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Dear Don:

The purpose of this letter is to transmit site condition information (attached) for three of the ten test sites as part of the Seismic Hazard Characterization Program. These three sites are Limerick, Harris and Millstone. If you need clarification on any of this information feel free to call me.

Sincerely,

Jeff Kimball, Geophysicist
Seismology Section
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Attachment:
As stated

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Summary

Limerick: Rock site. Sedimentary rock consisting of siltstone, sandstone and shale of Triassic age. Average V_p = 12,500 ft/sec Vs=6,100 ft/sec.

Shearon Harris: Rock site. Sedimentary rock consisting of siltstone and fine grained sandstones interbedded with shale and conglomerate. V_p = 10,900 to 13,600 ft/sec Vs = 5600 ft/sec.

Millstone: Mainly a rock site. Metamorphic rock consisting of crystalline bedrock made up of gneiss. V_p = 12,800 to 13,500 ft/sec Vs = 6500 ft/sec. A few structures founded on shallow soil over rock including the control and emergency generator buildings. For analysis the thickness of the soil should be assumed as 30 feet. For 0 to 20 ft Vp = 2,250 ft/sec Vs = 1000 ft/sec and for 20 to 30 ft V_p = 7575 ft/sec Vs = 1750 ft/sec.

Limerick

2.5.4.4.2 Shear Wave Velocity Survey

A shear wave velocity survey was performed to further evaluate dynamic bedrock characteristics. Shear wave velocities were computed from the records obtained using two Sprengnether 3-component engineering seismographs. Observations were made at distances of between 500 and 1000 feet from the shot point, at the locations indicated on Figure 2.5-21. An apparent shear wave velocity (Vs) of 6100 feet per second was derived from the line run perpendicular to the rock strike, roughly in a north-south direction. In the second line, which parallels the approximate east-west strike of the bedding plane, an apparent shear wave velocity of 5800 feet per second was measured. Using elastic theory, a Poisson's ratio of about 0.3 can be calculated using these shear wave velocities and average compressional wave data across the site. Shear wave data are included in Table 2.5-3A.

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2.5.4.4.3 Uphole Velocity Survey

An uphole velocity survey was performed in the pump test well at the location shown on Figure 2.5-21. Measurements were obtained using a Porta-Seis refraction seismograph, with small explosive charges as energy sources, and an inhole cable with 25-foot geophone spacings. Repeated shots were made and the cable was withdrawn in 5-foot increments.

The uphole velocity survey was made to determine variations in the vertical compressional wave velocity of the underlying rock. Compressional wave velocities (Vp) measured were 7700 fps from depth 110 to 140 feet, and 12,600 fps from depths 37 to 110 feet and from 140 to 187 feet.

2.5.4.4.4 Micromotion Measurements

Measurements of the ambient background motion of the site and its response to natural motion generators, such as wind and tides, give an index of the dynamic properties of the materials underlying the site. An attempt was made to measure these motions in the proposed plant area using the Dames and Moore microtremor equipment. This equipment is a highly sensitive, electronic, vibration recording device capable of magnification up to 150,000 times, and it is accurate over a frequency range of about 0.4 to 30 cycles per second. The 3 component micromotion observation was made on the existing ground surface (prior to construction), near the test well used for the uphole velocity survey, as shown on Figure 2.5-21.

Limerick

required. Descriptions of the fracture zones are presented in Section 2.5.1.2.5; their locations at final foundation grades are shown on Figure 2.5-13. Treatment of these fracture zones is discussed in Section 2.5.4.12.

Engineering evaluation of the site geology is discussed in Section 2.5.1.2.7. The bedrock at the site contains no unstable minerals or hazardous conditions. The stress regime within the bedrock materials is low and stable. There are no mines in the site area and no significant fluid withdrawal. The bedrock in the construction area is competent and provides satisfactory foundation support for plant structures.

2.5.4.2 Properties of Subsurface Materials

The principal plant structures are founded on bedrock. The spray pond is excavated partly in soil and partly in rock. All or portions of other facilities not founded on bedrock are founded on natural soil or manmade fills. The locations of the major plant structures are shown on Figure 2.1-3. Results of laboratory tests for foundation and construction materials are presented in Ref 2.5-39 and 2.5-51, and in FSAR Sections 2.5.1.2, 2.5.4.2, 2.5.4.4, 2.5.4.5, 2.5.4.7 and 2.5.4.10.

2.5.4.2.1 Properties of Foundation Rocks

The seismic Category 1 reactor and diesel-generator enclosures, as well as the turbine and radwaste enclosures, are founded on hard, competent bedrock. The bedrock consists of siltstone, sandstone, and shale of Brunswick lithofacies of Triassic age. The Brunswick is described in Section 2.5.1.2. The Lockatong lithofacies, represented by the Sanatoga Members, interfinger with the Brunswick in the northern part of the site area. The Sanatoga Member consists of blue-gray calcareous argillite with two distinct beds of black carbonaceous shale. The spray pond is underlain by both the Lockatong and Brunswick lithofacies.

Bedding and jointing patterns are well developed in the foundation rocks. Bedding plane spacing varies from a few inches to several feet. Bedding planes strike generally east - west and dip to the north at 8° to 20°. Two major joint systems are prevalent in the area. Both are vertical or nearly vertical; they strike approximately N 20° to 50° E and N 50° to 60° W. Three fracture zones and two minor clay seams along bedding were encountered in the main power block foundation excavations; they are described in Section 2.5.1.2.5. Treatment of these zones is described in Section 2.5.4.12.

Limerick

values in this zone; however, because foundations for the main plant structures including the power block, radwaste, and pumphouse enclosures are carried to unweathered rock, rock weathering is not significant to foundation design for these facilities.

Nevertheless it was recognized that occasional localized features such as fracture zones or clay seams encountered in the foundation rock would require evaluation as they became exposed. Accordingly, foundation rock was mapped and evaluated for such features by experienced engineering geologists during the course of construction. Measures to improve foundation cnditions were carried out at certain areas where potential rock weakness was encountered. Detailed discussion of these measures is provided in Section 2.5.4.12.

2.5.4.2.2 Properties of Foundation Soils

The in-situ soils are residual in nature, derived from weathering of siltstone, standstone, and shale. The properties of these soils were determined by laboratory testing.

Testing of the in-situ soils at the spray pond [illegible] Geotechnical Engineers, Inc. The complete [illegible] is given in Ref. 2.5-[illegible]. The properties [illegible] in Sections 2.5.4.2.2.1 through 2.5.4.[illegible] Table 2.5-4 (sheet 1).

The properties of the in-situ soils other than spray pond were determined by Dames & Moore. The complete laboratory test results are included in Ref. 2.5-51. The properties of these soils are described in Section 2.5.4.2.2.4 and are summarized in Table 2.5-4 (sheet 2).

2.5.4.2.2.1 Index Properties of Soils at Spray Pond

The index properties include the following:

a. Visual and laboratory classification of samples - ASTM D 2488

b. Mechanical analysis - ASTM D 422

c. In-situ moisture content and unit weight - ASTM D 2216

d. Atterberg limits - ASTM D 423 and D 424

e. Specific gravity tests - ASTM D [illegible]4

The in-situ soil of the spray pond includes clayey silt, sandy silt, and silty fine sand, with varying amounts of gravel-sized rock fragments. The predominant soil is clayey silt, classified

Shearon Harris

TABLE 2.5.2-3

RESULTS OF SEISMIC REFRACTION SURVEY

Depth (ft.)	Material	Shear Wave Velocity (ft. per sec.)	Compressional Wave Velocity (ft. per sec.)	Poisson's Ratio
0-8	residual soil	500*	1,500	.44
8-16	weathered and fractured rock	2500	5,500	.37
Below 16	sound bedrock	5600	12,000	.35

*This velocity was assumed on the basis of previous experiences under similar conditions.

Millstone Amplification

2.5.4.4.3 Seismic Velocity Measurements

Seismic velocity measurements using an "explosive" source were conducted at the site to determine compressional "P" wave velocities and transverse, or shear, "S" wave velocities of the underlying materials. Both down-hole and cross-hole techniques were utilized. Elastic parameters for basal till and bedrock obtained from these tests were used as the design basis for foundations on these materials. The field procedure is described in detail in Appendix 2.5H.

In the containment area, where bedrock is shallow, velocity measurements in the rock using cross-hole techniques were uniform throughout the depths investigated, which ranged from el +10 feet to el -50 feet. Down-hole velocity measurements were made from el +5 feet to el -99 feet. There was good agreement in the values between the two techniques.

Velocity measurements of the overburden materials further distinguish between the two tills at the site. Shear wave velocity for the ablation till is approximately one-third lower than for the denser basal till.

The following seismic velocity profile is representative of materials in the vicinity of the turbine building:

Elevation (ft)	Material	Seismic Technique	"P" Wave (fps)	"S" Wave (fps)
+15 to +4	Ablation Till	Cross-hole	5,600	1,400
+4 to-24	Basal Till	Cross-hole	6,800	2,200
-24 to -44	Bedrock	Cross-hole	12,800	6,500

The following seismic velocity profile is representative of materials in the vicinity of the reactor containment structure:

Elevation (ft)	Material	Seismic Technique	"P" Wave (fps)	"S" Wave (fps)
+10 to -50	Bedrock	Cross-hole	12,800	6,500
+5 to-99	Bedrock	Down-hole	13,500	6,500

Seismic velocity measurements were made using an "impact" source of shear wave energy to determine "P" and "S" wave velocities of materials underlying the discharge tunnel in the area of the Millstone 1 ventilation stack. Bedrock is overlain by basal till, ablation till, alluvium, and fill. The overburden in this area is up to 60 feet in thickness. In these tests, geophones were lowered into 2-inch receiving holes to pick up arrival times generated from impact blows on a split-spoon sampler positioned at the same elevation. The following seismic velocity profile is representative of materials in the vicinity of the discharge tunnel near the ventilation stack:

Millstone

Elevation (ft)	Material	"P" Wave (fps)	"S" Wave (fps)
+14 to +2	Fill	1,363-3,060	814-1,238
+2 to -13	Alluvium	4,820-5,818	383-684
-13 to -18	Ablation Till	6,053-6,597	398-654
-18 to -30	Basal Till	7,539-7,603	1,246-2,387

The following conservatively estimated elastic constants were used for investigating dynamic response of structures, based on "P" wave and "S" wave velocity measurements from "explosive" and "impact" sources:

Material	Young's Modulus, E (psi)	Shear Modulus, G (psi)	Poisson's Ratio
Rock	4×10^6	1.5×10^6	0.33
Basal Till	4×10^5	1.4×10^5	0.44
Ablation Till	2.7×10^4	9.0×10^3	0.49

2.5.4.5 Excavations and Backfill

The extent of excavations and backfill for major Seismic Category I structures is shown on Figure 2.5.4-40. Final grading, which includes dredging and backfilling in the vicinity of the circulating and service water pumphouse, is shown on Figure 2.5.4-41. Profiles delineating the extent of the excavation and backfill are shown on Figures 2.5.4-33 through 2.5.4-35. Geologic mapping of the excavated surfaces is described in Section 2.5.4.1.1.

2.5.4.5.1 Excavation

The founding materials for major plant structures are listed in Table 2.5.4-14. Most of the major safety related structures are founded on bedrock, with the exception of the control building, emergency diesel generator building, and the hydrogen recombiner building. The control building is founded on 1 to 4 feet of compacted structural backfill overlying basal till of thickness varying between 1 foot on the east side and 15 feet on the west. The emergency generator enclosure building wall footings are founded on basal till. The diesel generator pads are supported on approximately 8 feet of structural backfill
241.3 overlying basal till as shown on Figure 2.5.4-55 (Geologic Profile J-J'). The hydrogen recombiner is founded on concrete fill overlying bedrock.

Most of the circulating water discharge tunnel is founded on bedrock.
241.1 Near the ventilation stack, for a distance of approximately 500 feet, the discharge tunnel is founded on crushed stone and concrete fill overlying basal till. Section 2.5.4.8.4 and Figure 2.5.4-51 (Geologic Profile H-H") describe the founding conditions of the discharge tunnel in this area.

The service water intake lines are founded on bedrock in the main plant area; however, between the main plant area and the pumphouse they are

Millstone

TABLE 2.5.4-14

FOUNDATION SETTLEMENT DATA FOR MAJOR STRUCTURE

Structure	Foundation Bearing Load (psf)	Enbedment Depth (ft)	Founding Material	Average Thickness Till (ft)	Average Thickness Structural Fill (ft)	Dimensions of Foundation Material (ft)	Foundation Type	Maximum Calculated Static Settlement (in)
Containment	8,000	62.7	Rock	-	-	158 diameter	Mat	0.04
Main Steam Valve	5,000	15.0	Rock	-	-	70 × 60	Mat	0.01
Auxiliary	5,000	24.5	Rock	-	-	177 × 102	Mat	0.02
Engineered Safety Features	3,500	24.5	Rock	-	-	139 × 23	Mat	0.01
Control ✓	3,500	24.5	Till	0 to 10	-	125 × 105	Mat	0.02 to 0.03
Emergency Generator Enclosure	1,600	15.0	Structural Fill	10	20	65 × 72	Mat and Strip Footings	0.22
Emergency Generator Oil Tank	1,600	22.5	Till	10	4	65 × 32	Mat	0.01
Refueling Water Storage Tank	4,000	9.0	Rock	-	-	45 diameter	Mat	less than 0.01
Demineralized Water [illegible]age Tank	4,000	9.5	Rock	-	-	35 diameter	Mat	less than 0.01
Fuel	5,500	21.0	Rock		-	93 × 112	Mat	less than 0.01
Waste [illegible] (Liqu[illegible]	3,500	23.5	Till	2 to 8	-	112 × 36	Mat	0.04
Hydrogen Recombiner	[illegible],000	4.0	Concrete Fill	-	13	39 × 27	Mat	less than 0.01