Chapter 10

GUIDELINES FOR CORE LOGGING

These guidelines incorporate procedures and methods used by many field offices and are appropriate for "standard" engineering geology/geotechnical log forms, computerized log forms, and many of the modified log forms used by various Bureau of Reclamation (Reclamation) offices.

General

Introduction

This chapter describes the basic methods for engineering geology core logging and provides examples and instructions pertaining to format, descriptive data, and techniques; procedures for working with drillers to obtain the best data; caring for recovered core; and water testing in drill holes. The chapter also provides a reference for experienced loggers to improve their techniques and train others. Most of the discussions and examples shown pertain to logging rock core, but many discussions apply to soil core logging, standard penetration resistance logs, and drive tube sample logging.

Purpose, Use, and Importance of Quality Core Logging

The ability of a foundation to accommodate structure loads depends primarily on the deformability, strength, and groundwater conditions of the foundation materials. The remediation of a hazardous waste site can be formulated only by proper characterization of the site. Clear and accurate portrayal of geologic design and evaluation data and analytical procedures is paramount. Data reported in geologic logs not only must be accurate, consistently recorded, and concise, but also must provide quantitative and qualitative descriptions.

Logs provide fundamental data on which conclusions regarding a site are based. Additional exploration or testing, final design criteria, treatment design, methods of construction, and eventually the evaluation of structure performance may depend on core logs. A log may present important data for immediate interpretations or use, or may provide data that are used over a period of years. The log may be used to delineate existing foundation conditions, changes over time to the foundation or structure, serve as part of contract documents, and may be used as evidence in negotiations and/or in court to resolve contract or possible responsible party (PRP) disputes.

For engineering geology purposes, the basic objectives of logging core are to provide a factual, accurate, and concise record of the important geological and physical characteristics of engineering significance. Characteristics which influence deformability, strength, and water conditions must be recorded appropriately for future interpretations and analyses. Reclamation has adopted recognized indexes, nomenclature, standard descriptors and descriptive criteria, and alphanumeric descriptors for physical properties to ensure that these data are recorded uniformly, consistently, and accurately. Use of alphanumeric descriptors and indexes permits analysis of data by computer. These descriptors, descriptive criteria, examples, and supporting discussions are provided in chapters 3, 4, and 5.

Exploration should be logged or, as a minimum, reviewed by an experienced engineering geologist. The logger should be aware of the multiple uses of the log and the needs and interests of technically diverse users. The experienced logger concentrates on the primary purposes of the individual drill hole as well as any subordinate purposes, keeping in mind the interests of others with varied geological backgrounds including geotechnical engineers, contract drillers, construction personnel, and contract lawyers. An experienced logger tailors the log to meet these needs, describing some seemingly minor features or conditions which have engineering significance, and excluding petrologic features or geologic conditions having only minor or academic interest. Less experienced loggers may have a tendency to concentrate on unnecessary garnishment, use irrelevant technical terms, or produce an enormously detailed log which ignores the engineering geology considerations and perhaps the purpose for completing the drill hole. Adequate descriptions of recovered cores and samples can be prepared solely through visual or hand specimen examination of the core with the aid of simple field tests. Detailed microscopic or laboratory testing to define rock type or mineralogy generally are necessary only in special cases.

Empirical design methods, such as the Rock Mass Rating System Geomechanics Classification (RMR) and Q-system Classification (Q), are commonly used for design of underground structures and are coming into common use for other structures as well. If these methods are used, the necessary data must be collected during core logging.

If hazardous waste site characterization is the primary purpose of the drilling, the log should concentrate on providing data for that type of investigation.

Drilling and logging are to determine the in-place condition of the soil or rock mass. Any core condition, core loss, or damage due to the type of bit, barrel, or other equipment used, or due to improper techniques used in the drilling and handling processes should be described. Such factors may have a marked effect on the amount and condition of the core recovered, particularly in soft, friable, weathered, intensely fractured materials or zones of shearing. Geologic logs require the adequate description of materials; a detailed summary of drilling equipment, methods, samplers, and significant engineering conditions; and geologic interpretations. Complete geologic logs of drill holes require adequate descriptions of recovered surficial deposits and bedrock, a detailed summary of drilling methods and conditions, and appropriate physical characteristics and indexes to ensure that adequate engineering data are available for geologic interpretation and analysis.

Format and Required Data for the Final Geologic Log

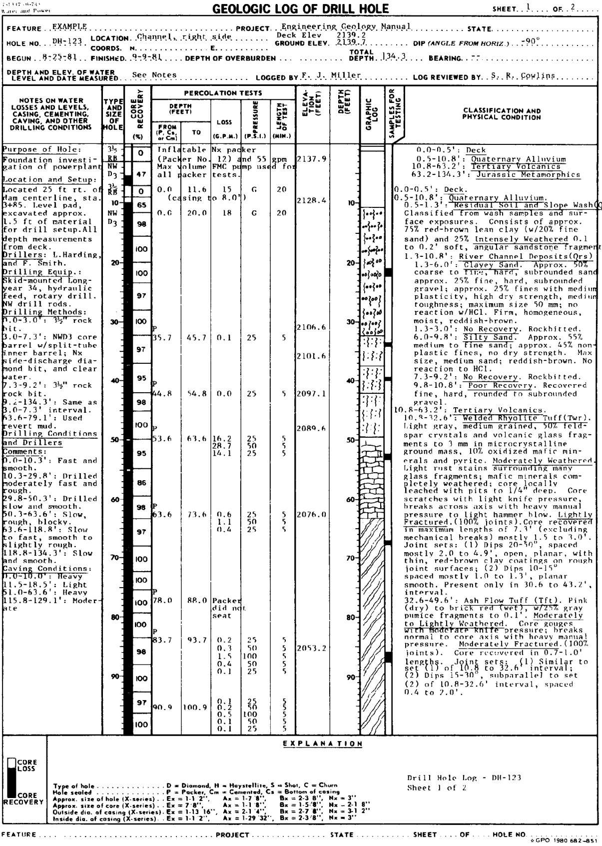
Organization of the Log

The log forms are divided into five basic sections: a heading block; a left-hand column for notes; a center column for indexes, additional notes, water tests and graphics; a right-hand column for classification and physical conditions; and a comments/explanation block at the bottom. Data required for each column are described in the following discussion and the referenced example logs. Log DH-123, figure 10-1, and log B-102, figure 10-2, are the most complete and preferred examples; other variations are presented but in some cases are not complete.

Heading

The heading block at the top of the form provides spaces for supplying project identifying information, feature,

CORE LOGGING



Water and Power

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 2

FEATURE EXAMPLE PROJECT Engineering Geology Manual STATE

HOLE NO. DH-123 LOCATION Channel, right side Deck Elev 2139.2

COORDS. N. E. GROUND ELEV. 2139.7 DIP (ANGLE FROM HORIZ.) -90°

BEGUN 8-25-81 FINISHED 9-9-81 DEPTH OF OVERBURDEN TOTAL DEPTH 134.3 BEARING --

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED See Notes LOGGED BY F. J. Miller LOG REVIEWED BY S. R. Cowlins

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

Purpose of Hole: Foundation investigation of powerplant

Location and Setup: Located 25 ft rt. of dam centerline, sta. 3+85. Level pad, excavated approx. 1.5 ft of material for drill setup. All depth measurements from deck.

Drillers: L. Harding, and F. Smith.

Drilling Equip.: Skid-mounted Longyear 34, hydraulic feed, rotary drill. NW drill rods.

Drilling Methods:
0.0-3.0': 3½" rock bit.
3.0-7.3': NWD3 core barrel w/split-tube inner barrel; Nx side-discharge diamond bit, and clear water.
7.3-9.2': 3½" rock rock bit.
9.2-134.3': Same as 3.0-7.3' interval.
63.6-79.1': Used revert mud.

Drilling Conditions and Drillers Comments:
0.0-10.3': Fast and smooth.
10.3-29.8': Drilled moderately fast and rough.
29.8-50.3': Drilled slow and smooth.
50.3-63.6': Slow, rough, blocky.
63.6-118.8': Slow to fast, smooth to slightly rough.
118.8-134.3': Slow and smooth.

Caving Conditions:
0.0-10.0': Heavy
11.5-18.5': Light
51.0-63.6': Heavy
115.8-129.1': Moderate

TYPE AND SIZE OF HOLE: 3½ RB; NW D3; 3½ RB; NW D3

CORE RECOVERY (%): 0, 47, 0, 65, 98, 100, 100, 97, 100, 97, 95, 98, 100, 95, 86, 98, 97, 100, 100, 100, 100, 98, 100, 97, 100

PERCOLATION TESTS

Inflatable Nx packer (Packer No. 12) and 55 gpm Max volume FMC pump used for all packer tests.

DEPTH (FEET) FROM (P, Cs, or Cm)	DEPTH (FEET) TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)
					2137.9
0.0	11.6	15	G	20	2128.4
(casing to 8.0')					
0.0	20.0	18	G	20	
P					2106.6
35.7	45.7	0.1	25	5	
					2101.6
P 44.8	54.8	0.0	25	5	2097.1
P					2089.6
53.6	63.6	16.2 28.7 14.1	25 50 25	5 5 5	
P 63.6	73.6	0.6 1.1 0.4	25 50 25	5 5 5	2076.0
P 78.0	88.0	Packer did not seat			
P 83.7	93.7	0.2 0.3 1.5 0.4 0.1	25 50 100 50 25	5 5 5 5 5	2053.2
90.9	100.9	0.1 0.2 0.5 0.1 0.1	25 50 100 50 25	5 5 5 5 5	

CLASSIFICATION AND PHYSICAL CONDITION

0.0-0.5': Deck
0.5-10.8': Quaternary Alluvium
10.8-63.2': Tertiary Volcanics
63.2-134.3': Jurassic Metamorphics

0.0-0.5': Deck.

0.5-10.8': Quaternary Alluvium.

0.5-1.3': Residual Soil and Slope Wash(Qc) Classified from wash samples and surface exposures. Consists of approx. 75% red-brown lean clay (w/20% fine sand) and 25% Intensely Weathered 0.1 to 0.2' soft, angular sandstone fragments.

1.3-10.8': River Channel Deposits(Qrs)

1.3-6.0': Clayey Sand. Approx. 50% coarse to fine, hard, subrounded sand approx. 25% fine, hard, subrounded gravel; approx. 25% fines with medium plasticity, high dry strength, medium toughness; maximum size 50 mm; no reaction w/HCl. Firm, homogeneous, moist, reddish-brown.

1.3-3.0': No Recovery. Rockbitted.

6.0-9.8': Silty Sand. Approx. 55% medium to fine sand; approx. 45% non-plastic fines, no dry strength. Max size, medium sand; reddish-brown. No reaction to HCl.

7.3-9.2': No Recovery. Rockbitted.

9.8-10.8': Poor Recovery. Recovered fine, hard, rounded to subrounded gravel.

10.8-63.2': Tertiary Volcanics.

10.8-32.6': Welded Rhyolite Tuff(Twr). Light gray, medium grained, 50% feldspar crystals and volcanic glass fragments to 3 mm in microcrystalline ground mass, 10% oxidized mafic minerals and pyrite. Moderately Weathered. Light rust stains surrounding many glass fragments; mafic minerals completely weathered; core locally leached with pits to 1/4" deep. Core scratches with light knife pressure, breaks across axis with heavy manual pressure to light hammer blow. Lightly Fractured.(100% joints).Core recovered in maximum lengths of 7.3' (excluding mechanical breaks) mostly 1.5 to 3.0'. Joint sets: (1) Dips 20-30°, spaced mostly 2.0 to 4.9', open, planar, with thin, red-brown clay coatings on rough joint surfaces; (2) Dips 10-15° spaced mostly 1.0 to 1.3', planar smooth. Present only in 30.6 to 43.2', interval.

32.6-49.6': Ash Flow Tuff (Tft). Pink (dry) to brick red (wet), w/25% gray pumice fragments to 0.1'. Moderately to Lightly Weathered. Core gouges with moderate knife pressure; breaks normal to core axis with heavy manual pressure. Moderately Fractured.(100% joints). Core recovered in 0.7-1.0' lengths. Joint sets: (1) Similar to set (1) of 10.8 to 32.6' interval; (2) Dips 15-30°, subparallel to set (2) of 10.8-32.6' interval, spaced 0.4 to 2.0'.

EXPLANATION

CORE LOSS

CORE RECOVERY

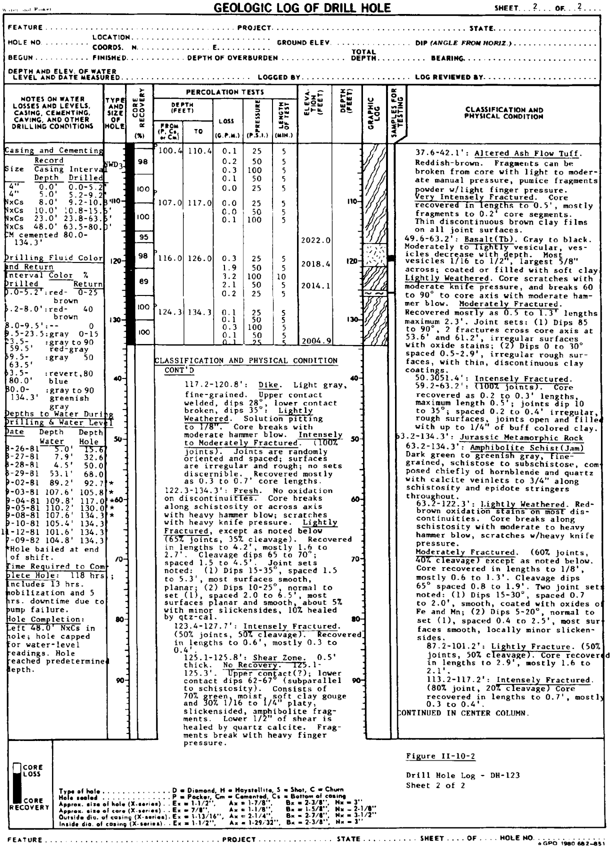
Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

Drill Hole Log - DH-123
Sheet 1 of 2

FEATURE PROJECT STATE SHEET OF HOLE NO.

☆GPO 1980 682-851

Figure 10-1.—Drill hole log, DH-123, sheet 1 of 2.



Water and Power

GEOLOGIC LOG OF DRILL HOLE

SHEET 2 OF 2

FEATURE .... PROJECT .... STATE ....
HOLE NO. .... LOCATION .... COORDS. N. .... E. .... GROUND ELEV. .... DIP (ANGLE FROM HORIZ.) ....
BEGUN .... FINISHED .... DEPTH OF OVERBURDEN .... TOTAL DEPTH .... BEARING ....
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED .... LOGGED BY .... LOG REVIEWED BY ....

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

Casing and Cementing Record

Size	Casing Depth	Interval Drilled
4"	0.0'	0.0-5.2'
4"	5.0'	5.2-9.2'
NxCs	8.0'	9.2-10.8'
NxCs	10.0'	10.8-15.6'
NxCs	23.0'	23.8-63.5'
NxCs	48.0'	63.5-80.0'

CM cemented 80.0-134.3'

Drilling Fluid Color and Return

Interval Drilled	Color	% Return
0.0-5.2'	red-brown	0-25
5.2-8.0'	red-brown	40
8.0-9.5'	--	0
9.5-23.5	gray	0-15
23.5-59.5'	gray to red-gray	90
59.5-63.5'	gray	50
63.5-80.0'	revert, blue	80
80.0-134.3'	gray to greenish gray	90

Depths to Water During Drilling & Water Level

Date	Depth Water	Depth Hole
8-26-81	5.0'	15.6
8-27-81	7.9'	32.6
8-28-81	4.5'	50.0
8-29-81	53.1'	68.0
9-02-81	89.2'	92.7*
9-03-81	107.6'	105.8*
9-04-81	109.8'	117.0*
9-05-81	110.2'	130.0*
9-08-81	107.6'	134.3*
9-10-81	105.4'	134.3
11-12-81	101.6'	134.3
7-09-82	104.8'	134.3

*Hole bailed at end of shift.

Time Required to Complete Hole: 118 hrs; includes 13 hrs. mobilization and 5 hrs. downtime due to pump failure.

Hole Completion: Left 48.0' NxCs in hole; hole capped for water-level readings. Hole reached predetermined depth.

TYPE AND SIZE OF HOLE: NWD3

CORE RECOVERY (%): 98, 100, 100, 95, 98, 89, 100, 100

PERCOLATION TESTS

DEPTH (FEET) FROM (P, Cs, or Cm)	DEPTH (FEET) TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)
100.4	110.4	0.1	25	5
		0.2	50	5
		0.3	100	5
		0.1	50	5
		0.0	25	5
107.0	117.0	0.0	25	5
		0.0	50	5
		0.1	100	5
116.0	126.0	0.3	25	5
		1.9	50	5
		3.2	100	10
		2.1	50	5
		0.2	25	5
124.3	134.3	0.1	25	5
		0.1	50	5
		0.3	100	5
		0.1	50	5
		0.1	25	5

ELEVATION (FEET): 2022.0, 2018.4, 2014.1, 2004.9

DEPTH (FEET) · GRAPHIC LOG · SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

37.6-42.1': Altered Ash Flow Tuff. Reddish-brown. Fragments can be broken from core with light to moderate manual pressure, pumice fragments powder w/light finger pressure. Very Intensely Fractured. Core recovered in lengths to 0.5', mostly fragments to 0.2' core segments. Thin discontinuous brown clay films on all joint surfaces.

49.6-63.2': Basalt(Tb). Gray to black. Moderately to lightly vesicular, vesicles decrease with depth. Most vesicles 1/16 to 1/2", largest 5/8" across; coated or filled with soft clay. Lightly Weathered. Core scratches with moderate knife pressure, and breaks 60 to 90° to core axis with moderate hammer blow. Moderately Fractured. Recovered mostly as 0.5 to 1.3' lengths maximum 2.3'. Joint sets: (1) Dips 85 to 90°, 2 fractures cross core axis at 53.6' and 61.2', irregular surfaces with oxide stains; (2) Dips 0 to 30° spaced 0.5-2.9', irregular rough surfaces, with thin, discontinuous clay coatings.

50.3051.4': Intensely Fractured.

59.2-63.2': (100% joints). Core recovered as 0.2 to 0.3' lengths, maximum length 0.5'; joints dip 10 to 35°; spaced 0.2 to 0.4' irregular, rough surfaces, joints open and filled with up to 1/4" of buff colored clay.

63.2-134.3': Jurassic Metamorphic Rock

63.2-134.3': Amphibolite Schist(Jam) Dark green to greenish gray, fine-grained, schistose to subschistose, composed chiefly of hornblende and quartz with calcite veinlets to 3/4" along schistosity and epidote stringers throughout.

63.2-122.3': Lightly Weathered. Red-brown oxidation stains on most discontinuities. Core breaks along schistosity with moderate to heavy hammer blow, scratches w/heavy knife pressure.

Moderately Fractured. (60% joints, 40% cleavage) except as noted below. Core recovered in lengths to 1/8', mostly 0.6 to 1.3'. Cleavage dips 65° spaced 0.8 to 1.9'. Two joint sets noted: (1) Dips 15-30°, spaced 0.7 to 2.0', smooth, coated with oxides of Fe and Mn; (2) Dips 5-20°, normal to set (1), spaced 0.4 to 2.5', most surfaces smooth, locally minor slickensides.

87.2-101.2': Lightly Fracture. (50% joints, 50% cleavage). Core recovered in lengths to 2.9', mostly 1.6 to 2.1'.

113.2-117.2': Intensely Fractured. (80% joint, 20% cleavage) Core recovered in lengths to 0.7', mostly 0.3 to 0.4'.

CONTINUED IN CENTER COLUMN.

CLASSIFICATION AND PHYSICAL CONDITION CONT'D

117.2-120.8': Dike. Light gray, fine-grained. Upper contact welded, dips 28°, lower contact broken, dips 35°: Lightly Weathered. Solution pitting to 1/8". Core breaks with moderate hammer blow. Intensely to Moderately Fractured. (100% joints). Joints are randomly oriented and spaced; surfaces are irregular and rough; no sets discernible. Recovered mostly as 0.3 to 0.7' core lengths.

122.3-134.3': Fresh. No oxidation on discontinuities. Core breaks along schistosity or across axis with heavy hammer blow; scratches with heavy knife pressure. Lightly Fractured, except as noted below (65% joints, 35% cleavage). Recovered in lengths to 4.2', mostly 1.6 to 2.7'. Cleavage dips 65 to 70°; spaced 1.5 to 4.5'. Joint sets noted: (1) Dips 15-35°, spaced 1.5 to 5.3', most surfaces smooth, planar; (2) Dips 10-25°, normal to set (1), spaced 2.0 to 6.5', most surfaces planar and smooth, about 5% with minor slickensides, 10% healed by qtz-cal.

123.4-127.7': Intensely Fractured. (50% joints, 50% cleavage). Recovered in lengths to 0.6', mostly 0.3 to 0.4'.

125.1-125.8': Shear Zone. 0.5' thick. No Recovery. 125.1-125.3'. Upper contact(?); lower contact dips 62-67° (subparallel to schistosity). Consists of 70% green, moist, soft clay gouge and 30% 1/16 to 1/4" platy, slickensided, amphibolite fragments. Lower 1/2" of shear is healed by quartz calcite. Fragments break with heavy finger pressure.

☐ CORE LOSS

■ CORE RECOVERY

Type of hole .... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx – 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

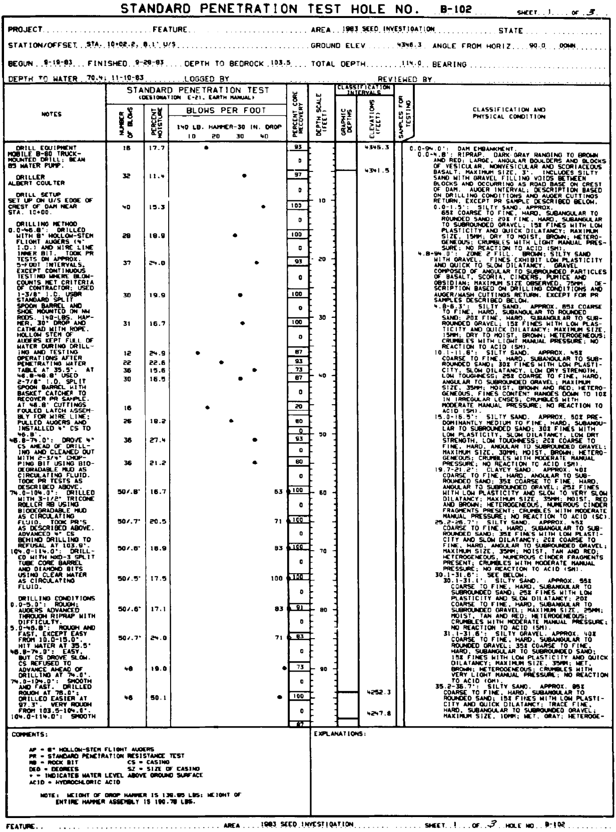
Figure II-10-2

Drill Hole Log - DH-123
Sheet 2 of 2

FEATURE .... PROJECT .... STATE .... SHEET .... OF .... HOLE NO. ....

GPO 1980 682-851

Figure 10-1.—Drill hole log, DH-123, sheet 2 of 2.



STANDARD PENETRATION TEST HOLE NO. B-102 SHEET 1 OF 3

PROJECT .... FEATURE .... AREA 1983 SEED INVESTIGATION STATE ....
STATION/OFFSET STA. 10+02.2, 8.1' U/S GROUND ELEV 4346.3 ANGLE FROM HORIZ 90.0 DOWN
BEGUN 9-19-83 FINISHED 9-28-83 DEPTH TO BEDROCK 103.5 TOTAL DEPTH 114.0 BEARING ....
DEPTH TO WATER 70.4; 11-10-83 LOGGED BY .... REVIEWED BY ....

NOTES

DRILL EQUIPMENT
MOBILE B-80 TRUCK-MOUNTED DRILL; BEAN 85 WATER PUMP.

DRILLER
ALBERT COULTER

DRILL SETUP
SET UP ON U/S EDGE OF CREST OF DAM NEAR STA. 10+00.

DRILLING METHOD
0.0-46.8': DRILLED WITH 8" HOLLOW-STEM FLIGHT AUGERS (4" I.D.) AND WIRE LINE INNER BIT. TOOK PR TESTS ON APPROX. 5-FOOT INTERVALS, EXCEPT CONTINUOUS TESTING WHERE BLOW-COUNTS MET CRITERIA OF CONTRACTOR; USED 1-3/8" I.D. USBR STANDARD SPLIT SPOON BARREL AND SHOE MOUNTED ON NW RODS. 140-LBS. HAMMER, 30" DROP AND CATHEAD WITH ROPE. HOLLOW STEM OF AUGERS KEPT FULL OF WATER DURING DRILLING AND TESTING OPERATIONS AFTER PENETRATING WATER TABLE AT 35.5'. AT 46.8-48.8' USED 2-7/8" I.D. SPLIT SPOON BARREL WITH BASKET CATCHER TO RECOVER PR SAMPLE. AT 46.8' CUTTINGS FOULED LATCH ASSEMBLY FOR WIRE LINE; PULLED AUGERS AND INSTALLED 4" CS TO 46.8'.
46.8-74.0': DROVE 4" CS AHEAD OF DRILLING AND CLEANED OUT WITH 2-3/4" CHOPPING BIT USING BIODEGRADABLE MUD AS CIRCULATING FLUID. TOOK PR TESTS AS DESCRIBED ABOVE.
74.0-104.0': DRILLED WITH 3-1/2" TRICONE ROLLER RB USING BIODEGRADABLE MUD AS CIRCULATING FLUID. TOOK PR'S AS DESCRIBED ABOVE. ADVANCED 4" CS BEHIND DRILLING TO REFUSAL AT 103.9'.
104.0-114.0': DRILLED WITH NXD-3 SPLIT TUBE CORE BARREL AND DIAMOND BITS USING CLEAR WATER AS CIRCULATING FLUID.

DRILLING CONDITIONS
0.0-5.0': ROUGH; AUGERS ADVANCED THROUGH RIPRAP WITH DIFFICULTY.
5.0-46.8': ROUGH AND FAST, EXCEPT EASY FROM 10.0-15.0'. HIT WATER AT 35.5'
46.8-74.0': EASY, BUT CS DROVE SLOW. CS REFUSED TO ADVANCE AHEAD OF DRILLING AT 74.0'.
74.0-104.0': SMOOTH AND FAST. DRILLED ROUGH AT 78.0'; DRILLED EASIER AT 97.3'. VERY ROUGH FROM 103.5-104.0'.
104.0-114.0': SMOOTH

STANDARD PENETRATION TEST (DESIGNATION E-21, EARTH MANUAL)

NUMBER OF BLOWS	PERCENT MOISTURE	BLOWS PER FOOT 140 LB. HAMMER-30 IN. DROP (10 20 30 40)	PERCENT CORE RECOVERY
18	17.7	●	93
			0
32	11.4	●	97
			0
40	15.3	●	100
			0
28	18.9	●	100
			0
37	24.8	●	93
			0
30	19.9	●	100
			0
31	16.7	●	100
			0
12	24.9	●	87
22	22.6	●	93
36	15.6	●	73
30	16.5	●	87
			0
16		●	20
26	18.2	●	80
			0
36	27.4	●	93
			0
36	21.2	●	80
			0
50/.8"	16.7	63 ●	100
			0
50/.7"	20.5	71 ●	100
			0
50/.6"	18.9	83 ●	100
			0
50/.5"	17.5	100 ●	100
			0
50/.6"	17.1	83 ●	91
			0
50/.7"	24.0	71 ●	83
			0
48	19.0	●	73
			0
46	50.1	●	100
			0
			87

DEPTH SCALE (FEET): 10, 20, 30, 40, 50, 60, 70, 80, 90

CLASSIFICATION INTERVALS — GRAPHIC DEPTHS / ELEVATIONS (FEET): 4346.3, 4341.5, 4252.3, 4247.8

SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

0.0-94.0': DAM EMBANKMENT.
0.0-4.8': RIPRAP. DARK GRAY RANGING TO BROWN AND RED; LARGE, ANGULAR BOULDERS AND BLOCKS OF VESICULAR, NONVESICULAR AND SCORIACEOUS BASALT; MAXIMUM SIZE, 3'. INCLUDES SILTY SAND WITH GRAVEL FILLING VOIDS BETWEEN BLOCKS AND OCCURRING AS ROAD BASE ON CREST OF DAM. AUGER INTERVAL; DESCRIPTION BASED ON DRILLING CONDITIONS AND AUGER CUTTINGS RETURN, EXCEPT PR SAMPLE DESCRIBED BELOW.
0.0-1.5': SILTY SAND. APPROX. 65% COARSE TO FINE, HARD, SUBANGULAR TO ROUNDED SAND; 20% FINE, HARD, SUBANGULAR TO SUBROUNDED GRAVEL; 15% FINES WITH LOW PLASTICITY AND QUICK DILATANCY; MAXIMUM SIZE, 15MM; DRY TO MOIST, BROWN; HETEROGENEOUS; CRUMBLES WITH LIGHT MANUAL PRESSURE; NO REACTION TO ACID (SM).
4.8-94.0': ZONE 2 FILL. BROWN; SILTY SAND WITH GRAVEL. FINES EXHIBIT LOW PLASTICITY AND QUICK TO SLOW DILATANCY. GRAVEL COMPOSED OF ANGULAR TO SUBROUNDED PARTICLES OF BASALT, SCORIA, CINDERS, PUMICE AND OBSIDIAN; MAXIMUM SIZE OBSERVED, 75MM. DESCRIPTION BASED ON DRILLING CONDITIONS AND AUGER/WASH CUTTINGS RETURN, EXCEPT FOR PR SAMPLES DESCRIBED BELOW.
4.8-6.3': SILTY SAND. APPROX. 65% COARSE TO FINE, HARD, SUBANGULAR TO ROUNDED SAND; 20% FINE, HARD, SUBANGULAR TO SUBROUNDED GRAVEL; 15% FINES WITH LOW PLASTICITY AND QUICK DILATANCY; MAXIMUM SIZE, 15MM; DRY TO MOIST, BROWN; HETEROGENEOUS; CRUMBLES WITH LIGHT MANUAL PRESSURE; NO REACTION TO ACID (SM).
10.1-11.6': SILTY SAND. APPROX. 45% COARSE TO FINE, HARD, SUBANGULAR TO SUBROUNDED SAND; 30% FINES WITH LOW PLASTICITY, SLOW DILATANCY, LOW DRY STRENGTH, LOW TOUGHNESS; 25% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED GRAVEL; MAXIMUM SIZE, 35MM; MOIST, BROWN AND RED; HETEROGENEOUS, FINES CONTENT RANGES DOWN TO 10% IN IRREGULAR LENSES; CRUMBLES WITH MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SM).
15.0-16.5': SILTY SAND. APPROX. 50% PREDOMINANTLY MEDIUM TO FINE, HARD, SUBANGULAR TO SUBROUNDED SAND; 30% FINES WITH LOW PLASTICITY, SLOW DILATANCY, LOW DRY STRENGTH, LOW TOUGHNESS; 20% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED GRAVEL; MAXIMUM SIZE, 30MM; MOIST, BROWN; HETEROGENEOUS; CRUMBLES WITH MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SM).
19.7-21.2': CLAYEY SAND. APPROX. 40% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED SAND; 35% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED GRAVEL; 25% FINES WITH LOW PLASTICITY AND SLOW TO VERY SLOW DILATANCY; MAXIMUM SIZE, 35MM; MOIST, RED AND BROWN; HETEROGENEOUS, NUMEROUS CINDER FRAGMENTS PRESENT; CRUMBLES WITH MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SC).
25.2-26.7': SILTY SAND. APPROX. 45% COARSE TO FINE, HARD, SUBANGULAR TO SUBROUNDED SAND; 35% FINES WITH LOW PLASTICITY AND SLOW DILATANCY; 20% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED GRAVEL; MAXIMUM SIZE, 35MM; MOIST, TAN AND RED; HETEROGENEOUS, NUMEROUS CINDER FRAGMENTS PRESENT; CRUMBLES WITH MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SM).
30.1-31.6': SEE BELOW.
30.1-31.1': SILTY SAND. APPROX. 55% COARSE TO FINE, HARD, SUBANGULAR TO SUBROUNDED SAND; 25% FINES WITH LOW PLASTICITY AND SLOW DILATANCY; 20% COARSE TO FINE, HARD, SUBANGULAR TO SUBROUNDED GRAVEL; MAXIMUM SIZE, 25MM; MOIST, TAN AND RED; HETEROGENEOUS; CRUMBLES WITH MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SM).
31.1-31.6': SILTY GRAVEL. APPROX. 40% COARSE TO FINE, HARD, SUBANGULAR TO ROUNDED GRAVEL; 35% COARSE TO FINE, HARD, SUBANGULAR TO SUBROUNDED SAND; 15% FINES WITH LOW PLASTICITY AND QUICK DILATANCY; MAXIMUM SIZE, 35MM; WET, BROWN; HETEROGENEOUS; CRUMBLES WITH VERY LIGHT MANUAL PRESSURE; NO REACTION TO ACID (GM).
35.2-36.7': SILTY SAND. APPROX. 85% COARSE TO FINE, HARD, SUBANGULAR TO ROUNDED SAND; 15% FINES WITH LOW PLASTICITY AND QUICK DILATANCY; TRACE FINE, HARD, SUBANGULAR TO SUBROUNDED GRAVEL; MAXIMUM SIZE, 10MM; WET, GRAY; HETEROGE-

COMMENTS:

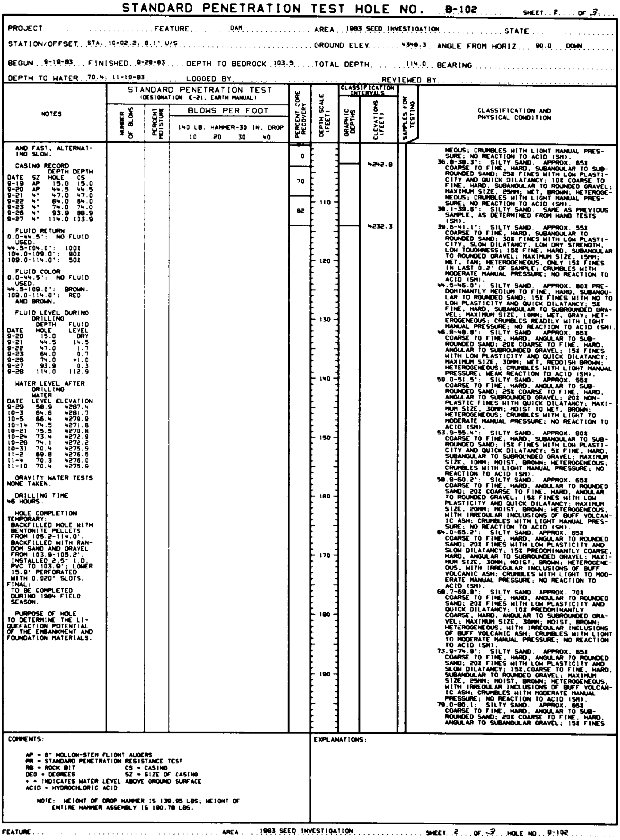
AP = 8" HOLLOW-STEM FLIGHT AUGERS
PR = STANDARD PENETRATION RESISTANCE TEST
RB = ROCK BIT CS = CASING
DEG = DEGREES SZ = SIZE OF CASING
+ = INDICATES WATER LEVEL ABOVE GROUND SURFACE
ACID = HYDROCHLORIC ACID

NOTE: WEIGHT OF DROP HAMMER IS 138.85 LBS; WEIGHT OF ENTIRE HAMMER ASSEMBLY IS 190.78 LBS.

EXPLANATIONS:

FEATURE .... AREA 1983 SEED INVESTIGATION SHEET 1 OF 3 HOLE NO. B-102

Figure 10-2.—Drill hole log, B-102, for Standard Penetration Test, sheet 1 of 3.



STANDARD PENETRATION TEST HOLE NO. B-102 SHEET 2 OF 3

PROJECT FEATURE DAM AREA 1983 SEED INVESTIGATION STATE
STATION/OFFSET STA. 10+02.2, 8.1' U/S GROUND ELEV. 4346.3 ANGLE FROM HORIZ 90.0 DOWN
BEGUN 9-19-83 FINISHED 9-28-83 DEPTH TO BEDROCK 103.5 TOTAL DEPTH 114.0 BEARING
DEPTH TO WATER 70.4; 11-10-83 LOGGED BY REVIEWED BY

NOTES	STANDARD PENETRATION TEST (DESIGNATION E-21, EARTH MANUAL) NUMBER OF BLOWS	PERCENT MOISTURE	BLOWS PER FOOT 140 LB. HAMMER-30 IN. DROP 10 20 30 40	PERCENT CORE RECOVERY	DEPTH SCALE (FEET)	CLASSIFICATION INTERVALS GRAPHIC DEPTHS	ELEVATIONS (FEET)	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
				0 70 82	110 120 130 140 150 160 170 180 190		4242.8 4232.3		

NOTES

AND FAST, ALTERNATING SLOW.

CASING RECORD

DATE	SZ	DEPTH HOLE	DEPTH CS
9-19	AP	15.0	15.0
9-20	AP	44.5	44.5
9-21	4"	47.0	47.0
9-22	4"	64.0	64.0
9-23	4"	74.0	74.0
9-26	4"	93.9	88.9
9-27	4"	114.0	103.9

FLUID RETURN
0.0-44.5': NO FLUID USED.
44.5-104.0': 100%
104.0-109.0': 90%
109.0-114.0': 50%

FLUID COLOR
0.0-44.5': NO FLUID USED.
44.5-109.0': BROWN.
109.0-114.0': RED AND BROWN.

FLUID LEVEL DURING DRILLING

DATE	DEPTH HOLE	FLUID LEVEL
9-20	15.0	DRY
9-21	44.5	14.5
9-22	47.0	1.7
9-23	64.0	0.7
9-26	74.0	+1.0
9-27	93.9	0.3
9-28	114.0	112.9

WATER LEVEL AFTER DRILLING

DATE	WATER LEVEL	ELEVATION
9-29	58.9	4287.4
10-3	64.6	4281.7
10-5	66.4	4279.9
10-14	74.5	4271.8
10-21	75.5	4270.8
10-24	73.4	4272.9
10-26	74.1	4272.2
10-31	70.4	4275.9
11-2	69.8	4276.5
11-4	70.3	4276.0
11-10	70.4	4275.9

GRAVITY WATER TESTS
NONE TAKEN.

DRILLING TIME
46 HOURS.

HOLE COMPLETION
TEMPORARY:
BACKFILLED HOLE WITH BENTONITE PELLETS FROM 105.2-114.0'.
BACKFILLED WITH RANDOM SAND AND GRAVEL FROM 103.9-105.2'.
INSTALLED 2.5" I.D. PVC TO 103.9'; LOWER 15.9' PERFORATED WITH 0.020" SLOTS.
FINAL:
TO BE COMPLETED DURING 1984 FIELD SEASON.

PURPOSE OF HOLE
TO DETERMINE THE LIQUEFACTION POTENTIAL OF THE EMBANKMENT AND FOUNDATION MATERIALS.

CLASSIFICATION AND PHYSICAL CONDITION

NEOUS; CRUMBLES WITH LIGHT MANUAL PRESSURE; NO REACTION TO ACID (SM).

36.8-38.3': SILTY SAND. APPROX. 65% COARSE TO FINE, HARD, SUBANGULAR TO SUBROUNDED SAND; 25% FINES WITH LOW PLASTICITY AND QUICK DILATANCY; 10% COARSE TO FINE, HARD, SUBANGULAR TO ROUNDED GRAVEL; MAXIMUM SIZE, 25MM; WET, BROWN; HETEROGENEOUS; CRUMBLES WITH LIGHT MANUAL PRESSURE; NO REACTION TO ACID (SM).

38.1-39.6': SILTY SAND. SAME AS PREVIOUS SAMPLE, AS DETERMINED FROM HAND TESTS (SM).

39.6-41.1': SILTY SAND. APPROX. 55% COARSE TO FINE, HARD, SUBANGULAR TO ROUNDED SAND; 30% FINES WITH LOW PLASTICITY, SLOW DILATANCY, LOW DRY STRENGTH, LOW TOUGHNESS; 15% FINE, HARD, SUBANGULAR TO ROUNDED GRAVEL; MAXIMUM SIZE, 15MM; WET, TAN; HETEROGENEOUS, ONLY 15% FINES IN LAST 0.2' OF SAMPLE; CRUMBLES WITH MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SM).

44.5-46.0': SILTY SAND. APPROX. 80% PREDOMINANTLY MEDIUM TO FINE, HARD, SUBANGULAR TO ROUNDED SAND; 15% FINES WITH NO TO LOW PLASTICITY AND QUICK DILATANCY; 5% FINE, HARD, SUBANGULAR TO SUBROUNDED GRAVEL; MAXIMUM SIZE, 10MM; WET, GRAY; HETEROGENEOUS; CRUMBLES READILY WITH LIGHT MANUAL PRESSURE; NO REACTION TO ACID (SM).

46.8-48.8': SILTY SAND. APPROX. 65% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED SAND; 20% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED GRAVEL; 15% FINES WITH LOW PLASTICITY AND QUICK DILATANCY; MAXIMUM SIZE, 30MM; WET, REDDISH BROWN; HETEROGENEOUS; CRUMBLES WITH LIGHT MANUAL PRESSURE; WEAK REACTION TO ACID (SM).

50.0-51.5': SILTY SAND. APPROX. 55% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED SAND; 25% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED GRAVEL; 20% NONPLASTIC FINES WITH QUICK DILATANCY; MAXIMUM SIZE, 30MM; MOIST TO WET, BROWN; HETEROGENEOUS; CRUMBLES WITH LIGHT TO MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SM).

53.9-55.4': SILTY SAND. APPROX. 80% COARSE TO FINE, HARD, SUBANGULAR TO SUBROUNDED SAND; 15% FINES WITH LOW PLASTICITY AND QUICK DILATANCY; 5% FINE, HARD, SUBANGULAR TO SUBROUNDED GRAVEL; MAXIMUM SIZE, 10MM; MOIST, BROWN; HETEROGENEOUS; CRUMBLES WITH LIGHT MANUAL PRESSURE; NO REACTION TO ACID (SM).

58.9-60.2': SILTY SAND. APPROX. 65% COARSE TO FINE, HARD, ANGULAR TO ROUNDED SAND; 20% COARSE TO FINE, HARD, ANGULAR TO ROUNDED GRAVEL; 15% FINES WITH LOW PLASTICITY AND QUICK DILATANCY; MAXIMUM SIZE, 20MM; MOIST, BROWN; HETEROGENEOUS, WITH IRREGULAR INCLUSIONS OF BUFF VOLCANIC ASH; CRUMBLES WITH LIGHT MANUAL PRESSURE; NO REACTION TO ACID (SM).

64.0-65.2': SILTY SAND. APPROX. 65% COARSE TO FINE, HARD, ANGULAR TO ROUNDED SAND; 20% FINES WITH LOW PLASTICITY AND SLOW DILATANCY; 15% PREDOMINANTLY COARSE, HARD, ANGULAR TO SUBROUNDED GRAVEL; MAXIMUM SIZE, 30MM; MOIST, BROWN; HETEROGENEOUS, WITH IRREGULAR INCLUSIONS OF BUFF VOLCANIC ASH; CRUMBLES WITH LIGHT TO MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SM).

68.7-69.8': SILTY SAND. APPROX. 70% COARSE TO FINE, HARD, ANGULAR TO ROUNDED SAND; 20% FINES WITH LOW PLASTICITY AND QUICK DILATANCY; 10% PREDOMINANTLY COARSE, HARD, ANGULAR TO SUBROUNDED GRAVEL; MAXIMUM SIZE, 30MM; MOIST, BROWN; HETEROGENEOUS, WITH IRREGULAR INCLUSIONS OF BUFF VOLCANIC ASH; CRUMBLES WITH LIGHT TO MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SM).

73.9-74.9': SILTY SAND. APPROX. 65% COARSE TO FINE, HARD, ANGULAR TO ROUNDED SAND; 20% FINES WITH LOW PLASTICITY AND SLOW DILATANCY; 15% COARSE TO FINE, HARD, SUBANGULAR TO ROUNDED GRAVEL; MAXIMUM SIZE, 25MM; MOIST, BROWN; HETEROGENEOUS, WITH IRREGULAR INCLUSIONS OF BUFF VOLCANIC ASH; CRUMBLES WITH MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SM).

79.0-80.1: SILTY SAND. APPROX. 65% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED SAND; 20% COARSE TO FINE, HARD, ANGULAR TO SUBANGULAR GRAVEL; 15% FINES

COMMENTS:

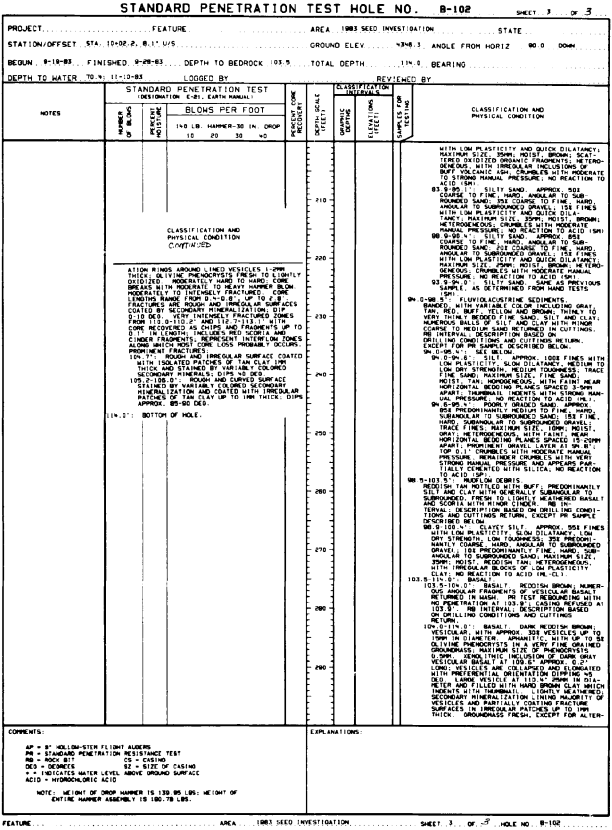
AP = 8" HOLLOW-STEM FLIGHT AUGERS
PR = STANDARD PENETRATION RESISTANCE TEST
RB = ROCK BIT CS = CASING
DEG = DEGREES SZ = SIZE OF CASING
+ = INDICATES WATER LEVEL ABOVE GROUND SURFACE
ACID = HYDROCHLORIC ACID

NOTE: WEIGHT OF DROP HAMMER IS 139.95 LBS; WEIGHT OF ENTIRE HAMMER ASSEMBLY IS 190.78 LBS.

EXPLANATIONS:

FEATURE AREA 1983 SEED INVESTIGATION SHEET 2 OF 3 HOLE NO. B-102

Figure 10-2.—Drill hole log, B-102, for Standard Penetration Test, sheet 2 of 3.



STANDARD PENETRATION TEST HOLE NO. B-102 SHEET 3 OF 3

PROJECT ... FEATURE ... AREA 1983 SEED INVESTIGATION ... STATE ...

STATION/OFFSET STA. 10+02.2, 8.1' U/S ... GROUND ELEV. 4348.3 ANGLE FROM HORIZ 90.0 DOWN

BEGUN 9-19-83 FINISHED 9-28-83 DEPTH TO BEDROCK 103.5 TOTAL DEPTH 114.0 BEARING ...

DEPTH TO WATER 70.4; 11-10-83 LOGGED BY ... REVIEWED BY ...

NOTES	STANDARD PENETRATION TEST (DESIGNATION E-21, EARTH MANUAL)			PERCENT CORE RECOVERY	DEPTH SCALE (FEET)	CLASSIFICATION INTERVALS		SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
	NUMBER OF BLOWS	PERCENT MOISTURE	BLOWS PER FOOT 140 LB. HAMMER-30 IN. DROP 10 20 30 40			GRAPHIC DEPTHS	ELEVATIONS (FEET)		

WITH LOW PLASTICITY AND QUICK DILATANCY; MAXIMUM SIZE, 35MM; MOIST, BROWN; SCATTERED OXIDIZED ORGANIC FRAGMENTS; HETEROGENEOUS, WITH IRREGULAR INCLUSIONS OF BUFF VOLCANIC ASH; CRUMBLES WITH MODERATE TO STRONG MANUAL PRESSURE; NO REACTION TO ACID (SM).

83.9-85.1': SILTY SAND. APPROX. 50% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED SAND; 35% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED GRAVEL; 15% FINES WITH LOW PLASTICITY AND QUICK DILATANCY; MAXIMUM SIZE, 35MM; MOIST, BROWN; HETEROGENEOUS; CRUMBLES WITH MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SM)

88.9-90.4': SILTY SAND. APPROX. 65% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED SAND; 20% COARSE TO FINE, HARD, ANGULAR TO SUBROUNDED GRAVEL; 15% FINES WITH LOW PLASTICITY AND QUICK DILATANCY; MAXIMUM SIZE, 25MM; MOIST, BROWN; HETEROGENEOUS; CRUMBLES WITH MODERATE MANUAL PRESSURE; NO REACTION TO ACID (SM).

93.9-94.0': SILTY SAND. SAME AS PREVIOUS SAMPLE, AS DETERMINED FROM HAND TESTS (SM).

94.0-98.5': FLUVIOLACUSTRINE SEDIMENTS. BANDED, WITH VARIABLE COLOR INCLUDING GRAY, TAN, RED, BUFF, YELLOW AND BROWN; THINLY TO VERY THINLY BEDDED FINE SAND, SILT AND CLAY; NUMEROUS BALLS OF SILT AND CLAY WITH MINOR COARSE TO MEDIUM SAND RETURNED IN CUTTINGS. RB INTERVAL; DESCRIPTION BASED ON DRILLING CONDITIONS AND CUTTINGS RETURN, EXCEPT FOR PR SAMPLE DESCRIBED BELOW.

94.0-95.4': SEE BELOW.

94.0-94.6': SILT. APPROX. 100% FINES WITH LOW PLASTICITY, SLOW DILATANCY, MEDIUM TO LOW DRY STRENGTH, MEDIUM TOUGHNESS; TRACE FINE SAND; MAXIMUM SIZE, FINE SAND; MOIST, TAN; HOMOGENEOUS, WITH FAINT NEAR HORIZONTAL BEDDING PLANES SPACED 3-5MM APART; THUMBNAIL INDENTS WITH STRONG MANUAL PRESSURE; NO REACTION TO ACID (ML).

94.6-95.4': POORLY GRADED SAND. APPROX. 85% PREDOMINANTLY MEDIUM TO FINE, HARD, SUBANGULAR TO SUBROUNDED SAND; 15% FINE, HARD, SUBANGULAR TO SUBROUNDED GRAVEL; TRACE FINES; MAXIMUM SIZE, 10MM; MOIST, GRAY; HETEROGENEOUS, WITH FAINT, NEAR HORIZONTAL BEDDING PLANES SPACED 15-20MM APART; PROMINENT GRAVEL LAYER AT 94.8'; TOP 0.1' CRUMBLES WITH MODERATE MANUAL PRESSURE, REMAINDER CRUMBLES WITH VERY STRONG MANUAL PRESSURE AND APPEARS PARTIALLY CEMENTED WITH SILICA; NO REACTION TO ACID (SP).

98.5-103.5': MUDFLOW DEBRIS. REDDISH TAN MOTTLED WITH BUFF; PREDOMINANTLY SILT AND CLAY WITH GENERALLY SUBANGULAR TO SUBROUNDED, FRESH TO LIGHTLY WEATHERED BASALT AND SCORIA WITH MINOR CINDER. RB INTERVAL; DESCRIPTION BASED ON DRILLING CONDITIONS AND CUTTINGS RETURN, EXCEPT PR SAMPLE DESCRIBED BELOW.

98.9-100.4': CLAYEY SILT. APPROX. 55% FINES WITH LOW PLASTICITY, SLOW DILATANCY, LOW DRY STRENGTH, LOW TOUGHNESS; 35% PREDOMINANTLY COARSE, HARD, ANGULAR TO SUBROUNDED GRAVEL; 10% PREDOMINANTLY FINE, HARD, SUBANGULAR TO SUBROUNDED SAND; MAXIMUM SIZE, 35MM; MOIST, REDDISH TAN; HETEROGENEOUS, WITH IRREGULAR BLOCKS OF LOW PLASTICITY CLAY; NO REACTION TO ACID (ML-CL).

103.5-114.0': BASALT.

103.5-104.0': BASALT. REDDISH BROWN; NUMEROUS ANGULAR FRAGMENTS OF VESICULAR BASALT RETURNED IN WASH. PR TEST REBOUNDING WITH NO PENETRATION AT 103.9'; CASING REFUSED AT 103.9'. RB INTERVAL; DESCRIPTION BASED ON DRILLING CONDITIONS AND CUTTINGS RETURN.

104.0-114.0': BASALT. DARK REDDISH BROWN; VESICULAR, WITH APPROX. 30% VESICLES UP TO 15MM IN DIAMETER. APHANITIC, WITH UP TO 5% OLIVINE PHENOCRYSTS IN A VERY FINE GRAINED GROUNDMASS; MAXIMUM SIZE OF PHENOCRYSTS 0.5MM. XENOLITHIC INCLUSION OF DARK GRAY VESICULAR BASALT AT 109.6' APPROX. 0.2' LONG; VESICLES ARE COLLAPSED AND ELONGATED WITH PREFERENTIAL ORIENTATION DIPPING 45 DEG. LARGE VESICLE AT 110.4' 25MM IN DIAMETER AND FILLED WITH HARD BROWN CLAY WHICH INDENTS WITH THUMBNAIL. LIGHTLY WEATHERED; SECONDARY MINERALIZATION LINING MAJORITY OF VESICLES AND PARTIALLY COATING FRACTURE SURFACES IN IRREGULAR PATCHES UP TO 1MM THICK. GROUNDMASS FRESH, EXCEPT FOR ALTER-

CLASSIFICATION AND PHYSICAL CONDITION
CONTINUED

ATION RINGS AROUND LINED VESICLES 1-2MM THICK; OLIVINE PHENOCRYSTS FRESH TO LIGHTLY OXIDIZED. MODERATELY HARD TO HARD; CORE BREAKS WITH MODERATE TO HEAVY HAMMER BLOW. MODERATELY TO INTENSELY FRACTURED. CORE LENGTHS RANGE FROM 0.4-0.8', UP TO 2.8'. FRACTURES ARE ROUGH AND IRREGULAR SURFACES COATED BY SECONDARY MINERALIZATION; DIP 0-10 DEG. VERY INTENSELY FRACTURED ZONES FROM 110.0-110.2' AND 112.7-113.1' WITH CORE RECOVERED AS CHIPS AND FRAGMENTS UP TO 0.1' IN LENGTH; INCLUDES RED SCORIA AND CINDER FRAGMENTS; REPRESENT INTERFLOW ZONES ALONG WHICH MOST CORE LOSS PROBABLY OCCURS.

PROMINENT FRACTURES:

104.7': ROUGH AND IRREGULAR SURFACE COATED WITH ISOLATED PATCHES OF TAN CLAY 1MM THICK AND STAINED BY VARIABLY COLORED SECONDARY MINERALS; DIPS 40 DEG.

105.2-108.0': ROUGH AND CURVED SURFACE STAINED BY VARIABLY COLORED SECONDARY MINERALIZATION AND COATED WITH IRREGULAR PATCHES OF TAN CLAY UP TO 1MM THICK; DIPS APPROX. 85-90 DEG.

114.0': BOTTOM OF HOLE.

COMMENTS:

AP = 8" HOLLOW-STEM FLIGHT AUGERS
PR = STANDARD PENETRATION RESISTANCE TEST
RB = ROCK BIT CS = CASING
DEG = DEGREES SZ = SIZE OF CASING
+ = INDICATES WATER LEVEL ABOVE GROUND SURFACE
ACID = HYDROCHLORIC ACID

NOTE: WEIGHT OF DROP HAMMER IS 139.85 LBS; WEIGHT OF ENTIRE HAMMER ASSEMBLY IS 180.78 LBS.

EXPLANATIONS:

FEATURE ... AREA 1983 SEED INVESTIGATION ... SHEET 3 OF 3 HOLE NO. B-102

Figure 10-2.—Drill hole log, B-102, for Standard Penetration Test, sheet 3 of 3.

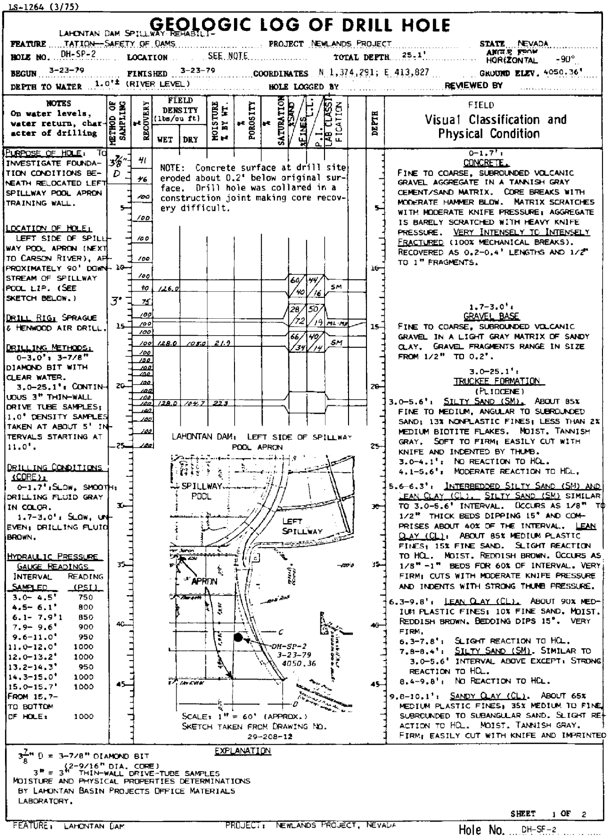
hole number, location, coordinates, elevation, bearing and plunge of hole, dates started and completed, and the name(s) of the person(s) responsible for logging and review. Locations should preferably be in coordinates unless station and offset are all that is available.

Provide both coordinates and station and offset if available. The dip or plunge of the hole can be the angle from horizontal or from vertical, but the reference point should be noted on the log. Spaces for depth to bedrock and water levels are also provided. All this information is important and should not be omitted. Below the heading, the body of the log form is divided into a series of columns covering the various kinds of information required according to the type of exploratory hole.

Data Required for the "Drilling Notes" Column

Data for the left-hand column of all drill hole logs are similar whether for large-diameter sampling, Standard Penetration Tests, rock core, or push-tube sampling logs. These data are field observations and information provided by the driller on the Daily Drill Reports. Examples are provided for some of these data headings; a suggested guideline and preferred order is presented in the following paragraphs but may differ depending on the purpose and type of exploration. Headers for data can indicate whether depths are in feet (ft) or meters (m), eliminating the need to repeat "ft" or "m" for each interval entry. An example of the Drilling Notes column is provided on figures 10-1 through 10-4.

General Information.—This includes headers and data for the hole purpose, the setup or site conditions, drillers, and drilling and testing equipment used.



LS-1264 (3/75)

GEOLOGIC LOG OF DRILL HOLE

FEATURE LAHONTAN DAM SPILLWAY REHABILITATION—SAFETY OF DAMS PROJECT NEWLANDS PROJECT STATE NEVADA
HOLE NO. DH-SP-2 LOCATION SEE NOTE TOTAL DEPTH 25.1' ANGLE FROM HORIZONTAL -90°
BEGUN 3-23-79 FINISHED 3-23-79 COORDINATES N 1,374,291; E 413,827 GROUND ELEV. 4050.36'
DEPTH TO WATER 1.0'± (RIVER LEVEL) HOLE LOGGED BY REVIEWED BY

NOTES On water levels, water return, character of drilling

PURPOSE OF HOLE: TO INVESTIGATE FOUNDATION CONDITIONS BENEATH RELOCATED LEFT SPILLWAY POOL APRON TRAINING WALL.

LOCATION OF HOLE: LEFT SIDE OF SPILLWAY POOL APRON (NEXT TO CARSON RIVER), APPROXIMATELY 90' DOWNSTREAM OF SPILLWAY POOL LIP. (SEE SKETCH BELOW.)

DRILL RIG: SPRAGUE & HENWOOD AIR DRILL.

DRILLING METHODS:
0-3.0': 3-7/8" DIAMOND BIT WITH CLEAR WATER.
3.0-25.1': CONTINUOUS 3" THIN-WALL DRIVE TUBE SAMPLES; 1.0' DENSITY SAMPLES TAKEN AT ABOUT 5' INTERVALS STARTING AT 11.0'.

DRILLING CONDITIONS (CORE):
0-1.7': SLOW, SMOOTH; DRILLING FLUID GRAY IN COLOR.
1.7-3.0': SLOW, UNEVEN; DRILLING FLUID BROWN.

HYDRAULIC PRESSURE GAUGE READINGS

INTERVAL SAMPLED	READING (PSI)
3.0- 4.5'	750
4.5- 6.1'	800
6.1- 7.9'1	850
7.9- 9.6'	900
9.6-11.0'	950
11.0-12.0'	1000
12.0-13.2'	1000
13.2-14.3'	950
14.3-15.0'	1000
15.0-15.7'	1000
FROM 15.7- TO BOTTOM OF HOLE:	1000

METHOD OF SAMPLING	% RECOVERY	FIELD DENSITY (lbs/cu ft) WET	FIELD DENSITY (lbs/cu ft) DRY	MOISTURE % BY WT.	% POROSITY	% SATURATION	%SAND / %FINES	L.L. / P.I.	LAB CLASSIFICATION
3⅞" D	41								
	46								
	100								
	100								
	100								
	100								
	100								
	90	126.0					60/40	44/16	SM
3"	75								
	100						28/72	50/19	ML-MH
	100								
	100								
	100	128.0	105.0	21.9			66/34	40/14	SM
	100								
	100								
	100								
	100								
	100								
	100								
	100								
	100	128.0	104.7	22.3					
	100								
	100								
	100								
	100								

NOTE: Concrete surface at drill site eroded about 0.2' below original surface. Drill hole was collared in a construction joint making core recovery difficult.

LAHONTAN DAM: LEFT SIDE OF SPILLWAY POOL APRON

SCALE: 1" = 60' (APPROX.)
SKETCH TAKEN FROM DRAWING NO. 29-208-12

FIELD
Visual Classification and Physical Condition

0-1.7':
CONCRETE.
FINE TO COARSE, SUBROUNDED VOLCANIC GRAVEL AGGREGATE IN A TANNISH GRAY CEMENT/SAND MATRIX. CORE BREAKS WITH MODERATE HAMMER BLOW. MATRIX SCRATCHES WITH MODERATE KNIFE PRESSURE; AGGREGATE IS BARELY SCRATCHED WITH HEAVY KNIFE PRESSURE. VERY INTENSELY TO INTENSELY FRACTURED (100% MECHANICAL BREAKS). RECOVERED AS 0.2-0.4' LENGTHS AND 1/2" TO 1" FRAGMENTS.

1.7-3.0':
GRAVEL BASE
FINE TO COARSE, SUBROUNDED VOLCANIC GRAVEL IN A LIGHT GRAY MATRIX OF SANDY CLAY. GRAVEL FRAGMENTS RANGE IN SIZE FROM 1/2" TO 0.2'.

3.0-25.1':
TRUCKEE FORMATION
(PLIOCENE)

3.0-5.6': SILTY SAND (SM). ABOUT 85% FINE TO MEDIUM, ANGULAR TO SUBROUNDED SAND; 13% NONPLASTIC FINES; LESS THAN 2% MEDIUM BIOTITE FLAKES. MOIST. TANNISH GRAY. SOFT TO FIRM; EASILY CUT WITH KNIFE AND INDENTED BY THUMB.
3.0-4.1': NO REACTION TO HCL.
4.1-5.6': MODERATE REACTION TO HCL.

5.6-6.3': INTERBEDDED SILTY SAND (SM) AND LEAN CLAY (CL). SILTY SAND (SM) SIMILAR TO 3.0-5.6' INTERVAL. OCCURS AS 1/8" TO 1/2" THICK BEDS DIPPING 15° AND COMPRISES ABOUT 40% OF THE INTERVAL. LEAN CLAY (CL): ABOUT 85% MEDIUM PLASTIC FINES; 15% FINE SAND. SLIGHT REACTION TO HCL. MOIST. REDDISH BROWN. OCCURS AS 1/8"-1" BEDS FOR 60% OF INTERVAL. VERY FIRM; CUTS WITH MODERATE KNIFE PRESSURE AND INDENTS WITH STRONG THUMB PRESSURE.

6.3-9.8': LEAN CLAY (CL). ABOUT 90% MEDIUM PLASTIC FINES; 10% FINE SAND. MOIST. REDDISH BROWN. BEDDING DIPS 15°. VERY FIRM.
6.3-7.8': SLIGHT REACTION TO HCL.
7.8-8.4': SILTY SAND (SM). SIMILAR TO 3.0-5.6' INTERVAL ABOVE EXCEPT: STRONG REACTION TO HCL.
8.4-9.8': NO REACTION TO HCL.

9.8-10.1': SANDY CLAY (CL). ABOUT 65% MEDIUM PLASTIC FINES; 35% MEDIUM TO FINE, SUBROUNDED TO SUBANGULAR SAND. SLIGHT REACTION TO HCL. MOIST. TANNISH GRAY. FIRM; EASILY CUT WITH KNIFE AND IMPRINTED

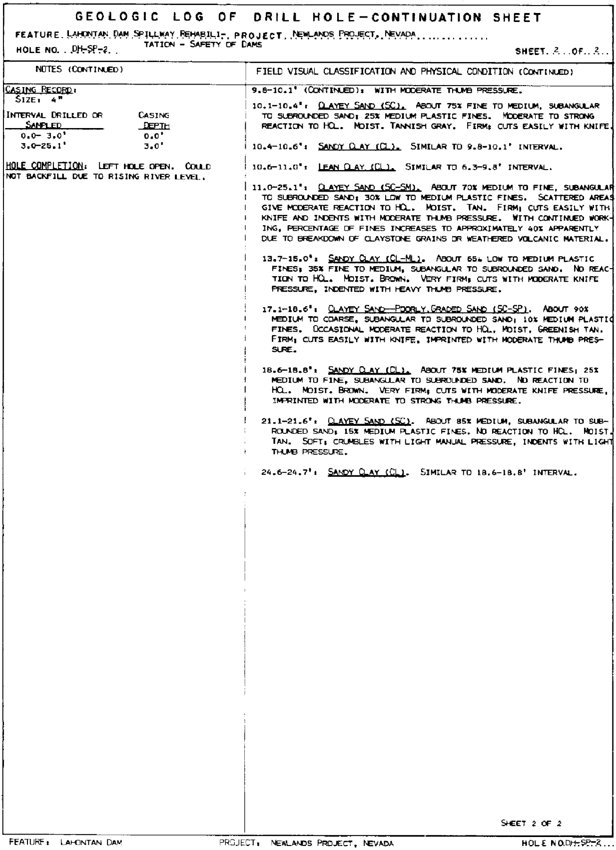
EXPLANATION

3⅞" D = 3-7/8" DIAMOND BIT (2-9/16" DIA. CORE)
3" = 3" THIN-WALL DRIVE-TUBE SAMPLES
MOISTURE AND PHYSICAL PROPERTIES DETERMINATIONS BY LAHONTAN BASIN PROJECTS OFFICE MATERIALS LABORATORY.

SHEET 1 OF 2

FEATURE: LAHONTAN DAM PROJECT: NEWLANDS PROJECT, NEVADA Hole No. DH-SP-2

Figure 10-3.—Drill hole log, DH-SP-2, sheet 1 of 2.



GEOLOGIC LOG OF DRILL HOLE—CONTINUATION SHEET

FEATURE. LAHONTAN DAM SPILLWAY REHABILI-TATION - SAFETY OF DAMS PROJECT. NEWLANDS PROJECT, NEVADA

HOLE NO. DH-SP-2 SHEET 2 OF 2

NOTES (CONTINUED)

CASING RECORD:

SIZE: 4"

INTERVAL DRILLED OR SAMPLED	CASING DEPTH
0.0- 3.0'	0.0'
3.0-25.1'	3.0'

HOLE COMPLETION: LEFT HOLE OPEN. COULD NOT BACKFILL DUE TO RISING RIVER LEVEL.

FIELD VISUAL CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)

9.8-10.1' (CONTINUED): WITH MODERATE THUMB PRESSURE.

10.1-10.4': CLAYEY SAND (SC). ABOUT 75% FINE TO MEDIUM, SUBANGULAR TO SUBROUNDED SAND; 25% MEDIUM PLASTIC FINES. MODERATE TO STRONG REACTION TO HCL. MOIST. TANNISH GRAY. FIRM; CUTS EASILY WITH KNIFE.

10.4-10.6': SANDY CLAY (CL). SIMILAR TO 9.8-10.1' INTERVAL.

10.6-11.0': LEAN CLAY (CL). SIMILAR TO 6.3-9.8' INTERVAL.

11.0-25.1': CLAYEY SAND (SC-SM). ABOUT 70% MEDIUM TO FINE, SUBANGULAR TO SUBROUNDED SAND; 30% LOW TO MEDIUM PLASTIC FINES. SCATTERED AREAS GIVE MODERATE REACTION TO HCL. MOIST. TAN. FIRM; CUTS EASILY WITH KNIFE AND INDENTS WITH MODERATE THUMB PRESSURE. WITH CONTINUED WORKING, PERCENTAGE OF FINES INCREASES TO APPROXIMATELY 40% APPARENTLY DUE TO BREAKDOWN OF CLAYSTONE GRAINS OR WEATHERED VOLCANIC MATERIAL.

13.7-15.0': SANDY CLAY (CL-ML). ABOUT 65% LOW TO MEDIUM PLASTIC FINES; 35% FINE TO MEDIUM, SUBANGULAR TO SUBROUNDED SAND. NO REACTION TO HCL. MOIST. BROWN. VERY FIRM; CUTS WITH MODERATE KNIFE PRESSURE, INDENTED WITH HEAVY THUMB PRESSURE.

17.1-18.6': CLAYEY SAND—POORLY GRADED SAND (SC-SP). ABOUT 90% MEDIUM TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 10% MEDIUM PLASTIC FINES. OCCASIONAL MODERATE REACTION TO HCL, MOIST, GREENISH TAN. FIRM; CUTS EASILY WITH KNIFE, IMPRINTED WITH MODERATE THUMB PRESSURE.

18.6-18.8': SANDY CLAY (CL). ABOUT 75% MEDIUM PLASTIC FINES; 25% MEDIUM TO FINE, SUBANGULAR TO SUBROUNDED SAND. NO REACTION TO HCL. MOIST. BROWN. VERY FIRM; CUTS WITH MODERATE KNIFE PRESSURE, IMPRINTED WITH MODERATE TO STRONG THUMB PRESSURE.

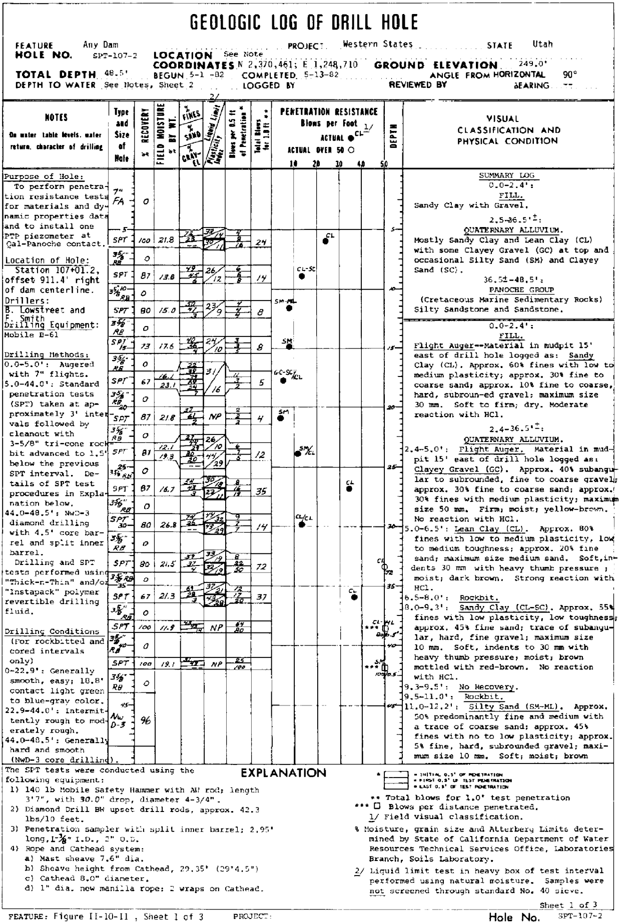
21.1-21.6': CLAYEY SAND (SC). ABOUT 85% MEDIUM, SUBANGULAR TO SUBROUNDED SAND; 15% MEDIUM PLASTIC FINES. NO REACTION TO HCL. MOIST. TAN. SOFT; CRUMBLES WITH LIGHT MANUAL PRESSURE, INDENTS WITH LIGHT THUMB PRESSURE.

24.6-24.7': SANDY CLAY (CL). SIMILAR TO 18.6-18.8' INTERVAL.

SHEET 2 OF 2

FEATURE: LAHONTAN DAM PROJECT: NEWLANDS PROJECT, NEVADA HOLE NO. DH-SP-2

Figure 10-3.—Drill hole log, DH-SP-2, sheet 2 of 2.



GEOLOGIC LOG OF DRILL HOLE

FEATURE Any Dam PROJECT Western States STATE Utah
HOLE NO. SPT-107-2 LOCATION See Note
COORDINATES N 2,370,461; E 1,248,710 GROUND ELEVATION 249.0'
TOTAL DEPTH 48.5' BEGUN 5-1-82 COMPLETED 5-13-82 ANGLE FROM HORIZONTAL 90°
DEPTH TO WATER See Notes, Sheet 2 LOGGED BY REVIEWED BY BEARING --

NOTES On water table levels, water return, character of drilling

Purpose of Hole:
To perform penetration resistance tests for materials and dynamic properties data and to install one PTP piezometer at Qal-Panoche contact.

Location of Hole:
Station 107+01.2, offset 911.4' right of dam centerline.

Drillers:
B. Lowstreet and F. Smith

Drilling Equipment:
Mobile B-61

Drilling Methods:
0.0-5.0': Augered with 7" flights.
5.0-44.0': Standard penetration tests (SPT) taken at approximately 3' intervals followed by cleanout with 3-5/8" tri-cone rock bit advanced to 1.5' below the previous SPT interval. Details of SPT test procedures in Explanation below.
44.0-48.5': NwD-3 diamond drilling with 4.5' core barrel and split inner barrel.
Drilling and SPT tests performed using "Thick-n-Thin" and/or "Instapack" polymer revertible drilling fluid.

Drilling Conditions
(For rockbitted and cored intervals only)
0-22.9': Generally smooth, easy; 18.8' contact light green to blue-gray color.
22.9-44.0': Intermittently rough to moderately rough.
44.0-48.5': Generally hard and smooth (NwD-3 core drilling).

Type and Size of Hole	% Recovery	Field Moisture % by Wt.	% Fines / % Sand / % Gravel	Liquid Limit / Plasticity Index 2/	Blows per 0.5 ft of Penetration *	Total Blows for 1.0 ft **	Penetration Resistance, Blows per Foot 1/
7" FA	0						
SPT	100	21.8	72 28 --	33/14 30/11	4 8 16	24	CL ●
3⅝" RB	0						
SPT	87	13.8	49 45 6	26/12	6 6 8	14	CL-SC ●
3⅝" RB	0						
SPT	80	15.0	55 42 3	23/9	4 4 4	8	SM-ML ●
3⅝" RB	0						
SPT	73	17.6	40 56 4	24/10	3 3 5	8	SM ●
3⅝" RB	0						
SPT	67	16.1 23.1	22 38 [illegible] 69 24 7	31/16	11 3 2	5	GC-SC/CL ●
3⅝" RB	0						
SPT	87	21.8	37 61 2	NP	2 2 2	4	SM ●
3⅝" RB	0						
SPT	81	12.1 19.3	27 44 29 80 20 --	26/10 44/29	6 7 5	12	SM/CL ●
3⅝" RB	0						
SPT	87	16.7	54 43 3	30/18 27/11	8 16 19	35	CL ●
3⅝" RB	0						
SPT	80	26.8	74 26 --	44/32 43/29	9 7 7	14	CL/CL ●
3⅝" RB	0						
SPT	80	21.5	59 37 4	33/19 32/19	8 22 50	72	CL ○ 72
3⅝" RB	0						
SPT	67	21.3	69 28 3	37/21 43/28	12 17 20	37	CL ●
3⅝" RB	0						
SPT	100	11.9	53 33 14	NP	64 80		CL-ML *** □ 80/0.5'
3⅝" RB	0						
SPT	100	19.1	51 49 --	NP	25 100		SM *** □ 100/0.5'
3⅝" RB	0						
NwD-3	96						

VISUAL CLASSIFICATION AND PHYSICAL CONDITION

SUMMARY LOG
0.0-2.4':
FILL.
Sandy Clay with Gravel.

2.5-36.5'±:
QUATERNARY ALLUVIUM.
Mostly Sandy Clay and Lean Clay (CL) with some Clayey Gravel (GC) at top and occasional Silty Sand (SM) and Clayey Sand (SC).

36.5±-48.5':
PANOCHE GROUP
(Cretaceous Marine Sedimentary Rocks)
Silty Sandstone and Sandstone.

0.0-2.4':
FILL.
Flight Auger--Material in mudpit 15' east of drill hole logged as: Sandy Clay (CL). Approx. 60% fines with low to medium plasticity; approx. 30% fine to coarse sand; approx. 10% fine to coarse, hard, subroun-ed gravel; maximum size 30 mm. Soft to firm; dry. Moderate reaction with HCl.

2.4-36.5'±:
QUATERNARY ALLUVIUM.
2.4-5.0': Flight Auger. Material in mudpit 15' east of drill hole logged as: Clayey Gravel (GC). Approx. 40% subangular to subrounded, fine to coarse gravel; approx. 30% fine to coarse sand; approx. 30% fines with medium plasticity; maximum size 50 mm. Firm; moist; yellow-brown. No reaction with HCl.
5.0-6.5': Lean Clay (CL). Approx. 80% fines with low to medium plasticity, low to medium toughness; approx. 20% fine sand; maximum size medium sand. Soft, indents 30 mm with heavy thumb pressure; moist; dark brown. Strong reaction with HCl.
6.5-8.0': Rockbit.
8.0-9.3': Sandy Clay (CL-SC). Approx. 55% fines with low plasticity, low toughness; approx. 45% fine sand; trace of subangular, hard, fine gravel; maximum size 10 mm. Soft, indents to 30 mm with heavy thumb pressure; moist; brown mottled with red-brown. No reaction with HCl.
9.3-9.5': No Recovery.
9.5-11.0': Rockbit.
11.0-12.2': Silty Sand (SM-ML). Approx. 50% predominantly fine and medium with a trace of coarse sand; approx. 45% fines with no to low plasticity; approx. 5% fine, hard, subrounded gravel; maximum size 10 mm. Soft; moist; brown

EXPLANATION

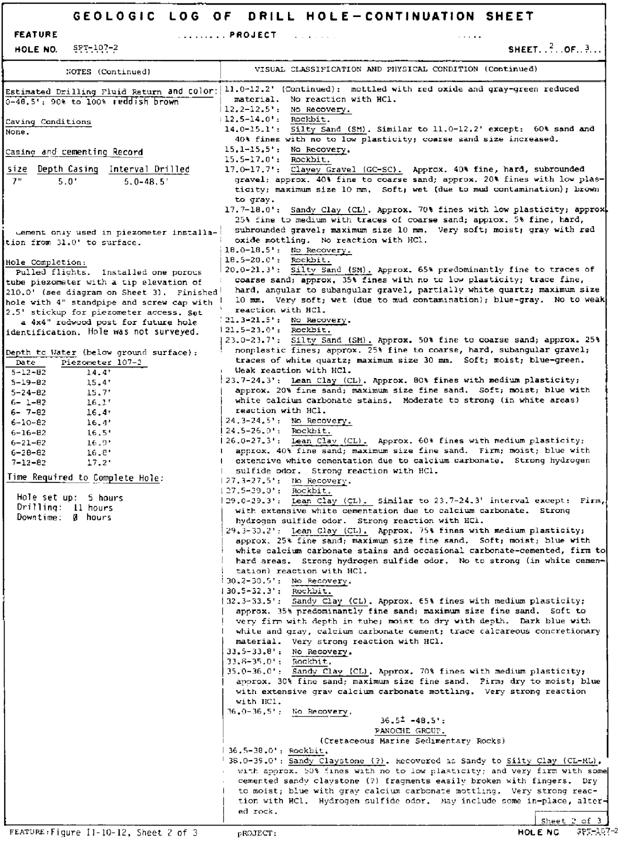
The SPT tests were conducted using the following equipment:
1) 140 lb Mobile Safety Hammer with AW rod; length 3'7", with 30.0" drop, diameter 4-3/4".
2) Diamond Drill BW upset drill rods, approx. 42.3 lbs/10 feet.
3) Penetration sampler with split inner barrel; 2.95' long, 1-3/8" I.D., 2" O.D.
4) Rope and Cathead system:
   a) Mast sheave 7.6" dia.
   b) Sheave height from Cathead, 29.35' (29'4.5")
   c) Cathead 8.0" diameter.
   d) 1" dia. new manilla rope: 2 wraps on Cathead.

* = INITIAL 0.5' OF PENETRATION
= FIRST 0.5' OF TEST PENETRATION
= LAST 0.5' OF TEST PENETRATION
** Total blows for 1.0' test penetration
*** □ Blows per distance penetrated.
1/ Field visual classification.
% Moisture, grain size and Atterberg Limits determined by State of California Department of Water Resources Technical Services Office, Laboratories Branch, Soils Laboratory.
2/ Liquid limit test in heavy box of test interval performed using natural moisture. Samples were not screened through standard No. 40 sieve.

Sheet 1 of 3

FEATURE: Figure II-10-11, Sheet 1 of 3 PROJECT: Hole No. SPT-107-2

Figure 10-4.—Drill hole log, SPT-107-2, sheet 1 of 3.



GEOLOGIC LOG OF DRILL HOLE—CONTINUATION SHEET

FEATURE .... PROJECT ....

HOLE NO. SPT-107-2

SHEET..2..OF..3...

NOTES (Continued)

Estimated Drilling Fluid Return and color:
0-48.5': 90% to 100% reddish brown

Caving Conditions
None.

Casing and cementing Record

size	Depth Casing	Interval Drilled
7"	5.0'	5.0-48.5'

Cement only used in piezometer installation from 31.0' to surface.

Hole Completion:
Pulled flights. Installed one porous tube piezometer with a tip elevation of 210.0' (see diagram on Sheet 3). Finished hole with 4" standpipe and screw cap with 2.5' stickup for piezometer access. Set a 4x4" redwood post for future hole identification. Hole was not surveyed.

Depth to Water (below ground surface):

Date	Piezometer 107-2
5-12-82	14.4'
5-19-82	15.4'
5-24-82	15.7'
6- 1-82	16.1'
6- 7-82	16.4'
6-10-82	16.4'
6-16-82	16.5'
6-21-82	16.9'
6-28-82	16.8'
7-12-82	17.2'

Time Required to Complete Hole:

Hole set up: 5 hours
Drilling: 11 hours
Downtime: 0 hours

VISUAL CLASSIFICATION AND PHYSICAL CONDITION (Continued)

11.0-12.2' (Continued): mottled with red oxide and gray-green reduced material. No reaction with HCl.

12.2-12.5': No Recovery.

12.5-14.0': Rockbit.

14.0-15.1': Silty Sand (SM). Similar to 11.0-12.2' except: 60% sand and 40% fines with no to low plasticity; coarse sand size increased.

15.1-15.5': No Recovery.

15.5-17.0': Rockbit.

17.0-17.7': Clayey Gravel (GC-SC). Approx. 40% fine, hard, subrounded gravel; approx. 40% fine to coarse sand; approx. 20% fines with low plasticity; maximum size 10 mm. Soft; wet (due to mud contamination); brown to gray.

17.7-18.0': Sandy Clay (CL). Approx. 70% fines with low plasticity; approx. 25% fine to medium with traces of coarse sand; approx. 5% fine, hard, subrounded gravel; maximum size 10 mm. Very soft; moist; gray with red oxide mottling. No reaction with HCl.

18.0-18.5': No Recovery.

18.5-20.0': Rockbit.

20.0-21.3': Silty Sand (SM). Approx. 65% predominantly fine to traces of coarse sand; approx. 35% fines with no to low plasticity; trace fine, hard, angular to subangular gravel, partially white quartz; maximum size 10 mm. Very soft; wet (due to mud contamination); blue-gray. No to weak reaction with HCl.

21.3-21.5': No Recovery.

21.5-23.0': Rockbit.

23.0-23.7': Silty Sand (SM). Approx. 50% fine to coarse sand; approx. 25% nonplastic fines; approx. 25% fine to coarse, hard, subangular gravel; traces of white quartz; maximum size 30 mm. Soft; moist; blue-green. Weak reaction with HCl.

23.7-24.3': Lean Clay (CL). Approx. 80% fines with medium plasticity; approx. 20% fine sand; maximum size fine sand. Soft; moist; blue with white calcium carbonate stains. Moderate to strong (in white areas) reaction with HCl.

24.3-24.5': No Recovery.

24.5-26.0': Rockbit.

26.0-27.3': Lean Clay (CL). Approx. 60% fines with medium plasticity; approx. 40% fine sand; maximum size fine sand. Firm; moist; blue with extensive white cementation due to calcium carbonate. Strong hydrogen sulfide odor. Strong reaction with HCl.

27.3-27.5': No Recovery.

27.5-29.0': Rockbit.

29.0-29.3': Lean Clay (CL). Similar to 23.7-24.3' interval except: Firm, with extensive white cementation due to calcium carbonate. Strong hydrogen sulfide odor. Strong reaction with HCl.

29.3-30.2': Lean Clay (CL). Approx. 75% fines with medium plasticity; approx. 25% fine sand; maximum size fine sand. Soft; moist; blue with white calcium carbonate stains and occasional carbonate-cemented, firm to hard areas. Strong hydrogen sulfide odor. No to strong (in white cementation) reaction with HCl.

30.2-30.5': No Recovery.

30.5-32.3': Rockbit.

32.3-33.5': Sandy Clay (CL). Approx. 65% fines with medium plasticity; approx. 35% predominantly fine sand; maximum size fine sand. Soft to very firm with depth in tube; moist to dry with depth. Dark blue with white and gray, calcium carbonate cement; trace calcareous concretionary material. Very strong reaction with HCl.

33.5-33.8': No Recovery.

33.8-35.0': Rockbit.

35.0-36.0': Sandy Clay (CL). Approx. 70% fines with medium plasticity; approx. 30% fine sand; maximum size fine sand. Firm; dry to moist; blue with extensive gray calcium carbonate mottling. Very strong reaction with HCl.

36.0-36.5': No Recovery.

36.5± -48.5':
PANOCHE GROUP.
(Cretaceous Marine Sedimentary Rocks)

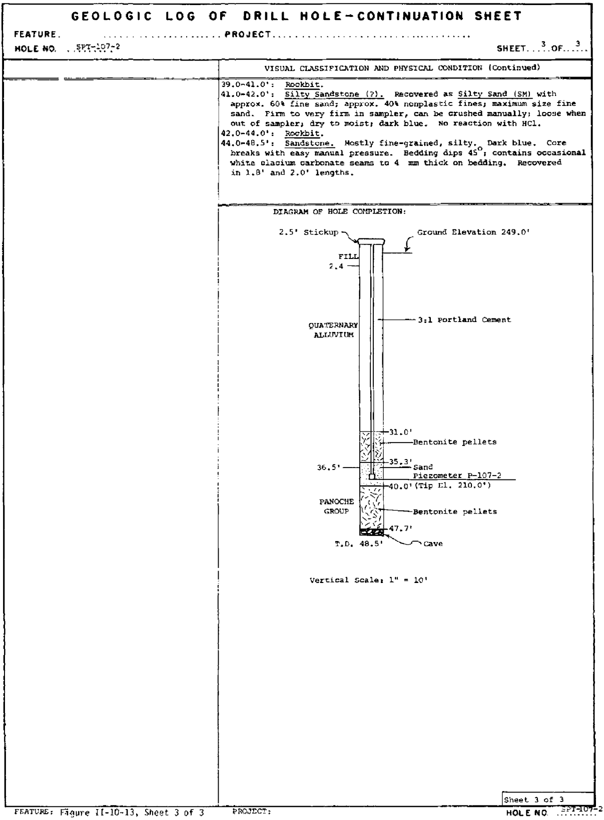
36.5-38.0': Rockbit.

38.0-39.0': Sandy Claystone (?). Recovered as Sandy to Silty Clay (CL-ML), with approx. 50% fines with no to low plasticity; and very firm with some cemented sandy claystone (?) fragments easily broken with fingers. Dry to moist; blue with gray calcium carbonate mottling. Very strong reaction with HCl. Hydrogen sulfide odor. May include some in-place, altered rock.

Sheet 2 of 3

FEATURE: Figure II-10-12, Sheet 2 of 3 PROJECT: HOLE NO. SPT-107-2

Figure 10-4.—Drill hole log, SPT-107-2, sheet 2 of 3.



GEOLOGIC LOG OF DRILL HOLE–CONTINUATION SHEET

FEATURE. .... PROJECT..

HOLE NO. ..SPT-107-2 SHEET...3.OF...3..

VISUAL CLASSIFICATION AND PHYSICAL CONDITION (Continued)

39.0-41.0': Rockbit.

41.0-42.0': Silty Sandstone (?). Recovered as Silty Sand (SM) with approx. 60% fine sand; approx. 40% nonplastic fines; maximum size fine sand. Firm to very firm in sampler, can be crushed manually; loose when out of sampler; dry to moist; dark blue. No reaction with HCl.

42.0-44.0': Rockbit.

44.0-48.5': Sandstone. Mostly fine-grained, silty. Dark blue. Core breaks with easy manual pressure. Bedding dips 45°; contains occasional white clacium carbonate seams to 4 mm thick on bedding. Recovered in 1.8' and 2.0' lengths.

DIAGRAM OF HOLE COMPLETION:

Vertical Scale: 1" = 10'

Sheet 3 of 3

FEATURE: Figure II-10-13, Sheet 3 of 3 PROJECT: HOLE NO. SPT-107-2

Figure 10-4.—Drill hole log, SPT-107-2, sheet 3 of 3.

1. Purpose of hole — Includes reason for drilling the hole, such as foundation investigation, materials investigation, instrumentation, sampling, or testing.

2. Drill site or setup — Includes general physical description of the location of the drill hole. Information on unusual setups, such as adjacent to a stream, or drilled from a barge, gallery, or adit, may help understand the unusual conditions.

3. Drillers — Names of drillers may be significant for reference or for evaluating or interpreting core losses, drilling rates, and other drilling conditions.

4. Drilling equipment —

- Drill rig (make and model)
- Core barrel(s), tube(s), special samplers (type and size)
- Bits (type and size)
- Drill rods (type and size)
- Collar (type)
- Water test equipment (rod or pipe size, hose size, pump type and capacity, and relative position and elevation of pressure gauges or transducers), packers (type—mechanical or pneumatic)

Example: Skid-mounted Sprague and Henwood Model 250. NWD3 bottom discharge bit with a 5-ft (1.5-m), split-tube inner barrel. 5-ft (1.5-m) NW rods. Water tested with NX pneumatic packer No. 12 with 1-1/4-inch (in) (32-millimeter [mm]) pipe, Bean pump with 35-gallons per minute (gal/min) (159 liters per minute) maximum volume, and 1-in (25-mm) water meter. (Water testing equipment can be a separate heading if desired.)

Drilling Procedures and Conditions.—These headers and data should include methods, conditions, driller's comments, and records for water losses, caving, or casing.

***1. Drilling methods* —** Synopsis of drilling, sampling, and testing procedures, including procedures and pressures for drive or push tubes used through the various intervals of the hole.

***2. Drilling conditions and driller's comments* —** Note by interval the relative penetration rate and the action of the drill during this process (i.e., 105.6-107.9: drilled slowly, moderate blocking off, hole advancing 15 minutes per foot [.3 meter]). Unusual drilling conditions should be summarized. Changes in drilling conditions may indicate differences in lithology, weathering, or fracture density. The geologist needs to account for variations in driller's descriptions; each driller may describe similar conditions with different adjectives or percentage estimates. Any other comments relative to ease or difficulty of advancing or maintaining the hole should be noted by depth intervals. Drillers' comments need to adequately describe conditions encountered while advancing the hole. Statements such as "normal drilling" or "no problems encountered" are not useful.

Differences in drilling speeds, pressures, and penetration rates may be related to the relative hardness and density of materials. Abrupt changes in drilling time may identify lithologic changes or breaks and also may pinpoint soft or hard interbeds within larger units. Often, these may be correlated with geophysical logs. If the driller provides useful and accurate records of drilling conditions and procedures, an accurate determination of the top and bottom of key marker horizons can be made even without core.

Drilling progress should be recorded while drilling; recovery can be improved by relating recovery to optimum pressures and speeds, as well as providing data for interpretation. For each run, the driller should record the time when starting to drill and when stopping to come out of the hole. Most of these drilling progress data are qualitative rather than quantitative values. Controlling factors are not only the type of materials encountered but also may be mechanical or driller variables. These variables may include type and condition of the bit, rotation speed, drilling fluid pressure, etc. THE PURPOSE OF THE BORING IS TO OBTAIN THE HIGHEST QUALITY CORE AND MOST COMPLETE RECOVERY AND INFORMATION, NOT JUST FEET PER HOUR OR SHIFT.

3. Drilling fluid — Type and where used (including drilling fluid additives). This may be combined with or discussed under the heading, drilling methods.

4. Drilling fluid return — Include interval/percent return. Drilling fluid return may be combined with color.

5. Drill fluid color — Include interval/color.

***6. Caving conditions* —** Intervals of cave with appropriate remarks about the relative amount of caving are to be noted. When possible, report the actual caving interval rather than the depth of the hole.

***7. Casing record* —** Casing depth is the depth of casing at the start of the drilled interval (see the example below).

***8. Advancement (push-tube or Standard Penetration Test (SPT) applications)* —** Include depth/ interval sampled.

***9. Cementing record* —** Note all intervals cemented and if intervals were cemented more than once. This information may be combined with the casing record, as shown below:

Example of casing and cementing record:

Interval drilled (feet)	Size (inch)	Casing depth (feet)
0.0-2.3	6 Cs	0.0
2.3-4.5	6 Cs	2.0
4.5-9.2	6 Cs	4.0
9.2-15.3	NxCs	8.0
15.3-18.7	NxCs	15.0
18.7-33.2	Cmt	12.1-18.7 Cmt

Hole Completion and Monitoring Data.—Data shown in this section of the left-hand column include hole completion, surveys, water levels, drilling rates or time, and reason for hole termination.

1. Borehole survey data **—** Include if obtained.

Example of survey data:

Depth	Bearing	Plunge
59		90°[1]
79	S 72°W	90°
99	S 75° W	89°
119	S 72° W	89°
Average	S 72° W	89°

[1] ° = degrees.

2. Water level data **—** Note depths and/or elevations, water quantities, and pressures from artesian flows. Water levels or flows should be recorded during hole advancement, between shifts, or at the beginning or end of a shift, but definitely should be recorded at completion of the hole and periodically thereafter. It may be advantageous to leave space or provide a note to refer the user to additional readings provided elsewhere on the log for subsequent measurements. Computer generated logs allow convenient updating of water levels long after the hole is completed.

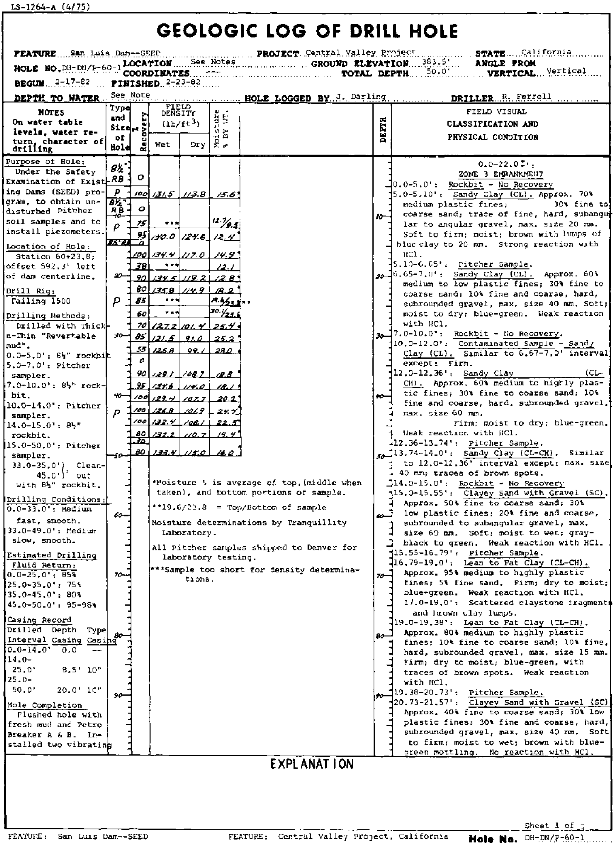
Examples of drill hole logs illustrate optional format and subsequent readings. Examples of how to record data are:

Date 1981	Hole depth (feet)	Depth to water (feet)
11-02	25.0	6.0
Bailed 100 gal:		
Level before		6.0
Level after		21.0

or:

Date	Hole depth (feet)	Depth to water (feet)
11-03-81	25.0	15.0
11-04-81	40.0	29.0
01-05-82	95.2	7.0
01-15-82	95.2	Flowing 25 gal/min
02-03-82	95.2	Flowing 5 gal/min at 5 pounds per square inch (lb/in$^{2)}$

***3. Hole completion* —** Indicate how hole was completed or backfilled; if jetting, washing, or bailing was employed; depth of casing left in hole or that casing was pulled; location and type of piezometers; location, sizes, and types of slotted pipes (including size and spacing of slots) or piezometer risers; type and depth of backfill or depths of concrete and/or bentonite plugs; location of isolated intervals; and elevation at top of riser(s). Hole completion can be shown graphically (see figure 10-5).



LS-1264-A (4/75)

GEOLOGIC LOG OF DRILL HOLE

FEATURE San Luis Dam--SEED **PROJECT** Central Valley Project **STATE** California

HOLE NO. DH-DN/P-60-1 **LOCATION** See Notes **GROUND ELEVATION** 383.5' **ANGLE FROM**

COORDINATES --- **TOTAL DEPTH** 50.0' **VERTICAL** Vertical

BEGUN 2-17-82 **FINISHED** 2-23-82

DEPTH TO WATER See Note **HOLE LOGGED BY** J. Darling **DRILLER** R. Ferrell

NOTES On water table levels, water return, character of drilling

Purpose of Hole:
Under the Safety Examination of Existing Dams (SEED) program, to obtain undisturbed Pitcher soil samples and to install piezometers.

Location of Hole:
Station 60+23.8; offset 592.3' left of dam centerline.

Drill Rig:
Failing 1500

Drilling Methods:
Drilled with Thick-n-Thin "Revertable mud".
0.0-5.0': 6¼" rockbit
5.0-7.0': Pitcher sampler.
7.0-10.0': 8½" rockbit.
10.0-14.0': Pitcher sampler.
14.0-15.0': 8½" rockbit.
15.0-50.0': Pitcher sampler.
33.0-35.0'} Clean-
45.0'}: out
with 8½" rockbit.

Drilling Conditions:
0.0-33.0': Medium fast, smooth.
33.0-49.0': Medium slow, smooth.

Estimated Drilling Fluid Return:
0.0-25.0': 85%
25.0-35.0': 75%
35.0-45.0': 80%
45.0-50.0': 95-98%

Casing Record

Drilled Interval	Depth Casing	Type Casing
0.0-14.0'	0.0	--
14.0-25.0'	8.5'	10"
25.0-50.0'	20.0'	10"

Hole Completion
Flushed hole with fresh mud and Petro Breaker A & B. Installed two vibrating

Type and Size of Hole	Recovery	FIELD DENSITY (lb/ft³) Wet	Dry	Moisture % BY WT.
8½" RB	0			
P	100	131.5	113.8	15.6*
8½" RB	0			
P	75	***		12.7/9.5
	95	140.0	124.6	12.4*
8½" RB	0			
	100	134.4	117.0	14.9*
	38	***		12.1
	90	134.5	119.2	12.8*
	80	135.8	114.9	18.2*
P	85	***		19.6/23.8**
	60	***		30.1/23.6
	70	127.2	101.4	25.4*
	85	121.5	91.0	25.2*
	55	126.8	99.1	28.0*
	0			
	90	129.1	108.7	18.8*
	95	134.6	114.0	18.1*
	100	129.4	107.7	20.2*
P	100	126.8	101.9	24.7*
	100	132.4	108.1	22.5*
	80	132.2	110.7	19.4*
	.30			
	80	133.4	115.0	16.0*

*Moisture % is average of top, (middle when taken), and bottom portions of sample.

**19.6/23.8 = Top/Bottom of sample

Moisture determinations by Tranquillity Laboratory.

All Pitcher samples shipped to Denver for laboratory testing.

***Sample too short for density determinations.

FIELD VISUAL CLASSIFICATION AND PHYSICAL CONDITION

0.0-22.0±':
ZONE 3 EMBANKMENT

0.0-5.0': Rockbit - No Recovery

5.0-5.10': Sandy Clay (CL). Approx. 70% medium plastic fines; 30% fine to coarse sand; trace of fine, hard, subangular to angular gravel, max. size 20 mm. Soft to firm; moist; brown with lumps of blue clay to 20 mm. Strong reaction with HCl.

5.10-6.65': Pitcher Sample.

6.65-7.0': Sandy Clay (CL). Approx. 60% medium to low plastic fines; 30% fine to coarse sand; 10% fine and coarse, hard, subrounded gravel, max. size 40 mm. Soft; moist to dry; blue-green. Weak reaction with HCl.

7.0-10.0': Rockbit - No Recovery.

10.0-12.0': Contaminated Sample - Sandy Clay (CL). Similar to 6.67-7.0' interval except: Firm.

12.0-12.36': Sandy Clay (CL-CH). Approx. 60% medium to highly plastic fines; 30% fine to coarse sand; 10% fine and coarse, hard, subrounded gravel, max. size 60 mm. Firm; moist to dry; blue-green. Weak reaction with HCl.

12.36-13.74': Pitcher Sample.

13.74-14.0': Sandy Clay (CL-CH). Similar to 12.0-12.36' interval except: max. size 40 mm; traces of brown spots.

14.0-15.0': Rockbit - No Recovery

15.0-15.55': Clayey Sand with Gravel (SC). Approx. 50% fine to coarse sand; 30% low plastic fines; 20% fine and coarse, subrounded to subangular gravel, max. size 60 mm. Soft; moist to wet; gray-black to green. Weak reaction with HCl.

15.55-16.79': Pitcher Sample.

16.79-19.0': Lean to Fat Clay (CL-CH). Approx. 95% medium to highly plastic fines; 5% fine sand. Firm; dry to moist; blue-green. Weak reaction with HCl.
17.0-19.0': Scattered claystone fragments and brown clay lumps.

19.0-19.38': Lean to Fat Clay (CL-CH). Approx. 80% medium to highly plastic fines; 10% fine to coarse sand; 10% fine, hard, subrounded gravel, max. size 15 mm. Firm; dry to moist; blue-green, with traces of brown spots. Weak reaction with HCl.

19.38-20.73': Pitcher Sample.

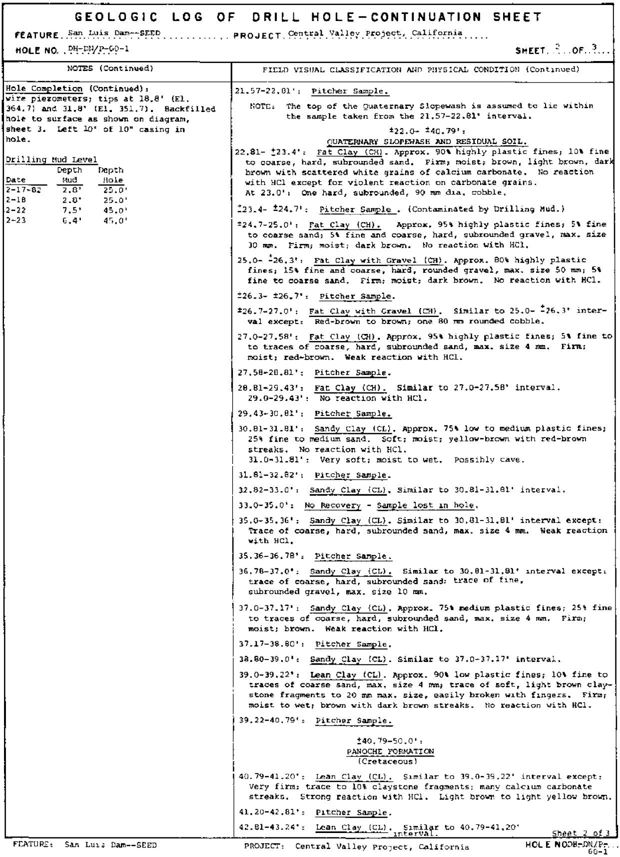
20.73-21.57': Clayey Sand with Gravel (SC) Approx. 40% fine to coarse sand; 30% low plastic fines; 30% fine and coarse, hard, subrounded gravel, max. size 40 mm. Soft to firm; moist to wet; brown with blue-green mottling. No reaction with HCl.

EXPLANATION

Sheet 1 of 3

FEATURE: San Luis Dam--SEED FEATURE: Central Valley Project, California **Hole No.** DH-DN/P-60-1

Figure 10-5.—Drill hole log, DH-DN/P-60-1, sheet 1 of 3.



GEOLOGIC LOG OF DRILL HOLE—CONTINUATION SHEET

FEATURE San Luis Dam--SEED PROJECT Central Valley Project, California

HOLE NO. DH-DN/P-60-1 SHEET 2 OF 3

NOTES (Continued)

Hole Completion (Continued): wire piezometers; tips at 18.8' (El. 364.7) and 31.8' (El. 351.7). Backfilled hole to surface as shown on diagram, sheet 3. Left 10' of 10" casing in hole.

Drilling Mud Level

Date	Depth Mud	Depth Hole
2-17-82	2.8'	25.0'
2-18	2.8'	25.0'
2-22	7.5'	45.0'
2-23	6.4'	45.0'

FIELD VISUAL CLASSIFICATION AND PHYSICAL CONDITION (Continued)

21.57-22.81': Pitcher Sample.

NOTE: The top of the Quaternary Slopewash is assumed to lie within the sample taken from the 21.57-22.81' interval.

±22.0- ±40.79':
QUATERNARY SLOPEWASH AND RESIDUAL SOIL.

22.81- ±23.4': Fat Clay (CH). Approx. 90% highly plastic fines; 10% fine to coarse, hard, subrounded sand. Firm; moist; brown, light brown, dark brown with scattered white grains of calcium carbonate. No reaction with HCl except for violent reaction on carbonate grains.
At 23.0': One hard, subrounded, 90 mm dia. cobble.

±23.4- ±24.7': Pitcher Sample . (Contaminated by Drilling Mud.)

±24.7-25.0': Fat Clay (CH). Approx. 95% highly plastic fines; 5% fine to coarse sand; 5% fine and coarse, hard, subrounded gravel, max. size 30 mm. Firm; moist; dark brown. No reaction with HCl.

25.0- ±26.3': Fat Clay with Gravel (CH). Approx. 80% highly plastic fines; 15% fine and coarse, hard, rounded gravel, max. size 50 mm; 5% fine to coarse sand. Firm; moist; dark brown. No reaction with HCl.

±26.3- ±26.7': Pitcher Sample.

±26.7-27.0': Fat Clay with Gravel (CH). Similar to 25.0- ±26.3' interval except: Red-brown to brown; one 80 mm rounded cobble.

27.0-27.58': Fat Clay (CH). Approx. 95% highly plastic fines; 5% fine to to traces of coarse, hard, subrounded sand, max. size 4 mm. Firm; moist; red-brown. Weak reaction with HCl.

27.58-28.81': Pitcher Sample.

28.81-29.43': Fat Clay (CH). Similar to 27.0-27.58' interval.
29.0-29.43': No reaction with HCl.

29.43-30.81': Pitcher Sample.

30.81-31.81': Sandy Clay (CL). Approx. 75% low to medium plastic fines; 25% fine to medium sand. Soft; moist; yellow-brown with red-brown streaks. No reaction with HCl.
31.0-31.81': Very soft; moist to wet. Possibly cave.

31.81-32.82': Pitcher Sample.

32.82-33.0': Sandy Clay (CL). Similar to 30.81-31.81' interval.

33.0-35.0': No Recovery - Sample lost in hole.

35.0-35.36': Sandy Clay (CL). Similar to 30.81-31.81' interval except: Trace of coarse, hard, subrounded sand, max. size 4 mm. Weak reaction with HCl.

35.36-36.78': Pitcher Sample.

36.78-37.0': Sandy Clay (CL). Similar to 30.81-31.81' interval except: trace of coarse, hard, subrounded sand; trace of fine, subrounded gravel, max. size 10 mm.

37.0-37.17': Sandy Clay (CL). Approx. 75% medium plastic fines; 25% fine to traces of coarse, hard, subrounded sand, max. size 4 mm. Firm; moist; brown. Weak reaction with HCl.

37.17-38.80': Pitcher Sample.

38.80-39.0': Sandy Clay (CL). Similar to 37.0-37.17' interval.

39.0-39.22': Lean Clay (CL). Approx. 90% low plastic fines; 10% fine to traces of coarse sand, max. size 4 mm; trace of soft, light brown claystone fragments to 20 mm max. size, easily broken with fingers. Firm; moist to wet; brown with dark brown streaks. No reaction with HCl.

39.22-40.79': Pitcher Sample.

±40.79-50.0':
PANOCHE FORMATION
(Cretaceous)

40.79-41.20': Lean Clay (CL). Similar to 39.0-39.22' interval except: Very firm; trace to 10% claystone fragments; many calcium carbonate streaks. Strong reaction with HCl. Light brown to light yellow brown.

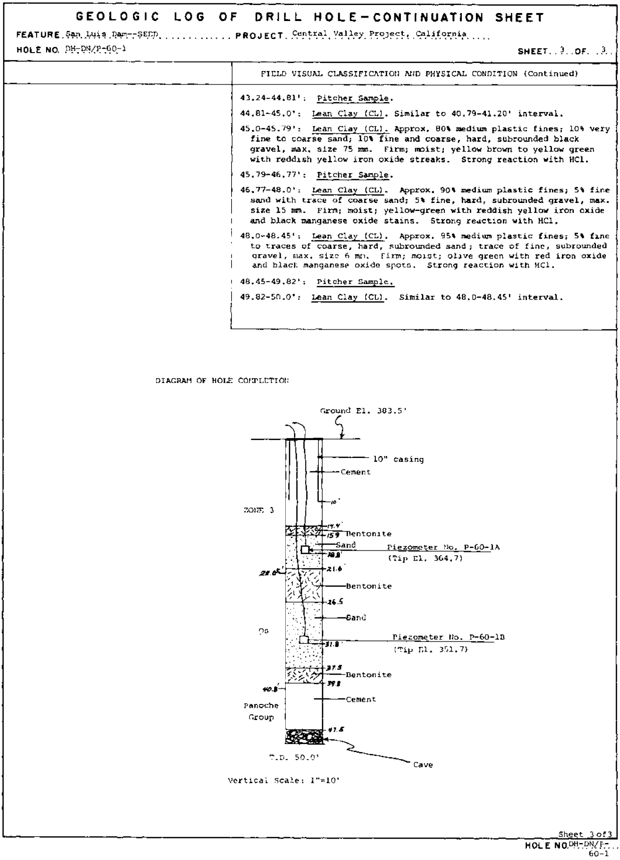
41.20-42.81': Pitcher Sample.

42.81-43.24': Lean Clay (CL). Similar to 40.79-41.20' interval.

Sheet 2 of 3

FEATURE: San Luis Dam--SEED PROJECT: Central Valley Project, California HOLE NO. DH-DN/P-60-1

Figure 10-5.—Drill hole log, DH-DN/P-60-1, sheet 2 of 3.



GEOLOGIC LOG OF DRILL HOLE—CONTINUATION SHEET

FEATURE San Luis Dam--SEDD PROJECT Central Valley Project, California
HOLE NO. DH-DN/P-60-1 SHEET 3 OF 3

FIELD VISUAL CLASSIFICATION AND PHYSICAL CONDITION (Continued)

43.24-44.81': Pitcher Sample.

44.81-45.0': Lean Clay (CL). Similar to 40.79-41.20' interval.

45.0-45.79': Lean Clay (CL). Approx. 80% medium plastic fines; 10% very fine to coarse sand; 10% fine and coarse, hard, subrounded black gravel, max. size 75 mm. Firm; moist; yellow brown to yellow green with reddish yellow iron oxide streaks. Strong reaction with HCl.

45.79-46.77': Pitcher Sample.

46.77-48.0': Lean Clay (CL). Approx. 90% medium plastic fines; 5% fine sand with trace of coarse sand; 5% fine, hard, subrounded gravel, max. size 15 mm. Firm; moist; yellow-green with reddish yellow iron oxide and black manganese oxide stains. Strong reaction with HCl.

48.0-48.45': Lean Clay (CL). Approx. 95% medium plastic fines; 5% fine to traces of coarse, hard, subrounded sand; trace of fine, subrounded gravel, max. size 6 mm. Firm; moist; olive green with red iron oxide and black manganese oxide spots. Strong reaction with HCl.

48.45-49.82': Pitcher Sample.

49.82-50.0': Lean Clay (CL). Similar to 48.0-48.45' interval.

DIAGRAM OF HOLE COMPLETION

Vertical Scale: 1"=10'

Sheet 3 of 3
HOLE NO. DH-DN/P-60-1

Figure 10-5.—Drill hole log, DH-DN/P-60-1, sheet 3 of 3.

4. ***Reason for hole termination*** **—** State whether the hole reached the planned depth or reason why the hole was stopped short.

5. ***Drilling time*** **—** Total time, setup time, drilling time, and downtime should be recorded on drillers' daily sheets and should also be recorded on the drill log. These records are essential for determining exploration program costs.

Center Columns of the Drill Log

Computer Logs.—Computer-generated logs offer several options for the content and format of the log such as permeability, penetration resistance, or rock properties which have some differences in format. Examples of each are shown in figures 10-2 through 10-5.

Standard Geologic Log Form.—The following discussion pertains to the center columns for the standard Reclamation log (form 7-1337). The columns shown on all figures are self-explanatory. The columns can be modified or new columns added to the existing log form for recording appropriate indexes or special conditions.

The percolation tests (water-pressure tests) column should record the general information of the tests. Additional data may be recorded on "water testing" log forms or drillers' reports.

Type and size of hole, elevation, and depth columns are self-explanatory.

Core recovery should be recorded in percent of recovery by run. Although desirable, core recovery does not necessarily require a visual graph. Core recovery should be noted carefully by the driller for each run on the daily drill reports; however, this column should be the record of those measurements determined by the geologist during logging. Measuring the core while in the split tube or sampler, if possible, will produce the most accurate recovery records.

A hole completion column may be added which graphically portrays how the hole was completed. If used, an explanation of the graphic symbols should be provided on the log form.

Rock quality designation (RQD) should be reported by core run. RQD should be included on the log in graph or tabular form regardless of the type project. RQD is used in almost any engineering application of the hole data. Most contractors are interested in RQD as an index of blasting performance, rippability, and stability. RQD is described and explained in chapter 5.

A lithologic log or graphic column is helpful to quickly visualize the geologic conditions. Appropriate symbols may be used for correlation of units, shear zones, water levels, weathering, and fracturing (see figure 10-1).

The samples and testing column should include locations of samples obtained for testing and can later have actual sample results inserted in the column, if the column is enlarged.

Modifications to Standard Log Form.—Modifications or adaptations of the center columns are permissible and, in some instances, encouraged. Examples are:

1. The use of a continuation sheet for longer drill logs saves time and is easier to type. The sheets may have only one column to continue the right-hand narrative, or may be divided into two or more

columns. See sheets 2 and 3 for drill hole SPT-107-2, figure 10-4, for an example; also see sheet 3 of 3 for drill hole DH-DN/P-60-1, figure 10-5.

2. The center column may be modified to portray additional data such as hole completion, various indexes, alphanumeric descriptors, or laboratory test data.

Standard penetration test hole SPT-107-2, figure 10-4, is a modified penetration resistance log which shows laboratory test results; a percent gravel/percent sand/ percent fines column; liquid limit/plasticity index (LL/PI) column, a field moisture column, and other modifications. Drill hole DH-SP-2, figure 10-3, has columns for reporting field density test results, moisture, porosity, percent saturation, percent fines/percent sand, LL/PI, and laboratory classification.

3. Another modification, shown on DH-SP-2, figure 10-3, is a drawing showing the location of the hole in relation to the structure being explored. Diagrams or graphs, such as water levels, may illustrate data better than a column of figures.

Required Data and Descriptions for the Right-Hand "Classification and Physical Condition" Column

General.—An accurate description of recovered core and a technically sound interpretation of nonrecovered core are the primary reasons for core logging. The logger needs to remember that any interpretation, such as a shear, must be based on observed factual data. The interpreted reason for the core loss is given, but usually it is best to define the area of core loss as the interval heading. For example:

> 99.4. to 101.6: No Recovery. Interpreted to be intensely fractured zone. Drillers reported blocking off, core probably ground up during drilling.
>
> 103.4 to 103.7: Open Joint?. Drillers reported 0.3-ft drop of drill rods during drilling and loss of all water. Joint surfaces in core do not match.
>
> 0.7 to 11.6: Silty Sand. Poor recovery, only 6.2 ft recovered from interval. Classification based on recovered material and wash samples.
>
> 0.9 to 3.2: Rockbitted. No samples recovered. (Usually this would be subheaded under a previous description, inferring the materials are the same as the last recovered).

Descriptions of Surficial Deposits.—Surficial deposits such as slope wash, alluvium, colluvium, and residual soil that are recovered from drill holes are described using USBR 5000 and 5005. If samples cannot be obtained, then description of the cuttings, percent return and color of drilling fluid, drilling characteristics, and correlation to surface exposures is employed. Always indicate what is being described—undisturbed samples, SPT or wash samples, cuttings, or cores. Descriptors and descriptive criteria for the physical characteristics of soils must conform to the established standards. Chapter 11 provides guidelines for soil and surficial deposit descriptions.

Extensive surficial deposits usually are described using geologic and soil classifications. Where surficial deposits are very shallow and not pertinent to engineering applications for design or remediation or where geologic classification such as landslides or talus is preferable, units may be given genetic or stratigraphic terms only. For example, Quaternary basin fill, recent stream channel deposit, Quaternary colluvium, zone 3 embankment, and random fill may be described generally; or these may be unit headings with group name subheadings. The format is:

> **Geologic and group name.** i.e., Alluvium, (sandy silt). Field classification in parentheses if classified, refer to chapters 3 and 11 for exceptions.
>
> **Classification descriptions.** Additional descriptors (particle sizes, strength, consistency, compactness, etc., from the USBR 5000 and 5005 standards descriptive criteria).
>
> **Moisture.** (dry to wet).
>
> **Color**.

If cores or disturbed samples are not available, describe as many of the above items as can be determined from cuttings, drill water color, drilling characteristics, correlation to surface exposures, etc. Remember that for rockbitted, no recovery, or poor recovery intervals, a classification and group name should be assigned as a primary identification.

Description of Rock.—Description of rock includes a rock unit name based on general lithologic characteristics followed by data on structural features and physical conditions. Bedrock or lithologic units are to be delineated and identified, not only by general rock types but by any special geological, mineralogical features with engineering significance, or those pertinent to interpretation of the subsurface conditions.

Any information which is characteristic of all of the rock units encountered normally is included under the main heading, producing more concise logs. Differences can be described in various subheadings. Rock core is to be described in accordance with descriptors and descriptive criteria presented in chapters 4 and 5. A suggested format is:

> ***1. Rock name* —** A simple descriptive name, sufficient to provide others with possible engineering properties of the rock type; may include geological age and/or stratigraphic unit name.
>
> ***2. Lithology (composition/grain sizes/texture/color)* —** Give a brief mineralogical description. Describe grain shape and size or sizes and texture using textural adjectives such as vesicular, porphyritic, schistose. (Do not use petrographic terms such as hypidiomorphic, subidioblastic). Other pertinent descriptions could include porosity, absorption, physical characteristics that assist in correlation studies, and other typical and/or unusual properties. Provide the wet color of fresh and weathered surfaces.
>
> Contacts should be described here also. If the contacts are fractured, sheared, open, or have other significant properties, the contacts should be identified and described under separate subheadings.
>
> ***3. Bedding/foliation/flow texture* —** Provide a description of thickness of bedding, banding, or foliation including the dip or inclination of these features.
>
> ***4. Weathering/alteration* —** Use established descriptors which apply to most of the core or use individual subheadings. For alteration other than

weathering, use appropriate descriptors. These may or may not be separate from weathering depending upon rock type and type of alteration. Also, include slaking properties if the material air or water slakes. (Weathering may be used as first or second order headings for some logs.)

***5. Hardness* —** Use established descriptors.

***6. Discontinuities* —** These include shears, joints, fractures, and contacts. Discontinuities control or significantly influence the behavior of rock masses and must be described in detail. Detailed discussions of indexes and of descriptive criteria, descriptors, and terminology for describing fractures and shears are provided in chapter 5 and 7.

Fractures or joints should be categorized into sets if possible, based on similar orientations, and each set should be described. When possible, each set should be assigned letter and/or number designations and variations in their physical properties noted by depth intervals. Significant individual joints also may be identified and described. Physical measurements such as spacing and orientation (dip or inclination from core axis), information such as composition, thickness, and hardness of fillings or coatings; character of surfaces (smooth or rough); and, when possible, fracture openness should be recorded. In drill core, the average length between fractures is measured along the centerline of the core for reporting any of the fracture indexes. However, when a set can be distinguished (parallel or subparallel joints), true spacing is measured normal to the fracture surfaces.

Description of Shears and Shear Zones.—Shears and shear zones should be described in detail, including data such as the percentage of the various components (gouge, rock fragments, and associated features such as dikes and veins) and the relationship of these components to each other. Gouge color, moisture, consistency and composition, and fragment or breccia sizes, shape, surface features, lithology, and strengths are recorded. The depths, dip or inclination, and true thickness, measured normal to the shear or fault contacts, also must be determined, if possible, along with healing, strength, and other associated features. A thorough discussion of shears and shear zones is contained in chapter 5.

Description of Core Loss.—The significance of core loss is often more important than recovered core. Lost core may represent the worst conditions for design concepts, or it may be insignificant, resulting from improper drilling techniques or equipment. Core losses, their intervals, and the interpreted reason for the loss should be recorded on the log.

Written Description Form.—The written description for physical conditions consists of main headings, indented subheadings, and text which describes the important features of the core. Headings and indented subheadings divide the core into readily distinguishable intervals which are pertinent to an engineering geology study. Assigned unit names should correlate with those unit names used for surface mapping. These headings may describe portions of the core or the entire core, depending on how well the headings encompass overall characteristics. Items characteristic of the entire core in one hole may be stated under the major heading; however, in other holes, this same information may have to be broken out into various subheadings because it is not applicable to the entire core. In this discussion, several logs are referenced as examples. These logs do not necessarily reflect the established standards, and each may be deficient in some format or context; they are existing logs which are included as examples of different situations which may be encountered. A discussion of headings follows:

> ***1. Main headings —*** The main heading usually divides surficial deposits from bedrock. However, other methods are also acceptable, for example, the summary log in figure 10-5.
>
> ***2. First order heading —*** The first order headings may be based on weathering or lithology. When the initial rock type exhibits more than one weathering break or the lithologic properties are most significant, lithology would be the first order heading. Weathering may be used as first order headings where significant. If a weathering break coincides with a lithologic break, or only one weathering break is present, they may both be included in the main heading. Depending on lithologies present, for example, if there is only one rock type, the first order headings may be based on fracturing. Lithology, weathering, or fracturing can also be the subject of the first order heading. In certain circumstances, a shear or shear zone or other feature could be given a first order or any lower order heading in order to emphasize a feature's presence or importance. The arrangement which will result in the simplest log is usually the best and should be used. The following examples illustrate the use of first, second, and third order headings. These examples are not intended to represent examples of complete logs.
>
> An example in which weathering is preferred as the first order heading is:

0.0-5.0: SLOPE WASH (main heading).—General description could include the total description of the unit.

5.0-200.0: PALEOZOIC CALAVERAS GROUP (main heading).

5.0-100.3: Moderately Weathered (first order heading based on weathering; descriptions of weathering applicable to all lithologies could be presented here).

5.0-10.9: Basalt
10.9-20.1: Limestone
20.1-50.3: Shale
50.3-100.3: Sandstone

100.3-150.0: Slightly Weathered
100.3-120.2: Sandstone
120.2-150.0: Shale

150.0-200.6: Fresh Shale

An example in which lithology is preferred as the first-order subheading is:

0.0-5.0: SLOPE WASH (main heading).—General description, could include the total description of the unit.

5.0-200.6: PALEOZOIC CALAVERAS GROUP (main heading).—General description applicable to all lithologies.

5.0-100.3: Sandstone (first order heading based on lithology)

5.0-10.2: Intensely weathered

10.2-40.1: Moderately weathered

40.1-80.2: Slightly weathered

80.2-100.3: Fresh

100.3-150.1: Fresh Shale (first order heading which combines weathering and lithology)

150.1-200.6: Fresh Diabase

3. Second order heading — The second order heading and the associated description contain the char-acteristics of the rock that are unique to an interval that is not described in the main and first order headings. The second order heading usually is based on weathering if the first order heading is based on lithology. If the first order heading is based on weathering, the second order heading would usually be based on lithology. Fracture data can be described here if similar throughout the interval; if not, divide fracture data into third order headings.

4. Third order heading — The third order heading is usually based on fracture data, subordinate features, variations in lithology, etc. This includes variations of rock quality within a certain lithology due to shears, joints, bedding or foliation joints, or other discontinuities. Core recovery lengths are an indicator of fracturing and should be described under this heading, as in the interval from 87.2 to 101.2 in DH-123 figure 10-1. If the fractures are mainly prominent joint sets or other discontinuities, the spacing and orientation of individual sets, along with the overall fracture characteristics, should be noted.

5. Additional indentations **—** Additional indentations usually are used to describe important addi-tional subordinate features, such as veins or veinlets, variations in lithology, shears, and zones of non- or poor recovery.

In summary, any information consistent throughout a higher order heading, but usually included in a lower one, should be described in the higher order heading to prevent repetition.

Data Required for the Comments/Explanation Block

The comments/explanation block at the bottom of the log form is used for additional information. This may include abbreviations used, gauge height for packer tests, and notes. The hole start and completion date should be in the heading, as well as the date logged. Revision dates of the log should be noted to ensure that the most recent version of the log can be identified. (Date logged and any subsequent revision dates should be entered in this block). The computer log file name can be recorded in this block.

Method of Reporting Orientation of Planar Discontinuities and Structural Features

True dips can be measured directly in vertical holes. The dips of planar features in vertical holes are recorded as "dips 60°”or "60° dip" (see drawing 40-D-6499, figure 5-9). True dip usually is not known in angle holes; and, orientation is measured from the core axis and called inclination, i.e., "Joints are inclined 45° from the core axis" (figure 5-9). If dips are known from oriented core or other surveys, dips may be recorded instead of inclination in angle holes. Figure 5-9 demonstrates how misinterpretations can occur; the inclination of a joint in the core from a 45° inclined angle hole can be interpreted as a horizontal joint or as a vertical joint by rotating the core.

Core Recovery and Core Losses

Descriptions of core in the Classification and Physical Condition column should describe the recovered core, not only by physical measurements (maximum, minimum, and mostly range or average), but should identify and include the interpretation for any core losses, especially if the losses are thought to represent conditions different from the core recovered. Designers and other users of the completed log can incorporate into their design all the factual data that are seen and recorded. What is not seen or reported (core losses) is more difficult to incorporate into the design and may well be the most significant information. Also, core losses and interpretations of the reasons for their loss are significant engineering data that may correlate open joints, soft zones, or shears from boring to boring or from surface features to the subsurface explorations.

Core losses can result from three generalized conditions: inaccurate measurements by the drillers; poor drilling techniques, equipment, and handling; or geologic conditions. The geologist, using the depth of hole, recovered core, observations of the core, and drillers observations, is the individual to make interpretations of the core loss. All core should be measured by the logger. If using a split-tube barrel, the core should be measured while in the barrel and always after core segments are fitted together (using the midpoint of core ends). Unaccountable losses should be reconciled, and the location of the loss determined.

Tape checks or rod checks are the most reliable and preferred methods for knowing the exact location of geologic conditions (top of each run is known with certainty) and where losses occur. All core runs should be measured and recorded; gains and losses can be transferred to adjacent runs and cancel out each other during the process of determining where the core loss is located. Inaccurate drillers' measurements, or locations where portions of the previously drilled interval was left in the hole (pulled off, or fell back in and redrilled), can be determined by examining and matching the end and beginning of each core run to see if they fit together or show signs of being redrilled. Gains may be attributed to pulling out the bottom of the hole, mismeasurement, recovering core left in the hole from the previous run, or recovery of expansive, slaking, or stress relieving materials.

Where unaccountable losses occur, the examination of core to determine the reason for that loss is critical. Poor drilling methods (excessive pressure, speed, excessive water discharge from the drill bit, not stopping when fluid return plugs), inaccurate measurements, or geologic conditions responsible for core losses should be determined. Core may have spun in the barrel after blocking; an intensely fractured zone may have been ground up; or a shear zone, open joint(s), solution cavity, or joint fillings may have been washed away. Geologic interpretation of the core loss is based on examining recovered core and the fractures present in the core. Drill water losses and color or changes in the drilling conditions noted by the driller may suggest an interpretation of the core loss. Where losses occur near a recovered clay "seam," clay coats fracture surfaces, slickensides and/or breccia and gouge are present, the core loss may be interpreted as a shear or shear zone. The description should include all the factual information—discontinuity surface orientations, slickensides, coatings, gouge and/or fractures; and the interpretation that the loss occurred in a shear. Depending on the confidence in the interpretation based on the observed conditions, the description can be given as "shear," or "shear?," or "probable shear zone." When a portion of a shear zone has been lost during drilling, the no recovery zone should be described as part of the shear and the loss or part of the loss included in the shear's thickness.

Samples

If the geologist selects representative or special samples for laboratory testing, an appropriate space should be left in the core box to ensure that when logs are reviewed or photographs are taken, core recovery is not misleading. Either filler blocks or a spacer which indicates the top and bottom depths of the sample and a sample number can be used to fill the sample space. For N-size cores, a length of 2- by 2-inch (50- by 50-mm) block or other spacers that fill the tray work well. These blocks also should be used to separate core runs. The lettering on the blocks should be easily readable at a distance. Spray painting the blocks white or yellow and lettering them with black waterproof pens enhances visibility and legibility. The sample interval, and sample number if desired, must be recorded in the Samples for Testing column on the log. Portions of the core may be preserved as representative samples or to protect samples from slaking or other deterioration.

Core Photography

General Photographic Methods

Transmittal of core photographs with the final logs is recommended. The photos may be included in the data package or as an appendix to the data report. Cores should be photographed while fresh. Before and after photographs of materials that slake or stress-relieve are recommended. The importance of photographing the core before it has been disturbed in transit and before its moisture content has changed cannot be overemphasized. If proper precautions during transport are followed, and the core is logged in a timely manner, reasonably good photographs can be obtained away from the drilling site. This permits the labeling of core features, if desired.

If possible, cores should be photographed in both color and black and white at 8- by 10-inch (200- by 250-mm) size. Black and white photographs do not degrade over time like color photographs. Core photographs should be submitted with the final logs in the geology data report; color photographs are best for data analysis.

Many methods are employed for photographing core. Each box of core can be photographed separately as the box is first filled or three or more boxes can be photographed at a time. There are advantages to both procedures:

- Greater detail and photographs depicting fresher conditions are the major advantages of photographing each box individually.

- When photographing several boxes at a time, transitional features, changes in weathering or fracturing, or large shear zones can be seen in one photograph.

The best method is a combination of the two. Pictures of individual boxes at the drill site and later pictures of the entire hole are the best of two worlds.

Individual Box Photography

Any portion of core that is in danger of altering or disaggregating because of slaking or "discing" due to stress relief, expansion, or shrinkage due to changes in moisture or confinement because of down time, ends of shifts, or weekends must be boxed and photographed. Under these circumstances, the core should be photographed while at or near the material natural condition (even if a box is only partially filled).

Each photograph should be taken from approximately the same distance so that the scale of each photograph is identical. The box should fill the frame of the camera, thereby obtaining the highest quality resolution or core detail, and the camera should be held as close to normal to the core as possible. A tripod should be used if possible. Tilting the core box and, if necessary, standing in a pickup bed or other vantage point may be helpful. Most core boxes can be tilted about 70 to 80° before any core is in danger of spilling out, so very little additional height is required. A simple 2- by 4-foot (0.6- by 1.2-m) wood frame may be constructed, or the core box may be leaned against a tool box, pickup tailgate, or other stable object. A Brunton compass can be used to ensure that the box and the camera are placed at a consistent, uniform angle. Shadows should be eliminated as much as possible.

All core should be photographed both wet and dry. In hot or dry weather, the unphotographed boxed core should be covered by moist cloth. When ready to photograph, any dry zones should be touched up using a wet cloth or paintbrush. In extremely hot weather, the boxed core can be sprayed or sprinkled with water. A water hose, garden sprayer, or spray bottle works well for this operation. Wait for the water to be absorbed so that there is no objectionable sheen or glare-producing film of water on the core at the instant of film exposure.

A labeled lid, letter board, or another frame which shows feature, drill hole number, photograph, or core box number, and depths of the top and bottom of the cored interval should be included in the photograph. A scale in feet and/or tenths of a foot or meters is helpful.

Photographing Multiple Boxes

As soon as possible after the core is removed from the barrel and boxed, the core should be photographed. To facilitate the photography, construct a frame capable of supporting three or more boxes at a time for use at the drill yard or core storage yard. Photograph the core dry then spray with water to bring back the natural moisture color. The same precautions about glare referred to previously should be followed.

A frame which shows the project, feature, hole number, box __ of __boxes, and from—to, as a minimum, should be used for the photograph. Other optional but recommended entries may include date photographed, and a scale.

Special Circumstances

Special photography such as closeups of shear zones or other special features may be worthwhile. When these photographs are taken, a common object or scale should be included to provide the viewer with relative or actual dimensions.

When cores are coated with drill mud, a brush, wet rag, or pocket knife should be used to wash or scrape off the mud so that materials are their natural color and features of the core are not obscured. This step obviously must be taken prior to logging the material.

Photograph Overlays

Acetate or mylar overlays on photographs of core can help interpretation of exposed features. Details shown may include labels for shears, weathering, lithologies, or items of special interest. Other items that may be shown on overlays are joint sets, and they may be coded by an alpha or numeric character or by colored ink.

Equipment Necessary for Preparing Field Logs

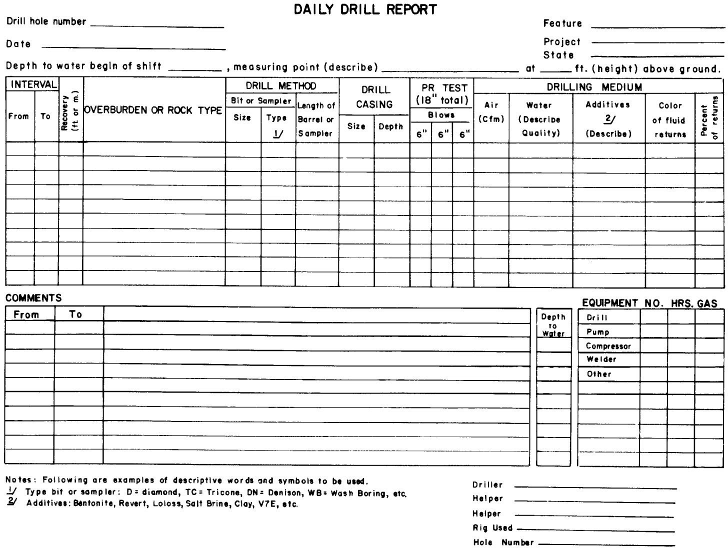
The following equipment or supplies are necessary for adequately preparing geologic logs:

Core recovery sheets and rough log forms or computer data sheets.—For recording core recovery and maintaining accurate depth measurements for determining core loss intervals.

Drillers' reports.—Daily drill reports (figure 10-6) to check measurements for core recovery, identifying changes in condition or contacts in intervals of poor recovery, determining reasons for core loss, and evaluating openness of fractures.

Knife.—Core hardness/strength characteristics; cleaning or scraping drill mud from core to allow logging and measurement of core recovery.

Hammer.—Core hardness/strength characteristics.



DAILY DRILL REPORT

Drill hole number ____________________

Date ____________________

Feature ____________________

Project ____________________

State ____________________

Depth to water begin of shift ________ , measuring point (describe) ____________________ at ______ ft. (height) above ground.

INTERVAL		Recovery (ft. or m.)	OVERBURDEN OR ROCK TYPE	DRILL METHOD			DRILL CASING		PR TEST (18" total)			DRILLING MEDIUM				
				Bit or Sampler		Length of Barrel or Sampler			Blows			Air (Cfm)	Water (Describe Quality)	Additives 2/ (Describe)	Color of fluid returns	Percent of returns
From	To			Size	Type 1/		Size	Depth	6"	6"	6"					

COMMENTS

From	To		Depth to Water

EQUIPMENT	NO.	HRS.	GAS
Drill			
Pump			
Compressor			
Welder			
Other			

Notes: Following are examples of descriptive words and symbols to be used.

1/ Type bit or sampler: D = diamond, TC = Tricone, DN = Denison, WB = Wash Boring, etc.

2/ Additives: Bentonite, Revert, Loloss, Salt Brine, Clay, V7E, etc.

Driller ____________________

Helper ____________________

Helper ____________________

Rig Used ____________________

Hole Number ____________________

Figure 10-6.—Daily drill report.

Tape measure or folding ruler (engineering scale with hundredths of feet or metric as appropriate).—Recovery measurements, thickness of units, shears and fillings, and spacing of fractures.

Protractor.—Measuring orientation of contacts, bedding and foliation, and fracture orientation.

Hydrochloric acid.—Mineral or cementing agent identification (3:1 distilled water to acid).

Hand lens.—Mineral or rock identification, minimum 10X.

Marking pen.—Waterproof ink for marking core for mechanical breaks, depth marks on core, sample marking.

Paintbrush and/or scrub brush, and water.—For cleaning core and for identifying wet color and incipient fractures.

Color identification charts (Munsel Color System or American Geological Institute Rock Color Chart).

Filler block (spacer) material.—For identifying non-recovery intervals and location of samples and for recording drill depths.

Sample preparation materials.—Wax, heater, container, brush, cheese cloth, etc.

Rock testing equipment.—Schmidt hammer, point load apparatus, pocket penetrometer or torvane.

Instruction to Drillers, Daily Drill Reports, and General Drilling Procedures

Communication between the geologist and driller is extremely important. Establishment of lines of communication, both orally and in writing, is key to a successful exploration program.

The role of the geologist in the drilling program is as an equal partner with the driller at the drill site. Establishment of this partnership at the beginning of the drilling program will result in better data. Failure to establish a good working relationship with the drill crew often results in unanswered questions and a poor quality end product. One way to establish good working rapport is to keep the drillers informed and to plan with them.

Drill Hole Plan

A suggested method for ensuring that a clear understanding of what the drilling requirements and expectations are from the drill hole is the preparation of a drill hole plan. The plan is prepared prior to starting the hole and after the geologist has used available interpretive data and has determined whether special testing and procedures or deviations in standard practice are required. This document provides the driller with information about safety, special site conditions, purpose of the hole, procedures to be followed, water testing requirements, materials expected to be recovered, any special sampling or geophysical testing required, and hole completion requirements.

Guidelines for Drillers

The following guidelines provide a framework for preparing written instructions for drill crews or for contract drill specifications. Also, the guidelines serve to help geologists correct poor drilling procedures, collect additional data, or improve core handling and logging.

Drill Setup.—To ensure that drill holes are completed at the desired location and along the correct bearing and plunge, the use of aiming stakes and a suitable device for measuring angles should be provided by the geologist and used by the drill crews. Drillers should use aiming stakes set by the geologist or survey crew for the specified bearing of the drill hole. The rig must be anchored properly so that it will not shift. If stakes have been removed or knocked over, they should be replaced by the geologist. Also, drillers must ensure the hole is drilled at the designated angle. The geologist should check the plunge angle with Brunton compass, and/or the drillers should use an appropriate measuring device.

Daily Drill Reports Preparation.—The drillers should prepare duplicate daily drill reports using carbon paper (additional copies of each report may be required on contract rigs). All copies must be legible and preferably printed. One copy should be provided to the geologist for monitoring progress and for preparation of the geologic log. The drill report has a space opposite each run for each item of information required; each of these spaces need to be filled out completely. Data should be added to the report or recorded in a notebook after each run. Drillers should record data as it occurs. See drawing 40-D-6484 (figure 10-6) as an example for reporting daily drill activities. Many field offices have local forms on which these data can be recorded. Comments regarding specific items to be recorded on the daily reports are contained in the following paragraphs.

1. ***Recording depths and core loss* —** Check for agreement on depths for intervals drilled by

consecutive shifts. Depths should be recorded in feet and tenths of feet or to the nearest centimeter, as appropriate. Tape checks or rod checks may be required at change of shift or more frequently when requested by the geologist. The section entitled "Core Recovery and Core Losses" contains instructions for proper use of core measurements, filler blocks (spacers), and tape checks. The driller is responsible for knowing the depth of the barrel and the hole at all times. Discrepancies between intervals drilled and recovery need to be resolved. Only standard length drill rods should be used. Core should be measured while it is still in the inner barrel and after it is placed in the core box. Record the most correct measurement of the two in the report. In the event core is left in the hole, the next run should be shortened accordingly; the left amount and proper hole entry and startup procedures should be followed to facilitate recovery.

***2. Recording drilling conditions* —** Make sure drilling conditions, such as fast or slow, hard or soft, rough or smooth, even or erratic, moderately fast or very slow, bit blocks off, etc., are indicated for each run. Record time in minutes per foot (meter) of penetration. Any changes in the drilling rate within a run also should be noted along with intervals of caving or raveling. If the bit becomes plugged or blocking off is suspected, the driller should stop drilling and pull the core barrel. Also, when drill circulation is lost, the driller should pull and examine the core.

***3. Drilling fluid return and color* —** The type, color, and estimated percent of drilling fluids returned should be recorded for each core run. The depth of changes in fluid loss or color is particularly important. If drilling mud is used, indicate number of sacks used per shift. In case of total loss of drilling fluid, it may be necessary to pressure test the interval.

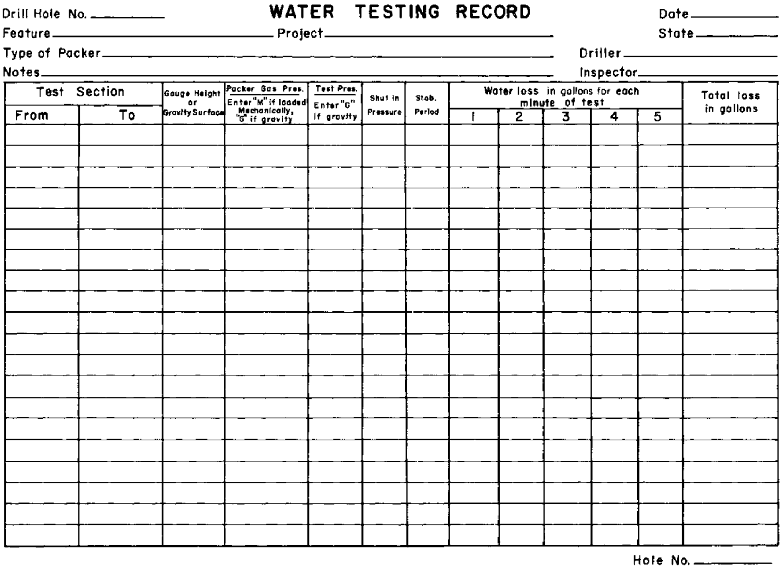
4. Description of core — Drillers need to describe the core in general terms; i.e., moderately hard, very hard, soft, clay seams, broken, color, etc. If familiar with the rock types, drillers may report more than just general terminology.

5. Water-pressure testing — Holes in rock are typically water tested in 10-foot (3-m) intervals at pressures of approximately ½ lb/in^2 (3.5 kilopascals [kPa]) to 1 lb/in^2 (6.90 kPa) per foot (1/3 m) of cover up to 100 lb/in^2 (690 kPa). NOTE: Pressures may be modified for each site. Factors such as density of materials, "overburden pressure" or "cover," bedding, purpose of testing, distances from free faces, water levels, and artesian pressures all must be taken into account so that pressure testing does not unintentionally hydrofracture the foundation or jack foundation materials. Pressures should be determined by the geologist. If a range of pressures is used, and disproportionately high water losses are obtained at the higher pressures, the pressures should be stepped down and water losses at the lower pressures recorded. Water test pressures should be stepped up 3 to 5 times and then stepped down. Flow versus pressure should be plotted; and if the relationship is not linear or smoothly curved, hydrofracturing or jacking may be occurring. If the decreasing pressure curve does not follow the increasing pressure curve, washing, plugging, or hydrofracturing or jacking may be occurring without the foundation materials returning to the prewater test state. Intentionally increasing the pressure until the foundation is fractured or jacked is a good way to determine appro-priate grout pressures. Gravity tests, overlapping pressure tests, and variations in the length of the interval tested may be used to ensure complete test data. For example, a packer interval of 8 feet (2.4 m) may be used if the hole is caving too badly to get 10 feet (3 m) of open hole. Also, if a packer will not seat at 10 feet (3 m) above the bottom of the hole and there is good rock at 12 feet (3.66 m), a 12-foot test interval may be used. If losses are above 15 gal/min (1.146 liters per second [L/sec]), exceed pump or system capacity, or water is known to be bypassing the packer, reduce the length of the packer interval and retest.

Losses should be recorded in gallons and tenths of gal/min (L/sec). The driller should record the water meter reading at 1-minute intervals, and the test should be run for a full 5 minutes at each pressure increment after the flow has stabilized. The driller should report the average flow in gal/min (L/sec) for the 5-minute test. Each driller should keep his own record of the packer data in case questions arise concerning the testing. A suggested form for recording data is shown in figure 10-7.

6. Casing or cementing depths — The depth of the casing or the cemented interval should be shown for each core run. Do not cement any more of the hole than is necessary to repair a caving or raveling interval. The use of additives such as calcium chloride or aluminum powder, if permitted, will reduce the set time. These materials should be added to the water and not to the cement.

7. Recording unusual conditions — All unusual conditions or events should be noted in the "Notes"



Drill Hole No. ____________

WATER TESTING RECORD

Date ____________

Feature ____________ Project ____________

State ____________

Type of Packer ____________

Driller ____________

Notes ____________

Inspector ____________

Test Section		Gauge Height or Gravity Surface	Packer Gas Pres. Enter "M" if loaded Mechanically, "G" if gravity	Test Pres. Enter "G" if gravity	Shut in Pressure	Stab. Period	Water loss in gallons for each minute of test					Total loss in gallons
From	To						1	2	3	4	5	

Hole No. ____________

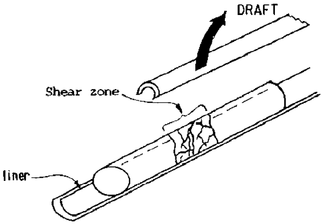
Figure 10-7.—Water testing record.

column of the report. This includes such items as sudden changes in drilling speed, loss of circulation, drop of drill string (open joints or cavities), casing and cementing procedures, caving, squeezing, packer failures, and gas.

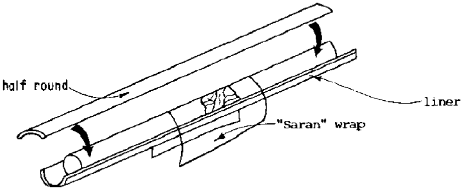
8. Recording setups, drilling, and downtime — Time must be noted on reverse side of report. Type, number, and size of bit is indicated here also.

9. Recording water level measurements — Measurement should be recorded at the start of each day shift and shown on the day shift report. Holes should be jetted or bailed prior to completion of the hole to obtain reliable water level data. Immediately after jetting or bailing, the depth to water should be recorded.

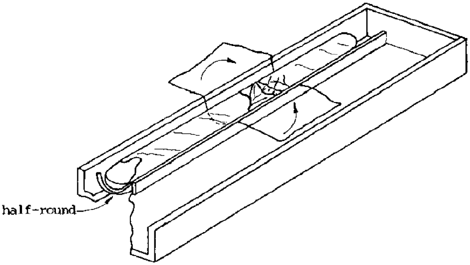
10. Care of core and core boxes — Split-tube (triple tube) core barrels should be used. If not used, the core should not be damaged when extracted from the core barrel. Do not beat on the barrel with a metal hammer; use a rubber mallet/hammer or a piece of wood. The best way to remove core from a solid barrel is by using a pump to pressurize the inside of the barrel and extrude the core (stand back!). The mud pump will work satisfactorily for this. Core should be extracted from the inner tube and carefully placed into core boxes by hand. The use of cardboard or plastic halfrounds is recommended (see figure 10-8. Core pieces should be fitted into the core box and fragments should be arranged to save space. Long pieces may be broken for better fit in the core box, but a line should be drawn across the core to denote mechanical breaks. If 5-foot (1.5-m) core



1. Remove upper split liner to expose fractured rock or shear zone.



2. Place "Saran" wrap over shear zone; then place half-round over top of core and wrap.



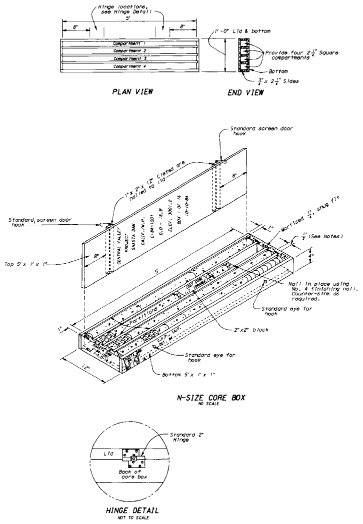
3. Take to core box, rotate liner, half-round and core 180° and place in core box; then wrap "Saran" wrap over top of core. An additional half-round may then be placed over the zone to protect it, or to write on. Shear zone may be lifted out of box as a unit if waxing of sample is desired.

Figure 10-8.—Use of half-round to protect core.

boxes are used, mechanical breaks to fit 5-foot runs in boxes are reduced. Figure 10-9 shows a typical core box for N-size core.

Core should be placed in the core box from left to right, with the top to the left, bottom to the right, starting at the top of the box so the core reads like a book. The ends and top of the box should be marked with black enamel paint or indelible felt pen. Core blocks, which mark the depths, are placed between each run and the depth marked. Data on the outside of the left end of the box should include the project, feature, drill hole number, box number, and depth interval in the box.

Filler blocks (spacers) are necessary to properly record information and minimize disturbance to the core during handling. Blocks should be placed with a planed side marked with either black enamel paint or indelible felt-tip pen; 2- by 2-inch (50- by 50-mm) blocks work well for N-size core. All core runs must be separated with blocks properly labeled at the top and bottom of the run. Sample intervals should be marked in the boxes using wooden blocks of lengths equal to the missing core so that the sample may be returned to the box. Gaps for core losses should not be left in the core box. Core left in the hole and recovered on the next run may be added to the previous run. Filler blocks inserted where unaccountable core losses occur should show the length of loss in tenths of feet, as follows: LC (lost core) 0.3 foot, or NR (no recovery) 0.3 foot. The core loss block indicates that a certain length of core was unaccountably lost within a run, and the block should be placed at the depth of the core loss. If the point of core loss cannot be determined, the block can be placed in the core box at the bottom of



NOTES

1. Box construction - Ends, sides, partitions, lid, and bottom shall be 1-inch nominal thickness from commercial grade No. 2 pine or better, and surfaced on all sides. The grain shall be parallel to the long axis. All pieces shall be seasoned to prevent objectional warping. All joints shall be securely fastened with 8d ring-shank nails, spaced on not over 6-inch centers and with at least two nails at each corner. The end shall be mortised 1/4 inch deep to accept partitions. The lid and bottom shall fit snugly within the frame work of the box.

2. Partitions shall be nominally 5 feet-long, 2-1/4 inches high, and 1/2 inch - thick. (See Note 12).

3. Spacer blocks. - Twelve spacer blocks shall be required for each box. Spacer blocks shall be constructed of 1-inch nominal clear lumber, 2-1/4 inches square; and are to be nailed in place at the bottom of each core run with number 4 finishing nails. Spacer blocks shall be painted white. These blocks shall be labeled to show: Run or Run pull number, depth of that Run, and the amount of lost core (or gain) that occurred during that run. Should some core be left in the hole, the driller shall limit his run so as not to overfill the core barrel. The gain shall be recorded when recovered.

4. Core loss blocks. - Core loss blocks shall be constructed from standard 2-by 2-inch wood or styrofoam stock. The length of these blocks shall be equivalent to the core loss interval and shall be inserted in the run wherever core loss occurs, with the exception that for accumulated (interval indeterminable) core loss, the block shall be placed at the end of the run and before the spacer block. Core loss blocks shall be painted fluoresent orange or tangerine.

5. Workmanship. - Boxes shall be constructed substantially to withstand rough usage and shall be nailed to secure members without splitting.

6. Core box labeling. - Labeling shall be stencilled on each box with black waterproof paint or equivalent. The following items shall be marked on the interior and exterior center of the lid:
   - A. Feature
   - B. Project
   - C. Region/State
   - D. Drill hole number
   - E. Surface Elevation/Location w/stationing
   - F. Drill interval
   - G. Box of boxes
   - H. Date

7. Feature Hole Number, depths and box number shall be stencilled on both ends of each box.

8. Depths in feet and tenths of a foot (meters) shall be marked clearly with a black-waterproof felt-tip pen, or equivalent, on the top of both box ends for each core compartment and the top of each spacer block. Core loss blocks shall be marked in like manner with the top and bottom of the loss interval. Core depths shall be marked at the top and bottom of each pattern.

9. Handling of core and boxes. - The top of the core shall be placed at the back left corner of the box, and the remaining core shall be placed proceeding left to right, back to front, throughout the remaining core compartments.

10. Unused portions of the partitions shall be filled with 2 by 2-inch wood or styrofoam stock, cut to fit.

11. Nail the lid into place only if required.

12. Clear plastic half rounds cut from PVC pipe are to be used when core is particularly susceptible to disturbance during handling and storage. If orientation of geologic features is anticipated when core is broken in short segments the core should be enclosed in two clear plastic half rounds and secured by tape. The inside diameter of the PVC pipe must be equivalent to the outside diameter of the core. For core handling and use of half rounds See figure II 10-17.
To accomodate the use of half rounds, modification may be required to the compartmental dimensions shown for the construction of the core box.

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

ENGINEERING GEOLOGY MANUAL
N-SIZE CORE BOX

DESIGNED GEOLOGY STAFF TECHNICAL APPROVAL M.L. Hill
DRAWN D.D. Droullard SUBMITTED M.L. Hill
CHECKED APPROVED
CHIEF, DIVISION OF GEOLOGY
DENVER, COLORADO
COMPUTER DRAFTING
OCTOBER, 1987
102-D-9

Figure 10-9.—Standard N-size core

the run, preceding the bottom of run block. Cavities may be marked on the block. All spacer, sample, and core loss blocks should be nailed to the bottom or sides of the box to prevent movement of the core.

At the drill site, core boxes should be lined up, preferably on boards or planks, in order from top to bottom, with labels and up side to left, in a safe area and kept covered with lids. While in the field, do not place boxes where sliding or caving of slopes is likely to occur and keep out of the way of vehicles and equipment. Core boxes, especially those containing soft, slaking, or intensely fractured core material, should be covered immediately to prevent damage by rain or drying. Tray partitions in boxes should be nailed so that nails do not protrude from bottom of boxes.

When the core is moved, be careful to prevent disturbance, breakage, or spilling. Damage to the core during transportation can be minimized by using nailed-down spacers and a 3/4- to 1-inch thick (19-25-mm) foam-rubber pad placed between the top of the core and the secured core box lid.

Hole Completion.—Completion of the drill hole should meet the requirements established by the exploration program and at the direction of the field geologist. Drill holes usually will be completed either with sufficient casing or plastic pipe to assure that the hole will stay open for later water level observations. In areas where vandalism may occur or when long-term monitoring is contemplated, a standpipe and suitable cap with lock should be installed. Completion information should be indicated on the driller's report. The drill hole number should be stamped or welded into the casing. If groundwater observation riser pipes have been installed, install a minimum 3-foot (1-m) length of surface casing with a locking cap as a standpipe to mark the drill hole and protect the riser pipe. Grouted in place, this standpipe can also serve to protect the observation well from infiltration by surface runoff.

Concrete Core Logging

Concrete structures are commonly cored to assess the quality of concrete or as part of foundation investigations on existing features. An early macroscopic assessment of concrete core is warranted for the following reasons:

- Concrete physical condition may suggest changes in the drilling program or sampling techniques that would be difficult to modify after drilling is complete. A different approach in drilling or sampling techniques may be necessary to determine the cause of distress or failure.

- Shipping, handling, and sample preparation may modify the concrete core by inducing, modifying, or masking fractures or causing core disintegration.

- Core could be lost or destroyed before reaching the laboratory.

- Macroscopic examination may provide the required information eliminating the need for a petrographic examination.

This section is based on American Society for Testing Materials Designations (ASTM) C 823-83 and C 856-83.

Purposes of Examination.—Investigations of in-service concrete conditions are usually done to: (a) determine the ability of the concrete to perform satisfactorily under anticipated conditions for future service; (b) identify the processes or materials causing distress or failure; (c) discover conditions in the concrete that caused or contributed to satisfactory performance or failure; (d) establish methods for repair or replacement without recurrence of the problem; (e) determine conformance to construction specification requirements; (f) evaluate the performance of the components in the concrete; and (g) develop data for fixing financial and legal responsibility.

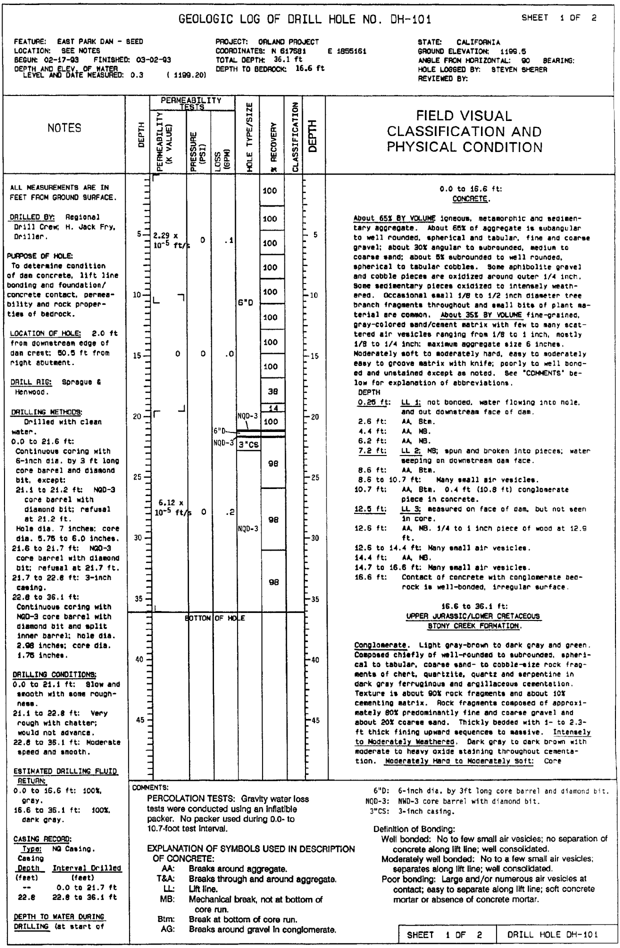
In addition to the usual drill log information, the following should be provided, if available:

- Reason for and objectives of the coring program.
- Location and original orientation of each core.
- Conditions of operation and service exposure.
- Age of the structure.
- Results of field tests, such as velocity and rebound or Schmidt hammer data.

Figure 10-10 is an example of a drill hole log showing the types of information that can be shown and a format for a log showing both rock and concrete core.

Examination.—Concrete core is commonly marked in the field showing the top and bottom depths at the appropriate ends and at any of the following features. Below are listed the major items to examine and record:

> ***Fractures* —** Cracks or fractures in core are best seen on smooth surfaces and can be accented by wetting and partial drying of the surface. Old crack surfaces are often different colors than fresh fracture



GEOLOGIC LOG OF DRILL HOLE NO. DH-101

SHEET 1 OF 2

FEATURE: EAST PARK DAM - SEED
LOCATION: SEE NOTES
BEGUN: 02-17-93 FINISHED: 03-02-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 0.3 (1199.20)

PROJECT: ORLAND PROJECT
COORDINATES: N 617681 E 1855161
TOTAL DEPTH: 36.1 ft
DEPTH TO BEDROCK: 16.6 ft

STATE: CALIFORNIA
GROUND ELEVATION: 1199.5
ANGLE FROM HORIZONTAL: 90 BEARING:
HOLE LOGGED BY: STEVEN SHERER
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE IN FEET FROM GROUND SURFACE.

DRILLED BY: Regional Drill Crew; H. Jack Fry, Driller.

PURPOSE OF HOLE: To determine condition of dam concrete, lift line bonding and foundation/concrete contact, permeability and rock properties of bedrock.

LOCATION OF HOLE: 2.0 ft from downstream edge of dam crest; 50.5 ft from right abutment.

DRILL RIG: Sprague & Henwood.

DRILLING METHODS: Drilled with clean water.
0.0 to 21.6 ft: Continuous coring with 6-inch dia. by 3 ft long core barrel and diamond bit, except:
21.1 to 21.2 ft: NQD-3 core barrel with diamond bit; refusal at 21.2 ft.
Hole dia. 7 inches; core dia. 5.75 to 6.0 inches.
21.6 to 21.7 ft: NQD-3 core barrel with diamond bit; refusal at 21.7 ft.
21.7 to 22.8 ft: 3-inch casing.
22.8 to 36.1 ft: Continuous coring with NQD-3 core barrel with diamond bit and split inner barrel; hole dia. 2.98 inches; core dia. 1.75 inches.

DRILLING CONDITIONS:
0.0 to 21.1 ft: Slow and smooth with some roughness.
21.1 to 22.8 ft: Very rough with chatter; would not advance.
22.8 to 36.1 ft: Moderate speed and smooth.

ESTIMATED DRILLING FLUID RETURN:
0.0 to 16.6 ft: 100%, gray.
16.6 to 36.1 ft: 100%, dark gray.

CASING RECORD:
Type: NQ Casing.

Casing Depth (feet)	Interval Drilled (feet)
--	0.0 to 21.7 ft
22.8	22.8 to 36.1 ft

DEPTH TO WATER DURING DRILLING (at start of

FIELD VISUAL CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 16.6 ft:
CONCRETE.

About 65% BY VOLUME igneous, metamorphic and sedimentary aggregate. About 65% of aggregate is subangular to well rounded, spherical and tabular, fine and coarse gravel; about 30% angular to subrounded, medium to coarse sand; about 5% subrounded to well rounded, spherical to tabular cobbles. Some aphibolite gravel and cobble pieces are oxidized around outer 1/4 inch. Some sedimentary pieces oxidized to intensely weathered. Occasional small 1/8 to 1/2 inch diameter tree branch fragments throughout and small bits of plant material are common. About 35% BY VOLUME fine-grained, gray-colored sand/cement matrix with few to many scattered air vesicles ranging from 1/8 to 1 inch, mostly 1/8 to 1/4 inch; maximum aggregate size 6 inches. Moderately soft to moderately hard, easy to moderately easy to groove matrix with knife; poorly to well bonded and unstained except as noted. See "COMMENTS" below for explanation of abbreviations.

DEPTH	
0.25 ft:	LL 1; not bonded, water flowing into hole, and out downstream face of dam.
2.6 ft:	AA, Btm.
4.4 ft:	AA, MB.
6.2 ft:	AA, MB.
7.2 ft:	LL 2; MB; spun and broken into pieces; water seeping on downstream dam face.
8.6 ft:	AA, Btm.
8.6 to 10.7 ft:	Many small air vesicles.
10.7 ft:	AA, Btm. 0.4 ft (10.8 ft) conglomerate piece in concrete.
12.5 ft:	LL 3; measured on face of dam, but not seen in core.
12.6 ft:	AA, MB. 1/4 to 1 inch piece of wood at 12.9 ft.
12.6 to 14.4 ft:	Many small air vesicles.
14.4 ft:	AA, MB.
14.7 to 16.6 ft:	Many small air vesicles.
16.6 ft:	Contact of concrete with conglomerate bedrock is well-bonded, irregular surface.

16.6 to 36.1 ft:
UPPER JURASSIC/LOWER CRETACEOUS
STONY CREEK FORMATION.

Conglomerate. Light gray-brown to dark gray and green. Composed chiefly of well-rounded to subrounded, spherical to tabular, coarse sand- to cobble-size rock fragments of chert, quartzite, quartz and serpentine in dark gray ferruginous and argillaceous cementation. Texture is about 90% rock fragments and about 10% cementing matrix. Rock fragments composed of approximately 80% predominantly fine and coarse gravel and about 20% coarse sand. Thickly bedded with 1- to 2.3-ft thick fining upward sequences to massive. Intensely to Moderately Weathered. Dark gray to dark brown with moderate to heavy oxide staining throughout cementation. Moderately Hard to Moderately Soft: Core

COMMENTS:

PERCOLATION TESTS: Gravity water loss tests were conducted using an inflatible packer. No packer used during 0.0- to 10.7-foot test interval.

EXPLANATION OF SYMBOLS USED IN DESCRIPTION OF CONCRETE:

AA:	Breaks around aggregate.
T&A:	Breaks through and around aggregate.
LL:	Lift line.
MB:	Mechanical break, not at bottom of core run.
Btm:	Break at bottom of core run.
AG:	Breaks around gravel in conglomerate.

6"D:	6-inch dia. by 3ft long core barrel and diamond bit.
NQD-3:	NWD-3 core barrel with diamond bit.
3"CS:	3-inch casing.

Definition of Bonding:
Well bonded: No to few small air vesicles; no separation of concrete along lift line; well consolidated.
Moderately well bonded: No to a few small air vesicles; separates along lift line; well consolidated.
Poor bonding: Large and/or numerous air vesicles at contact; easy to separate along lift line; soft concrete mortar or absence of concrete mortar.

SHEET 1 OF 2 DRILL HOLE DH-101

Figure 10-10.—Log of concrete and rock core.

surfaces. Old fracture surfaces often have reaction products or alteration of the surfaces. Fractures often follow structural weaknesses.

Reacted particles — Rims on gravel or sand are often caused by weathering processes unless other factors indicate chemical reactions with the cement paste. Crushed aggregate with rims probably is due to chemical reaction with the cement paste.

Reaction products — Crushed aggregate with rims usually indicates alteration in the concrete, such as alkali-silica reaction or alkali-carbonate reaction. Rims in paste bordering coarse aggregate and light colored areas in the paste may be gel-soaked or highly carbonated paste adjoining carbonate aggregate that has undergone an alkali-carbonate reaction. White areas of fairly hard, dry material or soft, wet material that has fractured and penetrated the concrete and aggregate or fills air voids should be recorded. Alkali aggregate reaction products can be differentiated from calcium carbonate deposits by using hydrocloric acid. The reaction products do not fizz.

Changes in size or type of fine and coarse aggregate — Sizes, shapes, and types of aggregate can vary in a structure due to changes in mixes, placement procedure, or sources and should be logged.

Voids — Voids (honeycomb, popcorn) are indicators of trapped air, inadequate vibration, or insufficient mortar to effectively fill the spaces among coarse aggregate particles. Voids should be described and the volume percent estimated.

Segregation of components **—** Concrete components can become segregated or concentrated during placement. Large aggregate sizes can separate from fine aggregate, and paste can separate from the aggregate, especially near forms or finished surfaces.

Cold joints or lift lines **—** Weak joints or zones can form in concrete due to long periods between buckets or mixer loads. Poor vibration or poor or improper preparation of previous lift surfaces can form zones of weakness or actual planes similar to joints in rock. These surfaces, called lift lines, should be described and any material on the surfaces described. Lift lines can be very subtle and difficult to locate. Design or construction data often provide clues as to where to look for lift lines and construction joints. The core should be examined wet. Clues to lift line locations are: (1) aligned aggregate along the surfaces each side of a line, (2) coarser aggregate above the lift line than is below the line, (3) different shape, gradation, or composition of aggregate above and below the lift line, (4) a thin line of paste on the lift line, and (5) no aggregate crosses the lift line.

Steel or other imbedded items **—** Reinforcing steel and orientations should be described as well as other materials encountered such as timber, steel lagging, dirt, or cooling pipes.

Changes in color of the cement **—** Changes in paste color can indicate reaction products or changes in cement type or cement sources and should be logged.

Aggregate-paste bond **—** The bond between the aggregate and cement should be described. A good bond is characterized by concrete breaking through the aggregate and not around the particles. A fair bond is characterized by concrete breaking through and around the aggregate. A poor bond has concrete breaking around the aggregate.

Aggregate rock type **—** The aggregate rock type can be important in determining the causes of concrete problems. For example, limestone often has chert inclusions suggesting an aggregate reaction, whereas an igneous rock such as granite probably will not react with cement. Both the coarse and fine aggregate should be examined.

Aggregate shape **—** Aggregate shape is usually unique to each source. Rounded or subrounded aggregate is probably natural. Angular (sharp) aggregate is probably crushed.

Mechanical breaks **—** Mechanical breaks in the core and whether the break is around or through the aggregate should be noted.