



Title:	GEOLOGIC LOGGING
Category:	GEO 4.8
Revised:	March 1998

STANDARD OPERATING PROCEDURE

GEOLOGIC LOGGING

© 1998 Ecology and Environment, Inc.

ecology and environment, inc.

368 Pleasant View Drive / Lancaster, New York 14086 / (716) 684-8060



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

None of the information contained in this Ecology and Environment, Inc., (E & E) publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use in connection with any method, apparatus, or product covered by letters patent, nor as ensuring anyone against liability for infringement of letters patent.

Anyone wishing to use this E & E publication should first seek permission from the company. Every effort has been made by E & E to ensure the accuracy and reliability of the information contained in the document; however, the company makes no representations, warranty, or guarantee in connection with this E & E publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use; for any violation of any federal, state, or municipal regulation with which this E & E publication may conflict; or for the infringement of any patent resulting from the use of the E & E publication.



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1. Introduction	1
2. Drilling Logs	1
2.1 Basic Documentation	1
2.2 Technical Information	3
3. Soil Classification	4
4. Core Logging.....	12
4.1 Handling of Core.....	12
4.2 Rock Description.....	12
4.3 Core Labeling.....	19
4.4 Core Box Labeling	19
4.5 Core Storage.....	19
5. References	19



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1 Standard Penetration Test for Soil Density	4



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8	REVISED:	March 1998

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	Drilling Log.....	2
2	USCS Soil Classification Chart.....	5
3	Rock Descriptive Terms.....	6
4	Rock Qualitative Designation (RQD)	7
5	Narrative Lithologic Description	8
6	ASTM Criteria For Describing Soil	9
7	Sediment Particle Size and Shape Estimates.....	11
8	Core Box	13



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

1. Introduction

Geologic logging involves keeping detailed records during the drilling of boreholes, the installation of monitoring wells, and the excavation of test pits, and entering the geologic descriptions of the soil and rock samples recovered on a standardized form. E & E has adapted a standardized geotechnical logbook (see DOC 2.4 in E & E's Standard Operating Procedures [SOPs]) that contains items deemed important to record when installing monitoring wells, piezometers, and/or soil borings. This document discusses general procedures for completing geologic logs.

2. Drilling Logs


2.1 Basic Documentation

When drilling boreholes, the project geologist should maintain a log that describes each borehole. The E & E Geotechnical Logbook contains records for boreholes. The following basic information should be entered on the heading of each drilling log sheet (see Figure 1):

- Borehole/well number;
- Project name;
- Site location;
- Dates and times that drilling was started and completed;
- Drilling company;
- E & E geologist's name;
- Drill rig type used to drill the borehole;
- Drilling method(s) used to drill the borehole;



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

 DRILLING LOG FOR _____

Project Name _____

Site Location _____

Date Started/Finished _____

Drilling Company _____

Driller's Name _____

Geologist's Name _____

Geologist's Signature _____

Rig Type(s) _____

Drilling Method(s) _____


Bit Size(s) _____ Auger Size(s) _____

Auger/Split Spoon Refusal _____

Total Depth of Borehole is _____

Total Depth of Corehole is _____

Water Level (TOIC)		
Date	Time	Level (Feet)

Well Location Sketch 

Depth (Feet)	Sample Number	Blows on Sampler	Soil Components CL SI S GR	Rock Pile	Penetration Times	Run Number	Core Recovery	RQD	Fracture Sketch	HNu/OVA (ppm)	Comments
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											

Figure 1 Drilling Log



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

- Bit and auger size(s);
- Depth of auger/split barrel sampler refusal;
- Total depth of borehole;
- Total depth of corehole (if applicable);
- Water level at time of completion measured from top of inside casing (TOIC); and
- A well location sketch.

2.2 Technical Information

During the drilling of a borehole, specific technical information about the unconsolidated material and rock encountered should be recorded on the drilling log sheet. The following minimum technical information should be recorded:

- Depth that sample was collected or encountered;
- Sample number assigned (if applicable);
- The number of blow counts required to drive the split barrel sampler 2 feet at 6-inch intervals (see Table 1);
- Description of soil components (see Figure 2);
- Description of rock profile (see Figure 3);
- Rock qualitative designation (RQD) (see Figure 4);
- Rock penetration time;
- Core run number (if applicable) and percent recovery; and
- Organic vapor readings in the sample.



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

**Table 1 Standard Penetration Test for
Soil Density**

N-Blows/Feet	Relative Density
Cohesionless Soils	
0 - 4	Very loose
4 - 10	Loose
10 - 30	Medium
30 - 50	Dense
50	Very dense
Cohesive Soils	
2	Very soft
2 - 4	Soft
4 - 8	Medium
8 - 15	Stiff
15 - 30	Very stiff
30	Hard

3. Soil Classification

Soils should be described using the Unified Soil Classification System (USCS) in the narrative lithologic description section of Figure 5. Figure 6 is a summary of the American Society for Testing and Materials (ASTM) criteria for describing soils. Soil descriptions should be concise, stressing major constituents and characteristics, and should be given in a consistent order and format. The following order is recommended by the ASTM:

1. Soil name. The basic name of the predominant constituent and a single-word modifier indicating the major subordinate constituent.
2. Gradation or Plasticity. Granular soils (i.e., sands or gravels) should be described as well-graded, poorly-graded, uniform, or gap-graded, depending on the gradation of the minus 3-inch fraction. Cohesive soils (i.e., silts and clays) should be described as nonplastic, slightly plastic, moderately plastic, or highly plastic, depending on results of the manual evaluation for plasticity.
3. Particle size distribution. An estimate of the percentage and grain-size range of each subordinate constituent of the soil. This description may also include a description of angularity (see Figure 7).
4. Color. The basic color of the soil.



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

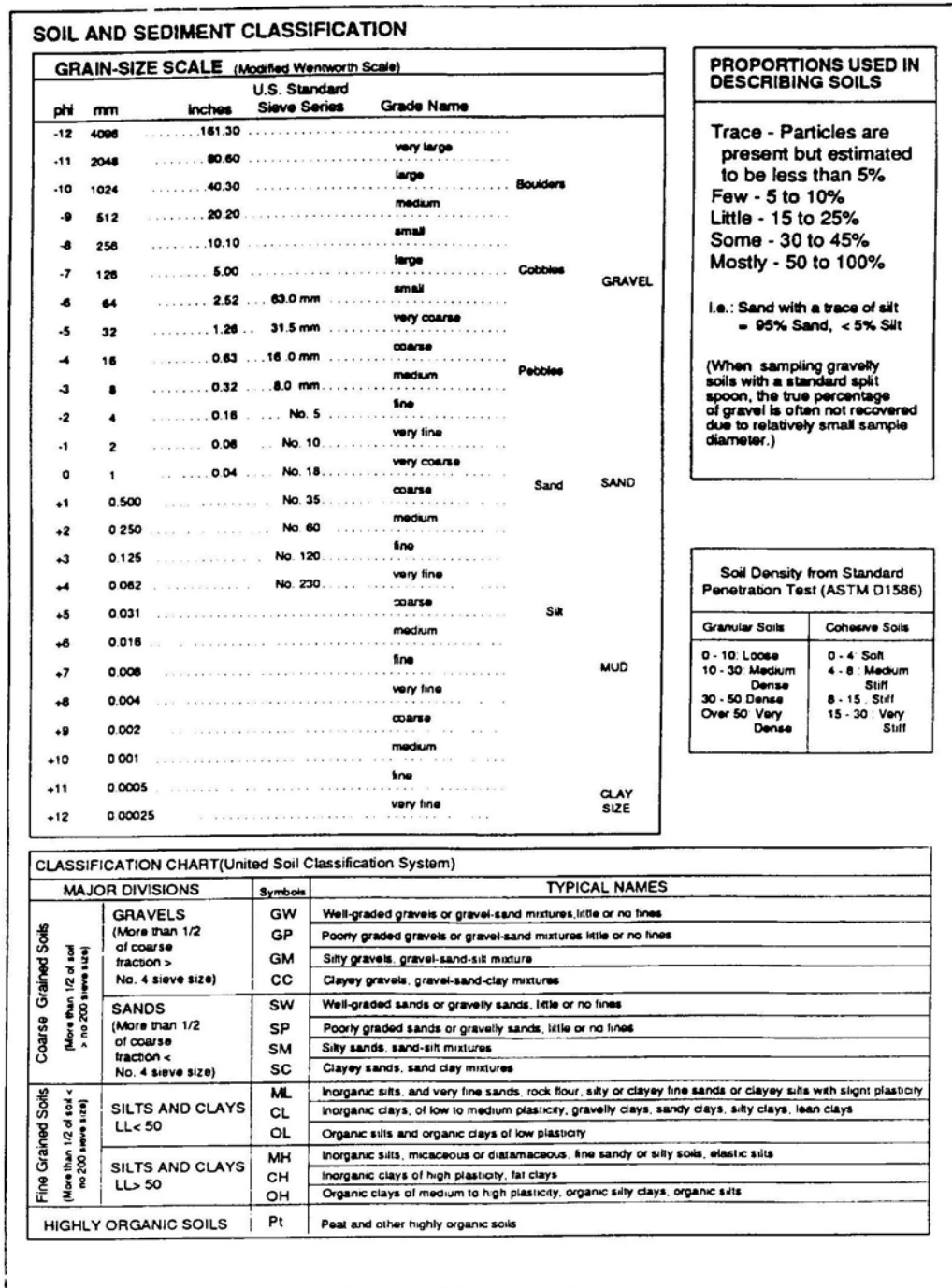


Figure 2 USCS Soil Classification Chart



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

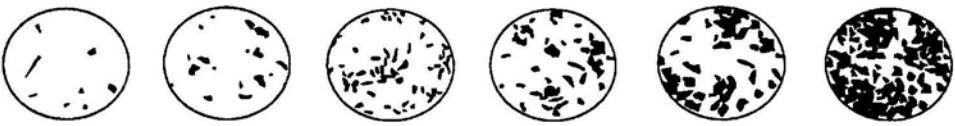
ROCK DESCRIPTIVE TERMS		
Term		Defining Characteristics
Hardness	Soft	Scratched by fingernail
	Moderately Hard	Scratched easily by penknife
	Hard	Difficult to scratch with a penknife
	Very Hard	Cannot be scratched by penknife
Weathering	Unweathered	Rock is unstained. May be fractured, but discontinuities are not stained.
	Slightly	Rock is unstained. Discontinuities show some staining on the surfaces of rocks, but discoloration does not penetrate rock mass.
	Moderate	Discontinuity surfaces are stained. Discoloration may extend into rock along discontinuity surfaces.
	High	Individual rock fragments are thoroughly stained and may be crumbly.
	Severe	Rock appears to consist of gravel-sized fragments in a "soil" matrix. Individual fragments are thoroughly discolored and can be broken with fingers.
Bedding Planes	Laminated	< .04 in.
	Parting	.04 in. - .24 in.
	Banded	.24 in. - 1 in.
	Thin	1 in. - 4 in.
	Medium	4 in. - 12 in.
	Thick	12 in.- 36 in.
	Massive	> 36 in.
Joints and Fracture Spacing	Very tight	< 2 in.
	Tight	2 in. - 1ft.
	Moderately tight	1ft. - 3 ft.
	Wide	3 ft. - 10 ft.
	Very wide	> 10 ft.
Voids	Porous	< 5.1 cm
	Pitted	5.1 - 30.5 cm
	Vug	30.5 cm - 91.4 cm
	Cavity	91.4 cm - 3 M
		> 3 M
Rock Particle Percent Composition Estimation		
		
<div>1%</div> <div>5%</div> <div>10%</div> <div>15%</div> <div>25%</div> <div>50%</div>		

Figure 3 Rock Descriptive Terms



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

ROCK QUALITY DESIGNATION (RQD) AND FRACTURE FREQUENCY

Core borings are a useful means of obtaining information about the quality of rock mass. The recoverable core indicates the character of the intact rock and the number and character of the natural discontinuities.

Another quantitative index that has proved useful in logging NX core is a rock quality designation (RQD) developed by Deere (1963). The RQD is a modified core recovery percentage in which all the pieces of sound NX core over 4 inches long are counted as recovery. The length of the core run is the distance to the nearest tenth of a foot from the corrected depth of the hole at the end of the previous run to the corrected depth of the hole at the end of subject run. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. The RQD is a more general measure of the core quality than the fracture frequency. Core loss, weathered and soft zones, as well as fractures, are accounted for in this determination. The RQD provides a preliminary estimate of the variation of the *in situ* rock mass properties from the properties of the "sound" portion of the rock core. Thus, a general estimate of the behavior of the rock mass can be made. An RQD approaching 100 percent denotes an excellent quality rock mass with properties similar to that of an intact specimen. RQD values ranging from 0 to 50 percent are indicative of a poor quality rock mass having a small fraction of the strength and stiffness measured for an intact specimen.

RQD (Rock Quality Designation)

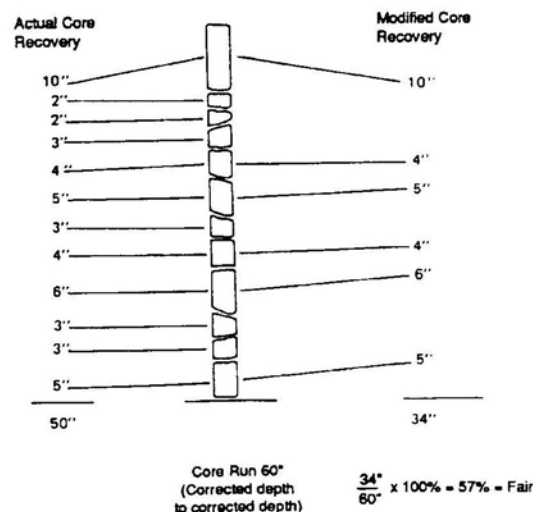
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

An example of determining the RQD from a core run of 60 inches measured from corrected depth to corrected depth is given in Diagram 1. For this particular case, the core recovery was 50 inches and the modified core recovery was 34 inches. This yields an RQD of 57 percent, classifying the rock mass in the fair category.

Problems arise in the use of RQD for determining the *in situ* rock mass quality. The RQD evaluates fractures in the core caused by the drilling process, as well as in natural fractures previously existing in the rock mass. For example, when the core hole penetrates a fault zone or a joint, additional breaks may form that, although not natural fractures, are caused by natural planes of weakness existing in the rock mass. These fresh breaks occur during drilling and handling of the core and are not related to the quality of the rock mass. The skill of the driller will affect the amount of breakage and the core loss that occurs. Poor drilling techniques will "penalize" the rock by lowering its apparent quality. It is difficult to distinguish between drilling breaks and those natural and incipient fractures that reflect the quality of the rock mass. In certain instances, it may be advisable to include all fractures when estimating RQD. Obviously, some judgement is involved in core logging.

Another problem with the use of the RQD index is that the determinations are not sensitive to the tightness of the individual joints, whereas in some instances, the *in situ* deformation modulus may be strongly affected by the average joint opening.

RQD OF A SINGLE CORE RUN*



* Typical calculation of RQD of a single core run. Note that the run is calculated from corrected depth to corrected depth.

Figure 4 Rock Qualitative Designation (RQD)



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

SCREENED WELL		OPEN-HOLE WELL	
Stick-up _____ ft	Lock Number _____	Stick-up _____ ft	
Inner Casing Material _____		Inner Casing Material _____	
Inner Casing Inside Diameter _____ inches		Inner Casing Inside Diameter _____ inches	
GROUND SURFACE			
Top of Grout _____ ft	Quantity of Material Used:	Top of Grout _____ ft	
Borehole Diameter _____ inches	Bentonite Pellets _____	Bottom of Outer Casing _____ ft	
Top of Seal at _____ ft	Cement _____	Borehole Diameter _____ ft	
Bottom of Seal at _____ ft	Cement/Bentonite _____	Bedrock _____ ft	
Top of Screen at _____ ft	Grout _____	Bottom of Rock Socket/ Grout/ Casing _____ ft	
Pack Type/Size:	Top of Sand Pack _____	Corehole Diameter _____	
<input type="checkbox"/> Sand _____	Screen Slot Size _____	Bottom of Corehole _____ ft	
<input type="checkbox"/> Gravel _____	Screen Type _____		
<input type="checkbox"/> Natural _____	<input type="checkbox"/> PVC _____		
Bottom of Screen at _____ ft	<input type="checkbox"/> Stainless Steel _____		
	Bottom of Hole at _____ ft		
	Bottom of Sandpack at _____		

NOTE: See pages 109 and 110 for well construction diagrams

Depth-ft.	NARRATIVE LITHOLOGIC DESCRIPTION	Moisture Content		
		Dry	Moist	Wet
1		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 5 Narrative Lithologic Description



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

ASTM CRITERIA FOR DESCRIBING SOIL			
Criteria for Describing Angularity of Coarse-Grained Particles		Criteria for Describing Dry Strength	
Description	Criteria	Description	Criteria
Angular	Particles have sharp edges and relatively plane side with unpolished surfaces	None	The dry specimen crumbles into powder with mere pressure of handling
Subangular	Particles are similar to angular description but have rounded edges	Low	The dry specimen crumbles into powder with some finger pressure
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges	Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
Rounded	Particles have smoothly curved side and no edges	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 shard surface
Criteria for Describing Dilatancy		Criteria for Describing Structure	
Description	Criteria	Description	Criteria
None	No visible change in the specimen.	Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.	Laminated	Alternating layers of varying materials or color with the layers less than 6 mm thick; note thickness.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.	Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Criteria for Describing Toughness		Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Description	Criteria	Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.	Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.
Medium	Medium pressure is required to roll the thread to near plastic limit. The thread and the lump have medium stiffness.	Homo-geneous	Same color and appearance throughout.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.		

Figure 6 ASTM Criteria For Describing Soil



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

CRITERIA FOR DESCRIBING SOIL (Cont.)			
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		
Criteria for Describing Consistency			
Description	Criteria		
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)		
Soft	Thumb will penetrate soil about 1 inch (25 mm)		
Firm	Thumb will indent soil about 1/4 inch (6 mm)		
Hard	Thumb will not indent soil but readily indented with thumbnail		
Very Hard	Thumbnail will not indent soil		
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		
Criteria for Describing Particle Shape			
The particle shape shall be described as follows where length, width, and thickness refer to greatest, intermediate, and least dimensions of a particle, respectively (see page 104).			
Flat	Particles with width/thickness ratio > 3		
Elongated	Particles with length/width ratio > 3		
Flat and Elongated	Particles meet criteria for both flat and elongated		
Criteria for Describing Plasticity			
Description	Criteria		
Nonplastic	A 1/8 inch (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 rolled 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.		
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
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		

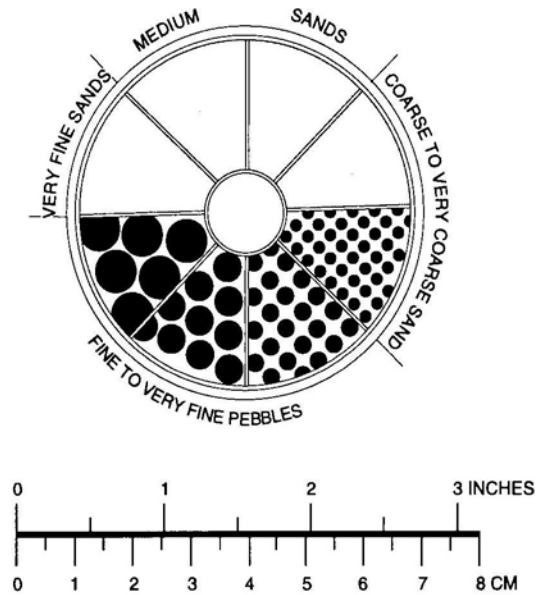
Figure 6 ASTM Criteria for Describing Soil (cont.)



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

SEDIMENT PARTICLE SIZE AND SHAPE ESTIMATES

GRAPH FOR DETERMINING SIZE OF SEDIMENTARY PARTICLES



COBBLES RANGE FROM 6.4 TO 25.6 cm (~2.5 TO 10.1 INCHES)
BOULDERS ARE LARGER THAN 25.6 cm (>10.1 INCHES)

SEDIMENT PARTICLE SHAPES

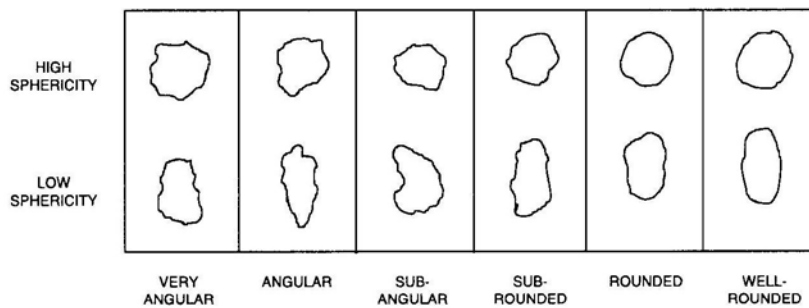


Figure 7 Sediment Particle Size and Shape Estimates



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

5. Moisture content. The amount of soil moisture (dry, moist, or wet).
6. Relative density or consistency. An estimate of density of a granular soil or consistency of a cohesive soil, usually based on the standard penetration test results (see Table 1).
7. Soil Structure or Mineralogy. Description of discontinuities, inclusions, and structures. Includes joints, fissures, and slickensides.

4. Core Logging

4.1 Handling of Core

After the core has been recovered from the corehole and the core barrel has been opened, the core should be placed in a core box. The top of the core should be placed at the back left corner of the core box, and the remaining core placed to the right of the preceding section (see Figure 8). The core box should be filled in this manner, moving to the front sections of the core box. The beginning of each run should be marked on the core and also noted with a marked wooden block.

4.2 Rock Description

Each stratigraphic unit in the core shall be logged. A line marking the depth of the top and the bottom of the unit shall be drawn horizontally. In classifying the rock, the geologist should avoid being too technical, as the information presented must be used by numerous people with widely divergent backgrounds.

The classification and description of each unit should be given in the following order, as applicable:

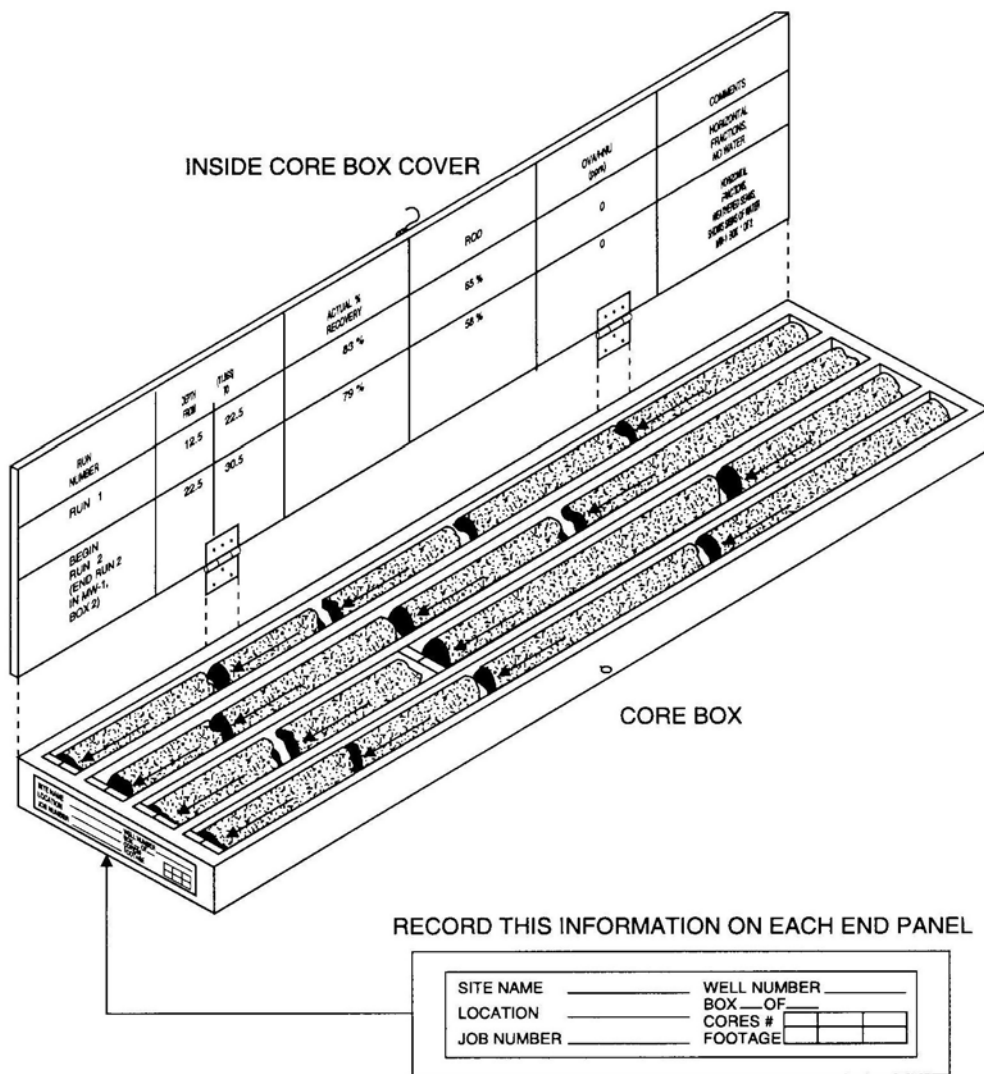
1. Unit designation (Miami oolite, Clayton Formation, Chattanooga shale);
2. Rock type;
3. Hardness;
4. Degree of weathering;
5. Texture;
6. Structure;



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

ABC LANDFILL SYRACUSE, NEW YORK XA-6022	MONITORING WELL MW-1 BOX 1 OF 2 CORE RUN 1 12.5' - 22.5' BEGINNING CORE RUN 2 22.5' - 30.5'
---	--

EXAMPLE: OUTSIDE CORE BOX COVER



SIDE PANELS

Figure 8 Core Box



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8	REVISED:	March 1998

7. Color;
8. Solution and void conditions;
9. Swelling properties;
10. Slaking properties; and
11. Additional description, such as mineralization, size, and spacing shale seams, etc.

Variations from the general description of the unit and features not included in the general description shall be indicated by brackets and lines to show the depth and the interval in the core where the feature exists. These variations and features shall be identified by terms that will adequately describe the feature or variation so as to delineate it from the unit. These may be zones or seams of different color, texture, etc., from that of the unit as a whole, such as staining; variations in texture; shale seams, gypsum seams, chert nodules, calcite masses, etc.; mineralized zones; vuggy zones, joints, fractures; open and/or stained bedding planes; faults, shear zones, gouge; cavities' thickness, open or filled, nature of filling, etc.; or any core left in the bottom of the hole after the final pull.

Rock Type and Lithology

1. Rock will be classified according to the following 24 types:
 - Sandstone
 - Conglomerate
 - Coal
 - Compaction Shale
 - Cemented Shale
 - Indurated Clay
 - Limestone
 - Chalk
 - Gneiss
 - Schist



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

- Graywacke
 - Quartzite
 - Dolomite
 - Marble
 - Soapstone and Serpentine
 - Slate
 - Granite
 - Diorite
 - Gabbro
 - Rhyolite
 - Andesite
 - Basalt
 - Tuff or Tuff Breccia
 - Agglomerate or Flow Breccia
2. Lithologic characteristics should be included to differentiate rocks of the same classification. These adjectives should be simple and easily understood, such as shaly, sandy, dolomitic, etc. Inclusions, nodules, and concretions should also be noted here.
 3. It is important to maintain a simple but accurate rock classification. The rock type and lithologic characteristics are essentially used to differentiate the rock units encountered.

Hardness

The terms for hardness, as outlined below, were modified to include the use of a rock hammer.

1. **Very soft** or plastic - can be deformed by hand (has a rock-like character but can be broken easily by hand).



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

2. **Soft** - can be scratched with a fingernail (cannot be crumbled between fingers but can be easily pitted with light blows of a geology hammer).
3. **Moderately hard** - can be scratched easily with a knife; cannot be scratched with a fingernail (can be pitted with moderate blows of a geology hammer).
4. **Hard** - difficult to scratch with a knife (cannot be pitted with a geology hammer but can be chipped with moderate blows of the hammer).
5. **Very hard** - cannot be scratched with a knife (chips can be broken off only with heavy blows of the geology hammer).

Weathering

The degree and depth of weathering is very important and should be accurately detailed in the general description and clearly indicated on the drill log.

1. **Unweathered** - no evidence of any mechanical or chemical alteration.
2. **Slightly weathered** - superficial discoloration, alteration, and/or discoloration along discontinuities; less than 10% of the rock volume is altered; strength is essentially unaffected.
3. **Moderately weathered** - discoloration is evident; surface is pitted and altered, with alterations penetrating well below rock surfaces; 10% to 50% of the rock is altered; strength is noticeably less than unweathered rock.
4. **Highly weathered** - entire section is discolored; alteration is greater than 50%; some areas of slightly weathered rock are present; some minerals are leached away; retains only a fraction of its original strength (wet strength is usually lower than dry strength).
5. **Decomposed** - saprolite; rock is essentially reduced to a soil with a relic rock texture; can be molded or crumbled by hand.

Texture

Texture is used to denote the size of the grains or crystals comprising the rock, as opposed to the arrangement of the grains or crystals, which is considered a structure.

1. **Aphanitic** - grain diameter less than 0.004 inch (0.1 mm); individual grains or crystals are too small to be seen with the naked eye.



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

2. **Fine-grained, finely crystalline** - grain diameter between 0.004 inch (0.1 mm) and 0.003 (1 mm); grains or crystals can be seen with the naked eye.
3. **Medium-grained, crystalline** - grain diameters between 0.003 foot (1 mm) and 0.0175 foot (5 mm).
4. **Coarse-grained, coarsely crystalline** - grain diameter greater than 0.0175 foot (5 mm).

Structure

The structural character of the rock shall be described in terms of grain or crystal alignment, bedding, and discontinuities, as applicable. The terms may be used singularly or paired.

1. **Foliation and/or lineation** - give approximate dip uniformity, degree of distinctiveness, banding, etc.
2. **Joints:**
 - a. Type - bedding, cleavage, foliation, extension, etc.
 - b. Degree of openness - tight or open.
 - c. Surface or joint plane characteristics - smooth, rough, undulating.
 - d. Weathering - degree, staining.
 - e. Frequency - see (4).
3. **Fractures, shears, gouge:**
 - a. Nature - single plane or zone. (Note thickness.)
 - b. Character of materials in plane or zone.
 - c. Slickensides.
4. **Frequency:**
 - a. Intact - spacing greater than 6 feet (2 m).
 - b. Slightly jointed (fractured) - spacing 3 feet (1 m) to 6 feet (2 m).
 - c. Moderately jointed (fractured) - spacing 1 foot (0.3 m) to 3 feet (1 m).
 - d. Highly jointed (fractured) - spacing 0.3 foot (9.1 cm) to 1 foot (0.3 m).
 - e. Intensely jointed (fractured) - spacing less than 0.3 foot (9.1 cm).
5. **Bedding** is used to describe the average thickness of the individual beds within recognized unit, and the terms thick, medium, or thin should not be applied to the individual beds. "Parting" and "band" are used to describe single stratum as outlined below:
 - a. Massive - over 3 feet thick (1 m).
 - b. Thick - 1 foot (30.5 cm) to 3 feet (1 m) thick.
 - c. Medium - 0.3 foot (9.1 cm) to 1 foot (30.5 cm) thick.
 - d. Thin - 0.1 foot (3.0 cm) to 0.3 foot (9.1 cm) thick.



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8	REVISED:	March 1998

- e. Band - 0.02 foot (6 mm) to 0.1 foot (3.0 cm) thick, described to the nearest 0.01 foot.
- f. Parting - less than 0.02 foot (6 mm).
- g. Paper-thin parting.

The terms and descriptions for the structure of the rock are to be used to describe the character of the rock units recognized and are not to be used as a substitute for describing individual discontinuities. Except for areas where the rock is intensely fractured or jointed, each discontinuity should be described on the log as to position, dip, staining, weathering, breccia, gouge, etc.

Color is often valuable in correlating or differentiating samples, but can be misleading or uninformative. The color of a sample should represent the sample in terms of basic hues (i.e., red, blue, gray, black), supplemented with modifying hues as required (i.e., bluish gray, mottled brown). The core should be surface wet when describing the color; if it is dry, the log should indicate "dry color." Subjective colors, such as buff or maroon, should not be used. Specific color charts, such as the Munsell Color Chart or the Color Index in the Colorado School of Mines, Quarterly, Volume 50, No. 1, are useful in describing color of samples. When such a chart or index is used, it should be noted on the log in the remarks column.

Solution and Void Conditions shall be described in detail, as these features can affect the strength of the rock and can indicate potential seepage paths through the rock. When cavities are detected by drill action, the depth to top and bottom of the cavity should be determined by measuring the stick-up of the drill tools when the cavity is first encountered and again at the bottom, as it is very difficult to reconstruct cavities from the core alone. Filling material, when present and recovered, should be described in detail opposite the cavity. When no material is recovered from the area of the cavity, the inspector should note the probable conditions of the cavity as determined from observing the drilling action and the color of the drill fluid. If the drill action indicated material was present (i.e., slow rod drop, no loss of drill water, noticeable change in color of water return), it should be noted on the log that the cavity was probably filled and the materials should be described as best as possible from the cuttings or traces left on the core. If drill action indicates the cavity was open (i.e., no resistance to the drill tools, loss of drill fluid), this should be noted on the drill log. Partially filled cavities should also be noted. All of these observations require close observation of the drill action and water return by both the inspector and the driller; accurate measurement of stick-ups; and detailed inspection of the core. When possible, filling material should be wrapped in foil if left in the core box. If the material is to be tested or examined in the lab, it should be sealed in a jar with proper labels and a spacer, with a note showing the disposition of the material should be placed in the core box at the point from which the material was taken. Terms to describe voids encountered shall be as follows:

1. **Porous** - voids less than 0.003 foot (1 mm) in diameter.
2. **Pitted** - voids 0.03 foot (1 mm) to 0.02 foot (6 mm) in diameter.
3. **Vug** - voids 0.02 foot (6 mm) to the diameter of the core.
4. **Cavity** - voids greater than diameter of the core.



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

4.3 Core Labeling

The top of the core should be shown on each piece of core with an arrow written in a black, waterproof marker. The arrow will indicate which end of the core is nearer the ground surface. Other core markings may include locations of mechanical breaks and drilling footages.

4.4 Core Box Labeling

Each core box should be labeled as follows:

- On the top left corner of the outer core box, the project name, site location (city and state), and project number should be written.
- On the lower right corner of the outer core box, the corehole number (e.g., MW1, BH2), core box number (e.g., 1 of 2, 2 of 2), and the interval of the core run contained in the core box should be written.
- The side panels should be marked as indicated in Figure 8.
- The inside of the core box cover should be marked as indicated in Figure 8.

4.5 Core Storage

It is important to use proper-sized (HQ or NQ) wooden core boxes for rock core storage. After labeling the box and before closing the box for final storage or shipment, wooden spacers should be inserted into each compartment that contains rock core. This will prevent lateral movement of the cores, which could damage the rock material during handling.

After properly logging, labelling, and packing the cores, the core boxes should be stored in a dry location, preferably off of the floor on a pallet. The boxes can be stacked to a reasonable height so as not to be unstable, with end labelling facing out.

5. References

American Society for Testing and Materials (ASTM), 1975, Test Method for Classification of Soils for Engineering Purposes, ASTM D2487-69, Philadelphia, Pennsylvania.

_____, 1975, Recommended Practice of Description of Soils, ASTM D2488-69, Philadelphia, Pennsylvania.



TITLE:	GEOLOGIC LOGGING		
CATEGORY:	GEO 4.8		March 1998

Deere, D.V., 1963, Technical Description of Rock Cores for Engineering Purposes: Rock Mechanics and Engineering Geology, Vol. 1, No. 1, pp. 16-22.

Dow Chemical, 1980, Field Data Handbook, Dowell Division of Dow Chemical Company, Houston, Texas.

Driscoll, J.T., R.V. Dietrich, and R.M. Foose, 1989, AGI Data Sheets for Geology in the Field, Laboratory, and Office, Third Edition, American Geological Institute, Alexandria, Virginia.

U.S. Army Corps of Engineers, St. Louis District, Inspector's Manual, St. Louis, Missouri.

U.S. Environmental Protection Agency (EPA), 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document, Washington, D.C.