APPENDIX 2L

GEOLOGIC INVESTIGATION OF SOILS AND THE BEDROCK SURFACE AT UNIT 2 CONTAINMENT SITE. **SEABROOK** STATION

The information contained in this appendix was not revised, but has been extracted from the original FSAR and is provided for historical information.

GEOLOGIC INVESTIGATIONS

of

SOILS AND THE BEDROCK SURFACE

at

UNIT 2 CONTAINMENT SITE

SEABROOK STATION

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE
SEABROOK, NEW HAMPSHIRE

October 24, 1974

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Geological Investigations of Soils and the Bedrock Surface Unit 2 Containment Site Seabrook Station Seabrook, New Hampshire

During August and early September, 1974, four trenches 200' in length were excavated to bedrock on an "x" configuration across the area of the Unit 2 containment site at the Seabrook Station, New Hampshire.

The bedrock in the floor of these trenches is gneissoid quartz diorite of the Newburyport pluton, which is commonly fractured at less than 3' intervals in this area by an intersecting pattern of high-angle and low-angle joints. The most prominent and continuous joint se; within the containment area appears to be one which strikes N80-90E, dips steeply to the north, and is characterized by smooth chlorite-coated joint surfaces.

Unconsolidated overburden in the containment area ranges to a maximum of about 16' in thickness, and is characterized by a basal deposit of sand-silt-cobble till locally overlain by a blanket of medium-fine outwash sand. Glacial-marine clay lies between the till and outwash to the east of the containment. Where covered by outwash sand, the upper surface of the till is beveled to a gently undulating, sub-planar erosion surface upon which rest isolated eratic boulders ranging to 3' in diameter.

No evidence of Recent fault displacement was observed on the bedrock surface in the Unit 2 trenches. The sub-planar till/outwash contact horizon, which occurs in three of the four trenches, shows no evidence in these areas of static or dynamic deformation.

1. Purpose of Investigations

Bedrock at the site of the proposed Unit 2 containment is largely obscured by glacial till, glacial-marine clay and outwash sand. Boring E2-1, drilled in December 1972 to a depth of 159.2' on the vertical centerline of Unit 2, encountered thin zones of structural weakness in the diorite bedrock at intervals between elevations -75' and -110'.

These zones are characterized by smooth chlorite-rich surfaces on high-angle joints, and by closely-jointed zones in chlorite-rich portions of the bedrock. High-angle joints in Boring E2-1 dip from 60° to 85°, and most commonly dip 65-70°

Trenching investigations over the Unit 2 site were conducted in August-September 1974 for precautionary purposes, to ascertain the structure of the glacial deposits in the urea and to examine the nature of jointing in the underlying bedrock surface.

2. Borings Investigations Subsequent to Boring E2-1

During April 1974, Eoring E2-5 was drilled to a depth of 97.8' at a iocatior, 33' N13E (True) of the centerline of Unit 2 (see Appendix I for boring log) . This boring encountered joints with minor chlorite coatings at various elevations, with a zone of smooth chlorite-coated joints between -64 to -79' elevations. These joints dip 55° to 75°, and frequently show pyrite crystal growths over the chlorite surfaces.

During May-June 1974, four inclined borings, E2-15, E2-16, E2-17 and E2- 18, were put down around the periphery of the Unit 2 containment site to develop information relative to engineering of the containment excavation . Logs and orientation data for these borings are presented in a July 31, 1974 report prepared by Geotechnical Engineers, Inc., Winchester, Massachusetts (see Appendix II) .

Borings E2-15 and E2-16, along the west and south edges of the containment, respectively, encountered very few chlorite-coated joints. A polished joint at 88' depth in E2-15 appears likely to represent the projection to depth of a prominent chlorite-coated high-angle joint which is observed on the bedrock surface to trend east-west through the centerline of Unit 2. There are no anomalously polished joints in Boring E2-16.

Boring E2-17, drilled northerly across the east edge of the containment site, encountered polished chlorite-coated joints intermittently at depths of 62-67', 82', 87', 98-103', 137' and 152-156'. Some of these joints appear to correlate with the prominent east-west joint which trends through the centerline of Unit 2. This prominent joint appears to split into a number of high-angle branches as it passes east into the zone of influence of Boring E2-17.

Boring E2-18 encountered numerous individual joints which have minor chlorite coatings. No anomalously polished or chlorite-rich joints were found, however, in the 168' inclined depth drilled.

When examined in conjunction with joint mapping of the bedrock surface (Figure 2), Borings E2-15, E2-16, E2-17 and E2-18 do not indicate the presence of a through-going fault structure in the area of Unit 2. These borings do appear, however, to suggest that the most prominent or continuous high-angle chlorite-coated joint system in the containment area trends approximately east-west (True) through the central part of the containment, and dips 70-80° to the north.

3. Trench Excavations

During August 1974, four trenches were excavated with a backhoe to bedrock across the 'Unit 2 site, to form an "x" whose legs are each approximately 203' long and intersect at right angles at the vertical centerline of the Unit. The legs trend approximately True North, East , South and West (see Figure 1) .

Ground surface elevations in the area of the trenches range from about +10' to +20' . The elevation of the bedrock surface in the floor of the trenches ranges from about -3' at Station 1+80 in the East trench, to +14' at Station 1+85 in the South trench. Profiles of the bedrock surface along the centerlines of the trenches, as surveyed by Public Service Company 'of New Hampshire personnel, are shown on Figures 1 and 3.

4. Bedrock Exposed in the Trenches

Figure 2 shows by half-tone shading the areas of bedrock mapped by J. R. Rand in the several trenches. Although the trenches were excavated to bedrock, throughout, the bedrock in the low elevation areas was too obscured by water and mud to permit the observation of joints or other pertinent structural features. Although much of the bedrock surface is rough and irregular due to glacial plucking or breaking by the backhoe, wide areas of the bedrock are locally smooth and show glacial striations.

Throughout the area exposed by the trenches the bedrock consists predominantly of gneissoid, sometimes quartzitic, quartz diorite which ranges in grain size from fine- to medium-grained. Coarse

hornblende diorite occurs locally in the West and South trenches. Gneissoid banding commonly strikes about N80W and dips very steeply to the north. No diabase dikes were observed in the trenches or in the several borings in the area. The bedrock is commonly fresh and hard in the containment area, with weathering effects limited to surface staining on joints.

A. Faulting

No evidence of offset of the 'bedrock surface or the overlying glacial sediments was observed in the trenches. Welded breccia fabric, which is seen locally in drill core both in the Unit 2 area and elsewhere throughout the site area, can be seen exposed on a smooth glacially-scoured bedrock surface approximately 5' to the southwest of Boring E2-1 in the trench excavation. This breccia is 1-2" wide, strikes approximately east-west, dips steeply, is annealed and compact, and shows no offset of the glaciated bedrock surface.

B. Jointing

As shown on Figure 2, jointing in the bedrock is closely spaced throughout the Unit 2 containment area, occurring at intervals which rarely exceed 5' and commonly occurring at less than 3' intervals.

High-angle joints (greater than 50° dips) occur in three prominent orientations:

Strike N65-70W	Dip 65-80N
Strike N05-20W	Dip 65-85W
Strike N80-90E	Dip 65-90N

At the centerline of Unit 2, the most continuous joint trend is N80-90E with steep dips to the north. This set is seen commonly to have chlorite-coated surfaces. The N65-70W joints appear to converge and terminate against the N80-90E set, while the N05-20W joints are characteristically short and discontinuous. Slickenside striations which occur on many of the joints exhibit widely divergent directions of movement.

Low-angle joints (less than 50° clips) appear to be somewhat more common than high-angle joints, and occur generally in three prominent orientations:

Strike N25-40E	Dip 35-40° NW and SE
Strike N 15-30W	Dip 35-40° NE and SW
Strike N80-90E	Dip 35-45° North

Low-angle joint surfaces are commonly planar, and occasionally show slickenside striations, with no consistent striation orientation from joint to joint.

From about Station 1+15 to 1+50 in the East trench, the bedrock is subject to closely-spaced jointing, and the upper 1-3' of the bedrock was sufficiently fractured to permit excavation by t'ne backhoe. Joints in this area are chlorite-coated and smooth, and show some polishing on conchoidal surfaces. Thin gray clay fillings occur locally in discontinuous patches between some joints. Slickensides show no preferred orientation, and no strike direction could be determined for this zone.

5. Unconsolidated Glacial Deposits

As shown on trench profiles on Figure 3, brown sand-silt-cobble till directly overlies the bedrock surface throughout the area exposed by the four trenches. Till rises to ground surface throughout the length of the South trench, and rises locally to ground surface in the North trench and in the area of the Unit 2 centerline. Where the till does not rise to ground surface in the trenches, the upper surface of the till is a gently undulating, sub-planar erosion surface on which was deposited a layer of medium-fine outwash sand. At the east end of the East trench, a sequence of interbedded, evenly-layered marine clays and sands lies between the till and the overlying outwash sand layer. At scattered intervals in the West, North and East trenches, isolated boulders ranging to 3' in diameter lie enclosed in outwash sand and rest on the upper surface of the till.

Subsequent to backhoe excavation of the trenches, the contact horizon between the till and overlying outwash sand was exposed and cleaned by hand throughout the length of its exposure in the West, North and East trenches. The contact was inspected and photographed by J. R. Rand throughout its exposed length in these trenches, and its elevation determined by transit leveling along both walls of each of these trenches. The extent of the outwash sand deposits in the trench walls and the elevations of the till/outwash contact from place to place are shown on Figure 2.

No features were observed along this till/outwash contact in any of the trenches to suggest either static or dynamic deformation subsequent to deposition of the sand on the beveled till surface. Throughout the zone of close and slippery bedrock jointing between Stations 1+15 and 1+50 in the East trench, the overlying till/outwash contact horizon is sub-planar and continuous.

Glacial materials overlying the bedrock surface throughout the South trench are limited to unsorted, non-layered sand-silt-cobble till. These materials locally show a crude stratification, and nowhere exhibit structures suggestive of post-depositional deformation.

6. Conclusions

Examination of the overburden, bedrock surface and bedrock joints in the Unit 2 trench excavations has revealed several distinctive features which are indicative of the tectonic stability of the bedrock at the site:

A. Intermittent crudely-stratified horizons in the glacial till are not displaced over joints in the underlying bedrock.

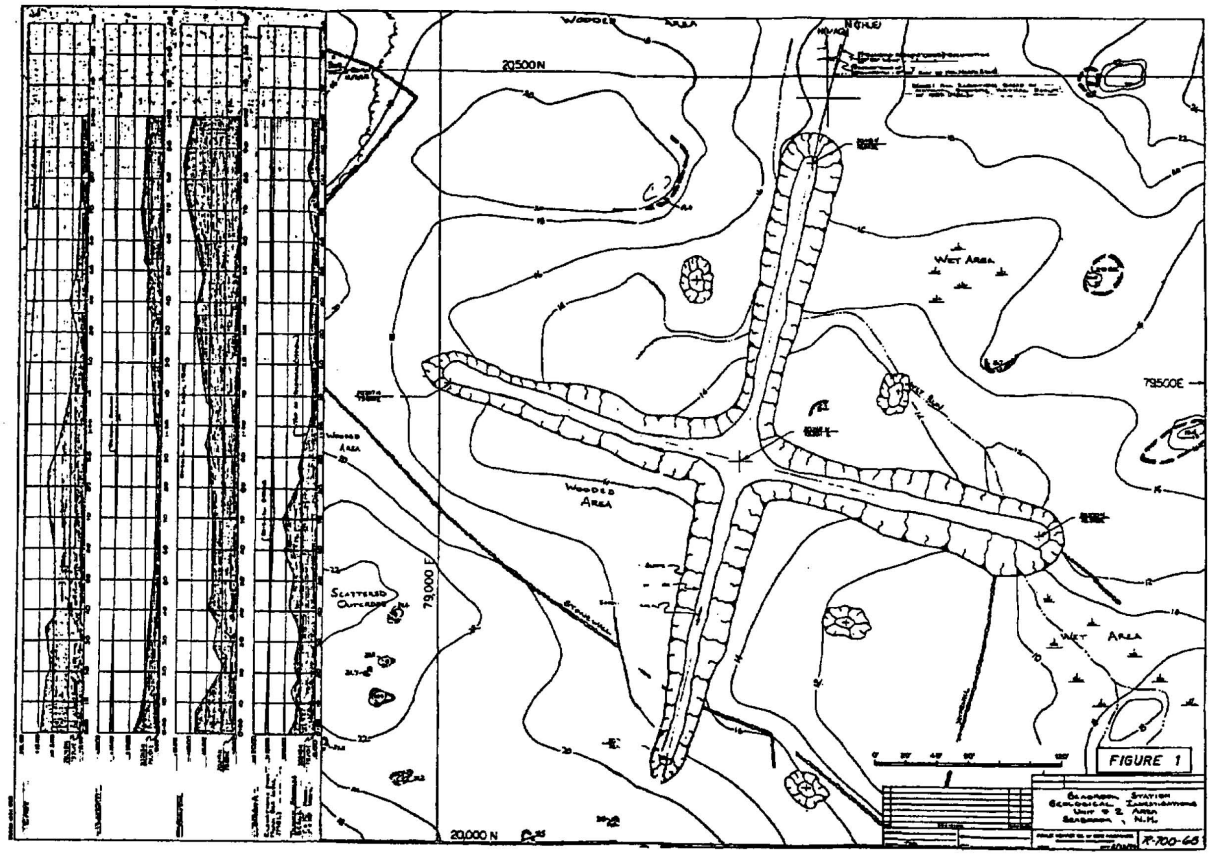
B. The undulating, sub-planar erosion surface at the top of the till is through-going and not subject to structural offsets or other deformations suggestive of faulting,

C. Local exposures of glacially-scoured bedrock surfaces are smooth across joints in the bedrock.

D. Slickenside striations on closely-spaced bedrock joints exhibit widely divergent orientations, with no preferred attitude or orientation.

John R. Rand
Consulting Geologist

FIGURES


20500N
79500E
79000 E
20,000 N
Wet Area
Wooded Area
Scattered Outcrops
FIGURE 1

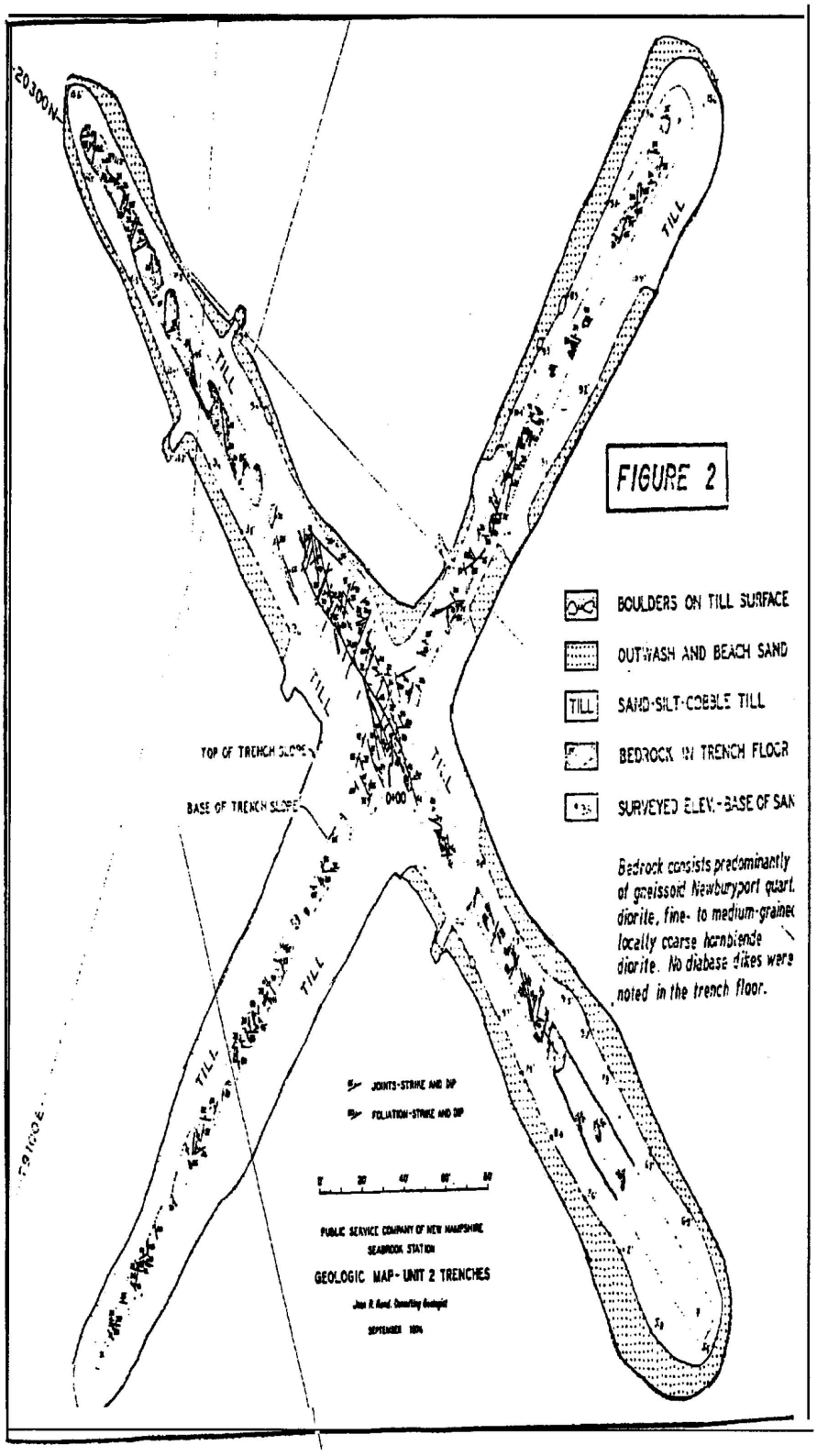
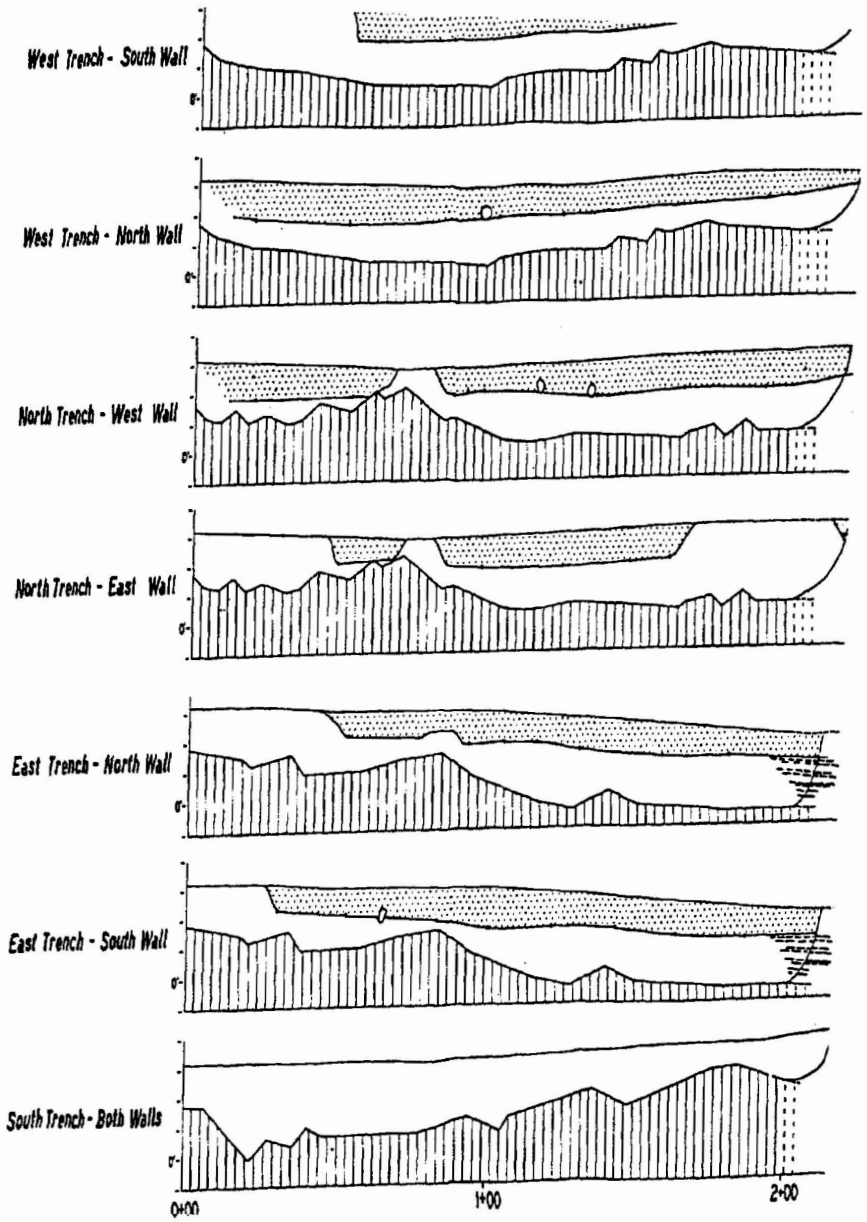


FIGURE 2
BOULDERS ON TILL SURFACE
OUTWASH AND BEACH SAND
TILL
SAND-SILT-COBBLE TILL
BEDROCK IN TRENCH FLOOR
SURVEYED ELEV.-BASE OF SAN
Bedrock consists predominantly of gneissoid Newburyport quart. diorite, fine- to medium-grained locally coarse hornblende diorite. No diabase dikes were noted in the trench floor.
TOP OF TRENCH SLOPE
BASE OF TRENCH SLOPE
JOINTS-STRIKE AND DIP
FOLIATION-STRIKE AND DIP
PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE
SEABROOK STATION
GEOLOGIC MAP- UNIT 2 TRENCHES
SEPTEMBER 1974



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SEABROOK STATION

SOILS PROFILES - UNIT 2 TRENCHES

John R. Rand, Consulting Geologist

SEPTEMBER 1974

FIGURE 3

APPENDIX I
Boring Log - Boring E2-5

BORING LOCATION N20272, E72215; Plant Site | INCLINATION Vertical | BEARING | DATE START/FINISH April 25, 1974 / April 29, 1974

CASING ID 3 in. | CORE SIZE 2-1/8 in. | TOTAL DEPTH 87.7 ft | DRILLED BY American Drilling & Boring - A. Whitaker

GROUND EL (MSL) 116.5 ft | DEPTH TO WATER DATE -1.5 ft / April 30, 1974 | LOGGED BY Soil - K. J.; Pdh.; Rock - J. H. Hazel

EL. MSL ft	SAMPLE Depth ft	Type and No.	N or Rec.	RATE OF ADV. min/ft	WATER CONTENT or RQD %	Graphic	PRESSURE TEST gpm psi	Computed k 10^{-4} cm/sec	STRIKE, DIP F = Foliation J = Joint C = Contact B = Bedding	CORE BREAKS	SOIL AND ROCK DESCRIPTIONS (Weathering, defects, etc.)	(Type, texture, mineralogy, color, hardness, etc.)
116.5	0	S1	4								Dark brown topsoil with roots.	
	0.5	S2	3						TOP OF SAND		Similar to Sample S1.	
	1.5	S2A	2						TOP OF TILL		Tan fine SAND (SP) brown silty fine sand. Uniform; fines are nonplastic.	
	2.0	S3	22								Light rusty brown very slightly silty uniform fine sand.	
		S3A	17								Light brown fine to medium gravelly sand. Fines are nonplastic; widely graded.	
		S4	28								Similar to Sample S3A, but less gravelly.	
		S5	33								Rusty brown silty fine sand. Uniform; fines are nonplastic; gray-brown gravelly pocket.	
		S6	47								Similar to Sample S3A, contains gray silty fine sand layer 10 mm thick.	
	4.0	S7	100/1						TOP OF ROCK		Refusal - No sample.	
	10	NX-1	100		40						Slight wx Rusty Vertical joint Slight wx	Fresh and hard. Local high angle joints show surface wx effects. Partings dip 10 to 20°.
0	20	NX-2	100		43						Slight wx Moderate wx Slight wx Vuggy	
	30	NX-3	100		38						Minor chlorite 68° No chlorite Slight wx Minor chlorite	Fresh and hard. Joints and partings show minor surface wx effects. Some minor chlorite coatings.
-20	40	NX-4	100		42						Pyrite Minor chlorite	
	50	NX-5	98		70						68° Minor chlorite	Fresh and hard. High-angle joint sets widely spaced. Slight surface wx effects on joints.
-40	60	NX-6	99		65						Minor chlorite 65° Chlorite	Fresh and hard. High-angle joints not closely-only slight surface wx effects on joints. Most partings dip 30 to 45°.
		NX-7	100		73						68° Chlorite Partings at 45°	
	70	NX-8	100		50						68° Minor chlorite Vertical joint Slight wx 65° Chlorite	
-60	80	NX-9	94		35						Chlorite Chlorite-slippery 65° joints Chlorite	Fresh and hard. Subject to closely-spaced high-angle jointing with chloritic coatings. Pyrite stals overgrowths on chlorite.
	90	NX-10	100		0						Chips 0° chlorite Chlorite-pyrite stals	
-80		NX-11	92		31						65° joints Chlorite	
	87.7								BOTTOM OF HOLE			

	Type	Description
	Fine quartzite	Diorite (?) Medium-fine to medium grained medium gray. Contains magnetic disseminated through rock. Fine quartzite is not magnetic.
	Magnetic	Diorite (?) or feldspathic metaquartzite (?). Medium fine grained, medium gray. Locally foliated, variable orientations. Magnetic.
	Magnetic	Diorite (?) or feldspathic metaquartzite (?). Medium fine grained, medium gray. Locally medium-grained, feldspathized rock attracts magnet.
	Magnetic	Diorite (?) or feldspathic metaquartzite (?). Medium fine grained, medium gray. Local wavy foliation. Notably magnetic.
	Magnetic	Diorite. Medium-fine grained, medium gray. Locally foliated, generally massive. Attracts magnet quite noticeably. Chlorite coatings on joints are locally overgrown with pyrite.

LEGEND

N - Standard penetration resistance, blows/ft
Rec - Length recovered/length cored, %
RQD - Length of sound core 4 in. and longer/length cored, %
S - Split spoon sample ▽ Groundwater
U - Undisturbed samples
S - Shelby tube N - Denison
F - Fixed piston P - Pitcher
O - Osterberg G - GEI
D - Drilling break k - Coefficient of permeability
wx - Weathered, weathering

NOTES

1) - Scale of soil log doubled to accommodate descriptions.
2) - No clays present; therefore no water contents were determined.
3) - Rate of advance not available.

SEABROOK STATION

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE

YANKEE ATOMIC ELECTRIC COMPANY

united engineers

Date: July 5, 1974 | Project 7286

PAGE 1 of 1 | LOG OF BORING B-5

GEOTECHNICAL ENGINEERS INC