Addendum to the Groundwater Sampling and Analysis Plan for Corrective Action and Compliance Monitoring, International Paper Retail Packaging Facility, Wilmington, North Carolina

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Certification Page

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Roger Lague
Plant Manager

Addendum to the Groundwater Sampling and Analysis Plan for Corrective Action and Compliance Monitoring

The *Groundwater Sampling and Analysis Plan for Corrective Action and Compliance Monitoring* (SAP) (Radian 1998) addresses collection of groundwater samples at the International Paper Retail Packaging Facility in Wilmington, North Carolina (the facility), to satisfy the requirements of the facility's Hazardous Waste Management Permit NCD072 022 726 (Permit). This addendum to the SAP specifies additional groundwater sampling and analysis activities that will be implemented to evaluate the performance of the enhanced natural attenuation corrective action at the facility. These activities include installation of one new monitoring well, collection of additional field parameter measurements during each groundwater sampling event, and two additional groundwater sampling events to be performed in conjunction with the initial implementation of corrective action. Each of these activities is described below.

Installation of Groundwater Monitoring Well MW-34

One additional shallow groundwater monitoring well, designated MW-34, will be installed to provide additional monitoring of the performance of the enhanced natural attenuation corrective action system. MW-34 will be installed approximately 75 ft due west of well MW-9 (Figure 1). MW-34 will be added to the monitoring well network for corrective action monitoring and will be sampled as specified in the SAP and this Addendum.

Well MW-34 will be constructed in accordance with North Carolina well construction standards (NC Administrative Code, Title 15, Subchapter 2C, .0100). The well will be completed in the upper water-bearing zone and will extend to a total depth of 20 ft or the contact between the undifferentiated surficial sediments and the siliceous limestone "cap rock" (Castle Hayne Formation), whichever is less. The borehole for MW-34 will be advanced using decontaminated hollow-stem auger drilling methods. A drilling contractor certified in North Carolina will perform the installation, under the supervision of a qualified geologist. The geologist will log the subsurface lithology based on field observations of the drill cuttings. The types of deposits encountered will be recorded on the lithologic logs using the ASTM Standard D-2488 group symbol classification system in accordance with Exponent SOP-49 (Attachment A). Lithologic logs will also include descriptions of soil color using Munsell color charts, visually estimated moisture content, and a textural description of the cuttings. If encountered, the top of the Castle Hayne Formation will be noted clearly on the log.

Typical construction details for well MW-34 are shown in Figure 2. The well will be constructed of 2-in. Schedule-40 PVC casing with flush-threaded couplings. The well will be screened over the lower 10 ft of the total well depth, using a 10-ft section of

0.010-in. mill-slotted PVC well screen with an end plug. Blank PVC casing will extend from the top of the screen to the ground surface. Stainless-steel centralizers will be attached at the top and bottom of the well screen. The annular space will be backfilled with No. 10–20 Colorado silica or equivalent to approximately 1 ft above the top of the screen. A 1- to 2-ft-thick bentonite seal will be placed on top of the sand pack. The bentonite seal will be hydrated with clean water and allowed to set for sufficient time to ensure a proper seal. High-solids bentonite grout or bentonite chips will be placed from the bentonite seal to within 2 ft of the ground surface. A surface seal consisting of Portland cement will be placed from the top of the bentonite to the ground surface. The surface completion will consist of an aboveground monument with a steel protective riser. In accordance with North Carolina requirements, a permanent identification plate will be affixed to the riser indicating the drilling contractor and registration number, the date the well was completed, the total depth of the well, the depth to the screen, and a warning that the well is not to be used for water supply and that the groundwater may contain hazardous materials.

Following construction and a minimum 24-hour stabilization period for the grout and surface seal, MW-34 will be developed to remove fine-grained materials from within and around the sand pack. Development will be achieved by pumping and surging until the discharge water is clear of fine materials, or until a minimum of 10 casing volumes have been removed, whichever occurs first. All development water will be properly contained in UN-approved drums and disposed. Following installation, a professional land surveyor will survey the location of well MW-34 to a horizontal accuracy of 1.0 ft. The reference elevation will be determined to an accuracy of 0.01 ft.

Collection of Additional Field Parameters

In addition to the three field parameters (i.e., temperature, pH, and specific conductivity) listed in Appendix A of the facility's Hazardous Waste Management Permit (NCD 072 022 726), dissolved oxygen (DO) concentration, ferrous and total iron concentrations, and oxidation-reduction potential (Eh) will be measured at each well sampled during each groundwater sampling event at the facility, during both the corrective action and the compliance monitoring periods.

All field parameters will be measured during purging of each well. Flow from the discharge tubing will be directed into a flow-through cell for the field parameter measurements. Use of the flow-through cell will minimize groundwater contact with the atmosphere, which could influence some field parameter measurements (i.e., temperature, DO, and Eh). Field parameters (pH, temperature, specific conductivity, DO, and Eh) will be measured and recorded at every purge volume. These parameters will be measured following the methods described in SOP-56 (Attachment A) using a YSI multimeter model YSI 600XL (or equivalent), which will be calibrated daily and operated in accordance with the manufacturer's recommendations. In addition, a grab sample will be collected at every purge volume from the discharge of the flow-through cell to measure iron concentrations and turbidity. Ferrous and total iron concentrations will be measured using the methods described in SOP-61. Turbidity measurements will be made using a

DRT-15CE turbidimeter (or equivalent) following Exponent SOP-424. A minimum of three well volumes, or the number of well volumes required until field parameters stabilize within 10% of the previous reading, whichever is greater, will be removed prior to sample collection. Discharge from the flow-through cell will be directed into a secondary container and transferred to a UN-approved drum for proper handling and disposal.

Sampling Schedule

As specified in the SAP, groundwater samples will be collected semiannually in April and October of each year from six existing monitoring wells (POC-1, MW-9, MW-21, MW-23, MW-25, and MW-31) during the corrective action monitoring period. The new monitoring well (MW-34) will also be monitored semiannually during the corrective action monitoring period. In addition, one groundwater sample will be collected annually during the corrective action monitoring period, in October of each year, from well MW-10, completed in the lower water-bearing unit.

Two additional sampling events are proposed during the corrective action monitoring period for wells MW-9, MW-31, and MW-34 to provide additional performance data following the initial application of ORC®. These sampling events will be performed one month and three months after the initial application of ORC® at the facility—proposed to occur immediately after the April 2000 groundwater sampling event. Therefore, the two additional sampling events are planned for May and July of 2000. Groundwater samples collected during these additional monitoring events will be analyzed for the field and laboratory parameters specified above and in the SAP.

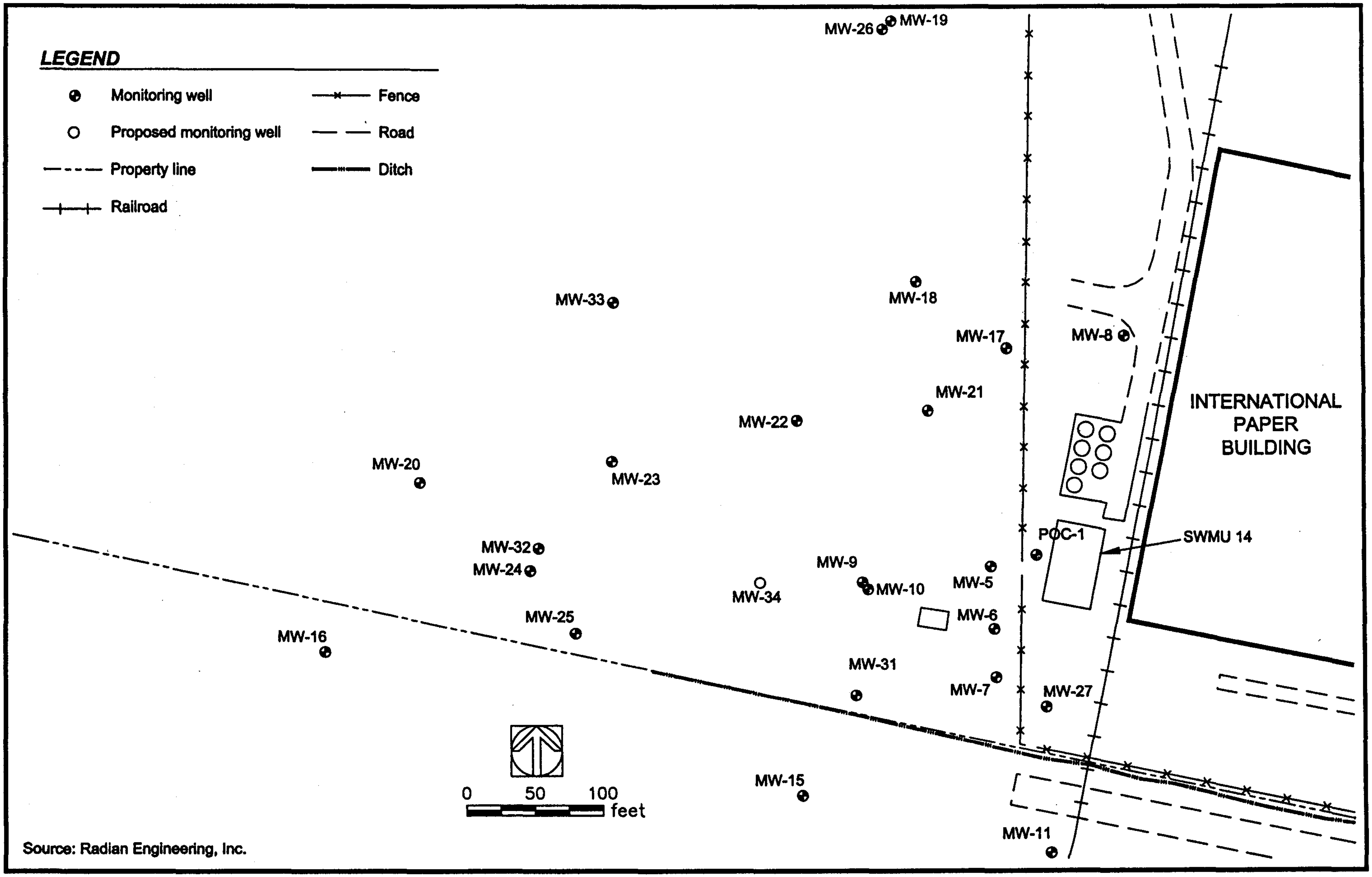

Figure 1. Monitoring well network, International Paper facility, Wilmington, North Carolina.

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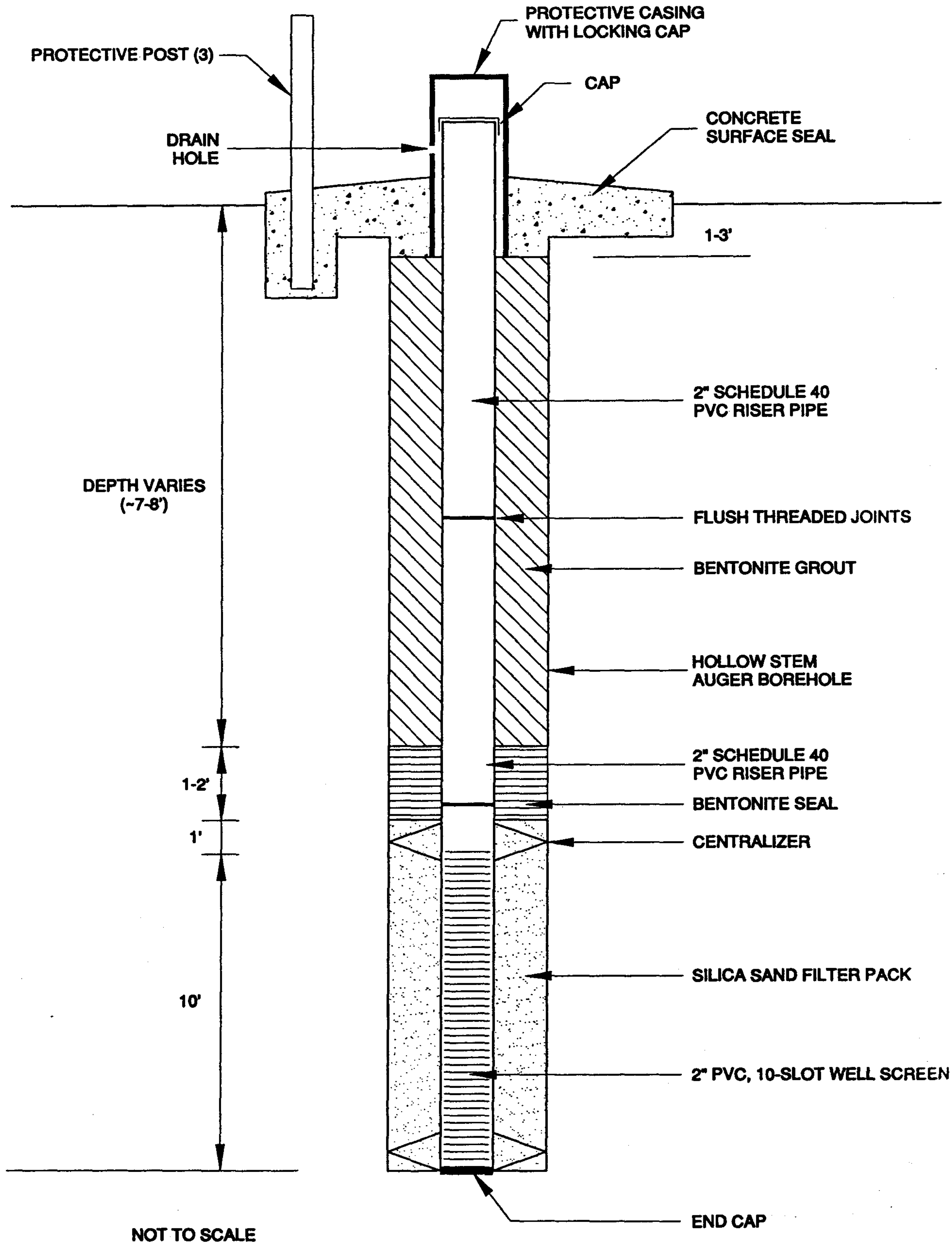

Figure 2. Typical shallow monitoring well design.

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Attachment A

Exponent Standard Operating Procedures

Note: SOP 49 cited within.

STANDARD OPERATING PROCEDURE

LOGGING OF SOIL BOREHOLES
SOP 48

The following procedures for completing the Field Borehole Log Form (Attachment 48-1) establish the minimum information that must be recorded in the field to adequately characterize soil boreholes and are to be used for Exponent projects where soil boring techniques are performed during field exploration. An example of a completed field borehole log form is attached. These procedures are written for boreholes using mechanical equipment. All pertinent sections should be used for hand-augured or hand-dug boreholes.

These procedures include minor modifications to ASTM D-2488-84 (Attachment 48-2) to emphasize environmental investigations as opposed to geotechnical investigations (for which the standards were written). Field staff are encouraged to examine ASTM D-2488-84 in its entirety. Because environmental projects are each unique and specific job requirements can vary widely, the minimum standards presented may need to be supplemented with additional technical descriptions or field test results. However, all field borehole logs, regardless of special project circumstances, must include information addressed in this SOP to achieve the minimum acceptable standards required by Exponent.

HEADING INFORMATION

Project Number: Use the standard Exponent contract number.

Client: Identify the name of the client and the project site location.

Location: If stationing, coordinates, mileposts, or similar are applicable, identify the location of the project. If this information is not available, identify the facility (e.g., 20 ft northeast of Retort #1).

Drilling Method: Identify the bit size and type, drilling fluid (if used), method of drilling (e.g., rotary, hollow-stem auger, cable tool), and the name of the drill rig (e.g., Mobil B61, CME 55).

Diameter: Provide the diameter of the borehole. If the borehole has variable diameters, provide the depth interval for each diameter.

Sampling Method: Identify the type of sampler(s) used (e.g., standard split spoon, Dames & Moore sampler, grab).

Drilling Contractor: Provide the name of the drilling contractor.

Exponent Staff: Enter the name(s) of Exponent staff performing logging and sampling activities.

Water Level Information: Provide the date, time, depth to static water, and casing depth. Generally, water levels should be taken each day before resuming drilling and at the completion of drilling. If water is not encountered in the boring, this information should be recorded.

Boring Number: Provide the boring number. A numbering system should be developed prior to drilling that does not conflict with other site information, such as previous drilling or other sampling activities.

Sheet: Number the sheets consecutively for each boring and continue the consecutive depth numbering.

Drilling Start and Finish: Provide the drilling start and finish dates and times.

For consecutive sheets, provide, at a minimum, the job number, the boring number, and the sheet number.

TECHNICAL DATA

Sampler Type: Provide the sampler type (e.g., SS = split spoon, DM = Dames & Moore split spoon, G = grab).

Depth of Casing: Enter the depth of the casing below ground surface immediately prior to sampling.

Driven/Recovery: Provide the length that the sampler was driven and the length of sample recovered in the sampler. This column would not apply to grab samples.

Sample Number/Sample Depth: Provide the sample number. The sample numbering scheme should be established prior to drilling. One method is to use the boring number and consecutive alphabetical letters. For instance, the first sample obtained from Boring MW-4 would be identified as 4A and the second would be identified as 4B, and so on. Another method for sample identification is naming the boring number with the depth.

For example, the sample from Boring 1 at 10 ft would be labeled B1-10'. The depth of the sample is the depth of the casing plus the length to the middle of the recovered sample to the nearest 0.1 ft. Typically, split spoon samplers are 18 in. long. Samples should be obtained from the middle of the recovered sample. The depth of the sample with the casing at 10 ft would then be 10.7 ft.

Number of Blows: For standard split spoon samplers, record the number of blows for each 6 in. of sampler penetration or the "N" value, which is the sum of the blows in the last two 6-in. intervals. A typical blow count of 6, 12, and 14 is recorded as 6/12/14 or as an "N" of 26. Final boring logs will record "N" values. Refusal is a penetration of more than 6 in. but less than 12 in. with a total blow count of 100 or a penetration of less than 6 in. with a blow count of 50. A partial penetration of 50 blows for 4 in. is recorded as 50/4 in. For nonstandard split spoons (e.g., 5-ft spoon used for continuous sampling), total blows will be recorded.

Blank Columns: Two blank columns are provided. Project managers are encouraged to use these columns for site-specific information, usually related to the contaminants of concern. Examples for a hydrocarbon site would be sheen and OVM readings of the samples.

Depth: Use a depth scale that is appropriate for the complexity of the subsurface conditions. The boxes located to the right of the scale should be used to graphically indicate sample locations as shown in the example.

Surface Conditions: Describe the surface conditions (e.g., paved, 4-in. concrete slab, grass, natural vegetation and surface soil, oil-stained gravel).

Soil Description: The soil description and definition of soil contacts should follow the format described in SOP 49.

Comments: Include all pertinent observations. Drilling observations might include drilling chatter, rod-bounce (boulder), sudden differences in drilling speed, damaged samplers, and malfunctioning equipment. Information provided by the driller should be attributed to the driller. Information on contaminants might include odor, staining, color, and presence or absence of some indicator of contamination. Describe what it is that indicates contamination (e.g., fuel-like odor, oily sheen in drill cuttings, yellow water in drill cuttings).

Attachment 48-1

Field Borehole Log Form

PTI ENVIRONMENTAL SERVICES

FIELD BOREHOLE LOG FORM

Client/Owner ____________________ Well Number __________

Project No. ____________________

Start Date ____________ Finish Date ____________

Ground Surface Conditions ____________________

Weather Conditions ____________________

Field Geologist ____________________

Contractor/Operator ____________________

Drill Type/Method ____________________

Boring Diameter ____________________

Location Sketch
(show dimensions to mapped features)

North Arrow

Groundwater Elevation ________ at Date ________

Well Casing Elevation ____________

Ground Surface Elevation ________ Datum ________

Water Level Information		
Date		
Time		
Depth to Water		
Hole to Depth		
Casing Depth		

Sample No.	Sampler Type						Depth Scale	Unified Symbol	Soil Description	Comments

Sampler: D/M, SPT, Thinwall (TW), Shelby Tube (S), Bulk (B), etc. (Add 'C' to sampler type if a catcher is used)

Sheet ______ of ______

PTI
ENVIRONMENTAL SERVICES

FIELD BOREHOLE LOG FORM

Sample No.	Samplor Type						Depth Scale	Unified Symbol	Water Level Information	
									Date	
									Time	
									Depth to Water	
									Hole to Depth	
									Casing Depth	
									Soil Description	Comments

Sampler: D/M, SPT, Thinwall (TW), Shelby Tube (S) Bulk (B), etc. (Add 'C' to sampler type if a catcher is used)

FF Rev 1/91

PTI 1

PTI Environmental Services — FIELD BOREHOLE LOG FORM

Client/Owner: Schoony's Truck Stop Well Number: PTI 1

Project No.: C565-01-01

Start Date: 10-5-93 Finish Date: 10-

Ground Surface Conditions: Asphalt/Concrete Road Base

Weather Conditions: Sunny ~60°F

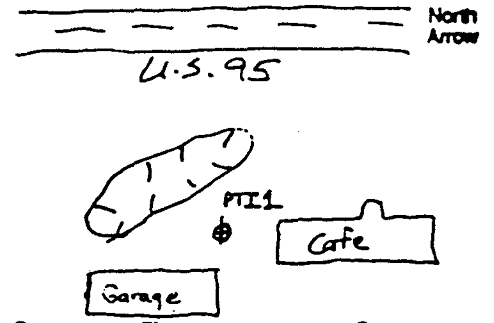
Field Geologist: Brady / Boyd

Contractor/Operator: Ruen Drilling

Drill Type/Method: ODEX - air rotary

Boring Diameter: 8 inches / 6 in. tricone @ 8'

Location Sketch (show dimensions to mapped features) — North Arrow



Groundwater Elevation ______ at Date ______

Well Casing Elevation ______

Ground Surface Elevation ______ Datum ______

Water Level Information				
Date				
Time				
Depth to Water				
Hole to Depth				
Casing Depth				

Sample No.	Sampler Type	% Rec.	PID	Sheen		Depth Scale	Unified Symbol	Soil Description	Comments
						0–1		Asphalt surface - cracked gravel base	Cy PID = 0 ppm
						1–4		Brown (med) m-coarse sandy silt 15% fine gravel, moist, No HC staining. SM/ML Grading to coarser material ↓	
PTI 1-5	SS	50	0	NS		5–6		Brown (med) silty m-coarse (sm) Sand ~25% f-med gravels, moist No HC stain	TIME 11:40 TAG 542089; Cy PID = 0 ppm
PTI 1-10	SS	40	0	NS		10–11		GM - Brown gravel - well graded (poorly sorted) ~75% f-med 35% silty sand, dry No HC stain	TIME 10:35 TAG 542090; W.Space PID = 0 ppm
PTI 1-15	SS	40	0	NS		15–16		GM - Med. Brown 75% f-med gravel 25% - sand & silt Dry, No HC stain.	TIME 11:20 TAG 542091
PTI 1-18.5	SS	20	0	NS		18–20		Lt Brown GM - 65% gravel (well graded) 35% sand & SILT Dry, No HC staining	TIME 11:30 TAG 542092

Sampler: D/M, SPT, Thinwall (TW), Shelby Tube (S), Bulk (B), etc. (Add 'C' to sampler type if a catcher is used)

Cy = cyclone
SS = split spoon

PTI 1

PTI ENVIRONMENTAL SERVICES FIELD BOREHOLE LOG FORM

Water Level Information		
Date		
Time		
Depth to Water		
Hole to Depth		
Casing Depth		

Sample No	Sampler Type	% Rec	PID	Sheen	Depth Scale	Unified Symbol	Soil Description	Comments
					21			
					22			sample collected at cyclone. Recovery <5%
23	SS	5%			23		GM - med-C Gravel 75% Sand & SILT 25% Moist, NO HC stains	
23.5	cy	-	0	NS	24			TIME 12:00 TAG 542093
					25			
					26			
					27			
					28			
28.5	cy	-	0	NS	29		SM - 65% SAND-SILT Brown (med.) 35% gravel F-med No HC stains, moist	TIME 12:30 TAG 542094
					30			
					31			
					32			
					33			
33.5	cy	-	0	NS	34		GM - 75% F-med gr. Brown 25% sand (little silt) No HC stain.	TIME 12:45 TAG 542095
					35			
					36			
					37			
					38			
38.5	cy	-	0	NS	39		GM - SAME AS ABOVE w/ less gravel and more sand (65%/35%)	TIME 13:10 TAG 542096
					40			
					41			
					42			
					43			
43.5	cy	-	0	NS	44		SP - Sand 75% poorly graded gravel 25% med. Brown, Moist, NO HC stains	TIME 13:25 TAG 542097
					45			
					46			
					47			
					48		Moist GW - Gravel 65% f-coarse (well graded)	Time TAG
48.5	cy	-	0	NS	49		Sub-rounded, broken rock frags. NO HC stai.	13:35 542098

Sampler: D/M, SPT, Thinwall (TW), Shelby Tube (S), Bulk (B), etc. (Add 'C' to sampler type if a catcher is used)

PTI 1

PTI ENVIRONMENTAL SERVICES

FIELD BOREHOLE LOG FORM

Date			
Time			
Depth to Water			
Hole to Depth			
Casing Depth			

Sample No	Sampler Type	% Rec	PID	SHEEN		Depth Scale	Unified Symbol	Soil Description	Comments
						50			
						51			
						52			
						53			
53.5	cy	–	0	NS		54		SAME AS ABOVE but drier and	TIME TAG
						55		more broken rock frags (c-gravels & cobbles)	14:50 542099
						56		75% gravel - 25% sand (GW)	
						57			
						58			TIME TAG
PTI 58.5	Cy	–	0	NS		59		SAME AS ABOVE	15:00 542100
						60		TD Hole @ 58.5'	

Sampler: D/M, SPT, Thinwall (TW), Shelby Tube (S), Bulk (B), etc. (Add 'C' to sampler type if a catcher is used)

Attachment 48-2

Standard Practice for Description and Identification of Soils (ASTM D-2488-84)

Designation: D 2488 - 84[ε1]

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε1 NOTE—Section 18 was added editorially in January 1989

1. Scope

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils.

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (See Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.5 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

3. Definitions

3.1 Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

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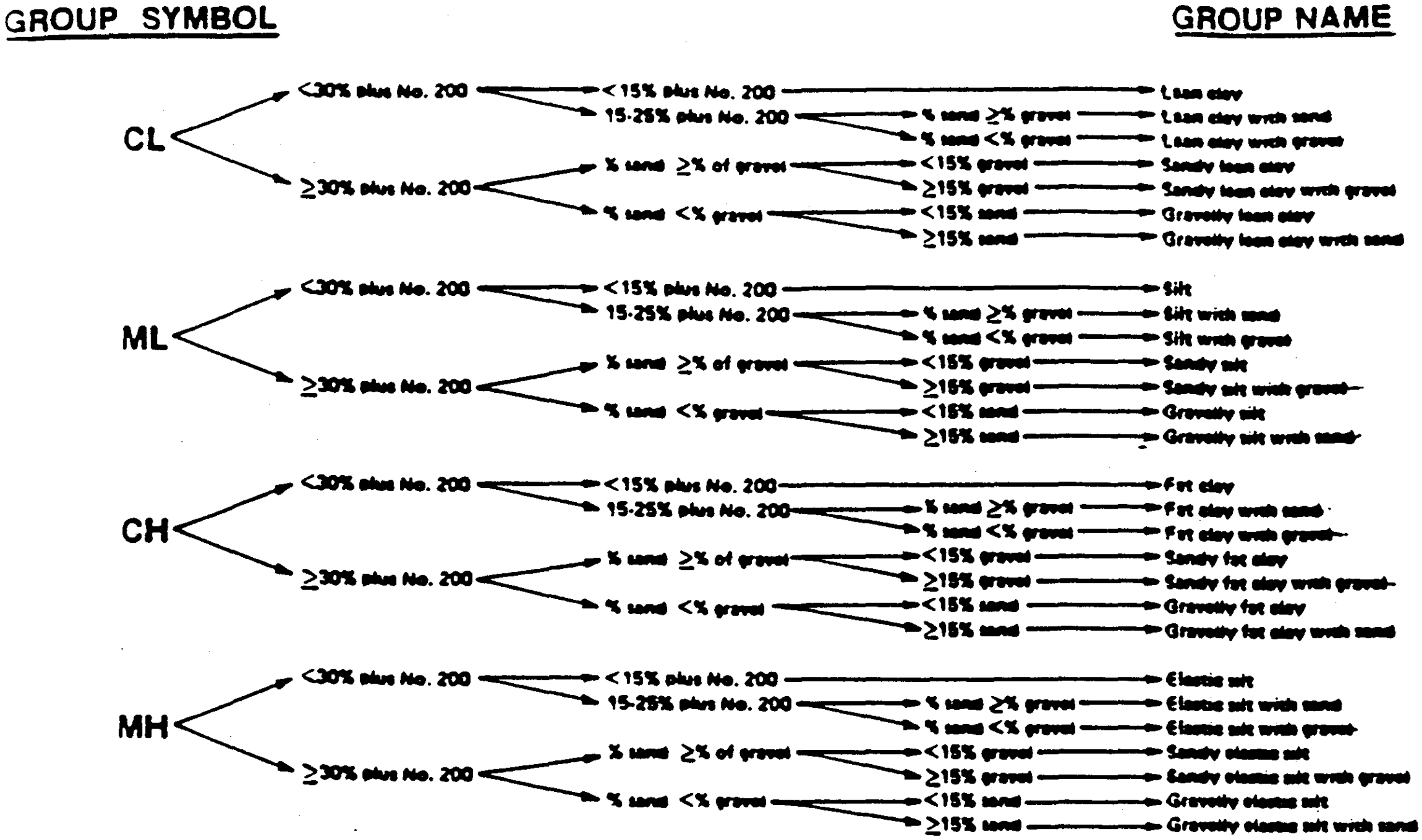
[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Oct. 3, 1984. Published December 1984. Originally published as D 2488 – 66 T. Last previous edition D 2488 – 69 (1975).

[2] *Annual Book of ASTM Standards*, Vol 04.08.



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

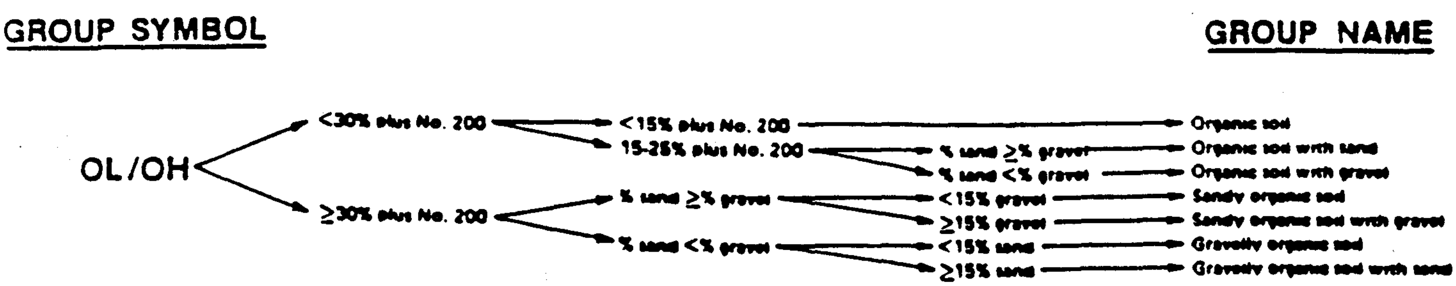
4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Figs. 1a and 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

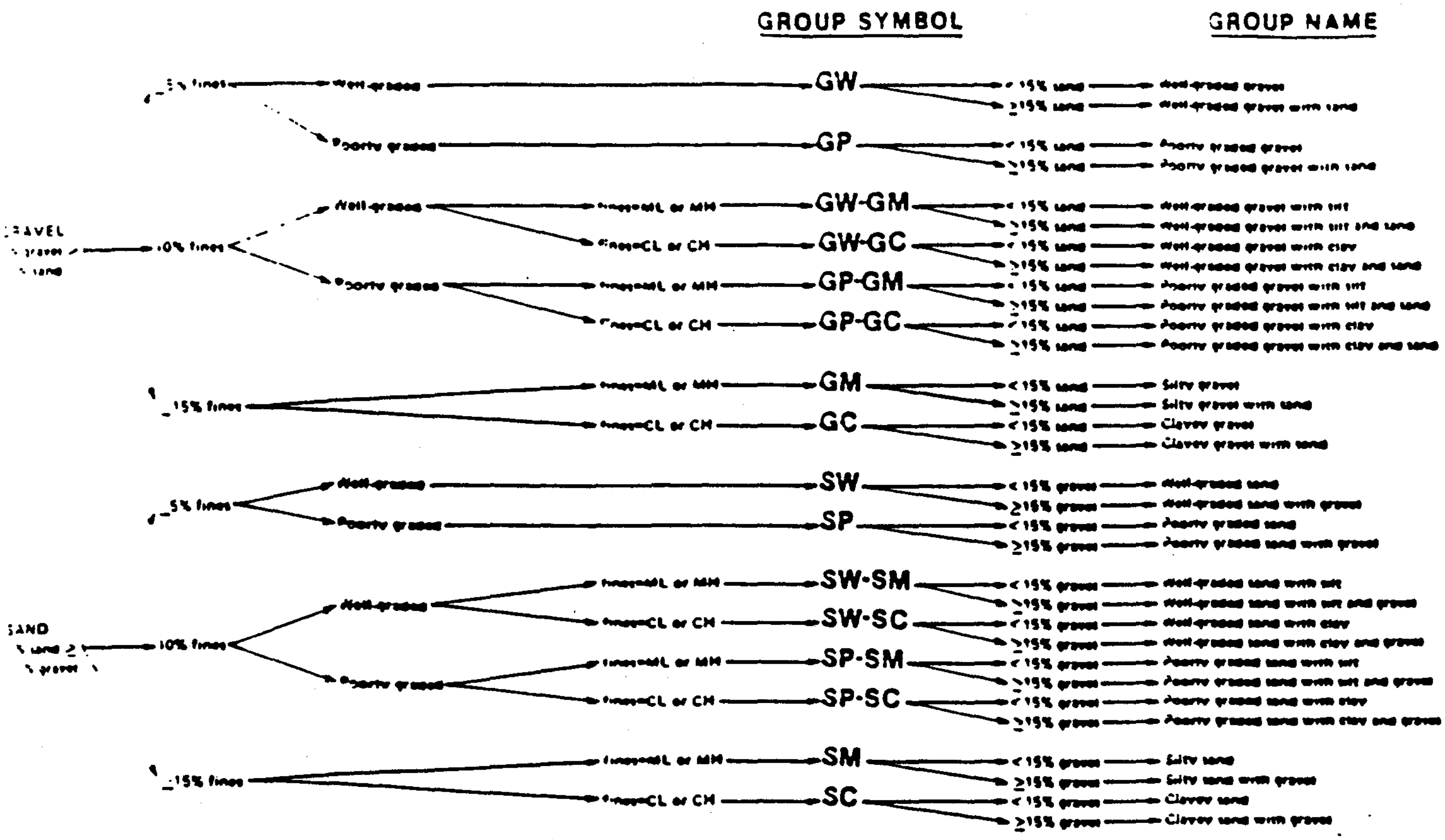
NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part

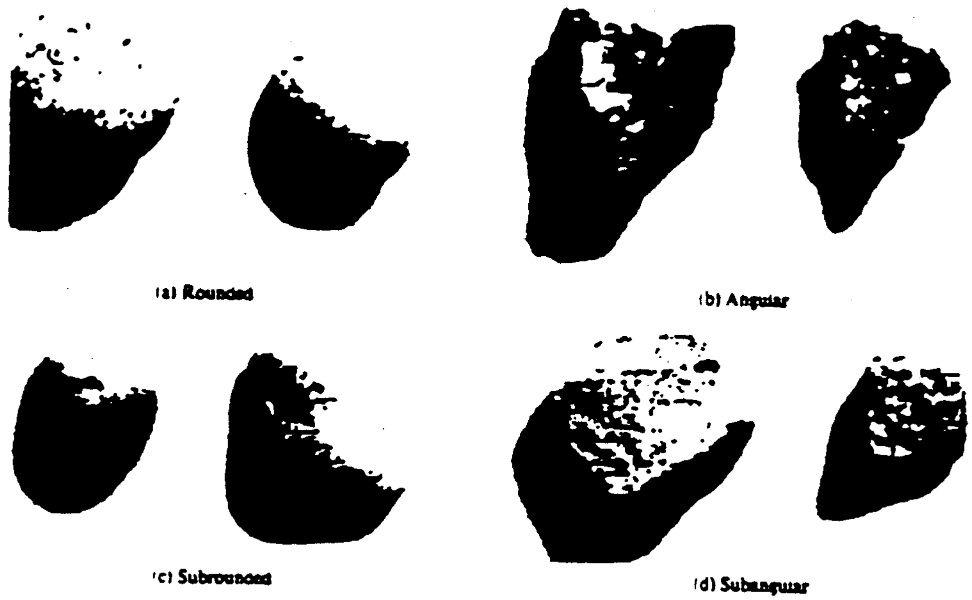


FIG. 3 Typical Angularity of Bulky Grains

concentrated hydrochloric acid (10 N) to three parts of distilled water. slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin. rinse thoroughly with water.

8.2 Caution—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate. accepted. or standard procedure.

NOTE 5—Preferably. the sampling procedure should be identified as having been conducted in accordance with Practices D 1452. D 1587. or D 2113. or Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 6—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number. a geologic stratum. a pedologic horizon or a location description with respect to a permanent monument. a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification. the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size. Sieve Opening	Minimum Specimen Size. Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (3/8 in.)	200 g (0.5 lb)
19.0 mm (3/4 in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 7—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix. the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount. the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only). gravel. cobbles. and boulders. as angular. subangular. subrounded. or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated. such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel. cobbles. and boulders as flat. elongated. or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise. do not mention the shape. Indicate the fraction of the particles that have the shape. such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils. and within a given locality it may also be useful in identifying materials of

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

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

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

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

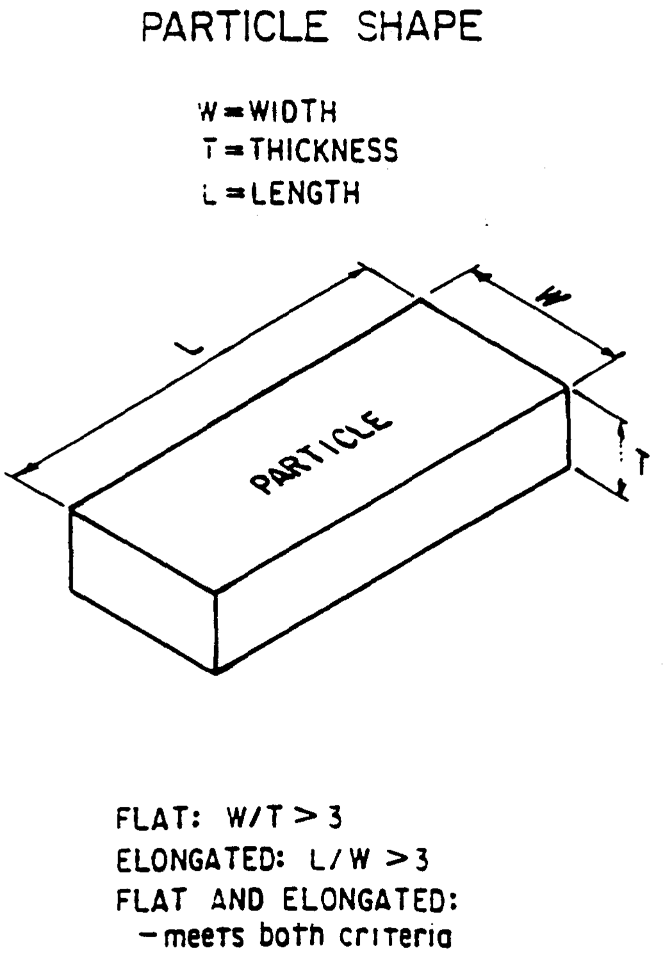


FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

TABLE 4 Criteria for Describing the Reaction With HCl

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

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.7. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

TABLE 6 Criteria for Describing 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

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm 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 soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 8—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 9—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength:*

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 10—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 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 accorance with the criteria in Table 8. 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.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy:*

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally,

TABLE 8 Criteria for Describing 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

TABLE 9 Criteria for Describing 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

TABLE 10 Criteria for Describing 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

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 Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness:*

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about 1/8 in. (3 mm) in 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 in. The thread will crumble at a diameter of 1/8 in. 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.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-in. (3-mm) 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

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils:*

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 11—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils:*

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

NOTE 12—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

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

15. **Procedure for Identifying Coarse-Grained Soils** (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 13—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 14—Other examples of soil descriptions and identification are given in Appendixes X1 and X2.

NOTE 15—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:

   Gravel—fine, coarse

   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Index Terms

18.1 Classification, soil classification, visual classification, soil description, clay, silt, sand, gravel, organic soils.

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP. SC/GC. GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP. SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML. CH/MH. SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH. MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity. the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol. except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL. SAND. AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar. and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time: the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then. do the same with the sand size particles and the fines. Then. mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half. set one-half to the side. and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight. not volume. However. the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

ASTM Designation: D 2573 – 72 (Reapproved 1978)

Standard Test Method for Field Vane Shear Test in Cohesive Soil[1]

This standard is issued under the fixed designation D 2573; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This method covers the field vane test in soft, saturated, cohesive soils. Knowledge of the nature of the soil in which each vane test is to be made is necessary for assessment of the applicability and interpretation of the test.

2. Summary of Method

2.1 The vane shear test basically consists of placing a four-bladed vane in the undisturbed soil and rotating it from the surface to determine the torsional force required to cause a cylindrical surface to be sheared by the vane; this force is then converted to a unit shearing resistance of the cylindrical surface. It is of basic importance that the friction of the vane rod and instrument be accounted for; otherwise, the friction would be improperly recorded as soil strength. Friction measurements under no-load conditions (such as the use of a blank stem in place of the vanes, or a vane that allows some free rotation of the rod prior to loading) are satisfactory only provided that the torque is applied by a balanced moment that does not result in a side thrust. As torsional forces become greater during a test, a side thrust in the instrument will result in an increase in friction that is not accounted for by initial no-load readings. Instruments involving side thrust are not recommended. The vane rod may be of sufficient rigidity that it does not twist under full load conditions; otherwise a correction must be made for plotting torque-rotation curves.

3. Apparatus

3.1 The vane shall consist of a four-bladed vane as illustrated in Fig. 1. The height of the vane shall be twice the diameter. Vane dimensions shall be as specified in Table 1. Sizes other than those specified in Table 1 shall be used only with the permission of the engineer in charge of the boring program. The ends of the vane may be tapered (see Fig. 1). The penetrating edge of the vane blade shall be sharpened having an included angle of 90°.

3.2 The vane shall be connected to the surface by means of steel torque rods. These rods shall have sufficient diameter such that their elastic limit is not exceeded when the vane is stressed to its capacity (Note 1). They shall be so coupled that the shoulders of the male and female ends shall meet to prevent any possibility of the coupling tightening when the torque is applied during the test. If a vane housing is used, the torque rods shall be equipped with well-lubricated bearings where they pass through the housing. These bearings shall be provided with seals to prevent soil from entering them. The torque rods shall be guided so as to prevent friction from developing between the torque rods and the walls of casing or boring.

NOTE 1—If torque *versus* rotation curves are to be determined, it is essential that the torque rods be calibrated (prior to use in the field). The amount of rod twist (if any) must be established in degrees per foot per unit torque. This correction becomes progressively more important as the depth of the test increases and the calibration must be made at least to the maximum depth of testing anticipated.

3.3 Torque shall be applied to the torque rods, thence to the vane. The accuracy of the torque reading should be such that it will produce a variation not to exceed ±25 lb/ft^2 (1.20 kPa) shear strength.

3.4 It is preferable to apply torque to the vane with a geared drive. In the absence of a geared drive, it is acceptable to apply the torque directly by hand with a torque wrench or equivalent. The duration of the test should be controlled by the requirements of 4.3.

4. Procedure

4.1 In the case where a vane housing is used, advance the

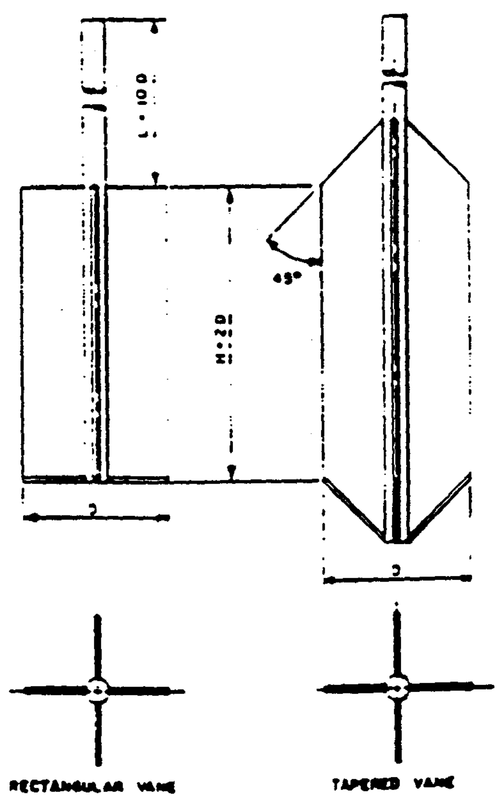


FIG. 1 Geometry of Field Vane

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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TABLE 1 Recommended Dimensions of Field Vanes[A]

Casing Size	Diameter, in. (mm)	Height, in. (mm)	Thickness of Blade, in. (mm)	Diameter of Vane Rod, in. (mm)
AX	1½ (38.1)	3 (76.2)	1/16 (1.6)	½ (12.7)
BX	2 (50.8)	4 (101.6)	1/16 (1.6)	½ (12.7)
NX	2½ (63.5)	5 (127.0)	1/8 (3.2)	½ (12.7)
4 in. (101.6 mm)[B]	3⅝ (92.1)	7¼ (184.1)	1/8 (3.2)	½ (12.7)

[A] Selection of the vane size is directly related to the consistency of the soil being tested, that is, the softer the soil the larger the vane diameter.
[B] Inside diameter.

housing to a depth which is at least five vane housing diameters less than the desired depth of the vane tip. Where no vane housing is used, stop the hole in which the vane is lowered at a depth such that the vane tip may penetrate undisturbed soil for a depth of at least five times the diameter of the hole.

4.2 Advance the vane from the bottom of the hole or the vane housing in a single thrust to the depth at which the test is to be conducted. Take precautions to make sure no torque is applied to the torque rods during the thrust.

4.3 With the vane in position, apply the torque to the vane at a rate which should not exceed 0.1°/s. This generally requires a time to failure of from 2 to 5 min, except in very soft clays where the time to failure may be as much as 10 to 15 min. In stiffer materials, which reach failure at small deformations, it may be desirable to reduce the rate of angular displacement so that a reasonable determination of the stress-strain properties can be obtained. During the rotation of the vane, hold it at a fixed elevation. Record the maximum torque. With apparatus with geared drives, it is desirable to record intermediate values of torque at intervals of 15 s or at lesser frequency if conditions require.

4.4 Following the determination of the maximum torque, rotate the vane rapidly through a minimum of 10 revolutions; the determination of the remoulded strength should be started immediately after completion of rapid rotation and in all cases within 1 min after the remoulding process.

4.5 In the case where soil is in contact with the torque rods, determine the friction between the soil and the rod by means of torque tests conducted on similar rods at similar depths with no vane attached. Conduct the rod friction test at least once on each site; this shall consist of a series of torque tests at varying depths.

4.6 In apparatus in which the torque rod is completely isolated from the soil, conduct a friction test with a blank rod (Note 2) at least once on each site to determine the magnitude of the friction of the bearings. In a properly functioning vane apparatus, this friction should be negligible.

NOTE 2—In some cases it is not necessary to remove the vane for the friction test. As long as the vane is not in contact with the soil, that is, where it is retracted into a casing, the friction measurement is not affected.

4.7 Conduct undisturbed and remoulded vane tests at intervals of not less than 2½ ft (0.76 m) throughout the soil profile when conditions will permit vane testing (Note 3). Do not conduct the vane test in any soil that will permit drainage or dilates during the test period, such as sands or silts or in soils where stones or shells are encountered by the vane in such a manner as to influence the results.

NOTE 3—This spacing may be varied only by the engineer in charge of the boring program.

5. Calculation

5.1 Calculate the shear strength of the soil in the following manner. The turning moment required to shear the soil is as follows:

$$T = s \times K$$

where:
T = torque, lbf·ft (or N·m),
s = shear strength of the clay, lbf/ft² (or kPa), and
K = constant, depending on dimensions and shape of the vane, ft³ (or m³).

5.2 Assuming the distribution of the shear strength is uniform across the ends of a cylinder and around the perimeter, calculate the value of K as follows:

Inch-Pound Units:

$$K = (\pi/1728) \times (D^2H/2) \times [1 + (D/3H)]$$

Metric Units:

$$K = (\pi/10^6) \times (D^2H/2) \times [1 + D/3H)]$$

where:
D = measured diameter of the vane, in. (or cm), and
H = measured height of vane, in. (or cm).

It is important that these dimensions are checked periodically to ensure the vane is not distorted or worn.

5.3 As the ratio of length to breadth of the vane is 2:1, the value of K may be simplified in terms of the diameter so that it becomes the following:

Inch-Pound Units:

$$K = 0.0021D^3$$

Metric Units:

$$K = 0.00000366D^3$$

5.4 Since the value of s is required, it is more useful to write the equation as follows:

$$s = T \times k$$

where:
k = $1/K$ and
T, the torque, is measured so that s can be calculated.

5.5 For the tapered vane of Fig. 1, the following modified equation may be used for the vane constant:

Inch-Pound Units:

$$K = 1/1728\,[\pi D^3 + 0.37\,(2D^3 - d^3)]$$

Metric Units:

$$K = 1/10^6\,[\pi D^3 + 0.37\,(2D^3 - d^3)]$$

where:
d = rod diameter, in. (cm). For a ½-in. (1.27-cm) rod this reduces to:

Inch-Pound Units:

$$K = 0.00225D^3 - 0.00003$$

Metric Units:

$$K = 0.00000388D^3 - 0.00000076$$

6. Report

6.1 For each vane test record the following observations:

6.1.1 Date of the test.

6.1.2 Boring number.

6.1.3 Size and shape of the vane (tapered or rectangular).

6.1.4 Depth of the vane tip.

6.1.5 Depth of the vane tip below the housing or bottom of the hole.

6.1.6 Maximum torque reading, and intermediate readings if required for the undisturbed test.

6.1.7 Time to failure of the test.

6.1.8 Rate of remoulding,

6.1.9 Maximum torque reading for the remoulded test, and

6.1.10 Notes on any deviations from standard test procedure.

6.2 In addition, record the following observations for the boring:

6.2.1 Boring number.

6.2.2 Location.

6.2.3 Log of the soil conditions.

6.2.4 Reference elevation.

6.2.5 Method of making the hole.

6.2.6 Description of the vane, that is, housed or not.

6.2.7 Description of the method of applying and measuring the torque.

6.2.8 Notes on the driving resistance.

6.2.9 Name of the drilling foreman, and

6.2.10 Name of the supervising engineer.

Note: SOP 48 cited within.

STANDARD OPERATING PROCEDURE

FIELD CLASSIFICATION OF SOIL
SOP 49

This SOP presents the field classification of soils to be used by Exponent field staff, which has been adopted ASTM from D-2488-84 (see SOP 48, Attachment 48-2). ASTM D-2488-84 uses the Universal Soil Classification (USC) system for naming soils. Field personnel are encouraged to study these procedures. Soil descriptions should be precise and comprehensive without being verbose. The overall impression of the soil should not be distorted by excessive emphasis on minor constituents. In general, the similarities of consecutive soil samples should be emphasized and minor differences de-emphasized. These descriptions will be used to interpret aquifer properties and other potential contaminant transport properties, rather than the exact mineralogy or tectonic environment.

Soil descriptions should be provided in the Soil Description column of the Field Borehole Log Form (Attachment 49-1) for each sample collected. If there is no difference between consecutive soil samples, subsequent descriptions can be noted as "same as above" or minor changes such as "increasing sand" or "becomes dark brown" can be added.

The format of soil descriptions for each sample or identified stratigraphic layer/soil horizon should be as follows:

1. Group symbol—The group symbol should be placed in the Unified Symbol column
2. USC group name—The USC name should be identical to the ASTM D-2488-84 Group Name with the appropriate modifiers
3. Minor components
4. Color
5. Moisture
6. Additional descriptions.

Examples of soil descriptions are provided in Table 49-1. The minimum elements of the soil descriptions are discussed below.

TABLE 49-1. EXAMPLE OF SOIL SAMPLE DESCRIPTIONS

SM	Silty fine to medium SAND, trace fine gravel and occasional roots, very dark gray, moist to wet
SW-SM	Fine to coarse SAND with silt, some fine gravel, mottled dark gray and tan, moist. Sand consists of 20 percent biotite flakes, no bedding observed
ML	Sand SILT, fine sand, dark gray, moist. Fractures predominantly vertical, at 1–3-in. spacing.
GW	Fine to coarse GRAVEL with 10 percent medium to coarse sand, trace woody debris, gray, moist to wet. Reddish brown staining noted within 2 ft of water table. Gravel is rounded and flat. River deposits.

DEFINITIONS OF SOIL TYPES

Table 49-2 presents the USC system. The USC system is an engineering properties system that uses grain size to classify soils. The first major distinction is between fine-grained soils (more than 50 percent passing the No. 200 sieve [75 μm/0.029 in.]) and coarse-grained soils (more than 50 percent retained by the No. 200 sieve).

Fine-grained soils are classified as either silts or clays. Field determinations of silts and clays are based on observations of dry strength, dilatancy, toughness, and plasticity. Field procedures for these tests are included in ASTM D-2488-84. If these tests are used, the results should be included in the soil description. At least one complete round of field tests should be performed for a site if these fine-grained materials are encountered, preferably at the beginning of the field investigation. The modifiers "fat" and "lean" are used by ASTM to describe soils of high and low plasticity. The soil group symbols (e.g., CL, MH) already indicate plasticity characteristics, and these modifiers are not necessary in the description. Soils with high plasticity can be emphasized by describing them as "silty CLAY with high plasticity." Plasticity is an important descriptor because it is often used to interpret whether an ML soil is acting as either a leaky or competent aquitard. For example, an ML soil can be dilatent/nonplastic and serve as a transport pathway, or it can be highly plastic and very impervious.

Coarse-grained soils are classified as either predominantly gravel or sand, with the No. 4 sieve (4.75 mm/0.19 in.) being the division. Modifiers are used to describe the relative amounts of fine-grained soil in a sample, as noted below:

Description	Percent Fines	Group Symbol
Gravel (sand)	<5 percent	GW, GP (SW, SP)
Gravel (sand) with silt (clay)	5–15 percent	Hyphenated names
Silt (clayey) with gravel (sand)	>15 percent	GM, GC (SM, SC)

The gradation of a coarse-grained soil is included in the specific soil name (i.e., fine to medium SAND with silt). Estimating the percent of size ranges following the group name is encouraged for mixtures of silt sand and gravel. Use of the modifiers "poorly graded" or "well graded" is not necessary because they are indicated by the group symbol.

A borderline symbol is shown with a slash (GM/SM). This symbol should be used when the soil cannot be distinctly placed in either soil group. A borderline symbol should also be used when describing interbedded soils of two or more soil group names when the thicknesses of the beds are approximately equal, such as "interbedded lenses and layers of fine sand and silt." The use of a borderline symbol should not be used indiscriminately. Every effort should be made to place the soil into a single group.

TABLE 49-2. SOIL CLASSIFICATION SYSTEM

Major Divisions			Group Symbol	Group Name
Coarse-Grained Soils More than 50 percent retained on No. 200 sieve	**Gravel** More than 50 percent of coarse fraction retained on No. 4 sieve	Clean gravel	GW	Well-graded gravel, fine to coarse gravel
			GP	Poorly graded gravel
		Gravel with fines	GM	Silty gravel
			GC	Clayey gravel
	Sand More than 50 percent of coarse fraction passes No. 4 sieve	Clean sand	SW	Well-graded sand, fine to coarse sand
			SP	Poorly graded sand
		Sand with fines	SM	Silty sand
			SC	Clayey sand
Fine-Grained Soils More than 50 percent passes No. 200 sieve	**Silt and clay** Liquid limit <50	Inorganic	ML	Silt
			CL	Clay
		Organic	OL	Organic silt, organic clay
	Silt and Clay Liquid limit ≥50	Inorganic	MH	Silt to high plasticity, elastic silt
			CH	Clay of high plasticity, fat clay
		Organic	OH	Organic clay, organic silt
Highly organic soils			PT	Peat

Notes: Field classification is based on visual examination of soil in general accordance with ASTM D-2488-84.

Soil classification using laboratory tests is based on ASTM D-2487-83.

Descriptions of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and/or test data.

Liquid limit-water content of soil-water where consistency changed from plastic to liquid.

MINOR COMPONENTS

Minor components, such as cobbles, roots, and construction debris, should be preceded by the appropriate adjective reflecting relative percentages: trace (0–5 percent), few (5–10 percent), little (15–25 percent), and some (30–45 percent). The word "occasional" can be applied to random particles of a larger size than the general soil matrix (i.e., occasional cobbles, occasional brick fragments). The term "with" indicates definite characteristics regarding the percentage of secondary particle size in the soil name. It will not be used to describe minor components. If a nonsoil component exceeds 50 percent of an interval, it should be stated in place of the group name.

COLOR

The basic color of a soil, such as brown, gray, or red, must be given. The color term can be modified by adjectives such as light, dark, or mottled. Especially note staining or mottling. This information may be useful to establish water table fluctuations or contamination. The Munsell soil color chart designation is the Exponent color standard. All color designations must be accompanied by a description of the moisture content of the soil when the color designation was made. It is generally preferable to determine color on moist samples; water may be added to the soil to achieve this moisture content.

MOISTURE CONTENT

The degree of moisture present in the soil should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed in Table 3 of ASTM D-2488-84.

ADDITIONAL DESCRIPTIONS

Features such as discontinuities, inclusions, joints, fissures, slickensides, bedding, laminations, root holes, and major mineralogical components should be noted if they are observed. Anything unusual should be noted. Additional soil descriptions may be made at the discretion of the project manager or as the field conditions warrant. The Field Borehole Log Form lists some optional descriptions, as does Table 13 of the ASTM standard. The reader is referred to the ASTM standard for procedures of these descriptions.

CONTACTS BETWEEN SOIL TYPES

The contact between two soil types must clearly be marked on the soil borehole log because it is very difficult to interpret borehole logs where soil sample descriptions change over a 5- or 10-ft sample interval if there is no indication of where this change occurred. If the contact is obvious and sharp, draw it in with a straight line. If it is gradational, a slanted line over the interval is appropriate. In the case where it is unclear, a dashed line over the most likely interval is used.

Attachment 49-1

Field Borehole Log Form

Sheet ________ of ________

PTI ENVIRONMENTAL SERVICES

FIELD BOREHOLE LOG FORM

Client/Owner ______________________ Well Number __________

Project No. ______________________________________

Start Date ________________ Finish Date ______________

Ground Surface Conditions ______________________________

Weather Conditions ______________________________

Field Geologist ______________________________

Contractor/Operator ______________________________

Drill Type/Method ______________________________

Boring Diameter ______________________________

Location Sketch
(show dimensions to mapped features)

North Arrow

Groundwater Elevation ________ at Date ________

Well Casing Elevation ________________

Ground Surface Elevation ________ Datum ________

Water Level Information		
Date		
Time		
Depth to Water		
Hole to Depth		
Casing Depth		

Sample No.	Sampler Type						Depth Scale	Unified Symbol	Soil Description	Comments

... Add (C) to sampler type if a catcher is used)

FF Rev 1/91

Sheet ______ of ______

PTI ENVIRONMENTAL SERVICES

FIELD BOREHOLE LOG FORM

Water Level Information				
Date				
Time				
Depth to Water				
Hole to Depth				
Casing Depth				

Sample No.	Sampler Type					Depth Scale	Unified Symbol	Soil Description	Comments

... (TW) Shelby Tube (S) Bulk (B) etc. (Add 'C' to sampler type if a catcher is used)

PTI 1

PTI ENVIRONMENTAL SERVICES

FIELD BOREHOLE LOG FORM

Client/Owner: Schoony's Truck Stop   Well Number: PTI 1

Project No.: C565-01-01

Start Date: 10-5-93   Finish Date: 10-

Ground Surface Conditions: Asphalt/Concrete Road Base

Weather Conditions: Sunny ~60°F

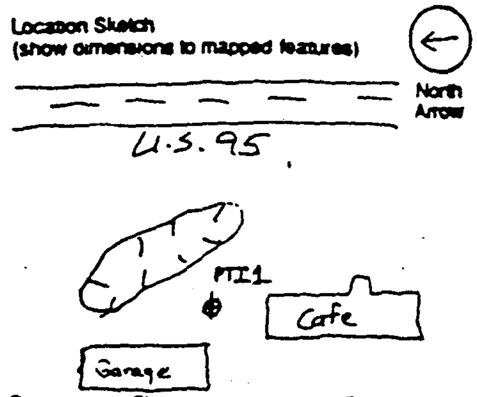
Field Geologist: Brady / Boyd

Contractor/Operator: Ruen Drilling

Drill Type/Method: ODEX - air rotary

Boring Diameter: 8 inches / 6 in. tricone @ 8'

Location Sketch (show dimensions to mapped features)



Groundwater Elevation ______ at Date ______

Well Casing Elevation ______

Ground Surface Elevation ______ Datum ______

Water Level Information			
Date			
Time			
Depth to Water			
Hole to Depth			
Casing Depth			

Sample No.	Sampler Type	% Rec.	PID	Sheen	Depth Scale	Unified Symbol	Soil Description	Comments
					0		Asphalt surface - cracked; gravel base	Cy PID = 0 ppm
					1–2		Brown (med) m-coarse sandy silt 15% fine gravel, moist. No HC staining	
					3		SM/ML Grading to coarser material ↓	
PTI 1-5	SS	50	0	NS	5		Brown (med) silty m-coarse (sm) Sand ~25% f-med gravels, moist. No HC stain	TIME 11:40 TAG 542089; Cy PID = 0 ppm
PTI 1-10	SS	40	0	NS	10		GM - Brown gravel - well graded (poorly sorted) ~75% f-med 25% silty sand, dry No HC stain	TIME 10:35 TAG 542090; W.Space PID = 0 ppm
PTI 1-15	SS	40	0	NS	15		GM - Med. Brown 75% f-med gravel 25% - sand & silt. Dry, No HC stain.	TIME 11:20 TAG 542091
PTI 1-18.5	SS	20	0	NS	18–20		Lt Brown GM - 65% gravel (well graded) 35% sand & SILT. Dry, No HC staining	TIME 11:30 TAG 542092

PTI 1

Sheet 2 of 3

PTI ENVIRONMENTAL SERVICES

FIELD BOREHOLE LOG FORM

Water Level Information			
Date			
Time			
Depth to Water			
Hole to Depth			
Casing Depth			

Sample No	Sampler Type	% Rec	PID	Sheen	Depth Scale	Soil Description	Comments
					21		
					22		sample collected at cyclone. Recovery <5%
23	SS	5%			23	GM - med-C Gravel 75% Sand & SILT 25% Moist NO HC stains	
23.5	CY	—	0	NS	24		TIME TAG
					25		12:00 542093
					26		
					27		
					28		
28.5	CY	—	0	NS	29	SM - 65% SAND-SILT Brown (med.) 35% gravel f-med NO HC stains, moist	TIME TAG
					30		12:30 542094
					31		
					32		
					33		
33.5	CY	—	0	NS	34	GM - 75% f-med gr. Brown 25% sand (little silt) NO HC stain	TIME TAG
					35		12:45 542095
					36		
					37		
					38		
38.5	CY	—	0	NS	39	GM - same AS ABOVE w/ less gravel and more sand (65% / 35%)	TIME TAG
					40		13:10 542096
					41		
					42		
					43		
43.5	CY	—	0	NS	44	SP - Sand 75% poorly graded gravel 25% med. Brown, Moist, NO HC Stains	TIME TAG
					45		13:25 542097
					46		
					47		
					48	Moist GW - Gravel 65% f-coarse (well graded)	TIME TAG
48.5	CY	—	0	NS	49	Sub-rounded, broken rock frags. NO HC stai[ns]	13:35 542098

PTI 1

PTI ENVIRONMENTAL SERVICES FIELD BOREHOLE LOG FORM

Water Level Information			
Date			
Time			
Depth to Water			
Hole to Depth			
Casing Depth			

Sample No	Sampler Type	% Rec	PID	SHEEN		Depth Scale	Unified Symbol	Soil Description	Comments
						50			
						51			
						52			
						53			
535	cy	-	0	NS		54		SAME AS ABOVE but drier and	TIME TAG
						55		more broken rock frags (c-gravels & cobbles)	14:50 542099
						56		75% gravel - 25% sand (GW)	
						57			
						58			TIME TAG
PTI2 535	Cy	-	0	NS				SAME AS ABOVE	15:00 542100
						59		TD Hole @ 58.5'	
						60			

... (S), Bulk (B), etc. (Add 'C' to sampler type if a catcher is used)

ATTACHMENT 49-3

Soil Profile Form and Code Key for the Description and Identification of Soils using the USDA Soil Conservation Service Method Described in the USDA SCS Soil Survey Manual (430-v, Issue 1)

Soil type: ______ Job: ______ Legal Description: T ___ R ___ Sec. ______
Classification: ______ Date: ______ Site No.: ______

Area/location: ______ Elevation: ______ Runoff: ponded, very slow, slow medium, rapid, very rapid Surf. Rck Class.: 0, 1, 2, 3, 5, 6, 7

Climate: ______ Slope: ______ Moisture: dry to ___ moist to ___ sl. moist to ___ wet to ___ % Coarse Frag.: ______

Vegetation: ______ Aspect: N, NE, E, SE, S, SW, W, NW Groundwater: ______ % Clay: ______

Parent Material: ______ Relief: convex, concave, planar Hydr. Cond.: low, moderate, high % Coarser V.F.S.: ______

Physiography: ______ Salt/Alkali: ______ Erosion Type: sheet, rill, gully, wind Control section depth: ______

Current Use: ______ Drainage: excessive, somewhat excessive, well, moderately well, somewhat poorly, poorly, very poorly Wtr. eros. class.: 0, 1, 2, 3, 4 Temperature: ______

Wind eros. class.: 0, 1, 2, 3, 4

Additional Comments: ______

Horizon	Depth	Color		Mottles	Texture	Structure	Consistency			Reaction	Boundary	Roots	Pores	Clay Films	% Gravel	% Cobbles	% Stones & Boulders
		Dry	Moist				Dry	Moist	Wet								
				0,1,2,3 f,m,c f d p		1,2,3 vf,f,m,c,vc gr,pl,sbk,abk pr,cl,m,sg	lo,so sh,h vh,eh	lo,vfr fr,fi vfi,efi	so,ss s,sv po,ps p,pv	eo,evsl esl,estr ev	a,c,g,d s,w,i,b	0,1,2,3 vf,f m,c	0,1,2,3 vf,f,m,c V,T,I	0,1,2,3 n,mk,k			
				0,1,2,3 f,m,c f d p		1,2,3 vf,f,m,c,vc gr,pl,sbk,abk pr,cl,m,sg	lo,so sh,h vh,eh	lo,vfr fr,fi vfi,efi	so,ss s,sv po,ps p,pv	eo,evsl esl,estr ev	a,c,g,d s,w,i,b	0,1,2,3 vf,f m,c	0,1,2,3 vf,f,m,c V,T,I	0,1,2,3 n,mk,k			
				0,1,2,3 f,m,c f d p		1,2,3 vf,f,m,c,vc gr,pl,sbk,abk pr,cl,m,sg	lo,so sh,h vh,eh	lo,vfr fr,fi vfi,efi	so,ss s,sv po,ps p,pv	eo,evsl esl,estr ev	a,c,g,d s,w,i,b	0,1,2,3 vf,f m,c	0,1,2,3 vf,f,m,c V,T,I	0,1,2,3 n,mk,k			
				0,1,2,3 f,m,c f d p		1,2,3 vf,f,m,c,vc gr,pl,sbk,abk pr,cl,m,sg	lo,so sh,h vh,eh	lo,vfr fr,fi vfi,efi	so,ss s,sv po,ps p,pv	eo,evsl esl,estr ev	a,c,g,d s,w,i,b	0,1,2,3 vf,f m,c	0,1,2,3 vf,f,m,c V,T,I	0,1,2,3 n,mk,k			
				0,1,2,3 f,m,c f d p		1,2,3 vf,f,m,c,vc gr,pl,sbk,abk pr,cl,m,sg	lo,so sh,h vh,eh	lo,vfr fr,fi vfi,efi	so,ss s,sv po,ps p,pv	eo,evsl esl,estr ev	a,c,g,d s,w,i,b	0,1,2,3 vf,f m,c	0,1,2,3 vf,f,m,c V,T,I	0,1,2,3 n,mk,k			
				0,1,2,3 f,m,c f d p		1,2,3 vf,f,m,c,vc gr,pl,sbk,abk pr,cl,m,sg	lo,so sh,h vh,eh	lo,vfr fr,fi vfi,efi	so,ss s,sv po,ps p,pv	eo,evsl esl,estr ev	a,c,g,d s,w,i,b	0,1,2,3 vf,f m,c	0,1,2,3 vf,f,m,c V,T,I	0,1,2,3 n,mk,k			

STANDARD OPERATING PROCEDURE

MEASUREMENT OF FIELD PARAMETERS USING A FLOW-THROUGH CELL
SOP 56

This SOP details the procedures for using a flow-through cell for measuring pH, EMF, dissolved oxygen, conductivity, and temperature in the field.

REQUIRED EQUIPMENT

Flow-through cell
Flow-through cell repair kit and extra gaskets of multiple sizes
Tygon® or similar plastic tubing
Peristaltic pump (or other pump capable of pumping a constant, relatively low flow rate)
Silicone tubing for the peristaltic pump discharge
Hose barbs and hose clamps to connect the plastic tubing to the silicone tubing
pH meter and electrode
EMF (mV) meter and electrode
Dissolved oxygen/temperature meter and electrode
Extra dissolved oxygen probe membrane and filling solution
Specific conductance/temperature meter and electrode
Commercial pH buffers (4, 7, and 10)
ZoBell's solution
Conductivity standard
Electrode filling solution (for an Ag/AgCl electrode)
Platinum electrode polishing paper
Kimwipes®
Chart with saturated-air dissolved oxygen concentrations at various temperatures for the elevation of the wells to be sampled
Deionized water

CALIBRATION AND CARE OF METERS AND ELECTRODES

pH

Inspect the pH electrode to ensure that it is filled with electrode filling solution. The pH meter should be calibrated using two pH buffers that bracket the expected pH of the sample. Follow the manufacturer's instructions for meter calibration. When not in use, the pH electrode should be stored in electrode storage solution. If this is not available, pH 7 buffer solution is acceptable. At no time should the electrode be allowed to dry out.

EMF

Inspect the EMF (mV) probe to ensure that it is filled with electrode filling solution. Rinse the electrode with deionized water and blot dry. Immerse the electrode in ZoBell's solution, and wait for the meter to stabilize. The EMF should be between approximately 200 and 250 mV. Record the EMF in the field logbook. Measure the temperature of the ZoBell's solution (the conductivity meter may be used to measure temperature), and record the temperature in the field logbook.

If the EMF reading is outside the specified range (200–250 mV), clean the electrode by the following procedure. Eject the filling solution from the electrode by pushing the epoxy case toward the top of the electrode; the filling solution will come out the bottom. Rinse the electrode at least twice by filling it and then ejecting the solution. Refill the electrode with filling solution. Rinse the outside of the electrode with deionized water, and measure the EMF of the ZoBell's solution again. If the electrode response is still out of the specified range, carefully clean the platinum disk on the bottom of the electrode with a Kimwipe® or with polishing paper that is provided with the electrode. When the electrode is being transported and stored, the platinum disk should be protected to prevent scratching.

Conductivity

To calibrate the conductivity meter, rinse the probe with conductivity standard, then immerse the probe in the conductivity standard. Measure the temperature and the conductivity of the standard. Record these measurements in the field logbook, along with the expected conductivity of the standard.

Dissolved Oxygen

Inspect the dissolved oxygen probe for integrity. The membrane should be intact and unwrinkled and no air bubbles should be present beneath the membrane. If the membrane integrity has been compromised, replace the membrane following manufacturer's instructions. When replacing the membrane, it is imperative that no air bubbles are trapped beneath the membrane. Different brands of dissolved oxygen meters are calibrated using different procedures. Refer to the manufacturer's instructions for the specific dissolved oxygen meter being used. Check the calibration by measuring dissolved oxygen in water-saturated air and comparing the measured value against the saturated-air chart for the elevation of the wells to be sampled. The dissolved oxygen probe should be stored in the calibration sleeve, which should always be kept moist. If the calibration sleeve is not available, the probe should be wrapped in a damp paper towel. At no time should the membrane be allowed to dry out.

MEASUREMENT OF FIELD PARAMETERS

1. The well from which samples are taken should be purged (three casing volumes) before measuring field parameters.

2. Calibrate the meters at each well (the dissolved oxygen probe usually only needs to be calibrated once per day), as described above.

3. Insert the probes into the flow-through cell. The gaskets should fit tightly around the probes, and any flow-through cell openings that do not contain a probe should be sealed with a plastic disc. The inflow of the flow-through cell (the flow goes from bottom to top) should be directed so that it passes directly over the dissolved oxygen probe. If the inflow is not directed properly, a piece of Tygon® tubing and a wire (a paper clip will work) can be used to direct the flow. Insert the wire into the tubing, and insert the tubing into the inflow opening at the bottom of the flow-through cell. Bend the wire to direct the flow.

4. Connect the outflow from the pump to the bottom of the flow-through cell. Pump water into the flow-through cell until the flow begins exiting through the top. Loosen the fittings around the probes, and bleed all air bubbles out of the flow-through cell.

5. Record the pH, EMF, dissolved oxygen, conductivity, and temperature in the field logbook about every 5 minutes until the readings stabilize.

STANDARD OPERATING PROCEDURE

IRON SPECIATION IN GROUNDWATER
SOP 61

FIELD SAMPLING AND ANALYSIS

1. Collect the groundwater sample using a peristaltic pump, passing the flow through an inline, 0.45-μm filter and depositing the sample directly into a 300-mL glass beaker.
2. Allow the beaker to overflow twice its volume to avoid oxygenation of the sample.
3. Collect the sample from the bottom of the beaker directly into a HACH Accuvac® vial for both Fe^{+2} and total iron analyses.
4. Zero the HACH DR100® spectrophotometer using groundwater collected from the glass beaker.
5. Calibrate the HACH DR100® spectrophotometer by preparing and analyzing standards at 1, 3, and 5 mg/L Fe^{+2}, in accordance with the manufacturer's operating instructions.
6. Analyze the sample for Fe^{+2} and total iron, and record the measurements in the field notebook.

QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control samples will consist of duplicates and blanks, both collected at a frequency of 1 for every 20 samples.

Standard Operating Procedure

Measurement of Turbidity Using a Portable Turbidity Meter SOP-424

The HF Scientific Turbidity meter model DRT-15CE is a portable unit that is approved by the U.S. Environmental Protection Agency for measuring the turbidity of potable water, waste water, and some other liquids. The HF meter provides a linear display of turbidity throughout all ranges, reporting results in nephelometric turbidity units (NTUs).

Operating Procedure

The procedure for measuring turbidity is as follows:

1. Clean both the Reference Standard cuvette and the sample cuvette with a lint-free wipe, such as a Kimwipe®.
2. Turn the turbidity meter switch to the "10" range, and place the Reference Standard into the optical well.
3. Turn the Reference Standard in the optical well until the reference ring notch matches the white locator pin. If the reference ring is not on the Reference Standard, turn the reference standard a full 360° and find the area with the lowest reading. Place the reference ring over the lid of the Reference Standard so that the notch will match with the locator pin.
4. Using the "Reference Adjust" arrows on the meter, adjust the display until it reads 0.02 NTU. The instrument is now calibrated and ready for use.
5. To measure turbidity in a sample, fill the sample cuvette with sample to within ½ inch of the top. Screw the cap on the cuvette and carefully clean the outside of the cell with a lint-free wipe. Place the cuvette into the optical cell.
6. Select the appropriate range for the sample (i.e., if the sample is mostly clear, take the measurement at the 0–10 NTU range setting) and take the reading from the display. If the sample is more turbid than the instrument setting, an up arrow will appear in the display, indicating that the operator should change the range to the next higher NTU range setting (i.e., 10–100 NTU).

7. Between samples, the sample cuvette should be rinsed out with deionized water. However, if the sample contains solutes that obviously do not wash out of the cuvette, follow Exponent SOP-3A to decontaminate the cuvette. It is imperative that the operator is careful not to scratch or chip the cuvettes.