected within a liner to facilitate removal of sample material from the sample barrel. The liners may only be available in a limited number of materials for a given sample tool, although overall, liners are available in brass, stainless steel, cellulose acetate butyrate (CAB), polyethylene terephthalate glycol (PETG), polyvinyl chloride (PVC) and Teflon®. For most LSASD investigations, the standard polymer liner material for a sampling tool will be acceptable. When the study objectives require very low reporting levels or unusual contaminants of concern, the use of more inert liner materials such as Teflon® or stainless steel may be necessary.
- *Sample Orientation* – When the liners and associated sample are removed from the sample tubes, it is important to maintain the proper orientation of the sample. This is particularly important when multiple sample depths are collected from the same push. It is also important to maintain proper orientation to define precisely the depth at which an aliquot was collected. Maintaining proper orientation is typically accomplished using vinyl end caps. Convention is to place red caps on the top of the liner and black caps on the bottom to maintain proper sample orientation. Orientation can also be indicated by marking on the exterior of the liner with a permanent marker.

- *Core Catchers* – Occasionally the material being sampled lacks cohesiveness and is subject to crumbling and falling out of the sample liner. In cases such as these, the use of core catchers on the leading end of the sampler may help retain the sample until it is retrieved to the surface. Core catchers may only be available in specific materials and should be evaluated for suitability. However, given the limited sample contact that core-catchers have with the sample material, most standard core-catchers available for a tool system will be acceptable.
- *Decontamination* – The cutting shoe and piston rod point are to be decontaminated between each sample, using the procedures specified for the collection of trace organic and inorganic compounds found in Field Equipment and Decontamination – SESDPROC-205, most recent version. Within a borehole, the sample barrel, rods, and drive head may be subjected to an abbreviated cleaning to remove obvious and loose material, but must be cleaned between boreholes using the procedures specified for downhole drilling equipment in Field Equipment and Decontamination – SESDPROC-205, most recent version.
- *Decommissioning* – Boreholes must be decommissioned after the completion of sampling. Boreholes less than 10 feet deep that remain open and do not approach the water table may be decommissioned by pouring 30% solids bentonite grout from the surface or pouring bentonite pellets from the surface, hydrating the pellets in lifts. Boreholes deeper than 10 feet, or any borehole that intercepts groundwater, must be decommissioned by pressure grouting with 30% solids bentonite grout, either through a re-entry tool string or through tremie pipe introduced to within several feet of the borehole bottom.
- *VOC and PFAS Sample Collection* – Observe precautions for volatile organic compounds and Per- and Polyfluoroalkyl Substances sample collection found in Section 3 of this procedure.

## 6 Split Spoon/Drill Rig Methods

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### 6.1 General

Split spoon sampling methods are used primarily to collect shallow and deep subsurface soil samples. All split spoon samplers, regardless of size, are basically split cylindrical barrels that are threaded on each end. The leading end is held together with a beveled threaded collar that functions as a cutting shoe. The other end is held together with a threaded collar that serves as the sub used to attach the spoon to the string of drill rod. Two basic methods are available for use, including the smaller diameter standard split spoon, driven with the drill rig safety hammer, and the larger diameter continuous split spoon,

advanced inside and slightly ahead of the lead auger during hollow stem auger drilling. The following sections describe each of the specific sampling methods, along with details specific to each method.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

## **6.2 Standard Split Spoon**

A drill rig is used to advance a borehole to the target depth. The drill string is then removed and a standard split spoon is attached to a string of drill rod. Split spoons used for soil sampling must be constructed of stainless steel and are typically 2.0-inches OD (1.5-inches ID) and 18-inches to 24-inches in length. Other diameters and lengths are common and may be used if constructed of the proper material. After the spoon is attached to the string of drill rod, it is lowered into the borehole. The safety hammer is then used to drive the split spoon into the soil at the bottom of the borehole. After the split spoon has been driven into the soil, filling the spoon, it is retrieved to the surface, where it is removed from the drill rod string and opened for sample acquisition.

## **6.3 Continuous Split Spoon**

The continuous split spoon is a large diameter split spoon that is advanced into the soil column inside a hollow stem auger. Continuous split spoons are typically 3 to 5 inches in diameter and either 5 feet or 10 feet in length, although the 5-foot long samplers are most common. After the auger string has been advanced into the soil column a distance equal to the length of the sampler being used it is returned to the surface. The sampler is removed from inside the hollow stem auger and the threaded collars are removed. The split spoon is then opened for sampling.

## **6.4 Special Considerations When Using Split Spoon Sampling Methods**

- Always discard the top several inches of material in the spoon before removing any portion for sampling. This material normally consists of borehole wall material that has sloughed off of the borehole wall after removal of the drill string prior to and during inserting the split spoon.
- Observe precautions for volatile organic compounds and Per- and Polyfluoroalkyl Substances sample collection found in Section 3.

## **7 Shelby Tube/Thin-Walled Sampling Methods**

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### **7.1 General**

Shelby tubes, also referred to generically as thin-walled push tubes or Acker thin-walled samplers, are used to collect subsurface soil samples in cohesive soils and clays during drilling activities. In addition to samples for chemical analyses, Shelby tubes are also used to collect relatively undisturbed soil samples for geotechnical analyses, such as hydraulic conductivity and permeability, to support hydrogeologic characterizations at hazardous waste and other sites.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with this device.

### **7.2 Shelby Tube Sampling Method**

A typical Shelby tube is 30 inches in length and has a 3.0-inch OD (2.875-inch ID) and may be constructed of steel, stainless steel, galvanized steel, or brass. They also typically are attached to push heads that are constructed with a ball-check to aid in holding the contained sample during retrieval. If used for collecting samples for chemical analyses, it must be constructed of stainless steel. If used for collecting samples for standard geotechnical parameters, any material is acceptable.

To collect a sample, the tube is attached to a string of drill rod and is lowered into the borehole, where the sampler is then pressed into the undisturbed material by hydraulic force. After retrieval to the surface, the tube containing the sample is then removed from the sampler head. If samples for chemical analyses are needed, the soil contained inside the tube is then removed for sample acquisition. If the sample is collected for geotechnical parameters, the tube is typically capped, maintaining the sample in its relatively undisturbed state, and shipped to the appropriate geotechnical laboratory.

### **7.3 Special Considerations When Using Split Spoon Sampling Methods**

Observe precautions for volatile organic compounds and Per- and Polyfluoroalkyl Substances sample collection found in Section 3.

## **8 Backhoe Sampling Method**

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### **8.1 General**

Backhoes may be used in the collection of surface and shallow subsurface soil samples. The trenches created by excavation with a backhoe offer the capability of collecting samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. If possible, the sample should be collected without entering the trench. Samples may be obtained from the trench wall or they may be obtained directly from the bucket at the surface. The following sections describe various techniques for safely collecting representative soil samples with the aid of a backhoe.

The depth measurement for the sample begins at the top of the soil horizon.

### **8.2 Scoop-and-Bracket Method**

If a sample interval is targeted from the surface, it can be sampled using a stainless steel scoop and bracket. First a scoop and bracket are affixed to a length of conduit and is lowered into the backhoe pit. The first step is to take the scoop and scrape away the soil comprising the surface of the excavated wall. This material likely represents soil that has been smeared by the backhoe bucket from adjacent material. After the smeared material has been scraped off, the original stainless steel scoop is removed and a clean stainless steel scoop is placed on the bracket. The clean scoop can then be used to remove sufficient volume of soil from the excavation wall to make up the required sample volume.

### **8.3 Direct-from-Bucket Method**

It is also possible to collect soil samples directly from the backhoe bucket at the surface. Some precision with respect to actual depth or location may be lost with this method but if the soil to be sampled is uniquely distinguishable from the adjacent or nearby soils, it may be possible to characterize the material as to location and depth. In order to ensure representativeness, it is also advisable to dress the surface to be sampled by scraping off any smeared material that may cross-contaminate the sample.

### **8.4 Special Considerations When Sampling with a Backhoe**

- Do not physically enter backhoe excavations to collect a sample. Use either procedure 8.2, Scoop-and-Bracket Method, or procedure 8.3, Direct-from-Bucket Method to obtain soil for sampling.

- Smearing is an important issue when sampling with a backhoe. Measures must be taken, such as dressing the surfaces to be sampled (see Section 2.3), to mitigate problems with smearing.
- Paint, grease and rust must be removed and the bucket decontaminated prior to sample collection.
- Observe precautions for volatile organic compound and PFAS sample collection found in Section 3.

## **9 Incremental Sampling Method**

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### **9.1 General**

ISM is a structured composite sampling and processing protocol that reduces data variability and provides an unbiased estimate of mean contaminant concentrations in the area targeted for sampling. ISM provides representative samples of specific soil volumes defined as decision units (DUs) by collecting numerous increments of soil (typically 30–100) that are combined, processed, and subsampled according to specific protocols. Triplicate samples are collected to measure and evaluate the reproducibility of the sample data.

Like all sampling approaches, ISM should be applied within a systematic planning framework. The size, orientation, and location of a DU is site-specific and represents the smallest volume of soil about which a decision is to be made (USEPA 1999, Ramsey and Hewitt 2005, HDOH 2008a, ADEC 2009). DUs are based on project-specific needs and site-specific DQOs. More detailed information on conducting sampling using ISM can be found in the Interstate Technology and Regulatory Council’s *Incremental Sampling Methodology* (ISM-1).

### **9.2 Field Implementation, Sample Collection, and Processing**

#### **9.2.1 Introduction**

The goal of most sampling efforts is to collect a sample that is representative of the target area (or DU). ISM is designed to collect representative and reproducible soil data. To help ensure data quality, all field sampling and field processing activities should be performed and supervised by personnel trained in ISM implementation

## 9.2.2 Sampling Tools

The selection of the appropriate sampling tool for collecting an ISM sample depends on the cohesiveness and composition of the soil substrate. The sampling tool should obtain cylindrical or core-shaped increments of a constant depth from the presented surface so that each increment collected is the same approximate volume and mass.

See Figures 1 and 2 for examples of sampling tools for nonvolatile ISM sample collection. Various other hand augers, core sampling tools, step probes, etc., are available from environmental or agricultural suppliers and are applicable to ISM if the specifications meet project DQOs. It is highly recommended that the proposed sampling tool is tested at the sample location prior to full mobilization to ensure that the sampling tool is appropriate for site conditions. If a pilot sampling effort is not possible, a variety of tools to address different soil types or site conditions should be taken into the field.

Note: Volatile ISM sample collection should follow Method 5035 recommendations. See Section 3 of this SOP.

## 9.2.3 Field Collection

Incremental soil samples are prepared by collecting multiple increments of soil (typically 30 or more) from a specified DU and physically combining these increments into a single sample, referred to as the “incremental sample.” Samples are collected in triplicate from different locations within the same DU. Sample increments locations can be selected by a random number generator or evenly spaced across the DU to ensure that the incremental sample is representative of the DU. Survey flags or other markers can be helpful in identifying increment collection locations prior to beginning sample location.

The number of increments to be collected from each DU of a site investigation should be evaluated during systematic planning as part of the DQO process and documented in the sampling and analysis plan (SAP). See section 5.3.2 of ISM-1 for subsurface ISM sample collection.

## 9.2.4 Field Handling of ISM Samples

ISM samples collect a larger volume of soil than discrete samples and will require a larger collection container than may be specified by the laboratory or that is typically used. For example, a gallon-sized sealable plastic bag or a liter glass jar may be used depending upon the suspect analytes. When building the incremental sample by collecting increments, it may be more practical to collect the sample in an aluminum pan, plastic bucket, stainless-steel bowl, or other easily transported

container until the entire sample has been collected. The final sample can then be processed in the field or transferred to a container for shipment to a laboratory for sample processing and analysis.

Processing of ISM samples is ideally performed in a laboratory. However, subsampling, disaggregation, drying, and sieving are some processing steps that may be required to be performed in the field. Field processing may be necessary if field analysis will be performed on the samples or if the laboratory is unable to perform the sample processing steps required. Any field processing steps should be rigorously performed to ensure that the sample representativeness is maintained through analysis. To ensure proper sample size reduction and representative subsampling, they should be performed using a 2-D Japanese slab cake and specialized subsampling tool, a riffle splitter, rotary cone sample splitter, or similar. Sample volume reduction of ISM samples should not be conducted with a stainless-steel spoon and a stainless-steel bowl. All sample processing equipment should be appropriately decontaminated between sample stations.

### **9.3 Special Considerations When Using Incremental Sampling Methods**

- Selection of an appropriately sized and positioned Decision Unit is important to ensuring quality data and useful results
- Steps should be taken throughout the sampling effort to ensure that the representativeness of the sample is maintained from collection through analysis
- Advance coordination with the laboratory is necessary to ensure that the laboratory has the capability and capacity to conduct any sample processing that may be necessary. If the lab cannot complete the required processing steps, the sampling team may need to perform the sample processing steps in the field.

**Figure 1**



**Figure 2**



## 10 References

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International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

LSASD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

LSASD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

LSASD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

LSASD Operating Procedure for Field X-Ray Fluorescence (XRF) Measurement, SESDPROC-107, Most Recent Version

LSASD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

LSASD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

Title 49 Code of Federal Regulations, Pts. 171 to 179, Most Recent Version

US EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Most Recent Version (Method 5035)

US EPA Region 4 Safety and Occupational Health Manual. Region 4 LSASD, Athens, GA, Most Recent Version

ITRC (Interstate Technology & Regulatory Council). 2012. Incremental Sampling Methodology. ISM-1. Washington, D.C.: Interstate Technology & Regulatory Council, Incremental Sampling Methodology Team. [www.itreweb.org](http://www.itreweb.org).

ITRC (Interstate Technology and Regulatory Council) April 2020 Fact Sheets: *Site Characterization Considerations, Sampling Precautions, and Laboratory Analytical Methods for Per- and Polyfluoroalkyl Substances (PFAS)*, and *Environmental Fate and Transport for Per- and Polyfluoroalkyl Substances*

## 11 Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the LSASD Quality Assurance Coordinator (QAC) on the LSASD local area network (LAN).

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Replaced Chief with Supervisor; General formatting changes.	April 22, 2023
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SESDPROC-300-R2, <i>Soil Sampling</i> , replaces SESDPROC-300-R1.	December 20, 2011
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SESDPROC-300-R1, <i>Soil Sampling</i> , replaces SESDPROC-300-R0.	November 1, 2007
SESDPROC-300-R0, Soil Sampling, Original Issue	February 05, 2007

Attachment 4  
SESDPROC-205-R3

**Region 4**  
**U.S. Environmental Protection Agency**  
**Science and Ecosystem Support Division**  
**Athens, Georgia**

**OPERATING PROCEDURE**


**Title: Field Equipment Cleaning and Decontamination**

**Effective Date:** December 18, 2015

**Number:** SESDPROC-205-R3

**Authors**


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The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

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<p>SESDPROC-205-R3, <i>Field Equipment Cleaning and Decontamination</i>, replaces SESDPROC-205-R2.</p> <p><b>Cover Page:</b> The author was changed to Brian Striggow. SESD's reorganization was reflected in the authorization section by making John Deatrack the Chief of the Field Services Branch. The FQM was changed from Bobby Lewis to Hunter Johnson.</p> <p><b>Revision History:</b> Changes were made to reflect the current practice of only including the most recent changes in the revision history.</p> <p><b>General:</b> Corrected any typographical, grammatical and/or editorial errors.</p> <p><b>Section 1.4:</b> Differentiate between Liquinox® and Luminox® detergents.</p> <p><b>Section 3.4:</b> Restore solvent rinse as alternative cleaning method.</p> <p><b>Section 3.7:</b> Added section on cleaning of 12 Volt electric submersible pumps.</p> <p><b>Section 3.8:</b> Added section on cleaning of bladder pumps.</p> <p><b>Section 3.9:</b> Added language on cleaning and transport of SP15/16 screens</p> <p><b>Section 3.10:</b> Added section on cleaning of rental pumps</p>	December 18, 2015
<p>SESDPROC-205-R2, <i>Field Equipment Cleaning and Decontamination</i>, replaces SESDPROC-205-R1.</p>	December 20, 2011
<p>SESDPROC-205-R1, <i>Field Equipment Cleaning and Decontamination</i>, replaces SESDPROC-205-R0.</p>	November 1, 2007
<p>SESDPROC-205-R0, <i>Field Equipment Cleaning and Decontamination</i>, Original Issue</p>	February 05, 2007

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# 1 General Information

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## 1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when cleaning and decontaminating sampling equipment during the course of field investigations.

## 1.2 Scope/Application

The procedures contained in this document are to be followed when field cleaning sampling equipment, for both re-use in the field, as well as used equipment being returned to the Field Equipment Center (FEC). On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that other procedures must be used to clean or decontaminate sampling equipment at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

## 1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on LAN and for maintaining records of review conducted prior to its issuance.

## 1.4 Definitions

- Decontamination: The process of cleaning dirty sampling equipment to the degree to which it can be re-used, with appropriate QA/QC, in the field.
- Deionized water: Tap water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard inductively coupled Argon Plasma Spectrophotometer (ICP) (or equivalent) scan. Deionized water obtained by other methods is acceptable, as long as it meets the above analytical criteria. Organic-free water may be substituted for deionized water.
- Detergent shall be a standard brand of phosphate-free laboratory detergent such as Liquinox® or Luminox®. Liquinox® is a traditional anionic laboratory detergent and is used for general cleaning and where there is

concern for the stability of the cleaned items in harsher cleaners. Luminox® is a specialized detergent with the capability of removing oils and organic contamination. It is used in lieu of a solvent rinse step in cleaning of equipment for trace contaminant sampling. Where not specified in these procedures, either detergent is acceptable.

- Drilling Equipment: All power equipment used to collect surface and sub-surface soil samples or install wells. For purposes of this procedure, direct push is also included in this definition.
- Field Cleaning: The process of cleaning dirty sampling equipment such that it can be returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.
- Organic-free water: Tap water that has been treated with activated carbon and deionizing units. At a minimum, the finished water must meet the analytical criteria of deionized water and it should contain no detectable pesticides, herbicides, or extractable organic compounds, and no volatile organic compounds above minimum detectable levels as determined by the Region 4 laboratory for a given set of analyses. Organic-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.
- Tap water: Water from any potable water supply. Deionized water or organic-free water may be substituted for tap water.

## 1.5 References

SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, Most Recent Version

SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

## **1.6 General Precautions**

### ***1.6.1 Safety***

Proper safety precautions must be observed when field cleaning or decontaminating dirty sampling equipment. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. At a minimum, the following precautions should be taken in the field during these cleaning operations:

- When conducting field cleaning or decontamination using laboratory detergent, safety glasses with splash shields or goggles, and latex gloves will be worn.
- No eating, smoking, drinking, chewing, or any hand to mouth contact should be permitted during cleaning operations.

### ***1.6.2 Procedural Precaution***

Prior to mobilization to a site, the expected types of contamination should be evaluated to determine if the field cleaning and decontamination activities will generate rinsates and other waste waters that might be considered RCRA hazardous waste or may require special handling.

## **2 Introduction to Field Equipment Cleaning and Decontamination**

### **2.1 General**

The procedures outlined in this document are intended for use by field investigators for cleaning and decontaminating sampling and other equipment in the field. These procedures should be followed in order that equipment is returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.

Sampling and field equipment cleaned in accordance with these procedures must meet the minimum requirements for the Data Quality Objectives (DQOs) of the study or investigation. If deviations from these procedures need to be made during the course of the field investigation, they will be documented in the field logbook along with a description of the circumstances requiring the use of the variant procedure.

Cleaning procedures for use at the Field Equipment Center (FEC) are found in SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC (SESDPROC-206).

### **2.2 Handling Practices and Containers for Cleaning Solutions**

Improperly handled cleaning solutions may easily become contaminated. Storage and application containers must be constructed of the proper materials to ensure their integrity. Following are acceptable materials used for containing the specified cleaning solutions:

- Detergent must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use.
- Tap water may be kept in tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.
- Deionized water must be stored in clean, glass or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.
- Organic-free water must be stored in clean glass or Teflon® containers prior to use. It may be applied using Teflon® squeeze bottles, or with the portable system.

### **2.3 Disposal of Cleaning Solutions**

Procedures for the safe handling and disposition of investigation derived waste (IDW); including used wash water and rinse water are in SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202).

### **2.4 Sample Collection Equipment Contaminated with Concentrated Materials**

Equipment used to collect samples of concentrated materials from investigation sites must be field cleaned before returning from the study. At a minimum, this should consist of washing with detergent and rinsing with tap water. When the above procedure cannot be followed, the following options are acceptable:

1. Leave with facility for proper disposal;
2. If possible, containerize, seal, and secure the equipment and leave on-site for later disposal;
3. Containerize, bag or seal the equipment so that no odor is detected and return to the SESD.

It is the project leader's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

### **2.5 Sample Collection Equipment Contaminated with Environmental Media**

Equipment used to collect samples of environmental media from investigation sites should be field cleaned before returning from the study. Based on the condition of the sampling equipment, one or more of the following options must be used for field cleaning:

1. Wipe the equipment clean;
2. Water-rinse the equipment;
3. Wash the equipment in detergent and water followed by a tap water rinse.
4. For grossly contaminated equipment, the procedures set forth in Section 2.4 must be followed.

Under extenuating circumstances such as facility limitations, regulatory limitations, or during residential sampling investigations where field cleaning operations are not feasible, equipment can be containerized, bagged or sealed so that no odor is detected and returned to the FEC without being field cleaned. If possible, FEC personnel should be notified that equipment will be returned without being field cleaned. It is the project leader's

responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

## **2.6 Handling of Decontaminated Equipment**

After decontamination, equipment should be handled only by personnel wearing clean gloves to prevent re-contamination. In addition, the equipment should be moved away (preferably upwind) from the decontamination area to prevent re-contamination. If the equipment is not to be immediately re-used it should be covered with plastic sheeting or wrapped in aluminum foil to prevent re-contamination. The area where the equipment is kept prior to re-use must be free of contaminants.

## **3 Field Equipment Decontamination Procedures**

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### **3.1 General**

Sufficient equipment should be transported to the field so that an entire study can be conducted without the need for decontamination. When equipment must be decontaminated in the field, the following procedures are to be utilized.

### **3.2 Specifications for Decontamination Pads**

Decontamination pads constructed for field cleaning of sampling and drilling equipment should meet the following minimum specifications:

- The pad should be constructed in an area known or believed to be free of surface contamination.
- The pad should not leak.
- If possible, the pad should be constructed on a level, paved surface and should facilitate the removal of wastewater. This may be accomplished by either constructing the pad with one corner lower than the rest, or by creating a sump or pit in one corner or along one side. Any sump or pit should also be lined.
- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed.
- Water should be removed from the decontamination pad frequently.
- A temporary pad should be lined with a water impermeable material with no seams within the pad. This material should be either easily replaced (disposable) or repairable.

At the completion of site activities, the decontamination pad should be deactivated. The pit or sump should be backfilled with the appropriate material designated by the site project leader, but only after all waste/rinse water has been pumped into containers for disposal. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for proper handling and disposal of these materials. If the decontamination pad has leaked excessively, soil sampling may be required.

### 3.3 "Classical Parameter" Sampling Equipment

"Classical Parameters" are analyses such as oxygen demand, nutrients, certain inorganic compounds, sulfide, flow measurements, etc. For routine operations involving classical parameter analyses, water quality sampling equipment such as Kemmerers, buckets, dissolved oxygen dunkers, dredges, etc., may be cleaned with the sample water or tap water between sampling locations as appropriate.

Flow measuring equipment such as weirs, staff gages, velocity meters, and other stream gauging equipment may be cleaned with tap water between measuring locations, if necessary.

Note: The procedures described in Section 3.3 are not to be used for cleaning field equipment to be used for the collection of samples undergoing trace organic or inorganic constituent analyses.

### 3.4 Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds

For samples undergoing trace organic or inorganic constituent analyses, the following procedures are to be used for all sampling equipment or components of equipment that come in contact with the sample:

#### 3.4.1 Standard SESD Method

1. An optional Liquinox® detergent wash step may be useful to remove gross dirt and soil.
2. Clean with tap water and Luminox® detergent using a brush, if necessary, to remove particulate matter and surface films.
3. Rinse thoroughly with tap water.
4. Rinse thoroughly with organic-free water and place on a clean foil-wrapped surface to air-dry.
5. Wrap the dry equipment with aluminum foil or bag in clean plastic. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused plastic sheeting.

#### 3.4.2 Alternative Solvent Rinse Method

The historical solvent rinse method of cleaning equipment for trace contaminant sampling remains an acceptable method.

1. Clean with tap water and Liquinox® detergent using a brush, if necessary, to remove particulate matter and surface films. Equipment may be steam cleaned (Liquinox® detergent and high pressure hot water) as an alternative to

brushing. Sampling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. PVC or plastic items should not be steam cleaned.

2. . Rinse thoroughly with tap water.
3. Rinse thoroughly with deionized water.
4. Rinse with an appropriate solvent (generally isopropanol).
5. Rinse with organic-free water and place on a clean foil-wrapped surface to air-dry.
4. Wrap the dry equipment with aluminum foil. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused.

### **3.5 Well Sounders or Tapes**

The following procedures are recommended for decontaminating well sounders (water level indicators) and tapes. Unless conditions warrant, it is only necessary to decontaminate the wetted portion of the sounder or tape.

1. Wash with Liquinox® detergent and tap water.
2. Rinse with tap water.
3. Rinse with deionized water.

### **3.6 Redi-Flo2® Pump**

**CAUTION – Do not wet the controller. Always disconnect power from the pump when handling the pump body.**

The Redi-Flo2® pump and any associated connected hardware (e.g., check valve) should be decontaminated between each monitoring well. The following procedures are required, depending on whether the pump is used solely for purging or used for purging and sampling.

#### ***3.6.1 Purge Only (Pump and Wetted Portion of Tubing or Hose)***

1. Disconnect power and wash exterior of pump and wetted portion of the power lead and tubing or hose with Liquinox® detergent and water solution.

2. Rinse with tap water.
3. Final rinse with deionized water.
4. Place pump and reel in a clean plastic bag and keep tubing or hose contained in clean plastic or galvanized tub between uses.

### **3.6.2 Purge And Sample**

Grundfos Redi-Flo2® pumps are extensively decontaminated and tested at the FEC to prevent contamination from being transmitted between sites. The relevant sections of SESDPROC-206, *Field Equipment Cleaning and Decontamination at the FEC*, should be implemented in the field where a high risk of cross-contamination exists, such as where NAPL or high-concentration contaminants occur. In most cases, the abbreviated cleaning procedure described below will suffice, provided that sampling proceeds from least to most contaminated areas.

1. Disconnect and discard the previously used sample tubing from the pump. Remove the check valve and tubing adapters and clean separately (See Section 3.6.3 for check valve). Wash the pump exterior with detergent and water.
2. Prepare and fill three containers with decontamination solutions, consisting of Container #1, a tap water/detergent washing solution. Luminox® is commonly used. An additional pre-wash container of Liquinox® may be used; Container #2, a tap water rinsing solution; and Container #3, a deionized or organic-free water final rinsing solution. Choice of detergent and final rinsing solution for all steps in this procedure is dependent upon project objectives (analytes and compounds of interest). The containers should be large enough to hold the pump and one to two liters of solution. An array of 2' long 2" PVC pipes with bottom caps is a common arrangement. The solutions should be changed at least daily.
3. Place the pump in Container #1. Turn the pump on and circulate the detergent and water solution through the pump and then turn the pump off.
4. Place the pump in Container #2. Turn the pump on and circulate the tap water through the pump and then turn the pump off.
5. Place the pump in Container #3. Turn the pump on and circulate deionized or organic-free water through the pump and then turn the pump off.

6. Disconnect power and remove pump from Container #3. Rinse exterior and interior of pump with fresh deionized or organic-free water.
7. Decontaminate the power lead by washing with detergent and water, followed by tap water and deionized water rinses. This step may be performed before washing the pump if desired.
8. Reassemble check valve and tubing adapters to pump. ALWAYS use Teflon® tape to prevent galling of threads. Firm hand-tightening of fittings or light wrench torque is generally adequate.
9. Place the pump and reel in a clean plastic bag.

### **3.6.3 Redi-Flo2® Ball Check Valve**

1. Remove the ball check valve from the pump head. Check for wear and/or corrosion, and replace as needed. During decontamination check for free-flow in forward direction and blocking of flow in reverse direction.
2. Using a brush, scrub all components with detergent and tap water.
3. Rinse with deionized water.
4. Rethread the ball check valve to the Redi-Flo2® pump head.

## **3.7 Mega-Monsoon® and GeoSub® Electric Submersible Pump**

As these pumps have lower velocities in the turbine section and are easier to disassemble in the field than Grundfos pumps, the outer pump housing should be removed to expose the impeller for cleaning prior to use and between each use when used as a sampling pump for trace contaminant sampling.

1. Remove check valves and adapter fittings and clean separately.
2. Remove the outer motor housing by holding the top of the pump head and unscrewing the outer housing from its O-ring sealed seat.
3. Clean all pump components per the provisions of section 3.4. Use a small bottle brush for the pump head passages
4. Wet the O-ring(s) on the pump head with organic-free water. Reassemble the outer pump housing to the pump head.
5. Clean cable and reel per Section 3.4.
6. Conduct final rinse of pump with organic-free water over pump and through pump turbine.

### **3.8 Bladder Pumps**

Bladder pumps are presumed to be intended for use as purge-and-sample pumps. The Geotech® bladder pump and Geoprobe Systems® mechanical bladder pump can be cleaned similarly.

1. Discard any tubing returned with the pump.
2. Completely disassemble the pump, being careful to note the initial position of and retain any springs and loose ball checks.
3. Discard pump bladder.
4. Clean all parts as per the standard cleaning procedure in Section 3.4.
5. Install a new Teflon® bladder and reassemble pump.

### **3.9 Downhole Drilling Equipment**

These procedures are to be used for drilling activities involving the collection of soil samples for trace organic and inorganic constituent analyses and for the construction of monitoring wells to be used for the collection of groundwater samples for trace organic and inorganic constituent analyses.

#### ***3.9.1 Introduction***

Cleaning and decontamination of all equipment should occur at a designated area (decontamination pad) on the site. The decontamination pad should meet the specifications of Section 3.2 of this procedure.

Tap water brought on the site for drilling and cleaning purposes should be contained in a pre-cleaned tank.

A steam cleaner and/or high pressure hot water washer capable of generating a pressure of at least 2500 PSI and producing hot water and/or steam, with a detergent compartment, should be obtained.

#### ***3.9.2 Preliminary Cleaning and Inspection***

Drilling equipment should be clean of any contaminants that may have been transported from off-site to minimize the potential for cross-contamination. The drilling equipment should not serve as a source of contaminants. Associated drilling and decontamination equipment, well construction materials, and equipment handling procedures should meet these minimum specified criteria:

- All downhole augering, drilling, and sampling equipment should be sandblasted before use if painted, and/or there is a buildup of rust, hard or caked matter, etc., that cannot be removed by steam cleaning (detergent and high pressure hot water), or wire brushing. Sandblasting should be performed prior to arrival on site, or well away from the decontamination pad and areas to be sampled.
- Any portion of the drilling equipment that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) and wire brushed (as needed) to remove all rust, soil, and other material which may have come from other sites before being brought on site.
- Printing and/or writing on well casing, tremie tubing, etc., should be removed before use. Emery cloth or sand paper can be used to remove the printing and/or writing. Most well material suppliers can provide materials without the printing and/or writing if specified when ordered. Items that cannot be cleaned are not acceptable and should be discarded.
- Equipment associated with the drilling and sampling activities should be inspected to insure that all oils, greases, hydraulic fluids, etc., have been removed, and all seals and gaskets are intact with no fluid leaks.

### ***3.9.3 Drill Rig Field Cleaning Procedure***

Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) between boreholes.

### ***3.9.4 Field Decontamination Procedure for Drilling Equipment***

The following is the standard procedure for field cleaning augers, drill stems, rods, tools, and associated equipment. This procedure does not apply to well casings, well screens, or split-spoon samplers used to obtain samples for chemical analyses, which should be decontaminated as outlined in Section 3.4 of this procedure.

1. Wash with tap water and detergent, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with detergent) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. Hollow-stem augers, drill

rods, etc., that are hollow or have holes that transmit water or drilling fluids, should be cleaned on the inside with vigorous brushing.

2. Rinse thoroughly with tap water.
3. Remove from the decontamination pad and cover with clean, unused plastic. If stored overnight, the plastic should be secured to ensure that it stays in place.

### **3.9.5 *Field Decontamination Procedure for Direct Push Technology (DPT) Equipment***

1. Certain specific procedures for the decontamination of DPT tools are described in the various sampling procedures, but the following general guidelines apply:
2. Prior to return to the Field Equipment Center, all threaded tool joints should be broken apart and the equipment cleaned per the provisions of *Section 2.5, Sample Collection Equipment Contaminated with Environmental Media* of this procedure.
3. Equipment that contacts the sample media and is cleaned in the field for reuse should be cleaned per the provisions of *Section 3.4, Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds* of this procedure. This would include piston sampler points and shoes, screen point sampler screens and sheaths, and the drive rods when used for groundwater sampling.
4. Equipment that does not directly contact the sample media and is cleaned in the field for reuse can generally be cleaned per the provisions of *Section 3.7.4, Field Decontamination Procedure for Drilling Equipment* of this procedure.
5. Stainless steel SP15/16 well screens require special care as the narrow slots are difficult to clean under even controlled circumstances and galvanic corrosion can release chrome from the screen surface. As soon as possible after retrieval, the screen slots should be sprayed from the outside to break loose as much material as possible before it can dry in place. To prevent galvanic corrosion, the screens must be segregated from the sampler sheaths, drive rods, and other carbon steel during return transport from the field.

### **3.10 Rental Pumps**

Completing a groundwater sampling project may require the use of rental pumps. Rental pumps are acceptable where they are of suitable stainless steel and Teflon® construction. These pumps should be cleaned prior to use using the procedures specified herein and a rinse-blank collected prior to use.