Millstone Power Station Unit 3
Safety Analysis Report

Chapter 2

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CHAPTER 2 - SITE CHARACTERISTICS

This section contains information on the geological, seismological, hydrological, meteorological, and demographic characteristics of the Millstone site and vicinity to show the adequacy of the site from the safety viewpoint.

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 SITE LOCATION AND DESCRIPTION

2.1.1.1 Specification of Location

The Millstone site is located in the Town of Waterford, New London County, Connecticut, on the north shore of Long Island Sound. The 524-acre site occupies the tip of Millstone Point between Niantic Bay on the west and Jordan Cove on the east and is situated 3.2 miles west-southwest of New London and 40 miles southeast of Hartford.

The Millstone 3 containment structure is located immediately north of Millstone 1 and 2. The geographical coordinates of the centerline of each reactor are as follows:

Unit	Latitude and Longitude	Northing and Easting
Millstone 3	N 41° 18'41"	N 174, 710
	W 72° 10'06"	E 759, 770
Millstone 2	N 41° 18'35"	N 174, 090
	W 72° 10'06"	E 759, 825
Millstone 1	N 41° 18'32"	N 173, 800
	W 72° 10'04"	E 759, 965

2.1.1.2 Site Area

The site is owned by two tenants in common: Connecticut Light & Power Company and Western Massachusetts Electric Company, except for that portion of land designated for the Millstone Nuclear Power Station, Unit 3 site which is owned by its participants in ownership. Figures 2.1-1 through 2.1-4 identify the site.

2.1.1.3 Boundaries for Establishing Effluent Release Limits

Millstone Point was thoroughly investigated for acceptability as a nuclear power plant site and found to be suitable by the Atomic Energy Commission before the Millstone 1 Construction Permit was issued in 1966, before the Millstone 1 Operating License DPR-21 was granted in 1970, prior to the issuance of the Millstone 2 Construction Permit in December 1970, and prior to the Millstone 2 Operating License DPR-65 in August 1976.

Studies and reviews in the areas of marine biology, meteorology, hydrology, and environmental radiation monitoring have been conducted since 1966.

The exclusion area, as described in Section 2.1.2, is considered the restricted area. The restricted area has been conspicuously posted and administrative procedures, including periodic patrolling, have been imposed to control access to the area. For the purpose of radiological dose assessment of accidents, the exclusion area boundary (EAB) was considered the actual site boundary for overland sectors, except in the Fox Island/discharge channel area on the south end of the site. For all water sectors, the nearest land site boundary distance was used.

The EAB boundary shown in Figure 2.1-3 is an example for a Millstone 3 containment release. The actual EAB distance varies as a function of the release point. The actual distances used for each sector for each release point are given in Table 2.3-34.

Any significant normal releases from Millstone 3 are discharged to the atmosphere via the Millstone stack or through various Millstone 3 vents. The distance from the Millstone stack to the nearest residential property boundary in the Millstone Point Colony development (Point A on Figure 2.1-3) is approximately 2,415 feet. This development, adjacent to the eastern site boundary, consists of single family homes on 104 half-acre lots. It was developed from 1951 to the present.

The Colony development has its own beach and boat docking facility, shown as Recreation Area on Figure 2.1-3, extending westward along Jordan Cove. The land is owned by Mr. H. Gardiner, Jr., who permits residents to use it for a fee of $1.00 per year.

The land of the Colony development, the private beach, and the Millstone site were all originally owned by Mr. Gardiner. One of the conditions of the sale of the site to the Hartford Electric Light Company and the Connecticut Light and Power Company was that permanent dwellings would never be permitted in the beach area. Because of this restriction, normal release doses are calculated at Point A rather than at the nearest point on the site boundary. The distance from the Millstone 3 turbine building to Point A is approximately 2,750 feet. Point A is northeast of both the Millstone 3 turbine building and the Millstone stack. The distance to the nearest land for each sector for each release point used in dose calculations for normal effluents is given in Section 2.3.4.2.

2.1.2 EXCLUSION AREA AUTHORITY AND CONTROL

2.1.2.1 Authority

The Millstone Nuclear Power Station site is owned by Dominion Nuclear Connecticut, Inc. (DNC). Figures 2.1-1 through 2.1-4 identify the site.

The exclusion area is equivalent to the area within the site boundary which is identified on Figure 2.1-3. DNC, the operating company for all three units at the Millstone site, has the controlling authority for the exclusion area. Accordingly, DNC has the authority to determine all activities within the exclusion area.

2.1.2.2 Control of Activities Unrelated to Plant Operation

The exclusion area is wholly owned as indicated above; DNC as the operating company has complete control of activities within the exclusion area, except for the passage of trains along the Providence & Worcester (P&W)/Amtrak Railroad track which runs east-west through the site.

To ensure the safety of people within the exclusion area during an emergency, an emergency plan (Section 13.3) for the site has been prepared. The plan includes provisions for alarms both inside and outside buildings and delineates the evacuation routes and assembly areas to be used. The safety of people living or working adjacent to the exclusion area is protected during emergencies according to the procedures outlined in the emergency plan. The State of Connecticut Emergency Plan also provides for the control of activities in that portion of the exclusion area extending offshore through a written agreement between the Applicants and the U.S. Coast Guard at their station in New London, Connecticut.

The owners have encouraged public use of portions of the site. Ownership rights have not, however, been relinquished, and the owners can, and have provision to, fulfill their obligations with respect to 10 CFR 20, “Standards for Protection Against Radiation”.

A portion of the exclusion area is leased to the Town of Waterford for public recreation and is used primarily for soccer and baseball games. Figure 2.1-3 shows the general location of these activities. No attempt is made to restrict the number of persons using these facilities. Estimates of maximum attendance indicate that about 2,000 visitors could be within the exclusion area at any one time at the soccer and baseball fields. The Emergency Plan provides for removal of the visitors on site. The number and configuration of roads and highways assure ready egress from the areas described above (Figures 2.1-2, 2.1-3 and 2.1-4).

2.1.2.3 Arrangements for Traffic Control

Should the need ever arise, provisions to enforce traffic control have been made through the Connecticut State Police, as described in the Millstone Nuclear Power Station Emergency Plan (Section 13.3).

2.1.2.4 Abandonment or Relocation of Roads

On August 30, 1965, a town meeting was called to close and discontinue roads to Millstone Point.

On April 30, 1966, when the 8-month time for public appeal had passed, discontinuance of Millstone Road became effective.

On May 31, 1966, the Connecticut Public Utility Commission gave approval to construct a new limited access highway with a new bridge being built to highway specification 20-44 over the present ConRail/Amtrak rail line approximately 305 meters (1,000 feet) east of Old Millstone Road Bridge No. 45.07.

On December 2, 1966, entrances to Millstone Point from the east via Gardners Wood Road and Jordan Road and from the west via Jordan Cove Road were closed. All access to Millstone Point was shifted to the new limited access highway, which is shown as New Millstone Road on Figure 2.1-3.

No further road closing is necessary.

2.1.2.5 Independent Spent Fuel Storage Installation (ISFSI)

Located on the east side of the site is an area that has been developed for an Independent Spent Fuel Storage Installation (ISFSI). The licensing basis of the ISFSI includes the Transnuclear Safety Analysis Report (SAR), Certificate of Conformance (C of C) No. 1004, Safety Evaluation Report (SER), and the 10 CFR 72.212 report which details compliance of the Millstone site with the requirements of the SAR, C of C and SER. The general location of the area is south of the switchyard, west of the Millstone access road between the switchyard and the crossing of the main rail spur, north of the Main Stack. The approximate location is shown in Figures 2.1-3 and 2.1-4. This area consists of reinforced concrete storage pads and approach aprons.

A heavy haul road is defined between the Unit 3 Railroad Canopy and the ISFSI area. This haul path has been evaluated to adequately support the loads imparted by the ISFSI equipment.

2.1.3 POPULATION DISTRIBUTION

2.1.3.1 Population Distribution within 10 miles

The total 1990 population within 10 miles of the station was estimated to be 120,443. This population is expected to increase to about 129,846 people by the year 2000 and to a total of approximately 142,277 people by the year 2030 (New York State Department of Economic Development, 1989 (Reference 2.1-1); State of Connecticut Office of Policy and Management, 1991 (Reference 2.1-2); US Department of Commerce, Bureau of the Census, 1990 Census of Population (Reference 2-1-3). The 10 mile area includes portions of, or all of, New London and Middlesex Counties in Connecticut and a small portion of Suffolk County on Fishers Island which is part of the town of Southold, New York. Figure 2.1-5 shows counties and towns within the 10 mile area. Town populations and population densities are provided in Table 2.1-1.

The Town of Waterford, in which Millstone 3 is located, contained a total population of 17,930 people in 1990 at an average density of 547 people per square mile (US Department of Commerce Bureau of the Census 1991) (Reference 2.1-3). The population growth of Waterford was small with the 1990 total representing only a 0.5 percent increase over its 1980 population. Compared to towns immediately surrounding it, with the exception of New London, Waterford had the lowest increase in population between 1980 and 1990 (US Department of Commerce Bureau of the Census, 1991 (Reference 2.1-3)).

Waterford's growth has been consistently slowing down over the past 30 years, as shown in Table 2.1-2. This slow growth is projected by state demographers to continue at a low rate through the year 2000, at which time the population is expected to reach 18,480. After that, it is projected to decrease in population. By the year 2010 (the last year of projections), the town's population is projected to be 18,080 (Connecticut Office of Policy and Management, Interim Population Projections, 1991 (Reference 2.1-2)). Population distribution by sector for the area within 20 Km of Millstone 3 for 1985 (the expected first year of operation) is shown in Table 2.1-3 and Figure 2.1-6 (Office of Policy and Management, State of Connecticut, Population Projections to the Year 2000, February 1980 (Reference 2.1-4)). Population distribution by sector for the area within 10 miles of Millstone 3 is shown for the years 1990, 2000, 2010, 2020 and 2030 in Tables 2.1-4 through 2.1-8, which are keyed to the population sectors identified in Figure 2.1-7.

Population distribution within 10 miles is based on 1990 US Census data by Census Block (Reference 2.1-3). The population within a Census Block was assumed to be distributed evenly over its land area, unless USGS 7.5 minute quadrangle maps indicated the population to be concentrated in only one portion of the Block. The proportion of each Block area in each grid sector was determined and applied to the Block total population, yielding the population in each grid sector. Population projections, by municipality, supplied by Connecticut's Office of Policy and Management provided growth factors for projection of populations (State of Connecticut Office of Policy and Management, Interim Population Projections, 1991 (Reference 2.1-2)).

2.1.3.2 Population Distribution within 50 Miles

The area within 50 miles of Millstone 3 includes portions, or all, of eight counties in Connecticut, four counties in Rhode Island and one county in New York. Figure 2.1-8 shows counties and towns within the 50 mile area. In 1990, the 50-mile area contained approximately 2,835,159 people (U.S. Department of Commerce), 1990 Census of Population and Housing (Reference 2.1-5)). This population is projected to increase to about 3,223,654 by the year 2030 (Connecticut Office of Policy and Management, 1991 (Reference 2.1-2); New York State Department of Economic Development, 1989 (Reference 2.1-1); Rhode Island Department of Administration, 1989 (Reference 2.1-6); US Department of Commerce, 1990 Census of Population and Housing, 1991 (Reference 2.1-5)). Population distribution by sector for the area within 80 Km of Millstone 3 for 1985 (the expected first year of operation) is shown in Table 2.1-9 and Figure 2.1-9 (Office of Policy and Management, State of Connecticut, Population Projections to the Year 2000, February 1980 (Reference 2.1-4); Economic Development Board, State of New York, Population Projections, 1978 (Reference 2.1-7); Rhode Island Statewide Planning Program, Population Projections, Technical Paper No. 83, Revised April 1979 (Reference 2.1-8)). Population distribution by sector for the area within 50 miles of Millstone 3 is shown for the years 1990, 2000, 2010, 2020 and 2030 in Tables 2.1-10 through 2.1-14, which are keyed to the population sectors identified in Figure 2.1-10.

Population distribution and projections within the 50 mile region surrounding Millstone 3 were calculated based on population by municipalities and were assigned to sectors based on land area allocation. Projections for the 50 mile area were based on country-wide projections.

2.1.3.3 Transient Population

Seasonal population increases resulting from an influx of summer residents total approximately 10,500. However, many of the beaches and recreation facilities in the area are used by residents, and therefore, do not represent any increase in population but instead a slight shift in population. There are, however, a number of schools, industries, and recreation facilities which create daily and seasonal variations in sector populations. Tables 2.1-15 through 2.1-17 show annular sector population variations resulting from school enrollments, industrial employment, and recreation facilities (with documented attendance).

2.1.3.4 Low Population Zone

The low population zone (LPZ) surrounding Millstone 3 encompasses an area within a radial distance of about 2.4 miles. The distance was chosen based on the requirements of 10 CFR 100.11. Figure 2.1-11 shows topographical features, transportation routes, facilities, and institutions within the LPZ.

The LPZ contained approximately 9,846 people in 1990, with an average density of 545 people per square mile. By the year 2030, the LPZ population is projected to increase to about 11,629, or an average density of 643 people per square mile (US Department of Commerce, Bureau of the Census, 1991 (Reference 2.1-3); Connecticut Office of Policy and Management, 1991 (Reference 2.1-2); US Geological Survey (Reference 2.1-9)). The LPZ population distribution for 1990 and 2030 is shown in Table 2.1-18. Table 2.1-19 shows the 1991-1992 school and employment distribution within the LPZ. Both tables are keyed to Figure 2.1-12.

Daily and seasonal variations due to transient population are minimal within the LPZ. Several beaches are located within the area; however, they are predominantly used by local residents and generally have no facilities for parking or accommodation of large groups. Three schools, Great Neck Elementary and Southwest Elementary in Waterford, and Niantic Elementary in East Lyme, are located within the LPZ. Major employment consists of the Connecticut National Guard facility and Hendel Petroleum. The New London Country Club is also located within the LPZ.

2.1.3.5 Population Center

The closest population center to Millstone 3 (as defined by 10 CFR 100 to contain > 25,000 residents) is the City of New London which contained a 1990 population of 28,540 people at an average population density of 5,189 people per square mile (US Department of Commerce Bureau of the Census 1991). The distance between Millstone 3 and the city's closest corporate boundary is about 3.3 miles to the northeast, just beyond the minimum distance requirement set by 10 CFR 100.

The city of New London is part of the New London - Norwich Metropolitan Statistical Area (MSA) which contained an estimated 266,819 people in 1990 (US Department of Commerce Bureau of the Census, 1991 (Reference 2.1-3). An MSA is an area, defined by the US Census Bureau, that always contains a city or cities of specified population, with contiguous cities or towns where the economic and social relationships meet the specified criteria of metropolitan character and integration.

The region within 50 miles of Millstone 3 includes portions, or all, of 11 MSAs. The populations of these areas are shown in Table 2.1-20.

There were 38 population centers within 50 miles of Millstone 3, containing 25,000 or more people in 1990. They are listed in Table 2.1-21 with the populations indicated.

2.1.3.6 Population Density

The population of the area within 50 miles of Millstone was approximately 2,835,159 in 1990, with an average density of 361 people per square mile. This density is lower than the NRC comparison figure of 500 people per square mile (NRC Regulatory Guide 1.70, Revision 3). Within 30 miles of Millstone, the population density is considerably less, at an average of 189 people per square mile. By 2030, the 50-mile population is projected to increase to 3,223,654 or an average population density of about 410 people per square mile, considerably lower than the NRC comparison figure for end-year plant life of 1,000 people per square mile. Within 30 miles, the average density will be 223 persons per square miles by the year 2030. Population densities by sector for the areas within 20 km and 80 km of Millstone 3 for 1985 (the expected first year of operation) are shown in Table 2.1-22 and 2.1-23, respectively. Population densities by sector for 1990 and 2030 are shown for within 10 miles of Millstone in Tables 2.1-24 and 2.1-25 respectively, which are keyed to Figure 2.1-7, and for within 50 miles of Millstone in Tables 2.1-6 and 2.1-27, respectively, which are keyed to Figure 2.1-10. Cumulative population densities for the areas within 80 km of Millstone 3 for 1985 (the expected first year of operation) are shown in Table 2.1-28. Cumulative population densities 1990 and 2030 are shown in Tables 2.1-29 and 2.1-30 respectively.

2.1.4 REFERENCES FOR SECTION 2.1

2.1-1 New York State Department of Economic Development, Interim County, MSA and Region Projections, 1980-2010, 1989.

2.1-2 Connecticut Office of Policy Management, Interim Population Projections Series 91.1, 1991.

2.1-3 US Department of Commerce, Bureau of the Census, 1990 Census of Population, P.L. 94-171 Counts by Census Block, 1991.

2.1-4 Office of Policy and Management, Comprehensive Planning Division, State of Connecticut, Population Projections for Connecticut Municipalities and Regions to the year 2000, February, 1980.

2.1-5 US Department of Commerce, Bureau of the Census, 1990 Census of Population and Housing - Connecticut, 1990 CPH-1-8, 1991.

2.1-6 Rhode Island Department of Administration, Projections by County, 1990-2020, 1989.

2.1-7 Economic Development Board, State of New York, Official Population Projections for New York State Counties, 1978.

2.1-8 Rhode Island Statewide Planning Program, Rhode Island Population Projections by County, City and Town, Technical Paper No. 83, Revised April 1979.

2.1-9 U.S. Geological Survey, 7.5-Minute Quadrangle maps.

2.1-10 US Nuclear Regulatory Commission, Regulatory Guide 1.70, Revision 3.

SUPPORTING REFERENCES

Massachusetts Institute for Social and Economic Research, Revised Projections of the Population of Massachusetts Cities and Towns to the Year 2000, 1991.

US Department of Commerce, Bureau of the Census, State and Metropolitan Area Book 1991, a Statistical Abstract Supplement, 1991.

US Department of Commerce, Bureau of the Census, 1990 Census P.L. 94-171 Counts by municipality - New York, 1991.

US Department of Commerce, Bureau of the Census, 1990 Census P.L. 94-171 Counts by municipality - Rhode Island, 1991.

US Department of Commerce, Bureau of the Census, Number of Inhabitants: Connecticut, PC(1)-A8, 1971; PC80-1-A8, 1981.

TABLE 2.1-1 1990 POPULATION AND POPULATION DENSITIES CITIES AND TOWNS WITHIN 10 MILES OF MILLSTONE

MUNICIPALITY	1990 POPULATION TOTAL	1990 POPULATION DENSITY (People/Square Mile)	1980 - 1990 CHANGE (%)
East Lyme	15,340	451	10.6
Groton (including City)	45,144	1,442	9.9
Ledyard	14,913	391	8.6
Lyme	1,949	61	7.0
Montville	16,673	397	1.3
New London	28,540	5,189	-1.0
Old Lyme	6,535	283	6.1
Old Saybrook	9,552	637	2.9
Waterford	17,930	547	0.5
Southold, New York (Fishers Island)	19,836	394	3.5

NOTES:

Based on 1990 US Census of Population and Housing.

Includes total 1990 population of all municipalities totally or partially within 10 miles of the site.

TABLE 2.1-2 POPULATION GROWTH 1960-1990

	TOTAL POPULATION				% CHANGE		
MUNICIPALITY	**1960**	**1970**	**1980**	**1990**	**1960-1970**	**1970-1980**	**1980-1990**
East Lyme	6,782	11,399	13,870	15,340	68.1	21.7	10.6
Groton	29,937	38,523	41,062	45,144	28.7	6.6	9.9
Ledyard	5,395	14,558	13,735	14,913	169.8	-5.7	8.6
Lyme	1,183	1,484	1,822	1,949	25.4	22.8	7.0
Montville	7,759	15,662	16,455	16,673	101.9	5.1	1.3
New London	34,182	31,630	28,842	28,540	-7.5	-8.8	-1.0
Old Lyme	3,068	4,964	6,159	6,535	61.8	24.1	6.1
Old Saybrook	5,274	8,468	9,287	9,552	60.6	9.7	2.9
Waterford	15,391	17,227	17,843	17,930	11.9	3.6	0.5

SOURCES:

1980 Census of Population, Number of Inhabitants, Connecticut, PC80-1-A8, 12/81.

1970 Census of Population, Number of Inhabitants, Connecticut, PC(1)-A8, 4/71.

1980 Final Population and Housing Counts, Connecticut, PHC80-V-8, 3/81.

1990 Census of Population and Housing, Connecticut, CPH-1-8, 7/91.

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TABLE 2.1-3 POPULATION DISTRIBUTION 1985 (0-20 km)

Distance (km)

Direction	0-2	2-4	4-6	6-8	8-10	10-20	Total
N	152	1,306	1,341	136	585	9,463	12,983
NNE	12	1,186	1,958	584	2,819	9,676	16,235
NE	326	1,250	763	15,113	8,239	13,641	39,332
ENE	267	513	3,063	3,559	8,491	19,484	35,377
E	366	896	1,169	976	534	4,816	8,757
ESE	0	127	0	0	0	1,184	1,311
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	340	340
SW	0	25	81	0	0	0	106
WSW	0	1,183	193	757	1,960	2,309	6,402
W	0	727	1,102	411	428	8,463	11,131
WNW	0	1,298	1,266	90	140	3,430	6,224
NW	0	852	799	426	418	3,758	6,253
NNW	311	694	902	795	503	6,321	9,526
Total	1,434	10,057	12,637	22,847	24,117	82,884	153,976

TABLE 2.1-4 POPULATION DISTRIBUTION WITHIN 10 MILES OF MILLSTONE - 1990 CENSUS

Distance to Plant

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTAL
N	16	722	866	784	116	213	542	209	536	1,717	5,721
NNE	13	359	1,146	1,978	1,861	1,622	1,666	2,242	2,192	3,142	16,221
NE	165	455	839	3,888	10,584	7,752	8,164	8,129	911	1,961	42,848
ENE	22	455	292	4,963	971	7,186	3,748	3,047	1,008	2,662	24,354
E	0	636	413	1,804	193	552	0	63	1,434	904	5,999
ESE	0	143	36	0	0	0	0	0	115	214	508
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	14	0	0	0	0	0	0	0	14
WSW	0	0	489	91	86	312	472	158	0	74	1,682
W	0	178	1,061	1,014	440	763	475	562	881	408	5,782
WNW	0	476	1,165	1,964	346	239	211	1,654	509	417	6,981
NW	0	634	873	1,192	1,140	644	599	101	209	81	5,473
NNW	148	314	892	522	646	918	221	429	456	314	4,860
Total	364	4,372	8,086	18,200	16,383	20,201	16,098	16,594	8,251	11,894	120,443

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TABLE 2.1-5 POPULATION DISTRIBUTION WITHIN 10 MILES OF MILLSTONE - 2000 PROJECTED

Distance to Plant

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTAL
N	18	778	932	845	126	230	582	225	578	1,852	6,166
NNE	14	387	1,234	2,131	2,006	1,749	1,796	2,415	2,366	3,389	17,487
NE	179	489	905	4,191	11,415	8,359	8,802	8,765	983	2,115	46,203
ENE	24	492	314	5,352	1,045	7,746	4,041	3,285	1,087	2,870	26,256
E	0	685	444	1,944	208	597	0	68	1,546	975	6,467
ESE	0	154	39	0	0	0	0	0	125	233	551
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	14	0	0	0	0	0	0	0	14
WSW	0	0	528	98	92	336	509	169	0	78	1,810
W	0	192	1,144	1,093	473	821	513	606	950	436	6,228
WNW	0	514	1,255	2,118	373	258	227	1,783	548	448	7,524
NW	0	684	940	1,285	1,229	695	646	108	226	88	5,901
Total	393	4,715	8,710	19,621	17,663	21,781	17,354	17,886	8,900	12,823	129,846

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TABLE 2.1-6 POPULATION DISTRIBUTION WITHIN 10 MILES OF MILLSTONE - 2010 PROJECTED

Distance to Plant

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTAL
N	18	803	961	871	129	237	600	230	595	1,908	6,352
NNE	14	399	1,272	2,197	2,068	1,804	1,853	2,492	2,437	3,495	18,031
NE	184	504	930	4,321	11,767	8,617	9,074	9,036	1,013	2,180	47,626
ENE	25	507	324	5,518	1,078	7,988	4,166	3,387	1,119	2,960	27,072
E	0	707	458	2,005	215	616	0	70	1,593	1,005	6,669
ESE	0	159	41	0	0	0	0	0	138	255	593
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	15	0	0	0	0	0	0	0	15
WSW	0	0	545	102	95	346	525	175	0	79	1,867
W	0	198	1,179	1,126	488	847	530	625	981	443	6,417
WNW	0	529	1,294	2,184	385	266	234	1,838	566	461	7,757
NW	0	705	969	1,325	1,267	716	666	111	232	90	6,081
NNW	163	350	992	582	718	1,021	245	476	506	350	5,403
Total	404	4,861	8,980	20,231	18,210	22,458	17,893	18,440	9,180	13,226	133,883

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TABLE 2.1-7 POPULATION DISTRIBUTION WITHIN 10 MILES OF MILLSTONE - 2020 PROJECTED

Distance to Plant

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTAL
N	19	828	990	899	133	243	620	236	613	1,968	6,549
NNE	14	411	1,310	2,264	2,132	1,860	1,909	2,569	2,513	3,602	18,584
NE	188	519	960	4,455	12,134	8,885	9,355	9,318	1,044	2,247	49,105
ENE	25	523	333	5,689	1,110	8,236	4,296	3,492	1,151	3,052	27,907
E	0	728	472	2,067	222	635	0	72	1,642	1,036	6,874
ESE	0	162	41	0	0	0	0	0	144	268	615
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	15	0	0	0	0	0	0	0	15
WSW	0	0	562	105	98	356	541	180	0	80	1,922
W	0	205	1,216	1,161	504	874	546	644	1,011	450	6,611
WNW	0	544	1,336	2,252	398	274	242	1,895	583	476	8,000
NW	0	727	998	1,365	1,308	738	687	114	239	93	6,269
NNW	168	361	1,023	600	738	1,053	253	491	523	362	5,572
Total	414	5,008	9,256	20,857	18,777	23,154	18,449	19,011	9,463	13,634	138,023

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TABLE 2.1-8 POPULATION DISTRIBUTION WITHIN 10 MILES OF MILLSTONE - 2030 PROJECTED

Distance to Plant

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTAL
N	19	855	1,021	927	136	250	638	242	631	2,027	6,746
NNE	14	425	1,351	2,334	2,196	1,916	1,968	2,650	2,590	3,712	19,156
NE	193	535	990	4,592	12,510	9,160	9,644	9,606	1,075	2,315	50,620
ENE	26	539	343	5,866	1,145	8,492	4,428	3,598	1,188	3,147	28,772
E	0	751	487	2,132	229	655	0	73	1,692	1,068	7,087
ESE	0	167	43	0	0	0	0	0	151	281	642
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	15	0	0	0	0	0	0	0	15
WSW	0	0	580	108	101	366	558	185	0	81	1,979
W	0	212	1,254	1,197	520	901	561	663	1,043	458	6,809
WNW	0	560	1,377	2,323	409	281	249	1,956	602	490	8,247
NW	0	748	1,029	1,407	1,349	761	708	116	246	95	6,459
NNW	174	371	1,055	618	761	1,085	261	507	539	374	5,745
Total	426	5,163	9,545	21,504	19,356	23,867	19,015	19,596	9,757	14,048	142,277

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TABLE 2.1-9 POPULATION DISTRIBUTION 1985 (0-80 km)

Distance (km)

Direction	0-20	20-40	40-60	60-80	Total
N	12,983	24,346	48,558	22,966	108,853
NNE	16,235	48,297	28,695	42,400	135,627
NE	39,332	13,723	24,719	224,759	302,533
ENE	35,377	27,604	33,732	117,868	214,581
E	8,757	14,326	8,982	122	32,187
ESE	1,311	0	674	0	1,985
SE	0	2,038	0	0	2,038
SSE	0	4,457	0	0	4,457
S	0	8,906	2,657	0	11,563
SSW	340	8,979	21,915	2,602	33,836
SW	106	5,869	20,269	210,804	237,048
WSW	6,402	554	0	20,268	27,224
W	11,131	33,197	98,419	361,418	504,165
WNW	6,224	16,353	124,272	276,965	423,814
NW	6,253	12,395	102,235	483,164	604,047
NNW	9,526	13,152	55,071	129,100	206,849
Total	153,977	234,196	570,198	1,892,436	2,850,807

TABLE 2.1-10 POPULATION DISTRIBUTION WITHIN 50 MILES OF MILLSTONE - 1990 CENSUS

Distance to Plant

Sector	0-10	10-20	20-30	30-40	40-50	Total
N	5,721	22,283	26,357	32,610	18,658	105,629
NNE	16,221	34,824	23,730	27,465	35,598	137,838
NE	42,848	9,444	11,334	29,987	199,334	292,947
ENE	24,354	23,914	16,498	43,001	99,721	207,488
E	5,999	10,712	7,992	10,920	0	35,623
ESE	508	0	0	836	0	1,344
SE	0	0	807	0	0	807
SSE	0	0	2,420	0	0	2,420
S	0	1,614	13,541	0	0	15,155
SSW	0	2,443	12,569	14,807	4,498	34,317
SW	14	938	22,042	8,252	143,933	175,179
WSW	1,682	2,471	0	0	20,389	24,542
W	5,782	27,956	34,384	184,723	267,465	520,310
WNW	6,981	12,474	27,895	148,259	259,824	455,433
NW	5,473	6,215	31,331	191,767	365,578	600,364
NNW	4,860	8,809	17,850	115,424	78,820	225,763
Total	120,443	164,097	248,750	808,051	1,493,818	2,835,159

TABLE 2.1-11 POPULATION DISTRIBUTION WITHIN 50 MILES OF MILLSTONE - 2000 PROJECTED

Distance to Plant

Sector	0-10	10-20	20-30	30-40	40-50	Total
N	6,166	24,028	28,707	35,404	20,273	114,578
NNE	17,487	37,551	25,721	29,926	38,135	148,820
NE	46,203	10,183	12,196	31,611	206,940	307,133
ENE	26,256	25,744	17,663	45,998	105,848	221,509
E	6,467	11,497	8,553	11,687	0	38,204
ESE	551	0	0	895	0	1,446
SE	0	0	878	0	0	878
SSE	0	0	2,635	0	0	2,635
S	0	1,759	14,742	0	0	16,501
SSW	0	2,660	13,688	16,122	4,897	37,367
SW	14	1,022	24,000	8,985	156,725	190,746
WSW	1,810	2,641	0	0	22,201	26,652
W	6,228	29,887	36,343	195,006	281,709	549,173
WNW	7,524	13,340	29,762	156,623	273,153	480,402
NW	5,901	6,660	33,435	200,205	380,339	626,540
NNW	5,239	9,492	19,194	121,620	83,732	239,277
Total	129,846	176,464	267,517	854,082	1,573,952	3,001,861

TABLE 2.1-12 POPULATION DISTRIBUTION WITHIN 50 MILES OF MILLSTONE - 2010 PROJECTED

Distance to Plant

Sector	0-10	10-20	20-30	30-40	40-50	Total
N	6,352	24,773	30,056	36,785	21,101	119,067
NNE	18,031	38,716	26,730	31,421	39,720	154,618
NE	47,626	10,499	12,626	32,221	210,368	313,340
ENE	27,072	26,652	18,530	48,258	109,494	230,006
E	6,669	11,986	8,981	12,272	0	39,908
ESE	593	0	0	940	0	1,533
SE	0	0	920	0	0	920
SSE	0	0	2,761	0	0	2,761
S	0	1,847	15,445	0	0	17,292
SSW	0	2,788	14,344	16,896	5,132	39,160
SW	15	1,073	25,151	9,416	164,248	199,903
WSW	1,867	2,689	0	0	23,267	27,823
W	6,417	30,426	37,096	199,100	286,889	559,928
WNW	7,757	13,590	30,311	159,776	278,156	489,590
NW	6,081	6,807	34,052	202,762	384,902	634,604
NNW	5,403	9,778	19,778	123,964	85,735	244,658
Total	133,883	181,624	276,781	873,811	1,609,012	3,075,111

TABLE 2.1-13 POPULATION DISTRIBUTION WITHIN 50 MILES OF MILLSTONE - 2020 PROJECTED

Distance to Plant

Sector	0-10	10-20	20-30	30-40	40-50	Total
N	6,549	25,541	31,470	38,219	21,963	123,742
NNE	18,584	39,916	27,784	32,989	41,349	160,622
NE	49,105	10,825	13,051	32,748	213,221	318,950
ENE	27,907	27,557	19,336	50,343	112,285	234,428
E	6,874	12,452	9,376	12,811	0	41,513
ESE	615	0	0	981	0	1,596
SE	0	0	965	0	0	965
SSE	0	0	2,894	0	0	2,894
S	0	1,939	16,184	0	0	18,123
SSW	0	2,922	15,033	17,707	5,379	41,041
SW	15	1,127	26,355	9,869	172,131	209,497
WSW	1,922	2,737	0	0	24,383	29,042
W	6,611	30,974	37,863	203,283	292,190	570,921
WNW	8,000	13,844	30,871	162,992	283,254	498,961
NW	6,269	6,957	34,678	205,354	389,518	642,776
NNW	5,572	10,070	20,382	126,369	87,794	250,187
Total	138,023	186,861	286,242	893,665	1,643,467	3,148,258

TABLE 2.1-14 POPULATION DISTRIBUTION WITHIN 50 MILES OF MILLSTONE - 2030 PROJECTED

Distance to Plant

Sector	0-10	10-20	20-30	30-40	40-50	Total
N	6,746	26,332	32,953	39,716	22,860	128,607
NNE	19,156	41,155	28,879	34,637	43,058	166,885
NE	50,620	11,159	13,494	33,286	216,112	324,671
ENE	28,772	28,495	20,176	52,519	115,158	245,120
E	7,087	12,937	9,789	13,375	0	43,188
ESE	642	0	0	1,024	0	1,666
SE	0	0	1,011	0	0	1,011
SSE	0	0	3,033	0	0	3,033
S	0	2,036	16,957	0	0	18,993
SSW	0	3,062	15,755	18,558	5,637	43,012
SW	15	1,183	27,619	10,342	180,394	219,553
WSW	1,979	2,787	0	0	25,554	30,320
W	6,809	31,532	38,647	207,551	297,607	582,146
WNW	8,247	14,102	31,441	166,276	288,449	508,515
NW	6,459	7,110	35,317	207,981	394,192	651,059
NNW	5,745	10,373	21,003	128,835	89,919	255,875
Total	142,277	192,263	296,074	914,100	1,678,940	3,223,654

TABLE 2.1-15 TRANSIENT POPULATION WITHIN 10 MILES OF MILLSTONE - 1991-1992 SCHOOL ENROLLMENT

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Total
N	0	310	0	0	0	0	0	74	0	413	797
NNE	0	0	0	374	897	2,073	174	0	0	444	3,962
NE	0	0	636	210	697	1,352	1,542	534	0	0	4,971
ENE	0	0	0	2,501	0	888	0	1,043	1,609	266	6,307
E	0	292	0	0	0	1,330	0	0	183	0	1,805
ESE	0	0	0	0	0	0	0	0	0	68	68
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	263	0	864	0	1,127
WNW	0	0	345	0	0	0	0	0	0	0	345
NW	0	0	0	843	0	0	0	0	0	0	843
NNW	0	0	0	298	1,250	0	0	0	0	0	1,548
TOTAL	0	602	981	4,226	2,844	5,643	1,979	1,651	2,656	1,191	21,773

Note: Includes student enrollment only.

Sources: Connecticut Department of Education listing of schools; Telephone survey conducted in March 1992.

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TABLE 2.1-16 TRANSIENT POPULATION WITHIN 10 MILES OF MILLSTONE (EMPLOYMENT)

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Total
N	0	0	0	300	0	0	0	0	0	200	500
NNE	0	0	0	0	0	0	375	375	107	277	1,134
NE	0	0	375	80	831	0	375	375	0	0	2,036
ENE	0	0	0	0	8,800	5,500	820	0	0	0	15,120
E	0	0	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	256	0	256
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	125	125	0	0	250
NW	0	500	0	0	0	0	125	125	0	0	750
NNW	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	500	375	380	9,631	5,500	1,820	1,000	363	477	20,046

Note: Firms with 50 employees or more. Excludes plant employee population.

Sources: Telephone survey conducted in March 1992.

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TABLE 2.1-17 TRANSIENT POPULATION WITHIN 10 MILES OF MILLSTONE STATE PARKS AND FORESTS (WITH DOCUMENTED ATTENDANCE)

FACILITY	LOCATION	TOTAL ANNUAL ATTENDANCE	SUMMER DAILY ATTENDANCE
State Parks:			
Bluff Point	ENE/E 6-8	97,641	490 *
Fort Griswold	ENE 5-6	58,965	200 *
Haley Farm	ENE/E 7-9	11,675	60 *
Harkness Memorial	E 2-3	157,962	790 *
Rocky Neck	W 3-5	412,495	2,360 **
State Forests:			
Nehantic	WNW/NNW 7-10	81,146	400 *

Notes:

* Daily summer attendance based on 90% of yearly attendance from April through September.

** Includes campers from April 15 to September 15.

Source:

State of Connecticut DEP - Office of Parks and Forests, 1990 Park Attendance.

TABLE 2.1-18 LOW POPULATION ZONE PERMANENT POPULATION DISTRIBUTIONS

DIRECTION	1990 CENSUS	2030 PROJECTED
N	1,298	1,536
NNE	903	1,065
NE	1,144	1,351
ENE	768	909
E	760	899
ESE	179	212
SE	0	0
SSE	0	0
S	0	0
SSW	0	0
SW	3	3
WSW	429	506
W	1,025	1,211
WNW	1,046	1,233
NW	1,167	1,377
NNW	1,124	1,327
TOTAL LPZ	9,846	11,629

Sources:

1990 Census of Population and Housing.
Connecticut Office of Policy and Management, Interim Population Projections Series 91.1, 4/91.

TABLE 2.1-19 LOW POPULATION ZONE SCHOOL ENROLLMENT AND EMPLOYMENT

DIRECTION	SCHOOL	EMPLOYMENT
N	310	0
NNE	0	0
NE	0	75
ENE	0	0
E	292	0
ESE	0	0
SE	0	0
SSE	0	0
S	0	0
SSW	0	0
SW	0	0
WSW	0	0
W	0	0
WNW	345	0
NW	0	500
NNW	0	0
TOTAL	947	575

Notes:

1991-1992 Student Enrollment.
Firms with 50 employees or more.

Source:

Telephone survey conducted in March 1992; Connecticut Department of Education school listing.

TABLE 2.1-20 METROPOLITAN AREAS WITHIN 50 MILES OF MILLSTONE 1990 CENSUS POPULATION

AREA	1990 POPULATION
Bridgeport - Milford, CT PMSA	443,722
Bristol, CT PMSA	79,488
Fall River, MA-RI PMSA	157,272
Hartford, CT PMSA	767,899
New Haven - Meriden, CT MSA	530,240
Nassau - Suffolk, NY PMSA	2,609,212
New Britain, CT PMSA	148,188
New London - Norwich, CT-RI MSA	266,819
Providence, RI PMSA	654,869
Waterbury, CT MSA	221,629
Middletown, CT PMSA	90,320

Notes:

PMSA - Primary Metropolitan Statistical Area.
MSA - Metropolitan Statistical Area.
Total population of metropolitan areas completely or only partially within 50 miles of the site.

Source:

1990 Census of Population

TABLE 2.1-21 POPULATION CENTERS WITHIN 50 MILES OF MILLSTONE

STATE	MUNICIPALITY	1990 POPULATION
Connecticut	Branford	27,603
	Bristol	60,640
	Cheshire	25,684
	East Hartford	50,452
	East Haven	26,144
	Enfield	45,532
	Glastonbury	27,901
	Groton	45,144
	Hamden	52,434
	Hartford	139,739
	Manchester	51,618
	Meriden	59,479
	Middletown	42,762
	Milford	49,938
	Naugatuck	30,625
	New Britain	75,491
	New Haven	130,474
	New London	28,540
	Newington	29,208
	Norwich	37,371
	Shelton	35,418
	Southington	38,518
	Stratford	49,389
	Vernon	29,841
	Wallingford	40,822
	Waterbury	108,961
	West Hartford	60,110
	West Haven	54,021
	Wethersfield	25,651
	Windsor	27,817

TABLE 2.1-21 POPULATION CENTERS WITHIN 50 MILES OF MILLSTONE

STATE	MUNICIPALITY	1990 POPULATION
Rhode Island	Coventry	31,083
	Cranston	76,060
	Johnston	26,542
	Newport	28,227
	Warwick	85,427
	West Warwick	29,268
New York	Brookhaven	407,779
	Southampton	44,976

Notes:

Municipalities with 25,000 people or more.

Municipalities completely or only partially within 50 miles.

Source: 1990 U.S. Census of Population and Housing.

TABLE 2.1-22 POPULATION DENSITY* 1985 (0-20 km)

Distance (km)

Direction	0-2	2-4	4-6	6-8	8-10	10-20	Average 0-20
N	194	575	345	25	83	161	166
NNE	15	522	504	106	405	169	212
NE	566	557	194	2,970	1,759	234	525
ENE	1,214	218	786	1,990	1,255	334	482
E	1,538	386	403	1,903	482	305	383
ESE	0	279	0	0	0	142	147
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	126	126
SW	0	305	686	0	0	0	520
WSW	0	1,153	270	1,187	980	178	369
W	0	545	308	80	61	171	167
WNW	0	727	324	17	20	60	83
NW	0	550	217	78	63	64	82
NNW	492	969	286	154	71	107	126
Average	409	546	375	570	428	166	236

NOTE:

* People per square kilometer.

TABLE 2.1-23 POPULATION DENSITY 1985 (0-80 km)

Distance (km)

Direction	0-20	20-40	40-60	60-80
N	166	103	124	42
NNE	212	205	73	77
NE	525	58	63	412
ENE	482	117	86	402
E	383	198	167	364
ESE	147	0	29	0
SE	0	87	0	0
SSE	0	98	0	0
S	0	88	96	0
SSW	126	104	122	112
SW	520	142	134	471
WSW	369	194	0	907
W	167	151	302	781
WNW	83	69	316	504
NW	82	53	260	879
NNW	126	56	140	235
Average	236	104	163	416

TABLE 2.1-24 POPULATION DENSITY WITHIN 10 MILES OF MILLSTONE 1990 (PEOPLE PER SQUARE MILE)

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Average
N	82	1,226	883	571	66	99	212	71	161	460	292
NNE	66	610	1,168	1,440	1,054	751	653	762	657	843	827
NE	842	772	855	2,830	5,993	3,591	3,200	2,761	273	526	2,183
ENE	112	772	298	3,612	550	3,328	1,469	1,035	302	714	1,241
E	0	1,080	421	1,313	109	256	0	21	430	242	306
ESE	0	243	37	0	0	0	0	0	34	57	26
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	14	0	0	0	0	0	0	0	1
WSW	0	0	498	66	49	145	185	54	0	20	86
W	0	302	1,082	738	249	353	186	191	264	109	295
WNW	0	808	1,188	1,429	196	111	83	562	153	112	356
NW	0	1,076	890	868	646	298	235	34	63	22	279
NNW	755	533	909	380	366	425	87	146	137	84	248
AVERAGE	116	464	515	828	580	585	394	352	155	199	384

Source: 1990 Census of Population.

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TABLE 2.1-25 POPULATION DENSITY WITHIN 10 MILES OF MILLSTONE 2030 (PEOPLE PER SQUARE MILE)

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Average
N	97	1,452	1,041	675	77	116	250	82	189	544	344
NNE	71	722	1,377	1,700	1,243	887	771	900	776	995	976
NE	985	908	1,009	3,345	7,084	4,243	3,780	3,263	322	621	2,579
ENE	133	915	350	4,272	648	3,933	1,736	1,222	356	844	1,466
E	0	1,275	496	1,553	130	303	0	25	507	286	361
ESE	0	284	44	0	0	0	0	0	45	75	33
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	15	0	0	0	0	0	0	0	1
WSW	0	0	591	79	57	170	219	63	0	22	101
W	0	360	1,278	872	294	417	220	225	313	123	347
WNW	0	951	1,404	1,692	232	130	98	664	180	131	420
NW	0	1,270	1,049	1,025	764	352	278	39	74	25	329
NNW	888	630	1,075	450	431	503	102	172	162	100	293
AVERAGE	136	548	608	979	685	691	466	416	183	235	453

Source: CT Office of Policy and Management, Interim Population Projections Series 91.1, 4/91.

MPS3 UFSAR

TABLE 2.1-26 POPULATION DENSITY WITHIN 50 MILES OF MILLSTONE 1990 (PEOPLE PER SQUARE MILE)

Sector	0-10	10-20	20-30	30-40	40-50	Average
N	292	378	269	237	106	215
NNE	827	591	242	200	202	281
NE	2,183	160	116	218	1,129	597
ENE	1,241	406	168	313	564	423
E	306	182	81	79	0	73
ESE	26	0	0	6	0	3
SE	0	0	8	0	0	2
SSE	0	0	25	0	0	5
S	0	27	138	0	0	31
SSW	0	41	128	108	25	70
SW	1	16	225	60	815	357
WSW	86	42	0	0	115	50
W	295	475	350	1,345	1,514	1,061
WNW	356	212	284	1,079	1,471	928
NW	279	106	319	1,396	2,070	1,224
NNW	248	150	182	840	446	460
AVERAGE	384	174	158	368	528	361

Source: 1990 Census of Population and Housing.

MPS3 UFSAR

TABLE 2.1-27 POPULATION DENSITY WITHIN 50 MILES OF MILLSTONE 2030 (PEOPLE PER SQUARE MILE)

Sector	0-10	10-20	20-30	30-40	40-50	Average
N	344	447	336	289	129	262
NNE	976	699	294	252	244	340
NE	2,579	190	138	242	1,224	662
ENE	1,466	484	206	382	652	499
E	361	220	100	97	0	88
ESE	33	0	0	7	0	3
SE	0	0	10	0	0	2
SSE	0	0	31	0	0	6
S	0	35	173	0	0	39
SSW	0	52	161	135	32	88
SW	1	20	281	75	1,021	447
WSW	101	47	0	0	145	62
W	347	536	394	1,511	1,685	1,187
WNW	420	240	320	1,210	1,633	1,036
NW	329	121	360	1,514	2,232	1,327
NNW	293	176	214	938	509	522
AVERAGE	453	204	189	416	594	410

Source: CT Office of Policy and Management, Interim Population Projections, Series 91.1, 4/91.

MPS3 UFSAR

TABLE 2.1-28 CUMULATIVE POPULATION DENSITY 1985

Distance (km)

Direction	0-20	20-40	40-60	60-80
N	166	119	122	87
NNE	212	207	132	108
NE	525	171	111	242
ENE	482	204	138	216
E	383	242	215	216
ESE	147	147	61	61
SE	0	86	86	86
SSE	0	98	98	98
S	0	86	88	88
SSW	126	105	116	116
SW	520	144	136	370
WSW	369	344	344	640
W	167	155	233	469
WNW	83	73	208	338
NW	82	60	172	482
NNW	126	73	110	165
Average	236	134	150	260

TABLE 2.1-29 CUMULATIVE POPULATION DENSITY WITHIN 50 MILES OF MILLSTONE 1990 (PEOPLE PER SQUARE MILE)

Sector	0-10	0-20	0-30	0-40	0-50
N	292	357	308	277	215
NNE	827	650	423	326	281
NE	2,183	666	360	298	597
ENE	1,241	615	367	343	423
E	306	213	140	113	73
ESE	26	6	3	4	3
SE	0	0	5	3	2
SSE	0	0	14	8	5
S	0	21	86	48	31
SSW	0	31	85	95	70
SW	1	12	130	100	357
W	295	430	386	805	1,061
WNW	356	248	268	623	928
NW	279	149	244	748	1,224
NNW	248	174	178	468	460
Average	384	226	189	267	361

MPS3 UFSAR

TABLE 2.1-30 CUMULATIVE POPULATION DENSITY WITHIN 50 MILES OF MILLSTONE 2030 (PEOPLE PER SQUARE MILE)

Sector	0-10	0-20	0-30	0-40	0-50
N	344	421	374	337	262
NNE	976	768	505	394	340
NE	2,579	787	426	346	662
ENE	1,466	730	438	414	499
E	361	255	169	138	88
ESE	33	8	4	5	3
SE	0	0	6	3	2
SSE	0	0	17	10	6
S	0	26	108	60	39
SSW	0	39	107	119	88
SW	1	15	163	125	447
WSW	101	61	27	15	62
W	347	488	436	906	1,187
WNW	420	285	305	701	1,036
NW	329	173	277	818	1,327
NNW	293	205	210	529	522
Average	453	266	223	307	410

MPS3 UFSAR

2.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY FACILITIES

2.2.1 LOCATIONS AND ROUTES

The area around the Millstone site contains three major industrial facilities (Dow Chemical Corporation, Pfizer Corporation, and Electric Boat Division of General Dynamics Corporation); two transportation facilities (Groton/New London) Airport and the New London Transportation Center; and four military installations (U.S. Navy Submarine Base, U.S. Coast Guard Academy, Camp Rell, and Stone's Ranch Military Reservation).

There is also an interstate highway (Interstate 95), passenger and freight railroad lines, gas distribution lines, above ground gas and oil storage facilities and two major waterways (Long Island Sound, Thames River) in the vicinity of the Millstone site.

There are no major gas transmission lines, oil transmission or distribution lines, underground gas storage facilities, drilling or mining operations, or military firing, or bombing ranges near the site.

The locations of the major industrial, transportation and military facilities are shown on Figure 2.2-1. Aircraft patterns and routes are shown on Figures 2.2-2 and 2.2-3. Figure 2.2-4 shows the road and highway system in the area of the Millstone site.

2.2.2 DESCRIPTIONS

2.2.2.1 Description of Facilities

A summary of the significant industrial, transportation, military, and industrial related facilities is shown in Table 2.2-1, as listed below.

1. Dow Chemical Corporation of Allen Point, Ledyard, Connecticut is located on the east bank of the Thames River approximately 10 miles north-northeast of the site. Dow Chemical is a producer of synthetic compounds and employs approximately 115 persons.

2. Pfizer Corporation of Eastern Point Road, Groton, Connecticut is located on the east bank of the Thames River, approximately 4.9 miles east-northeast of the site. Pfizer Corporation is a producer of pharmaceutical and medical supplies, employing approximately 3,000 persons.

3. Electric Boat Division of General Dynamics of Eastern Point Road, Groton, Connecticut is located approximately 5 miles east-northeast of the site. Electric Boat employs approximately 12,000 persons, and is a producer of submarines and oceanographic equipment for commercial industry and the U.S. Navy.

4. Groton/New London Airport, approximately 6 miles east-northeast of the site, handles regularly scheduled commercial passenger flights (Section 2.2.2.5). Approximately 13 persons are employed at Groton/New London Airport on a

full-time basis, excluding airline and car rental employees. The National Guard has an aircraft repair facility at the airport that has approximately 140 full-time employees.

5. The New London Transportation Center, located at City Pier, New London on the west bank of the Thames River, is approximately 4 miles northeast of the site. Approximately 20 persons are employed there on a full time basis.

6. U.S. Navy Submarine Base, Groton, Connecticut is located on the east bank of the Thames River, approximately 7 miles northeast of the site. The base population includes approximately 8,500 military personnel. In addition, there are about 1,800 civilian employees at the base.

7. The U.S. Coast Guard Academy, New London, Connecticut is located on the west bank of the Thames River, approximately 5.6 miles northeast of the site. Approximately 900 cadets attend the academy, while approximately 360 military and civilian personnel are employed here.

8. The Connecticut National Guard facility, located approximately 2 miles northwest of the site, is a training headquarters for the Connecticut Army National Guard. It is owned and operated by the Military Department of the State of Connecticut. On a full-time basis, it employs 16 persons (military and civilian), including the headquarters for the Connecticut Military Academy, Post Operations personnel, and the 745th Signal Company. On a part-time basis, during various weekends, Camp Rowland is occupied by varying numbers of troop units for administrative training maneuvers, billeting, and supply functions for the Connecticut Army National Guard. During the training maneuvers there may be from 300 to 1,200 people at the facility.

9. In addition to the Connecticut National Guard facility, the Military Department of the State of Connecticut also maintains a field training facility known as Stone's Ranch Military Reservation, located approximately 7 miles northwest of the site. Fourteen persons are employed here full-time for two regional motor vehicle and equipment maintenance shops. It is also occupied on a part-time basis by varying numbers of troop units for periods of field training for the Connecticut Army National Guard. During some weekend training sessions there may be up to 500 people at the facility.

10. Hess Oil Corporation of Eastern Point Road, Groton, Connecticut is located on the east bank of the Thames River, approximately 5 miles east-northeast of the site. It is located north of Pfizer Corporation, and south of General Dynamics-Electric Boat Division and services as a fuel storage facility. There are about 14 persons employed there on a full time basis.

11. There is one medium-sized propane storage area in the proximity of the Millstone site. Hendel Petroleum Company, is located in Waterford, approximately 2.5 miles northeast of the site on Great Neck Road, and employs about 75 people.

    On the Millstone site, at the Fire Training Facility located approximately 2,800 feet to the north of the protected area (3,400 feet to Unit 3 Control Room), are two 1,000 gallon propane cylinders. The two cylinders are used to supply propane to the fire simulator.

12. Montville Station is a Fossil Fuel powered electric generating plant operated by Connecticut Light & Power Company in Montville, Connecticut. It is located on the west bank of the Thames River, approximately 9.5 miles north-northeast of the site. Approximately 67 people are employed there.

2.2.2.2 Description of Products and Materials

1. Dow Chemical produces organic compounds, such as Styron, Styrofoam, and a base product of latex paints. All materials are moved to and from the company by truck and/or railroad.

2. Pfizer Corporation produces organic compounds and pharmaceutical materials, such as citric acid, antibiotics, synthetic medicines, vitamins and caffeine. All materials are moved to and from Pfizer Corporation by truck and/or railroad.

3. The nature of products produced at Electric Boat requires that they handle substantial amounts of nuclear material which is licensed under the Naval Reactors Division. All material is moved by truck, railroad, and/or barge to and from the company with the exception of completed ships which leave under their own power.

4. Groton/New London Airport (Section 2.2.2.5)

5. The New London Transportation Center is a large complex in downtown New London in the City Pier area. It encompasses numerous facilities, including a train station, several ferry companies, commercial and private boat slips, an interstate bus terminal, local bus interchangers, and commercial land transportation facilities. It serves as the prime entrance and exit for New London for civilian and commercial travel.

6. The U.S. Navy Submarine Base provides logistics as well as training and operation of the base and its ships (nuclear and non-nuclear). All materials are moved by truck, railroad, barge and/or ship to and from this government installation.

7. The U.S. Coast Guard Academy is headquarters for indoctrination and training of future officers in the Coast Guard. All materials used at the academy are of the software nature and are moved by truck.

8. The Connecticut National Guard facility is an administrative training center for troops of the Connecticut Army National Guard. Because of the solely administrative nature of its occupancy, the camp's operation has no effect on the Station's operation.

9. Stone's Ranch Military Reservation is a military field training facility for the Connecticut Army National Guard. Limited quantities of munitions and explosives are stored in underground bunkers at this facility. These materials are used in quarry operations for the Connecticut Army Corps of Engineers. No live ammunition is used at the facility. All materials are moved to and from Stone's Ranch by truck.

   In addition, a small paved utility landing strip is located at Stone's Ranch. While capable of handling light, fixed-wing aircraft, the strip is not routinely used except for occasional rotary-wing operations. Because of its distance from the site, the limited quantity of materials stored and used, and the type of aircraft operations occurring at the facility, Stone's Ranch Military Reservation does not pose any hazard to the Millstone station.

   No other military operations such as firing ranges, bombing ranges, ordnance depots, or missile sites exist near the Millstone site.

10. Hess Oil Corporation operates a fuel distribution and storage facility for home heating oil and kerosene. There are large above ground tanks capable of storing heating oil, residual fuel oil, and kerosene. The fuel arrives by ships or barges and is distributed by trucks.

11. Hendel Petroleum Company operates a fuel distribution facility for commercial and residential use. There are 5 above ground tanks (3-30,000 gallons and 2-16,000 gallons) which are capable of storing 126,000 gallons total of propane gas. The facility also stores 40,000 gallons of gasoline, and 40,000 gallons of No. 2 fuel oil. The propane for the facility arrives by train and truck, and is distributed by truck.

    The Fire Training Facility was constructed in 1994 for the purpose of training Millstone's fire brigade members. The Training Facility consists of six live burn “mock-ups” which replicate nuclear power plant fire hazards. Propane is used to fuel these “fireplaces.”

    Two 1,000 gallon propane storage cylinders are located at the Training Facility. These two cylinders are positioned such that their ends are pointed away from the Millstone site. Both cylinders are above ground domestic storage cylinders designed per ASME Code for Pressure Vessels, Section VIII Division 1-92.

12. The Montville Station Electric Generating Station is capable of providing 498 mW of electric power. Its generators are powered by fossil fuel. The fuel is stored in

three large above ground tanks, capable of storing approximately 175,000 barrels of fuel each, two medium above ground tanks, capable of storing approximately 12,000 barrels of fuel each, and two small above ground tanks, capable of storing approximately 250 barrels of fuel each. The fuel arrives by barges or trucks.

2.2.2.3 Pipelines

There are no major transmission lines within 5 miles of the site. There are two medium pressure gas distribution lines in the near proximity of the site. The nearest gas distribution line is approximately 2.9 miles from the site, located along Rope Ferry Road in Waterford. This 35 psi gas distribution line is a 6-inch plastic pipeline, buried approximately 3 feet deep. The control valve for this line is located at the intersection of Clark Lane and Boston Post Road in Waterford. The second gas distribution line, in place and pressurized, ends at and serves the shopping center complex, near the intersection of I-95 and Parkway North, approximately 4 miles north of the site. This 35 psi gas distribution line is an 8-inch plastic pipeline buried approximately 3 feet deep. The control valve for this line is located at the complex where it intersects with Parkway North.

There are no oil transmission or distribution lines within 5 miles of the Millstone site.

2.2.2.4 Waterways

Ships that pass by the site in the shipping channels of Long Island Sound are of two types: general cargo freighters, usually partially unloaded, with drafts of 20 to 25 feet, and deep draft tankers with drafts of 35 to 38 feet. Both of these classes of ships must remain at least 2 miles offshore to prevent running aground on Bartlett Reef.

No oil barges pass to the shore side of Bartlett Reef, and since there are no tank farms in Niantic Bay, no oil barges pass within 2 miles of the site. The largest oil barges have a capacity of 60,000 barrels and draw 15 feet 6 inches of water.

Barge traffic in the vicinity of the site has been diminishing over the past several years due to the decrease in the amount of oil used by area facilities. Barge traffic is heaviest during the winter months, and averages only 1 barge per day during these months. On the average of once a month, a barge carrying 15,000 barrels of sulfuric acid is towed past the site outside of Bartlett Reef. Approximately 10 ships per day traverse the Reef in the vicinity, 6 miles of the site.

For these reasons, it is concluded that shipping accidents would not adversely affect Millstone 3 safety related facilities.

2.2.2.5 Airports

There is one airport within 6 miles of the site: The Groton/New London Airport.

Groton/New London Airport, approximately 6 miles east- northeast of the site, handles regularly scheduled commercial passenger flights. It is served by two airlines: Action Airlines, and U.S. Air Express. It has two runways: 5-23, 5,000 feet long; and 15-33, 4,000 feet long; which are both illuminated. There is a control tower at Groton/New London, with ILS (Instrument Landing System) and VOR (Very High Frequency Omni Range). ILS is available on runway 5. As shown on Figure 2.2-2, the landing patterns used do not direct traffic near the Millstone site.

The largest commercial aircraft to use Groton/New London Airport on a regularly scheduled basis are Beachcraft 1900's which carry approximately 19 passengers. The only jets using the airport on a regular basis are two small chartered Cessna Citation which carry 10 passengers.

During fiscal year 1980-1981, an average of 96,000 civilian takeoffs and landings occurred at Groton/New London Airport. Comparatively, during Calendar Year 1995, about 78,700 civilian takeoffs and landings occurred.

The largest military aircraft to use Groton/New London Airport on an occasional basis is C-130's. There are also two C-23's. Additionally, there are several military helicopters stationed at the airport.

In 1995 there were approximately 4,490 military flights, approximately half of which were military helicopters. Millstone station is not in the flight path of these flights, and pilots are briefed to avoid the site.

The largest aircraft to ever use Groton/New London Airport is a Boeing 727. However, the use of this and other large aircraft at Groton/New London is limited and very infrequent.

As shown on Figure 2.2-3, the air lane nearest the site is V58 which is approximately 4 miles northeast of the site. Other adjacent air lanes include V16, which is approximately 6 miles northwest of the site, and V308, which is approximately 8 miles east of the site. The nearest high-altitude jet route, J121-581, passes approximately 9 miles southeast of the site. A second jet route, J55, passes approximately 12 miles northwest of the site.

2.2.2.6 Highways

The area around the Millstone site is served by interstate, state, and local roads. These are shown on Figure 2.2-4.

The nearest major highway which would be used for frequent transportation of hazardous materials is U.S. Interstate 95, which is located 4 miles from the Millstone site.

Other principal highways which pass near the site include U.S. Highway 1 which is located 3 miles from the site, and State Highway 156, located 1.5 miles from the site.

These separation distances exceed the minimum distance criteria given in Regulatory Guide 1.91, Revision 1 and provide assurance that any transportation accidents resulting in explosions or toxic gas releases of truck size shipments of hazardous materials would not have a significant adverse effect on the safe operation or shutdown capability of the unit. See Section 2.2.3 for a more detailed evaluation of potential accidents.

2.2.2.7 Railroads

The site is traversed from east to west by a Providence & Worcester (P&W)/Amtrak railroad right-of-way. The mainline tracks are about 1,795 feet from the Millstone 3 containment structure.

Both P&W and Amtrak trains are currently diesel powered. However, Amtrak, the operator of the passenger train service, plans to electrify its passenger trains, and has embarked on a project to construct overhead electric lines to power the trains. The project is currently scheduled for completion in 1997. These new lines will be 23 feet above the rails and will not affect the site nor the overhead transmission lines leading out of the site which traverse the railroad line above the tracks. Additionally, Amtrak is considering raising the track bed as much as 3 feet at various points along the railroad line, but does not plan to do this where it traverses the Millstone site.

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2.2.2.8 Projections of Industrial Growth

<u>Pipelines</u>

No expansion of facilities is presently planned in the area for oil distribution within the southeastern region of Connecticut. The gas distribution line along Rope Ferry Road ends at Waterford High School, approximately 2.9 miles from the Millstone site. The gas distribution line at I-95 and Parkway North ends at, and serves the shopping complex approximately 4 miles from the Millstone site.

Waterways

As previously mentioned, ship and barge traffic in the area of the Millstone site has decreased over the past several years. No new ship or barge traffic is anticipated at this time in the Niantic Bay area on Long Island Sound near the location of the intake structures.

Airports

No expansion of facilities at Groton/New London Airport is proposed although some improvements to the facility, such as expansion of the approach lights, and upgrading of the terminal and runways is planned. Southeastern Connecticut Regional Planning Agency (SCRPA) recommends that a master plan be prepared for the airport before any major physical improvements are made. The agency has previously adopted the policy that Groton/New London Airport should remain a small feeder airport providing connection to larger airports and direct service to a limited number of cities within a 500-mile radius.

Highways

Three major highway improvements were made for the area around the Millstone site. The section of Route 85 between I-95 and Route I-395 (Formally Route 52) was widened in 1989 in connection with the new shopping mall built on Route 85, the widening of "Cross Roads" between I-95 and Route 85 in 1990 for another new shopping mall on Cross Roads, and a new bridge between Waterford and East Lyme was completed in 1991 to replace the Niantic River Bridge with a high rise bridge one mile long. This high-level draw bridge replaced the older lower swing bridge, creating a smoother flow of traffic along State Highway 156.

Railroads

In 1982 there was a transfer of the operating rights of freight service over coastal trackage from ConRail to the Providence & Worcester (P&W) railroad. While this involved the trackage near the site, there was no appreciable change in either the amount or the nature of freight traffic.

Evaluation of potential accidents and identification of design basis events are discussed in Section 2.2.3.

2.2.3 EVALUATION OF POTENTIAL ACCIDENTS

The evaluation of potential accidents includes analysis of hazardous materials from both offsite industrial, transportation, and military facilities within a 5-mile radius of the Millstone site, as well as from specified onsite sources. Section 2.2.1 defines industrial, transportation, and military facilities that exist within 10 miles of the Millstone site. All major industrial plants are more than 5 miles from Millstone. Likewise, due to the innocuous nature of operations at nearby military installations, as well as the location of the Groton/New London airport and the nature of traffic and the flight routes into and out of the airport, no potential accidents from military installations or from aircraft have been postulated concerning the safe operation or shutdown capability of the plant.

Ships that pass by the site in the shipping channels of Long Island Sound are of two types: general cargo freighters, which usually are partially unloaded, with drafts of 20 to 25 feet, and deep draft tankers with drafts of 35 to 38 feet (Section 2.2.2.4). Both of these classes of ships must remain at least 2 miles offshore to avoid running aground on Bartlett Reef. Approximately ten ships per day transverse the shipping channels in the vicinity of the site (Section 2.2.2.4).

Since there are no tank farms in Niantic Bay, oil barges do not pass to the shore side of Bartlett Reef or within 2 miles of the site. Barge traffic is heaviest in the winter, averaging only one loaded oil barge daily, the largest having a capacity of 60,000 barrels and a draw of 15 feet-6 inches of water (Section 2.2.2.4). On the average of once a month, a barge carrying 15,000 barrels of sulfuric acid is towed past the site, outside of Bartlett Reef. Total round-trip traffic is less than 10 ships per day.

Section 2.2.2.4 defines the nature of water use relative to commercial shipping and recreational boating. The only safety related structure subject to this evaluation is the circulating and service water pumphouse. Since there is no commercial water traffic in the area of the pumphouse, the only consideration that exists is the remote possibility of a runaway barge colliding with the pumphouse.

The possible damage to the pumphouse by a drifting barge was investigated. The barge can approach the pumphouse only through the intake channel, which is perpendicular to the front of the pumphouse. The relatively shallow bay bottom surrounding the intake channel prevents the barge from hitting the side of the pumphouse. Should a barge hit the pumphouse from the front, damage would be limited to the front wall of the recirculation tempering water gallery, which projects seaward from the pumphouse. The service water pumps, which are the only safety related equipment housed in the pumphouse, are located approximately 50 feet from the front wall. The operation of these pumps would not be impaired and the water intake source would not be blocked, as the water intake source lies between elevations (-) 28 feet 0 inch and (-) 8 feet 0 inch.

For these reasons, it is concluded that shipping accidents would not adversely affect safety related facilities.

The possibility of facility impacts due to explosion or release of hazardous materials from industrial facilities was considered for two facilities listed in Section 2.2.2. Hendel Oil Company and Hess Oil Company were selected for evaluation based on proximity to the site and volume of material stored. Several incident conditions were modeled for each facility using "Automated Resource for Chemical Hazard Incident Evaluation" (ARCHIE) version 1.00 produced by FEMA/USDOT and USEPA. ARCHIE is a software planning tool which provides an integrated method for assessment of vapor dispersion, fire and explosion impacts related to the discharge of hazardous material into the terrestrial environment.

Inputs to the model include physical properties of the hazardous material such as molecular weight, boiling point, and vapor pressure for various temperatures. These were obtained from the Chemical Engineer's Handbook, Fifth Edition, 1973. The type and quantity of hazardous material on-hand at each facility was obtained from the facility managers. Conservative assumptions were made where applicable, the most notable of which was that all the tanks at a facility should be treated as one large tank for the purpose of calculating risks associated with fire or explosion. Non-fire or explosion hazards, such as toxic vapor dispersion were projected using the largest single tank at each facility, since a major fault in more than one storage tank in the absence of an explosion was considered unlikely.

The first event considered was the potential for toxic concentrations of propane to reach the site from a release of propane gas from a commercial facility, other than by explosion. A nearly instantaneous release (1 minute duration) coupled with stability class "F" (most stable) and a low wind velocity (4.5 mph) was chosen to minimize diffusion of the puff of propane. Hendel Oil Company has a 30,000 gallon tank which is located 2.5 miles from the site. The plume is conservatively assumed to be transported by the wind directly towards the Control Room ventilation intakes. The maximum concentration reached at the intakes will be approximately 7,311 ppm 31 minutes after tank rupture. Using the same input parameters and methodology to assess infiltration to the pressurized control room as in FSAR section 2.2.3.1.4, the concentration inside the control room should reach a maximum value of 13.4 ppm 61 minutes after the tank rupture. Both values are well below the toxic vapor limit of 20,000 ppm. The only scenario in which concentration anywhere on the Millstone site reaches or exceeds the toxic vapor limit would occur in the case of an instantaneous release of the contents of all 5 tanks (126,000 gallons) of propane from Hendel Oil Company without explosion or fire. In this unlikely event, concentrations at the control room intakes could reach 29,146 ppm 31 minutes after the start of the release. Concentrations inside the Control Room would reach 58 ppm (well below the toxic vapor limit), 61 minutes after the release.

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Due to its further distance from the site (5 miles), and the lesser volatility of the kerosene, #2 fuel oil, and residual fuel oil stored there, there is no impact on the Millstone plant from a fire or explosion at the Hess Oil facility. For these reasons, it is concluded that explosion or release of hazardous material from any of these facilities would not adversely affect the safe operation or shutdown capabilities of the plant.

Other land and water uses prevailing in the Millstone Point vicinity are such that the unit's intake of cooling water is not jeopardized by ice blockage and/or damage (the ocean temperatures prohibit significant icing), or release of corrosive chemicals or oil (only remote and distant offshore releases are possible).

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2.2.3.1 [redacted]

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The determination of design basis events therefore provides an analysis and discussion of:

1. missiles generated by offsite events near Unit 3;
2. unconfined vapor cloud explosion hazard;
3. hydrogen storage at the site; and
4. toxic chemicals stored at the site.

2.2.3.1.1 Missiles Generated by Events near the Millstone Site

The guidelines of NUREG-0800 state that the aggregate probability of exceeding plant design criteria associated with all identified external man made hazards be less than 10^{-6}. In particular the total probability of penetrating site proximity missile strikes on safety- related structures should be shown to be less than 10^{-7} per year or the design bases be modified to accommodate them.

The relative importance of potential sources of missiles is derived from two primary factors: (1) the nature of shipment loading, and (2) shipment frequency past the site. Several studies show that shipment of flammable compressed gases are the most likely sources to produce transportation tank fragments in the event of an accident. Depending on the nature of hazardous material and the actual accident scenario the tank fragments may travel sufficient distances and create a potential threat of damage upon impact to a safety related structure at the site.

The following algorithm is used to estimate the aggregate probability of a violent rupture or explosion from a rail shipment of hazardous materials capable of producing large missiles able to reach safety related structures at the site:

$$P_r = (i=1)RE\left(\frac{S_i L_i}{T_i}\right) \qquad (2.2.3\text{-}1)$$

where:

P_r = Aggregate probability of missiles generating ruptures or explosions from rail accidents of significance to safety related structures (events/year)

R = Number of hazardous materials likely to produce violent ruptures or explosions with significant missiles generating capability (dimensionless)

E = Frequency of events which result in explosions or violent ruptures capable of producing significant missiles (events/shipment)

S_i = Shipment frequency of i-th hazardous material past site (shipment/year)

L_i = Track exposure length for the i-th material (miles)

T_i = Average shipment trip length for i-th material (miles)

Number of Hazardous Materials, R

The hazardous materials considered likely to produce significant missiles in terms of size and potential range were selected from the Hazardous Materials Link Report (ConRail, 1980) between New Haven and New London, Connecticut, from January 1978 through June 1979. These materials were also found to be prevalent in more recent accident/incident data contained in special DOT Research and Special Programs Administration computer outputs of March 26, 1981 (Research and Special Programs Administration, U.S. Dept. of Transportation, March 1981), and April 15, 1981 (Research and Special Programs Administration, U.S. Dept. of Transportation, April 1981) tank car rupture data from the Railroad Tank Car Safety Research and Test Project Report, RA-01-2-7 (Association of American Railroads and Railway Progress Institute, 1972), and several other pertinent railroad accident reports by the National Transportation Safety Board (October 1971 through July 1980).

The materials selected (Table 2.2-2) are flammable compressed gases since they are known to produce a characteristic tank rupture event. The rupture event may range from a single over-pressure followed with fire to a boiling liquid vapor explosion (BLEVE).

Frequency of Events, E

The incidence of significant missile generating events is relatively infrequent in the transport of hazardous materials and the material specific data is unreliable to be useful for the present probabilistic analysis. In addition, specific data supplied by ConRail for the period March 30, 1976, through December 31, 1979, contained no incidents involving explosions. Instead, a comparison was made for propane transport by Battelle Memorial Institute in PNL-3308, Report of March 1980 (Giffen et al., 1980), and the DOT data in accident/incident bulletins for the years 1975-1979. In terms of violent tank car ruptures or explosions per tank car mile, the predicted values were as follows:

PNL-3308	3.1×10^{-9} events/tank car mile
DOT (75-79)	1.5×10^{-9} events/tank car mile

The Battelle report considers non-accident related tank ruptures as well as transportation accidents and it is further stated that about 20 percent of ruptures occur in non-accident situations. We have used Battelle event frequency in the present analysis, even though we recognize it to be demonstrably conservative. The present analysis also accounts for the contribution to the average rate from slightly higher incidence for propane and LPG shipments.

<u>Shipment Frequency, S_i</u>

Shipment frequencies are derived from applicable data in the ConRail link report for the period January 1978 through June 1979 (ConRail, 1980). Tank cars per year and per train for the commodities in question appear in Table 2.2-2.

More recent shipment frequency shipment data was obtained for the time period January 1992 through December 1992. Frequency of shipment of anhydrous ammonia has remained steady at 5 cars per year. Propane shipments have decreased to 35-40 cars per year. This evaluation was conservatively based on the January 1978 through June 1979 shipment data.

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[redacted]

<u>Average Shipment Trip Length, T_i</u>

The average shipment lengths for each hazardous material derived from one percent Waybill Sample of U.S. Tank Car shipments, or Appendix E to the Final Phase O2 Report, Accident Review, AAR-RPI No. RA 02-2-18 (1982).

Aggregate Probability of Missile Generating Ruptures, P_r

The results from the above analysis are summarized in Table 2.2-4. The aggregate probability of tank car violent ruptures or explosions which can produce significant missiles is conservatively estimated to be 5.6 x 10^{-9} per year. This is considerably below the NUREG-0800, Section 3.5.1.5, suggested limit (1 x 10^{-7}) for conservatively estimated explosion probability.

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We have used NASA Report 3023 computer program entitled "THRUST" to calculate the acceleration velocity and displacement distances of fragments propelled by a liquified compressed gas. The NASA analysis assumes that a large portion of the vessel containing a liquid/gas mixture, in equilibrium at greater than atmospheric pressure, separates from the rest of the storage vessel. As the liquid under pressure converts to gas when exposed to atmospheric pressure a thrust is produced causing the fragment to move away from the scene of accident.

The types of tank car fragments are illustrated in Table 2.2-5. In type A, the tank is shown to rupture in two equal halves. In type B, the tank car is assumed to split in 2:1 ratio and the smaller fragment is assumed to move away from the accident scene. Type C and D ruptures are not considered in this analysis because:

1. In type C, the man-way has no significant amount of liquid to provide it with thrust.

2. In type D, the leak is relatively too slow to create a violent change in vapor/liquid equilibrium within the tank.

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Discussion of Results

The Federal Railroad Administration retrofit standards “J”, “S”, and “T”, for pressurized tank car require thermal insulation protection head puncture shields, self-couplers, and upgraded safety relief valve capacities. According to Folden (Personal Communication between S.N. Bajpai, SWEC, and Robert Folden, Federal Railroad Administration, 1982), these retrofits have been installed on existing tank cars. The new compressed gas tank cars also meet these provisions in compliance with Docket HM144 and modified in subsequent notices under Titles 173 and 174. The compliance with retrofit standards is expected to result in substantial reduction in severity of violent ruptures. The Federal Railroad Administration believes that compressed flammable gas tank car head punctures and fire induced violent ruptures are greatly reduced or eliminated in 90 percent of the cases as a result of the improvements.

According to Folden, the “S”, “J”, and “T” retrofit requirements together with self-couplers have reduced the violent ruptures considerably. The ruptures in ammonia tank cars are principally due to material degradation. However, ruptures in ammonia tank are not violent. Folden described one incident involving ammonia in which “the tank just opened up along the seam and the ammonia escaped without any thrusting fragments.”

The present analysis is based on the data from past experience and does not include the safety improvements resulting from DOT required safety retrofits. This analysis also includes the contribution of non-accident ruptures because the Battelle (Giffen et al., 1980) propane risk assessment study has been used as the reference point for the calculation of the probability of catastrophic ruptures of other hazardous materials.

The overall risk to the Millstone plant due to catastrophic ruptures resulting from transport of hazardous materials is subject to additional reducing factors. These factors are included in NUREG-0800, Section 3.5.1.5, and according to the following model:

$$P_t = P_e \times P_{mr} \times P_{sc} \times P_p \times N \qquad (2.2.3\text{-}2)$$

where:

P_t = Total probability per year of a damaging missile strike

P_e = Probability of an explosion or rupture potentially capable of missile generation

P_{mr} = Probability of a missile reaching the plant (that is, distance to safety related structures)

P_{sc} = Probability of a missile striking a critical area

P_p = Probability of a missile energy exceeding the energy required to penetrate the safety related structures

N = Number of missiles per explosion

Railroad cars carrying hazardous materials and involved in a derailment do not necessarily result in tank car ruptures. Furthermore, not all ruptures result in the generation of missiles. In fact, data in AAR-RPI No. RA-01-2-7 (1972) shows that in approximately one-third of major ruptures, no significant missiles are generated. Therefore, it is reasonable to incorporate a conditional probability (P_m) of missile generation to the model. Thus the conditional probability of missile generation $P_m = 0.67$.

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The tank car fragments (e.g., elliptical head) have different punching-shear characteristics than a "flying telephone pole" moving at 200 mph. Tank car head missiles have been known to demolish brick walls, but tend to bounce off built stonewalls with little damage to the structure (Personal Communication between S.N. Bajpai and Robert Folden 1982).

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2.2.3.1.3

Compressed liquified gases are shipped over the railroad line adjacent to the Millstone site. These gases normally are propane and anhydrous ammonia. In the event of a catastrophic rupture, the liquified gas is released to the atmosphere under pressure, and a fraction of the liquid is vaporized. The remaining liquid, due to the cooling effect, remains as chilled liquid and vaporizes further upon contact with the ground. The rapid loss of lading results in the formation of an unconfined vapor cloud which is at least partially mixed with air.

The probability of a vapor cloud explosion on the railroad line adjacent to the Millstone site is based on the probability of a catastrophic rupture event, the probability of flammable vapor cloud formation, the probability of wind direction from the railroad sector (bounded by the 1 psi over-pressure radius), and the probability of the vapor cloud encountering an ignition source.

The probability of a flammable vapor cloud explosion is thus:

$$P_{ve} = \sum_{i=1}^{R} P_{ri} \times P_{rfi} \times f_w \times P_{ii} \qquad (2.2.3\text{-}3)$$

where:

P_{ve} = Probability per year of vapor cloud explosion

R = Number of hazardous materials likely to produce vapor cloud

P_{ri} = Probability of catastrophic rupture events per year for the i-th hazardous material

P_{vfi} = Probability of forming a flammable vapor cloud

f_w = Frequency of wind speed which promotes transport and mixing with air

P_{ii} = Probability of finding an ignition source given that a flammable vapor cloud is formed by the i-th hazardous material

Number of Hazardous Materials, R

The hazardous materials likely to produce an unconfined vapor cloud explosion due to a catastrophic rupture event on the railroad line adjacent to the Millstone Site are propane and anhydrous ammonia.

Probability of Catastrophic Rupture Events, P_{ri}

The probability of catastrophic rupture events per year involving the i-th hazardous material is estimated using the model described in Section 2.2.3.1.1 of this report. These probabilities are presented in Table 2.2-4.

Probability of Forming a Flammable Vapor Cloud, P_{rfi}

All catastrophic rupture events involving flammable compressed gases do not necessarily result in the formation of vapor clouds. The usual case is that ignition source is available in the immediate vicinity of accident and a fire usually results. Depending on the actual accident scenario, the fire, at worst, would cause the tank car contents to be released and result in the formation of a "fireball." The fireball accident scenario has no incident pressures associated with it to be of concern for the plant structures. However, the formation of a flammable vapor cloud and its subsequent ignition is of potential safety concern. The formation of a flammable vapor cloud also implies that an ignition source was not available in the immediate vicinity of the scene of accident.

Accidental spill data (U.S. Dept. of Transportation, March 1981) was used to estimate the probability of forming a vapor cloud given a catastrophic rupture event. This probability was conservatively estimated as 0.1.

Wind Speed Frequency, f_W

Favorable wind speed would allow optimum transport and mixing of air with the vapor cloud. The probability of favorable wind speed is assumed to be 1.0.

Probability of Encountering an Ignition Source, P_{ii}

In a catastrophic rupture event involving flammable compressed gases, an immediate encounter with an ignition source would typically result in a torching effect. In this case, the released gas is consumed immediately and the flames are confined locally. The torching effect can lead to an enlarged fire or, at worst, the formation of a “fireball.” The probability of encountering ignition is 1.0 in the immediate vicinity of the accident and decreases away from it. The probability of ignition for the torching effect, fire, and fireball formation is therefore, nearly 1.0.

The formation of a flammable vapor cloud in or around the scene of an accident implies that an immediate ignition source was not encountered. The probability of an unconfined vapor cloud encountering an ignition source then decreases from nearly one to some value less than 1.0, which is dependent upon the area of the vapor cloud.

The probability of ignition was estimated using Table 9-2 of the Battelle PNL 3308 Report (Giffen et al., 1980). The use of this table requires an estimation of the area of the vapor cloud for a conservatively estimated instantaneous release of the compressed liquid.

The area of the unconfined vapor cloud was estimated by calculating: (1) the weight, i.e., vapor volume, of the liquid which vaporizes upon exit from a tank car and, (2) the depth of the unconfined vapor cloud above the ground.

The weight fraction, which vaporizes upon exit from a tank car, is given by:

$$f = 1 - \exp\left[\frac{C_v}{\lambda}(T_b - T_i)\right] \qquad (2.2.3\text{-}4)$$

where:

C_v = Liquid heat capacity

λ = Heat of vaporization

T_b = Normal boiling point

T_i = Initial temperature of the stored liquid

f = Fraction of the liquid that flash vaporizes.

The fraction vaporized, for both the hazardous materials, was under 0.4. To be on the conservative side, the fraction vaporized was taken to be 0.5. Thus, knowing the weight of tank car lading which was vaporized, the volume of the vapor cloud was estimated. The fraction of air entrained in the vapor cloud was ignored for this purpose.

The thickness of the vapor cloud above ground level was estimated by the following relation given by Kaiser and Griffiths (1982):

$$L = \frac{gh\Delta p}{\rho_a u_*^2} \qquad (2.2.3\text{-}5)$$

where:

$L = 2$

h = Thickness of the vapor cloud

$\Delta\rho$ = Density differences between cloud vapor and ambient air

ρ_a = Density of air

u_* = The vapor cloud spreading velocity

The spreading velocity was assumed to be equal to the wind velocity.

The estimated ignition probabilities are presented in Table 2.2-7.

The Probability of an Unconfined Vapor Cloud Explosion

The probability of an unconfined vapor cloud explosion at Millstone 3 was calculated using the model discussed above. These probabilities are presented in Table 2.2-8.

The aggregate estimated probability of an unconfined vapor cloud explosion is 2.54×10^{-11}, which is several orders of magnitude lower than the recommended range in Regulatory Guide 1.91. The unconfined vapor cloud and associated explosion pressure, therefore, does not constitute a design basis event for the Millstone 3 plant.

2.2.3.1.4 Hydrogen Storage at the Site

Section 2.2.3.1 describes the generator hydrogen storage facility. Each high pressure storage tube is restrained from movement by its supporting frame and is provided with an approved shutoff valve, bursting disc assembly, and vent. The installation is posted with NO SMOKING signs located no further than a distance of 25 feet away. A fire wall is constructed between the hydrogen storage facility and the east-west access road. Unauthorized entry is prevented by chain link fencing and a locked gate. Since the generator hydrogen facility poses no hazard to safety related structures, systems, or components, no further consideration is therefore required.

2.2.3.1.5 Toxic Chemicals

The assessment of control room habitability following a postulated accidental release of hazardous chemicals includes both onsite and offsite sources. The analysis is based on Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Plant Control Room During a Postulated Hazardous Chemical Release." The release of any hazardous chemical stored onsite in a quantity greater than 100 pounds is considered, along with other potential releases from facilities within 5 miles of the control room. Transportation sources of hazardous chemicals frequently passing within 5 miles of the control room are also evaluated. Frequent shipments are defined as exceeding 10 per year for truck shipments, 30 per year for rail shipments, and 50 per year for barge shipments.

For the Millstone 3 site, two potential accidents involving two toxic chemicals were analyzed prior to Licensing Application. Chlorine was stored onsite in two separate 55 ton railroad tank cars. In addition, liquid propane had been transported prior to 1982 by ConRail within 5 miles of the site at a frequency greater than 30 railroad carloads per year. The chlorine tanks were removed in September 1986.

The effect of an accidental release of each of the chemicals on control room habitability was evaluated by calculating vapor concentrations as a function of time both outside and inside the control room. This calculation was performed using methodology outlined in NUREG-0570, Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release, and utilizing the assumptions described in Regulatory Guide 1.78. A brief description of the underlying assumptions follows.

In a postulated accident, the entire contents of the largest single storage container are released, resulting in a toxic vapor cloud and/or plume which is conservatively assumed to be transported by the wind directly toward the control room intakes. The formation of the toxic cloud or plume is dependent upon the chemical nature of the release and ambient environmental characteristics. The entire amount of the chemical stored as a gas is treated as a puff or a cloud which has a finite volume determined from the quantity and density of the stored chemical. A toxic substance stored as a liquid with a boiling point below the ambient temperature forms an instantaneous puff, due to flashing (rapid gas formation) of some fraction of the quantity stored. The remaining liquid forms a puddle which quickly spreads into a thin layer on the ground, subsequently vaporizing and forming a ground-level vapor plume. A liquid that has a boiling point above the ambient temperature forms a puddle which evaporates by forced convection, resulting in a ground-level plume with no flashing involved. In all cases, the puff and/or ground-level plume is dispersed by atmospheric turbulence as it is transported by the wind directly toward the control room intakes. The effects of this postulated accident scenario are described in Section 2.2.3.2.

The habitability of the control room is evaluated by comparing the calculated chemical concentrations inside the control room with known human toxicity limits. These limits are determined to be the lowest concentration of a chemical that could interfere with an operator's ability to function properly and are obtained from Regulatory Guide 1.78 and other appropriate references. The control room is considered to be uninhabitable when toxic limits are exceeded by estimates of control room concentration. The input data required for the analysis include the chemical's physical properties, control room parameters, atmospheric stability, wind speed, distance from the spill to the control room air intakes, quantity of chemical released, and toxicity limits. For low boiling point liquids (i.e., chlorine and propane), the boiling point, puff density, heat of vaporization, specific heat, and liquid density are required as input.

For the Millstone 3 toxic chemical evaluation, various atmospheric stability and wind speeds representing a wide range of meteorological conditions along with an ambient dry bulb temperature of 30°C (80°F), were utilized to obtain the condition which would result in a maximum control room concentration.

The control room parameters that were used as input to the propane analysis consisted of the following:

- Air intake height above ground: 65 feet
- Control room volume: 191,940 ft^3
- Normal ventilation flow rate: 1450 cfm

The control room volume used in this analysis is conservative relative to the actual value presented in Table 15.6-12.

A description of the operation of the control room pressurization system is presented in FSAR Section 9.4.1. For propane chemical sources, the contents of the largest single storage container were used as the amount of chemical released during a postulated accident.

2.2.3.2 Effects of Design Basis Events

The accidents involving transportation of propane and anhydrous ammonia have the potential of forming flammable vapor clouds as well as rail tank car missiles. However, the probability of these events near the Millstone 3 site is lower than the 1.0×10^{-7} per year for consideration of such events as recommended by NUREG-0800 (USNRC 1981a), Section 2.2.3. The transportation accidents on the ConRail rail line near the Millstone 3 site do not form a design

basis event. Therefore, probable effects of these accidents are not discussed. The results of the toxic chemical analysis are presented in Figure 2.2-5 for propane.

Withheld under 10 CFR 2.390 (d)(1)

[redacted]

2.2.4 REFERENCES FOR SECTION 2.2

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2.2-2 AAR-RPI No. RA-02-2-18, 1972. Association of American Railroads and Railway Progress Institute Final Phase 02 Report on Accident Review, Chicago III.

2.2-3 Chemical Rubber Company, 1972. Handbook of Chemistry and Physics 44th and 53rd Editions.

2.2-4 ConRail 1980. Hazardous Materials Link Report between New Haven and New London, Connecticut from January 1978 through June 1979.

2.2-5 Giffen, C.A. et al., 1980. An Assessment of the Risk of Transporting Propane by Truck and Train. Report prepared for the U.S. Department of Energy by Pacific Northwest Laboratory, Battelle Memorial Institute.

2.2-6 Iotti, R.C.; Krotuik W.J.; and DeBoisblanc, D.R. 1973. Report of Topical Meeting on Water Reactor Safety. USAEC Washington, D.C. Hazards to Nuclear Plants from a Near Site Gaseous Explosions. Paper, March 26-28, 1973.

2.2-7 Kaiser, G.D. and Griffiths, R.F. 1982. The Accidental Release of Anhydrous Ammonia: A Systematic Study of the Factors Influencing Cloud Density and Dispersion, Journal of the Air Pollution Control Association, Vol. 32, No. 1.

2.2-8 NASA Report 3023, 1978. Workbook for Estimating the Effects of Accidental Explosions in Propellant Ground Handling and Transport Systems.

2.2-9 NTSB-RAR-72-6, 1971. National Transportation Safety Board Railroad Accident Report for Houston, Tex.

2.2-10 NTSB-RAR-1, 1972. National Transportation Safety Board Accident Report for East St. Louis, Mo.

2.2-11 NTSB-RAR-75-7, 1974. National Transportation Safety Board Railroad Accident Report for Houston, Tex.

2.2-12 NTSB-RAR-79-11, 1979. National Transportation Safety Board Railroad Accident Report for Crestview, Fla.

2.2-13 NTSB-RAR-81-1, 1980. National Transportation Safety Board Railroad Accident Report for Muldraugh, Ky.

2.2-14 NUREG-0800, 1981. Standard Review Plan: Evaluation of Potential Accidents (Section 2.2.3).

2.2-15 Perry & Chilton 1973. Chemical Engineers Handbook, 5th Edition McGraw–Hill, Inc.

2.2-16 Personal Communication between S.N. Bajpai and Robert Folden, Federal Railroad Administration, Office of Safety, February 17, 1982.

2.2-17 Regulatory Guide 1.78, 1974. Assumptions for Evaluating the Habitability of a Nuclear Plant Control Room during a Postulated Hazardous Chemical Release.

2.2-18 Research and Special Programs Administration, U.S. Department of Transportation, Washington, D.C. 1981. Computer Printout of "Incidents Involving Deaths, Injuries, Damages Greater than $50,000 or Evacuations." Run Dated March 26, 1981, Covering Period December 22, 1970 to September 5, 1980.

2.2-19 Research and Special Programs Administration, U.S. Department of Transportation, Washington, D.C. 1981. Computer Printout of "Incidents Involving Fire and Explosions by ConRail." Run dated 4/15/81 Covering Period June 6, 1973 through November 1, 1980.

2.2-20 Rhoads, R.E. et al., 1978. An Assessment of Risk of Transporting Gasoline by Truck PNL-2133. Pacific Northwest Laboratory (Battelle Memorial Institute), Richland, Washington.

2.2-21 Siewert, R.D. 1972. Evacuation Areas for Transportation Accidents Involving Propellant Tank Pressure Bursts. NASA Technical Memorandum X68277.

2.2-22 Tilton, B.E. and Bruce, K.M. 1980. Review of Criteria for Vapor Phase Hydro Carbons, Environmental Criteria and Assessment Office. U.S. EPA-600/8-80 p 6-150.

2.2-23 U.S. Department of Transportation. Incidents Involving LPG and Ammonia, Computer Runs Prepared for Stone & Webster, 1981.

TABLE 2.2-1 DESCRIPTION OF FACILITIES

	Facility	Location	Approx. No. Persons Employed or Stationed	Approximate Distance From Site Miles	Sector
Industrial					
1. *	Dow Chemical Corp.	Ledyard	115	10+	NNE
2. **	Pfizer Corporation	Groton	3,000	4.9	ENE
3.**	Electric Boat (Division of General Dynamics	Groton	12,000	5	ENE
Transportation					
4. **	Groton/New London Airport (Trumbull)	Groton	153	6	ENE
5. **	New London Transportation Center	New London	20	4	NE
Military					
6. **	U.S. Navy Submarine Base	Groton	10,300	7	NE
7. **	U.S. Coast Guard Academy	New London	1,260	5.6	NE
8. **	Connecticut National Guard facility	East Lyme	16	2	NW
9. **	Stone's Ranch Military Reservation	East Lyme	14	7	NW
Industrial Related Facilities					
10. **	Hess Oil Corporation	Groton	14	5	ENE
11. **	Hendel Petroleum Co.	Waterford	75	2.5	NE
12. *	Montville Station Electric Generation Plant	Montville	67	10	NNE

NOTES:

* Not shown; located approximately near 10 mile radius, NNE of site.

** Location of facility on Figure 2.2-1.

MPS3 UFSAR

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TABLE 2.2-2 LIST OF HAZARDOUS MATERIALS POTENTIALLY CAPABLE OF PRODUCING SIGNIFICANT MISSILES

[redacted]

Withheld under 10 CFR 2.390 (d)(1)

TABLE 2.2-3 SUMMARY OF EXPOSURE DISTANCE CALCULATION

[redacted]

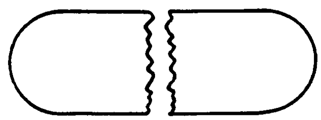
Withheld under 10 CFR 2.390 (d)(1)

TABLE 2.2-4 AGGREGATE PROBABILITY OF EXPLOSION OR VIOLENT RUPTURE CAPABLE OF MISSILE GENERATION

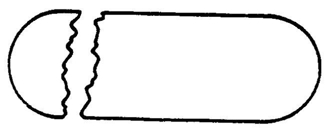
[redacted]

TABLE 2.2-5 TYPES OF TANK CAR MISSILES

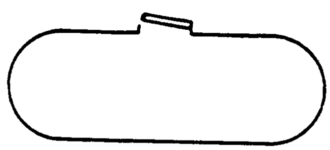
A. Tank Splits at Mid-Seam.



B. Tank Splits in 2:1 Ratio with the Smaller Section “Thrusting”.



C. Manway Separates



D. Tank Punctured at Head.

TABLE 2.2-6 TANK CAR FRAGMENT RANGE (FEET) AT 10-DEGREE LAUNCH ANGLE

	Postulated Missile Type (Table A)			
Hazardous Material	**Type A**	**Type B**	**Type C**	**Type D**
1. Propane	142	370	-	-
2. Anhydrous ammonia	264	803	-	-

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TABLE 2.2-7 ESTIMATED IGNITION PROBABILITIES

Hazardous Materials	Ignition Probabilities
[redacted]	[redacted]
[redacted]	[redacted]

Withheld under 10 CFR 2.390 (d)(1)

TABLE 2.2-8 PROBABILITY OF AN UNCONFINED VAPOR CLOUD EXPLOSION

Hazardous Material	Probability of Unconfined Vapor Cloud (Explosion Per Year)
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

2.3 METEOROLOGY

This section provides a meteorological description of the site and its surrounding areas. Supporting data are included in accompanying tables. Tables 2.3-1 through 2.3-18, 2.3-20 through 2.3-30 and 2.3-33 provide information about the site climatology and meteorology. They are the historical record for the site and are not updates on a continual basis. Table 2.3-19 also provides meteorological information but the information continues to be of interest and use to station personnel. As such, it will be updated to reflect major changes which affect plant safety or as needed. Tables 2.3-31 and 2.3-32 provide information regarding the ongoing site meteorological monitoring program and will be updated as necessary. Tables 2.3-34 through 2.3-77 provide information regarding atmospheric diffusion estimates. They also provide historical record for the site and are not updated on a continual basis.

2.3.1 REGIONAL CLIMATOLOGY

The climatology of the Millstone site region may be reasonably described by data collected by the National Weather Service at Bridgeport, Connecticut. The National Weather Service Station for Bridgeport is located at the Sikorsky Memorial (Bridgeport Municipal) Airport, approximately 50 miles west-southwest of the site. The airport is located on a peninsula which protrudes into Long Island Sound in a similar manner to the Millstone site peninsula.

The Bridgeport meteorological data are reasonably representative of the climate at the Millstone site since both Bridgeport and the site are influenced by similar synoptic scale and mesoscale meteorological conditions. Temperature data prior to January 1, 1948, and precipitation and snowfall data prior to March 1, 1948, are from cooperative observers in the Bridgeport area. Following these dates, all data were collected at Bridgeport Municipal Airport locations. From May 16, 1953, to February 29, 1960, and June 1, 1981, to June 30, 1982, the Bridgeport weather station was closed between the hours of 11 p.m. and 6 a.m. During these time periods, hourly data were recorded 16 hours per day by the National Weather Service (NOAA 1971, 1990).

2.3.1.1 General Climate

The general climate of the region is described with respect to types of air masses, synoptic features, general airflow patterns, temperature, humidity, precipitation, and relationships between synoptic-scale atmospheric processes and local meteorological conditions.

2.3.1.1.1 Air Masses and Synoptic Features

The Millstone site region has a continental climate, modified by the maritime influence of Long Island Sound and the Atlantic Ocean, immediately to the south and southeast. The general eastward movement of air encircling the globe at middle latitudes transports large air masses into the region. Four types of air masses usually produce the meteorology in the region of the Millstone site: cold, dry continental polar air originating in Canada; warm, moist tropical air originating over the Gulf of Mexico and the Atlantic Ocean; cool, damp maritime air originating over the North Atlantic; and modified maritime air originating over the Pacific Ocean. Constant interaction of these air masses produces a large number of migratory cyclones and accompanying weather fronts, passing near or over the site region throughout the year. These weather systems are strongest during the winter and decrease in intensity during the summer. Infrequently, a storm of tropical origin affects the Millstone site region.

2.3.1.1.2 Temperature, Humidity, and Precipitation

The mean annual temperature is approximately 51°F at Bridgeport, Connecticut. Due to the proximity of Long Island Sound and the Atlantic Ocean, both the heat of summer and the cold of winter are moderated. During the summer months, normal monthly temperatures near the shoreline average 3°F to 5°F cooler than nearby inland stations. Temperatures of 90°F or greater occur an average of seven days per year at Bridgeport, while temperatures of 100°F or greater have occurred only in July and August; with an extreme maximum of 103°F occurring in July 1957. Freezing temperatures have not been recorded during the summer months (NOAA 1990).

Winters are moderately cold, but seldom severe. Minimum daily temperatures during the winter months are usually below freezing, but subzero (°F) readings are observed, on the average, less than one day every two years. Below zero temperatures have been observed in each winter month, with an extreme minimum of -20°F occurring in February 1934 (NOAA 1971, 1990).

Table 2.3-1 presents monthly, seasonal, and annual averages and extremes of temperature at Bridgeport (NOAA 1970, 1975, 1975, 1978, 1981; Weather Bureau 1959; Weather Bureau 1960), while Table 2.3-2 gives the mean number of days with selected temperature conditions (NOAA 1970, 1974, 1975, 1978, 1981).

The normal annual precipitation at Bridgeport is well distributed throughout the year. Migratory low-pressure systems, and their accompanying frontal zones, produce most of the precipitation throughout the year. From late spring through early fall, bands of thunderstorms and convective showers produce considerable rainfall. These storms, often of short duration, frequently yield the heaviest short-term precipitation amounts. During the remainder of the year, the heaviest amounts of rain and snow are produced by storms moving up the Atlantic coast of the eastern United States. Precipitation of 0.01 inch or more occurs approximately 117 days annually (NOAA 1990).

On the average, relative humidity values are lowest during the winter and spring months in the early afternoon. Relative humidity values are at a maximum during the summer and fall months in the early morning hours. On occasions, the humidity is uncomfortably high for periods up to several days during the warmer months. Table 2.3-3 (NOAA 1970, 1974, 1975, 1978, 1981; NOAA 1949-1980) gives the monthly, seasonal, and annual averages and extremes of relative humidity.

2.3.1.1.3 Prevailing Winds

The weather pattern in the region is controlled by the global band of prevailing westerly winds throughout most of the year. These winds act as the steering currents for synoptic scale weather systems which produce day-to-day weather changes.

During the winter months, the predominating northwesterly winds transport cold, dry air from the northern United States and Canada into the region. From April through September, warm and often humid southwesterly winds occur most frequently. Winds from the south through the west-southwest sectors occur nearly 42 percent of the time during the summer months, displaying the increased activity of a sea breeze during these months. Table 2.3-4 presents monthly, seasonal, and annual frequency distributions of wind direction at Bridgeport, while Table 2.3-5 (NOAA 1949-1980) shows directional persistence. Winds were assumed to persist if they remained in the same 22.5-degree sector for at least 5 consecutive hours.

The annual frequency of calm winds (less than 2 mph) is 2.9 percent. The highest frequency of calm and light winds (less than or equal to 3 mph) occurs during the summer season. Higher wind speeds commonly occur from November through April when weather systems of synoptic scale are strongest. Wind speeds greater than 25 mph occur 6.2 percent of the time during the months of December through February. Table 2.3-6 (NOAA 1949-1980) gives the frequency distributions of wind speed at Bridgeport.

2.3.1.1.4 Relationships of Synoptic to Local Conditions

The inland terrain in Connecticut is not pronounced enough to produce any significant local modifications of synoptic conditions at the shoreline. The shoreline areas do, however, experience local modifications of synoptic patterns because of the temperature differences between air over land and air over water. The most pronounced modification is the development of a diurnal sea breeze, commonly experienced in the months of April through October on sunny days. During the daytime on these days, solar heating of land causes relative low pressure over land near ground level and relative high pressure over water offshore. This results in the setup of a mesoscale wind circulation near the shoreline from water to land, with a return flow aloft. This sea breeze is sometimes strong enough to set up in the face of an offshore pressure gradient (i.e., northerly winds) but it most commonly occurs as a reinforcement of the typical summertime southwesterly wind flow associated with an offshore high pressure system.

2.3.1.2 Regional Meteorological Conditions for Design and Operating Bases

Seasonal and annual frequencies of severe weather phenomena are provided in this subsection.

2.3.1.2.1 Strong Winds

Strong winds, usually caused by intense low pressure systems, tropical cyclones, or passages of strong winter frontal zones, occasionally affect the region. For the period from 1961 through 1990, the fastest mile wind speed recorded at Bridgeport was 74 mph occurring with a south wind in September 1985. Table 2.3-7 lists extreme wind speeds on a monthly, seasonal, and annual basis (NOAA 1990).

Fastest-mile wind speeds of 50, 60, 70, 75, and 90 mph are expected to recur at the site in intervals of approximately 2, 10, 25, 50, and 100 years, respectively, according to a study by Thom (1968). Based on observations from Montauk Point (located about 23 miles southeast of Millstone Point on the eastern tip of Long Island), the maximum reported wind speed in the region was associated with the passage of a hurricane during which sustained winds of 115 mph, with short-term gusts up to 140 mph (Dunn and Miller 1960) were observed.

2.3.1.2.2 Thunderstorms and Lightning

Thunderstorms most commonly occur during the late spring and summer months, although they have been observed during all months of the year. Severe thunderstorms with strong winds, heavy rain, intense lightning, and hail have infrequently affected the region. Table 2.3-8 presents the monthly, seasonal, and annual frequency of thunderstorm days at Bridgeport (NOAA 1990).

A study of storm data indicates that intense lightning often accompanies strong thunderstorms in the region. Lightning strikes have injured or killed people and animals, caused numerous power failures, and have damaged or destroyed dwellings by setting them afire (NOAA 1959-1981).

The frequency of lightning strikes during a thunderstorm is dependent upon the storm's intensity and development. A nomograph of the number of lightning strikes per year (normalized for a region with 30 thunderstorm days per year) as a function of isolated object height, indicates about 2 strikes per year for a 450-foot object located on level terrain (Viemeister 1961).

The quantity of charge flowing out of a single stroke is typically 20 coulombs with a range from 10 to 50 coulombs (Tverskoi 1965). The current strength may reach 1.0 to 1.5×10^5 amperes; but for 80 percent of the measured cases, it does not exceed 2.0×10^4 amperes (Tverskoi 1965). A reasonable estimate of 2.0 to 2.5×10^4 amperes (Tverskoi 1965; Neuberger 1965) is common for a fully developed thunderstorm.

2.3.1.2.3 Hurricanes

Storms of tropical origin occasionally affect the region during the summer and fall months. According to a statistical study by Simpson and Lawrence (1971), the 50-mile segment of coastline on which Millstone is located, was crossed by five hurricanes during the 1886 through 1970 period.

2.3.1.2.4 Tornadoes and Waterspouts

From a study of tornado occurrences during the period of 1955 through 1967 (augmented by 1968-1981 storm data reports), the mean tornado frequency in the one-degree (latitude-longitude) square where the Millstone site is located is determined to be approximately 0.704 per year (NOAA 1959-1981; Pautz 1969). Applying Thom's method for determining the probability of a tornado striking a point on the Millstone site, it is conservatively estimated to be 0.00055 per year with a recurrence expected every 1,804 years (Thom 1963). Section 2.3.2.3.1 discusses the design basis tornado.

Waterspouts have been observed over the waters of Long Island Sound (NOAA 1959-1981). Six waterspouts were observed off shore of Connecticut from 1955 through 1967 (Pautz 1969).

2.3.1.2.5 Extremes of Precipitation

The normal annual precipitation at Bridgeport is 43.63 inches. Since 1894, annual totals have ranged from a minimum of 23.03 inches in 1964, to a maximum of 73.93 inches in 1972. Monthly precipitation totals have ranged from 0.07 inch in June 1949 to 18.77 inches in July 1897. Since 1949, the maximum measured 24-hour rainfall has been 6.89 inches occurring in June 1972 (NOAA 1971, 1990).

Table 2.3-9 lists normal precipitation amounts and extreme 24-hour and monthly rainfall values at Bridgeport (NOAA 1970, 1974, 1975, 1978, 1981 and January - June 1982; Weather Bureau 1960). Table 2.3-10 lists estimated extreme short term precipitation quantities (Hershfield 1961).

2.3.1.2.6 Extremes of Snowfall

Measurable snowfall has occurred in the months of November through April, although heavy snowfall occurrences are usually confined to the months of December through March. The mean annual snowfall at the present Bridgeport location is 25.3 inches, with totals since 1932 ranging from 8.2 inches in the 1972-1973 season, to 71.3 inches in the 1933-1934 season. The maximum monthly snowfall, occurring in February 1934, was 47.0 inches. Since 1949, both the maximum measured snowfall in 24 hours (16.7 inches), and the greatest snowfall in one storm (17.7 inches) occurred during the same storm in February 1969. The maximum measured snowfall in 24 hours (16.7 inches) was matched again in January 1978. Snowfalls of 1.0 inch or more occur approximately 7 days annually. Table 2.3-11 gives the monthly, seasonal, and annual snowfall statistics (NOAA 1971, 1990).

The 100-year recurrence maximum snow load is estimated to be 31 lb/sq ft (ANSI 1972). Assuming a snow-to-water ratio of 8.7 to 1 (calculated using data from 10 snowstorms of 0.10-inch precipitation or more during 1974 and 1975 (NOAA 1974-1975), the corresponding 100-year snow depth is estimated to be about 52 inches. The 48-hour probable maximum winter precipitation snow accumulation is about 48 inches (Riedel et al., 1956). When added to a snowpack of 52 inches, the total snow depth is about 100 inches. Snow load data available from a study conducted by the Housing and Home Finance Agency (1952) also suggests that the total weight of the 100-year recurrence maximum snow load when added to the maximum probable single storm accumulation would be about 60 lb/sq ft, or total depth of about 100 inches. (See Section 2.3.2.3.3 for design snow load information.)

2.3.1.2.7 Hailstorms

Large hail, which sometimes accompanies severe thunderstorms, occurs infrequently in the Millstone area. Based on a 1955 through 1967 study (Pautz 1969), hailstones with diameters greater than or equal to 0.75 inch occur at an average of 1.4 times per year in the 1-degree (latitude-longitude) square where the Millstone site is located. During the period of 1959 through 1981, the largest hailstones observed in the 1-degree square containing the site were qualitatively described as “baseball” size, and occurred in Groton, Connecticut (5 miles northeast of the site), on May 29, 1969 (NOAA 1959-1981). Most hail reported in the area is less than 0.5 inches in diameter.

2.3.1.2.8 Freezing Rain, Glaze, and Rime

Freezing rain and drizzle are occasionally observed during the months of December through March, and only rarely observed in November and April. An average of 18.5 hours of freezing rain and 8.5 hours of freezing drizzle occur annually in the region. In the 32-year period, 1949 through 1980, all cases of freezing precipitation were reported as light (less than 0.10 inch per hour), except for 1 hour of moderate (0.10 to 0.30 inch per hour). Table 2.3-12 presents average monthly, seasonal, and annual occurrences of freezing precipitation at Bridgeport (NOAA 1949-1980).

According to a study by Bennett (1959), based on 9 years of data, ice accumulations of greater than 0.25 inch due to freezing precipitation may be expected to occur about one time per year. Ice accumulations greater than 0.50 inch may be expected about once every two years. The maximum ice accumulation is estimated to be 1.68 inches based on Bridgeport observations (NOAA 1949 through 1981), and assuming a conservative average rainfall of 0.07 inch per hour.

2.3.1.2.9 Fog And Ice Fog

The average annual fog frequency (with visibility less than 7 miles) is 13.3 percent at Bridgeport, with the maximum monthly frequency of fog (16.4 percent) occurring in May (NOAA 1949-1980). The average annual ground fog frequency is 2.2 percent, with October having the maximum monthly frequency of 3.4 percent. Only 1 hour of heavy ice fog, a winter phenomenon, has been recorded during the period of 1949 through 1980.

Heavy fog (visibility of 0.25 mile or less) occurs an average of 1.5 percent of the time, on about 29 days annually (NOAA 1970, 1974, 1975, 1978, 1981), and predominantly during the months of December through June. The maximum number of consecutive hours of heavy fog observed during the period 1949 through 1964 was 26. Table 2.3-13 presents monthly, seasonal, and annual frequencies of various fog conditions based on 1949 through 1980 data at Bridgeport, Connecticut (NOAA 1949-1980).

2.3.1.2.10 High Air Pollution Potential

The Millstone site is in an area of relatively infrequent episodes of high air pollution potential. The continuous progression of large scale weather systems across North America frequently changes the air mass in the region and allows only infrequent extended periods of air stagnation. According to Holzworth (1972), high meteorological potential for air pollution occurs an average of about two times per year. A stationary high-pressure system over the eastern United States is generally the cause of these high air pollution potential days.

2.3.1.2.11 Meteorological Effects on Ultimate Heat Sink

A depression of water levels in Long Island Sound may result from an intense storm or hurricane moving up the Atlantic coast. The most conservatively calculated depression (NNECO 1974a) does not exceed the operable depth of safety related service water pumps in the intake structure (Section 2.4).

2.3.2 LOCAL METEOROLOGY

Local meteorology for the Millstone site is described by weather observations taken over a 32-year period (1949 through 1980) at Bridgeport and by data collected during a 8-year period (1974 through 1981) by an instrumented meteorological tower at Millstone. The Bridgeport weather facility at Sikorsky Airport is located southeast of Bridgeport (an urban industrial area) and about 1 mile from Long Island Sound. The Millstone meteorological tower is located on a point of land right at the shore and is surrounded by water on three sides. The water temperatures in the eastern end of Long Island Sound (Millstone area) tend to be somewhat cooler than water temperatures in the western end (Bridgeport) because of water exchange with the Atlantic Ocean. This is particularly true in the summer. In spite of these differences in location, the meteorological conditions are similar. Millstone data for a 8-year period (1974 through 1981) were compared where possible to Bridgeport data for the same period. The comparisons indicated that meteorological conditions at the two locations were similar and thus that the 32-year Bridgeport data base can be used to reasonably represent long-term meteorology at Millstone.

2.3.2.1 Normal and Extreme Values of Meteorological Parameters

2.3.2.1.1 Wind Conditions

Table 2.3-14 shows monthly and annual summaries of wind speed and direction at Bridgeport for 1949 through 1980. Table 2.3-15 shows monthly and annual summaries of wind speed and direction at Millstone for 1974 through 1981, taken from the 10-meter level on the meteorological tower.

Table 2.3-16 compares the frequency of wind directions by quadrant at Millstone and Bridgeport for the comparison period (1974 through 1980, and 1974 through 1981) and relates both to the short-term (8-year) and long-term Bridgeport data base. There is good statistical agreement between the sites. Table 2.3-17 compares the frequency of wind speeds by quadrant in a similar manner. Wind speeds at Bridgeport are somewhat higher; this may be due to the greater elevation of the wind sensor at Bridgeport for a part of the comparison period and most of the long-term period. Nonetheless, there is reasonable agreement between the sites. Table 2.3-18 shows the directional persistence by compass sector of 10-meter winds at Millstone from 1974 through 1981. Table 2.3-5 shows the directional persistence by compass sector of winds at Bridgeport from 1949 through 1965.

2.3.2.1.2 Air Temperature and Water Vapor

Tables 2.3-1 and 2.3-3 give the normal and extreme values of air temperature and humidity for 32 years of Bridgeport data. Table 2.3-19 presents normal and extreme values of air temperature, dewpoint temperature, absolute humidity, and relative humidity for 19 years of Millstone data at the 10-meter level. Tables 2.3-20 and 2.3-21 compare Bridgeport and Millstone data for the same data period. Temperatures at Millstone are slightly cooler than at Bridgeport, probably reflecting cooler water temperatures around Millstone, the presence of an urban heat island affecting Bridgeport, and closer proximity of the Millstone instrumentation to the shoreline. Dewpoint temperatures are about the same at both sites. Relative humidity values are slightly higher at Millstone than at Bridgeport, reflecting the cooler temperatures at Millstone.

2.3.2.1.3 Precipitation

Tables 2.3-9 through 2.3-12 give the normal and extreme values of precipitation based on long term Bridgeport data. No precipitation data are collected at Millstone.

2.3.2.1.4 Fog and Smog

Table 2.3-13 provides a summary of fog conditions based on long term Bridgeport data. Most of the heavy fog in the Millstone area is an advection type caused by the passage of warm moist air over relatively cold water. Since Millstone has greater exposure to the cooler waters of eastern Long Island Sound and the Atlantic Ocean, the frequency of heavy fog there is expected to be somewhat greater than the frequency at Bridgeport. This expectation is borne out in Table 2.3-22, which compares heavy fog occurrence at Bridgeport to that at Block Island (NOAA 1970, 1974, 1975, 1978, 1981). Block Island has greater exposure to cool waters in all directions and experiences a higher frequency of heavy fog than Bridgeport. The frequency of occurrence of heavy fog at Millstone is probably greater than that at Bridgeport but less than that at Block Island. The Millstone meteorological tower at one time had a visibility monitor, and joint frequency summaries of visibility, wind direction, and atmospheric stability are provided for Millstone data in Table 2.3-23. The visibility monitor reflects the occurrence of haze, rain, and snow as well as fog and consequently may not be directly compared to either Bridgeport or Block Island fog occurrence data, which are derived from actual visual observations of fog.

Table 2.3-24 provides monthly frequencies of the duration of poor visibility conditions (less than 1 mile) as measured by the Millstone visibility monitor for a 8-year period. Similar information for Bridgeport is not available.

2.3.2.1.5 Atmospheric Stability

Table 2.3-25 shows the percentage distribution of stability data within the seven classes specified by Regulatory Guide 1.23 (Table 1.8-1) for the period 1949 through 1980 at Bridgeport. The method used to assign a datum to a particular stability class is based on a parameterization of incoming solar radiation and wind speed and is known as the STAR method. This method yields a low percentage of cases in the A stability class (Pasquill classification method) at Bridgeport because a solar angle of at least 60 degrees is required concurrent with relatively clear skies; this requirement is fulfilled only on sunny June and July days for a few hours around solar noon. Also, E, F, and G stabilities are constrained to occur only during nighttime hours by this program, and the Bridgeport data are thus unable to reflect daytime occurrences of stable conditions such as those associated with the shallow inversions of a sea breeze.

Table 2.3-26 shows the percentage distribution of stability data within seven classes for the 1974 through 1981 period at Millstone, based on vertical temperature difference measurement at three levels on the meteorological tower. Table 2.3-27 shows the same information, based on wind direction variance measurements at the four wind instrument levels on the tower.

Table 2.3-28 compares the stability class distribution at Bridgeport for the period 1974 through 1980 to that at Millstone for the period 1974 through 1981. The distributions are not particularly comparable because of the differences in methodology.

Table 2.3-29 shows cumulative frequency distributions of the duration of inversion conditions (E, F, and G stability class) by month for the 1974 through 1981 data at Millstone, based on vertical temperature difference measurements at three levels on the meteorological tower.

2.3.2.1.6 Seasonal and Annual Mixing Heights

Seasonal and annual mixing height data for Millstone are adapted from Holzworth (1972) and shown in Table 2.3-30. No direct measurements of mixing height are made.

2.3.2.2 Potential Influence of the Plant and Its Facilities on Local Meteorology

Millstone 3 uses a once-through cooling water system, discharging its cooling water into an existing quarry, into which Millstone Units 1 and 2 also discharge, and then into Long Island Sound. Thin wisps of steam fog occasionally form over the quarry and less frequently over the discharge plume during the winter months, depending on tidal conditions and temperature differences between air and water. This fog dissipates rapidly as it moves away from the water area. The areal extent of the steam fog is negligible.

2.3.2.3 Local Meteorological Conditions for Design and Operating Bases

2.3.2.3.1 Design Basis Tornado

The design basis tornado for Millstone 3 (used for missile damage estimates) was developed from Regulatory Guide 1.76 (Table 1.8-1). The specifications are as follows:

Maximum wind speed	360 mph
Rotational speed	290 mph
Maximum translational speed	70 mph
Pressure drop	3.0 psi
Rate of pressure drop	2.0 psi/sec

Based on descriptions of Connecticut tornadoes (NOAA 1959-1981; Pautz 1969), a tornado more severe than this has never been recorded in Connecticut.

2.3.2.3.2 Design Basis Hurricane

The design basis hurricane for Millstone (used for flooding and setdown estimates) was developed in the Millstone 3 PSAR (NNECO 1974b). The specifications are:

Central pressure index	27.26 inches
Peripheral pressure	30.56 inches
Radius to maximum winds	55 miles
Angle of maximum wind from direction of travel	115 degrees
Maximum gradient wind	124 mph
Speed of translation	17 mph

This design hurricane is considerably more intense than the worst on record (Hurricane of 1938).

2.3.2.3.3 Snow Load

The design total snow load (Section 2.3.1.2.6) for Millstone (used for Category I building design) is 60 lb/sq ft (depth of 100 inches). This is assumed to consist of a preexisting snowpack of depth 48 inches and a 2-day winter snowstorm delivering another 52 inches. Conditions like this have not been recorded on the Connecticut shoreline. The roofs of safety-related structures are designed for a snow load of 60 lb/sq ft. The roofs of nonsafety-related structures (convention) are designed for a snow load of 40 lb/sq ft which exceeds the ANSI requirement of 30 lb/sq ft.

2.3.2.3.4 Rainfall

The design maximum rainfall rate for Millstone (used in the original site flooding estimate) was 9.4 inches in 1 hour. Roof drainage was originally designed for a rainfall rate of 6.5 inches per hour. Site flooding and roof drainage have since been assessed for a rainfall rate of 17.4 inches in 1 hour. The maximum 24 hour rainfall recorded at Bridgeport was 6.89 inches in June 1972.

2.3.2.3.5 Adverse Diffusion Conditions

The occurrence of adverse diffusion conditions (low winds, high stabilities, sea breeze fumigation, long periods of directional persistence of winds, or long periods of persistence of high stabilities) used for diffusion estimates at Millstone, are considered in the methodology of the diffusion estimates that appear in Sections 2.3.4 and 2.3.5.

2.3.2.4 Topography

The topography around Millstone is marked by low rolling hills rising inland from the shoreline. The maximum height of the surrounding terrain within 5 miles of the site is about 250 feet above mean sea level (msl) at 3.2 miles to the north-northwest. To the south of the site, from east through west, is open water. Figure 2.3-1 shows the general topography of the Millstone area. Figures 2.3-2 and 2.3-3 show vertical profiles of maximum elevations versus distance from the plant for each of 16 compass sectors to 5 miles. Figures 2.3-4 through 2.3-5 are the vertical profiles to 50 miles.

2.3.3 ON-SITE METEOROLOGICAL MEASUREMENTS PROGRAM

The meteorological monitoring program at the Millstone site began in August 1965 to collect preoperational wind and temperature data for Millstone 1. The program initially consisted of collecting analog data from a 140-foot instrumented tower and manually digitizing these data into hourly values which served as the basis for appropriate joint frequency distributions and atmospheric diffusion analyses for both Millstone 1 and 2. After the publication of Regulatory Guide 1.23 (as Safety Guide 23 in 1972), the on-site meteorological program was found to be deficient with respect to the requirements of this guide regarding both data recovery rates and instrumentation specifications. In late 1973, a new meteorological tower which met the requirements of Regulatory Guide 1.23 was erected and instrumented. Eight full calendar years of data (1974, 1981) from this new tower are used in the climatological summaries presented in this section. The following sections refer only to the new tower and the on-site program after late 1973.

In 1992 a backup meteorological mast was installed near the EOF. The backup mast provides a secondary source of on-site meteorological data in the event data from the primary tower is not available. This mast consists of wind speed and direction instrumentation at the 33 foot level above grade. Atmospheric stability can be estimated using the variance of the wind direction. The backup mast 33 foot wind data can be extrapolated upward to provide estimates of wind at heights which correspond to the primary tower wind measurement elevations.

2.3.3.1 Measurement Locations and Elevations

All primary measurements are made at the meteorological tower. The tower is located on a point of land about 1,200 feet south-southeast of the Millstone 1 turbine building, which is the nearest large structure. The top of this building is at elevation 105 feet, msl. The base of the tower is at approximate elevation 15 feet msl; plant grade for Millstone 1 and 2 is 14 feet msl, and for Millstone 3 is 24 feet msl. The top of the tower is at 465 feet msl; the top of the Millstone stack is 389 feet msl. Figure 1.2-1 shows the tower location with respect to plant layout. The tower measures meteorological parameters at five levels. All measurements are taken on the tower except solar radiation which is taken to the south of the tower in a shadow-free area. Table 2.3-31 lists the measurements and their elevations. All measurements are continuous.

Backup meteorological measurements are made at the backup meteorological mast. The base of the backup mast is at 73 feet (MSL).

2.3.3.2 Meteorological Instrumentation

The instruments used on the tower and mast were selected for conformance with the recommendations of Regulatory Guide 1.23 and are listed in Table 2.3-32. All temperature sensors are mounted in aspirated radiation shields.

All instruments are calibrated quarterly by a trained instrument technician. Wind speed and direction sensors are removed from the tower and mast at least semiannually and replaced with newly calibrated sensors. The removed wind speed sensors are sent to an instrument vendor for replacement of worn components, recalibration to initial specifications, and certification. The removed wind direction sensors are reconditioned by an instrument technician by replacement of worn components, recalibration to initial specifications, and certification. Temperature sensors and temperature difference sensors are calibrated quarterly on the tower by immersion of both in ice baths; the resultant output is compared to 0°C.

Routine inspection visits to the tower and mast are conducted by instrument technicians who execute a checklist designed to identify any instrument problems. Additionally, emergency visits are made when a company meteorologist or other qualified person identifies an instrument problem through daily inspection of telemetered data. These procedures ensure prompt repair of any malfunctioning instrument and a high rate of data recovery.

2.3.3.3 Data Recording Systems and Data Processing

Tower and mast data is digitized and processed by data loggers. One data logger is located within the instrument shelter at the base of the tower and receives tower and solar radiation data and one data logger is located within the instrument shelter adjacent to the Site Training Facility and receives mast data. These data loggers provide digital data to the Unit 2 and Unit 3 plant process computers and to each of two Environmental Data Acquisition Network (EDAN) field minicomputers, through separate transmission paths. Tower and mast data is available for display at each of these four, redundant digital recording systems.

An EDAN host computer collects and saves data from all EDAN field minicomputers. Once loaded on the host computer, the data are available for inspection, editing, and analysis. Data is saved on a mirrored disk system on the host computer. Periodic database backups are performed to protect against data loss. Additionally, recent data is available on each field computer for restoration to the host, if necessary.

The EDAN field minicomputers are checked for correct operation during scheduled inspections by technicians. Emergency visits are made if inspection of telemetered data indicates the field minicomputer is malfunctioning. Correct operation of the host computer is checked every work day by a computer operator. Transfer of the data between the field and host computers is monitored by both a computer operator and by an automated process for detecting the failure of field computers to report to the host computer. Both field and host minicomputers undergo rigorous preventive maintenance programs. Troubleshooting is accomplished by on-call computer technicians. These procedures assure prompt repair of any malfunctioning component.

2.3.3.4 Quality Assurance for Meteorological System and Data

Figure 2.3-7 is a simplified diagram of the procedures developed to ensure that the entire path from sensor to the final data used for analyses is as free from errors as possible, that the data are of assured quality, that questionable or bad data are corrected or deleted, and that an adequate rate of data recovery is achieved. Table 2.3-33 shows the monthly and annual recovery rates for 8 years (1974, 1981) of Millstone meteorological data. Records are kept of the data in the form received (raw data) and in the final form (edited data). Records are also kept for the editing operations performed and the basis for these operations, such as calibration adjustments and the deletion of data during periods of instrument malfunction.

2.3.3.5 Data Analysis

The digital data recording system produces 15-minute average data that are directly suitable for input into site climatology or atmospheric diffusion models.

Monthly and annual joint frequency distributions of wind speed, wind direction, and atmospheric stability for each level on the meteorological tower are contained in Tables 2.3-15 and 2.3-18. These analyses are based on Millstone data collected during 1974 through 1981. Section 2.3.2 compares these analyses with the long- term Bridgeport data (1949 through 1980). The data used to prepare these analyses are available in printed form or on magnetic tape and upon request may be obtained from the Environmental Programs Department.

2.3.4 SHORT-TERM (ACCIDENT) DIFFUSION ESTIMATES

2.3.4.1 Objective

Accidents at Millstone 3 are assumed to result in airborne radioactive releases from various release points. For various time periods after an accident, atmospheric diffusion factors (X/Q) were calculated for emissions from Millstone 3 at the exclusion area boundary (EAB) and low population zone (LPZ) for each downwind sector.

The distances from each release point to the EAB in each sector are given in Table 2.3-34. The LPZ is taken to be 3860 meters in all sectors from any release point.

2.3.4.2 Calculation

Accident X/Q's were calculated using the basic methods of Regulatory Guide 1.145. For elevated releases, the X/Q's for the first four hours are calculated using a seabreeze fumigation model adapted from Regulatory Guide 1.3. X/Q values for the control room were calculated using approved methods such as Regulatory Guide 1.194.

2.3.4.3 Results

The calculated X/Q's used in DBA radiological consequence calculations are presented with the list of assumptions used in each calculation.

2.3.5 LONG TERM (ROUTINE) DIFFUSION ESTIMATES

2.3.5.1 Calculation Objective

Low levels of radioactivity are routinely released from the Millstone stack and the MP3 vent. Atmospheric Diffusion Factors (X/Q) based on site meteorological data are calculated for various downwind receptor locations of interest. The meteorological data is used to calculate the dose consequences to the public from routine airborne effluents. The calculated doses are submitted annually to the NRC.

2.3.5.2 Calculations

2.3.5.2.1 Release Points and Receptor Locations

Routine releases occur from both the MP3 vent and the Millstone stack. Releases from the Millstone stack are considered elevated. The distances from each release point to the nearest land and nearest residence in each downwind sector are listed in Table 2.3-34 and used in X/Q calculation.

2.3.5.2.2 Database

Calculations are performed on a quarterly basis using the actual meteorology for that period.

2.3.5.2.3 Models

All X/Q and D/G values are calculated from hourly in-site meteorological data via methods adapted from Regulatory Guide 1.111 using a conventional Gaussian plume model.

2.3.6 REFERENCES FOR SECTION 2.3

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TABLE 2.3–1 MONTHLY, SEASONAL, AND ANNUAL AVERAGES AND EXTREMES OF TEMPERATURE AT BRIDGEPORT, CONN. (1901-1981)

CLICK HERE TO SEE TABLE 2.3-1

TABLE 2.3–2 MEAN NUMBER OF DAYS WITH SELECTED TEMPERATURE CONDITIONS AT BRIDGEPORT, CONN. (1966-1981)

CLICK HERE TO SEE TABLE 2.3-2

TABLE 2.3–3 MONTHLY, SEASONAL, AND ANNUAL AVERAGES AND EXTREMES OF RELATIVE HUMIDITY AT BRIDGEPORT, CONN. (1949-1981)

CLICK HERE TO SEE TABLE 2.3-3

TABLE 2.3–4 MONTHLY, SEASONAL, AND ANNUAL FREQUENCY DISTRIBUTIONS OF WIND DIRECTION AT BRIDGEPORT, CONN. (1949-1980)

CLICK HERE TO SEE TABLE 2.3-4

TABLE 2.3–5 OCCURRENCE OF BRIDGEPORT WIND PERSISTENCE EPISODES WITHIN THE SAME 22.5-DEGREE SECTOR (1949-1965)

CLICK HERE TO SEE TABLE 2.3-5

TABLE 2.3–6 MONTHLY, SEASONAL, AND ANNUAL FREQUENCY DISTRIBUTIONS OF WIND DIRECTION AT BRIDGEPORT, CONN. (1949-1980)

CLICK HERE TO SEE TABLE 2.3-6

TABLE 2.3–7 MONTHLY, SEASONAL, AND ANNUAL WIND SPEED EXTREMES AT BRIDGEPORT, CONN. (1961-1990)

CLICK HERE TO SEE TABLE 2.3-7

TABLE 2.3–8 MEAN NUMBER OF DAYS OF THUNDERSTORM OCCURRENCE AT BRIDGEPORT, CONN. (1951-1981)

CLICK HERE TO SEE TABLE 2.3-8

TABLE 2.3–9 MONTHLY, SEASONAL, AND ANNUAL AVERAGES AND EXTREMES OF PRECIPITATION AT BRIDGEPORT, CONN. (1901-JUNE 1982)

CLICK HERE TO SEE TABLE 2.3-9

TABLE 2.3–10 ESTIMATED PRECIPITATION EXTREMES FOR PERIODS UP TO 24 HOURS AND RECURRENCE INTERVALS UP TO 100 YEARS

CLICK HERE TO SEE TABLE 2.3-10

TABLE 2.3–11 MONTHLY, SEASONAL, AND ANNUAL AVERAGES AND EXTREMES OF SNOWFALL AT BRIDGEPORT, CONN. (1893-JUNE 1990)

CLICK HERE TO SEE TABLE 2.3-11

TABLE 2.3–12 MONTHLY, SEASONAL, AND ANNUAL AVERAGES OF FREEZING RAIN AND DRIZZLE AT BRIDGEPORT, CONN. (1949-1980)

CLICK HERE TO SEE TABLE 2.3-12

TABLE 2.3–13 AVERAGE MONTHLY, SEASONAL, AND ANNUAL HOURS AND FREQUENCIES (PERCENT) OF VARIOUS FOG CONDITIONS (1949-1980) AT BRIDGEPORT, CONNECTICUT

CLICK HERE TO SEE TABLE 2.3-13

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980)

CLICK HERE TO SEE TABLE 2.3-14

TABLE 2.3–15 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR 33-FOOT WINDS AT MILLSTONE (1974-1981)

CLICK HERE TO SEE TABLE 2.3-15

TABLE 2.3–16 COMPARISON OF WIND DIRECTION FREQUENCY DISTRIBUTION BY QUADRANT AT BRIDGEPORT, CONN. AND MILLSTONE

CLICK HERE TO SEE TABLE 2.3-16

TABLE 2.3–17 COMPARISON OF AVERAGE WIND SPEED BY QUADRANT AT BRIDGEPORT, CONN. AND MILLSTONE

CLICK HERE TO SEE TABLE 2.3-17

TABLE 2.3–18 OCCURRENCE OF WIND PERSISTENCE EPISODES WITHIN THE SAME 22.5-DEGREE SECTOR AT MILLSTONE (1974-1981)

CLICK HERE TO SEE TABLE 2.3-18

TABLE 2.3–19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

A. Monthly and Annual Ambient Temperature

Month	Average Daily Mean		Average Daily Maximum		Average Daily Minimum		Extreme Maximum		Extreme Minimum	
	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)
January	-1.0	(30.3)	2.4	(36.4)	-4.5	(23.8)	14.7	(58.5)	-19.4	(-2.9)
February	-0.3	(31.5)	3.0	(37.3)	-3.6	(25.5)	16.9	(62.4)	-19.3	(-2.7)
March	3.1	(37.5)	6.4	(43.5)	-0.1	(31.8)	23.3	(73.9)	-14.0	(6.8)
April	7.7	(45.8)	11.0	(51.8)	4.7	(40.4)	27.3	(81.1)	-5.6	(21.9)
May	12.4	(54.3)	15.8	(60.5)	9.5	(49.0)	29.7	(85.5)	1.0	(33.8)
June	17.1	(62.8)	20.3	(68.6)	14.2	(57.5)	31.8	(89.2)	6.6	(43.9)
July	20.5	(69.0)	23.4	(74.1)	18.0	(64.3)	32.8	(91.0)	10.5	(50.9)
August	20.7	(69.3)	23.4	(74.1)	17.9	(64.3)	32.2	(90.0)	8.9	(48.0)
September	17.7	(63.8)	20.5	(68.9)	14.1	(57.4)	29.6	(85.3)	3.4	(38.1)
October	12.4	(54.3)	15.6	(60.0)	8.5	(47.2)	26.3	(79.3)	-1.8	(28.8)
November	7.5	(45.6)	10.7	(51.2)	4.1	(39.3)	22.7	(72.9	-9.1	(15.6)
December	2.0	(35.6)	5.3	(41.5)	-1.5	(29.4)	20.1	(68.1)	-20.6	(-5.1)
1/1/74 - 12/31/00	10.0	(50.0)	13.1	(55.7)	6.8	(44.2)	32.8	(91.0)	-20.6	(-5.1)

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TABLE 2.3-19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

B. Monthly and Annual Dew Point

	Average Daily Mean		Average Daily Maximum		Average Daily Minimum		Extreme Maximum		Extreme Minimum	
Month	**°C**	**(°F)**	**°C**	**(°F)**	**°C**	**(°F)**	**°C**	**(°F)**	**°C**	**(°F)**
January	-5.8	(21.5)	-1.7	(28.9)	-9.8	(14.4)	12.6	(54.7)	-29.0	(-20.2)
February	-5.5	(22.0)	-1.8	(28.8)	-9.2	(15.5)	10.1	(50.2)	-24.1	(-11.4)
March	-3.0	(26.7)	0.8	(33.4)	-6.5	(20.3)	13.0	(55.4)	-24.6	(-12.3)
April	1.2	(34.1)	4.4	(40.0)	-2.1	(28.2)	14.5	(58.1)	-17.0	(1.4)
May	6.6	(43.8)	9.5	(49.1)	3.8	(38.8)	19.3	(66.7)	-10.4	(13.4)
June	11.7	(53.1)	14.4	(57.9)	9.2	(48.5)	22.2	(72.0)	-3.3	(26.1)
July	15.1	(59.1)	17.5	(63.5)	12.8	(55.0)	24.7	(76.5)	2.4	(36.3)
August	15.5	(60.0)	17.9	(64.3)	13.1	(55.6)	24.3	(75.7)	0.3	(32.5)
September	12.0	(53.7)	14.9	(58.9)	9.3	(48.7)	24.4	(75.9)	-3.3.	(26.1)
October	6.1	(43.0)	9.5	(49.1)	2.9	(37.2)	20.4	(68.7)	-11.9	(10.6)
November	1.5	(34.7)	5.0	(41.0)	-2.0	(28.3)	16.6	(61.9)	-16.9	(1.6)
December	-3.5	(25.7)	0.5	(32.9)	-7.2	(19.0)	13.6	(56.5)	-29.3	(-20.7)
1/1/74 - 12/31/00	4.3	(39.8)	7.6	(45.6)	1.2	(34.1)	24.7	(76.5)	-29.3	(-20.7)

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TABLE 2.3-19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

C. Monthly and Annual Absolute Humidity

Month	Average Daily Mean		Average Daily Maximum		Average Daily Minimum		Extreme Maximum		Extreme Minimum	
	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)
January	3.3		4.3		2.4		11.1		0.5	
February	3.3		4.3		2.5		9.5		0.8	
March	4.0		5.1		3.1		11.3		0.7	
April	5.3		6.6		4.2		12.4		1.4	
May	7.6		9.1		6.3		16.6		2.3	
June	10.5		12.4		9.0		19.6		3.8	
July	12.9		15.0		11.2		22.7		5.7	
August	13.3		15.3		11.5		22.1		4.9	
September	10.7		12.8		9.0		22.3		3.8	
October	7.3		9.1		5.9		17.7		2.0	
November	5.4		6.9		4.2		14.1		1.4	
December	3.8		5.1		3.0		11.8		0.5	
1/1/74 - 12/31/00	7.3		8.8		6.0		22.7		0.5	

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TABLE 2.3-19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

D. Monthly and Annual Relative Humidity

	Average Daily Mean		Average Daily Maximum		Average Daily Minimum		Extreme Maximum		Extreme Minimum	
Month	**°C**	**(°F)**	**°C**	**(°F)**	**°C**	**(°F)**	**°C**	**(°F)**	**°C**	**(°F)**
January	71.2		85.7		56.4		100.0		18.1	
February	68.9		84.4		53.3		100.0		16.0	
March	67.0		82.9		50.7		100.0		14.8	
April	66.2		82.4		49.3		100.0		14.1	
May	69.8		85.1		53.5		100.0		14.7	
June	72.4		87.1		57.1		100.0		18.3	
July	72.3		86.0		58.4		100.0		23.6	
August	73.6		86.7		60.1		100.0		22.9	
September	71.2		85.3		57.2		100.0		19.9	
October	67.4		82.7		52.6		100.0		17.9	
November	67.0		80.7		53.0		100.0		16.1	
December	68.6		82.6		54.7		100.0		22.8	
1/1/74 - 12/31/00	69.6		84.3		54.7		100.0		14.1	

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TABLE 2.3-19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

E. Episodes of Ambient Temperature Below 0.0°F:

Date(s)	Time(s)	Minimum (°F)	Duration (hrs)
January 23, 1976	0300-0915	-2.0	6.50
January 18, 1977	0630-0800	-0.2	1.75
February 11, 1979	0315-0915	-2.7	6.25
February 12, 1979	0245-0315	-0.2	0.75
February 12, 1979	0345-0815	-1.5	4.75
February 14, 1979	0330-0830	-2.7	5.25
February 17, 1979	0700	-0.0	0.25
February 18, 1979	0230-0815	-2.0	6.00
December 25, 1980	0700-1400	-5.1	7.25
December 25-26, 1980	1645-0300	-1.8	10.50
January 5, 1981	0230-0300	-0.2	0.75
January 12, 1981	0445-0515	-0.0	0.75
January 12, 1981	0630-0800	-0.6	1.75
January 12, 1982	0800	-0.0	0.25
January 17-18, 1982	2215-0915	-2.9	11.25
January 22, 1984	0645	-0.0	0.25
January 22, 1984	0730	-0.4	0.25
January 16, 1994	0630-0930	-1.5	3.25
January 19, 1994	0545-0815	-0.6	2.75

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TABLE 2.3-19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

E. Episodes of Ambient Temperature Below 0.0°F:

Date(s)	Time(s)	Minimum (°F)	Duration (hrs)
January 27, 1994	0345-0515	-0.2	1.75
January 16, 1994	0545-0730	-0.6	2.00

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TABLE 2.3-19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

F. Episodes of Ambient Temperature Above 86.0°F:

Date(s)	Time(s)	Maximum (°F)	Duration (hrs)
July 18, 1977	1515-1800	87.6	3.00
July 7, 1981	1645-1830	88.7	2.00
June 24, 1983	1630-1700	86.9	0.75
July 16, 1983	1500-1615	88.7	1.50
July 16, 1983	1900	86.7	0.25
July 16, 1983	1945	86.5	0.25
August 20, 1983	1645-1845	89.4	2.25
July 12, 1984	1215-1515	91.0	3.25
July 24, 1984	1600-1830	88.2	2.75
August 8, 1984	1030-1230	90.0	2.25
August 17, 1984	1130-1730	88.3	6.25
August 31, 1984	1430-1730	89.6	3.25
August 18, 1987	1045-1245	87.6	2.25
July 23, 1989	1445	86.2	0.25
July 5, 1990	1245-1530	88.2	3.00
June 29, 1991	1145-1330	88.2	2.00
July 21, 1991	1800-1815	88.3	0.50
July 10, 1993	1615-1630	88.2	0.50
July 10, 1993	1715-1745	86.7	0.75

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TABLE 2.3-19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

F. Episodes of Ambient Temperature Above 86.0°F:

Date(s)	Time(s)	Maximum (°F)	Duration (hrs)
June 19, 1994	1445-1715	89.2	2.75
July 15, 1995	1815-2030	88.5	2.50
July 30, 1995	1600-1745	87.3	2.00
July 22, 1998	1500	86.7	0.25

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TABLE 2.3–20 COMPARISON OF MONTHLY AND ANNUAL AVERAGE DRY-BULB AND DEWPOINT TEMPERATURE AVERAGES AT BRIDGEPORT, CONN. AND MILLSTONE

CLICK HERE TO SEE TABLE 2.3-20

TABLE 2.3–21 COMPARISON OF MONTHLY AND ANNUAL AVERAGE RELATIVE HUMIDITY AVERAGES AT BRIDGEPORT AND MILLSTONE

CLICK HERE TO SEE TABLE 2.3-21

TABLE 2.3–22 MEAN NUMBER OF DAYS WITH HEAVY FOG AT BRIDGEPORT, CONN. AND BLOCK ISLAND, RHODE ISLAND (1951-1981)

CLICK HERE TO SEE TABLE 2.3-22

TABLE 2.3–23 WIND DIRECTION/STABILITY CLASS/VISIBILITY JOINT FREQUENCY DISTRIBUTION AT MILLSTONE

CLICK HERE TO SEE TABLE 2.3-23

TABLE 2.3–24 PERSISTENCE OF POOR VISIBILITY (≤ 1 MILE) CONDITIONS AT MILLSTONE (HOURS) (1974-1981)

CLICK HERE TO SEE TABLE 2.3-24

TABLE 2.3–25 BRIDGEPORT PASQUILL STABILITY CLASS DISTRIBUTION (1949-1980)

CLICK HERE TO SEE TABLE 2.3-25

TABLE 2.3–26 MILLSTONE STABILITY CLASS DISTRIBUTION USING DELTA-T FOR STABILITY DETERMINATION

CLICK HERE TO SEE TABLE 2.3-26

TABLE 2.3–27 MILLSTONE STABILITY CLASS DISTRIBUTION USING SIGMA THETA FOR STABILITY DETERMINATION

CLICK HERE TO SEE TABLE 2.3-27

TABLE 2.3–28 COMPARISON OF PASQUILL STABILITY CLASS DISTRIBUTION AT BRIDGEPORT, CONN. AND MILLSTONE

CLICK HERE TO SEE TABLE 2.3-28

TABLE 2.3–29 PERSISTENCE OF STABLE CONDITIONS (E, F, AND G STABILITIES) AT MILLSTONE (1974-1981)

CLICK HERE TO SEE TABLE 2.3-29

TABLE 2.3–30 SEASONAL AND ANNUAL ATMOSPHERIC MIXING DEPTHS AT MILLSTONE

CLICK HERE TO SEE TABLE 2.3-30

TABLE 2.3–31 ON-SITE METEOROLOGICAL TOWER MEASUREMENTS

PRIMARY METEOROLOGICAL TOWER

Elevation (above base) *		
(ft)	**(m)**	**Measurements**
447	136.3	Wind Speed and Variance Wind Direction and Variance Air Temperature Temperature Difference to 10 m Level
374	114.0	Wind Speed and Variance Wind Direction and Variance Temperature Difference to 10 m Level
142	43.3	Wind Speed and Variance Wind Direction and Variance Temperature Difference to 10 m Level
64	19.5	Air Temperature
33	10.0	Wind Speed and Variance Wind Direction and Variance Air Temperature Humidity
5	1.5	Solar Radiation **

BACKUP METEOROLOGICAL MAST

Elevation (above base) ***		
(ft)	**(m)**	Measurements
33	10.0	Wind Speed and Variance Wind Direction and Variance

* Base of tower at 15 ft msl
** Mounted on a platform to south of tower
*** Base of mast at 73 ft msl

TABLE 2.3–32 MILLSTONE METEOROLOGICAL TOWER INSTRUMENTATION

Parameter	Sensor	Model
Wind Speed	Climatronics	F460
Wind Direction	Climatronics	F460
Temperature	Climatronics	100093
Temperature Difference	Climatronics	100093
Humidity	Climatronics	100098
Solar Radiation	Eppley	848

TABLE 2.3–33 MONTHLY SUMMARY OF DATA RECOVERY RATES/ METEOROLOGICAL SYSTEM

CLICK HERE TO SEE TABLE 2.3-33

TABLE 2.3–34 DISTANCES FROM RELEASE POINTS TO RECEPTORS

DOWNWIND SECTOR	UNIT 3 CONTAINMENT TO EAB	MILLSTONE STACK TO EAB	UNIT 3 VENT TO NEAREST LAND	UNIT 3 VENT TO NEAREST RESIDENCE	MILLSTONE STACK TO LAND	MILLSTONE STACK TO NEAREST RESIDENCE
SSW	524 (2)	496 (2)	14,500	14,500	14,500	14,500
SW	524 (2)	496 (2)	3380	3380	3660	3820
WSW	524 (2)	496 (2)	3050	3050	3270	3290
W	524 (2)	496 (2)	2700	2700	3050	3070
WNW	524 (2)	649	2310	2310	2700	2760
NW	524 (2)	710	680	680	947	997
NNW	532	1029	690	690	1029	1029
N	782	1677	920	920	1695	1695
NNE	826	813	1550	1550	813	813
NE	548	496 (1)	840	840	496	736
ENE	524 (1)	496 (2)	600	810	1101	1560
E	524 (2)	496 (2)	1300	1300	1410	1480
ESE	524 (2)	496 (2)	1690	1690	1640	1760
SE	524 (2)	496 (2)	31,700	31,700	31,700	31,700
SSE	524 (2)	496 (2)	12,390	12,390	12,390	12,390
S	524 (2)	496 (2)	13,100	13,100	13,100	13,100

(1) Shortest Exclusion Area Boundary Distance in any Landward Sector

(2) Water Sector, SO(1) is used when greater than shoreline distance

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2.4 HYDROLOGIC ENGINEERING

The information given here is sufficient for making an independent hydrological engineering review of hydrologically related design bases, performance requirements, and bases for operation of structures, systems, and components important to safety. It considers the hydrological phenomena and conditions associated with the site. It also gives the flooding protection requirements and the emergency operation requirements.

2.4.1 HYDROLOGIC DESCRIPTION

This section describes the site and all safety related elevations, structures, exterior accesses, equipment, and systems from the standpoint of hydrologic considerations.

2.4.1.1 Site and Facilities

Millstone Point is located on the north shore of Long Island Sound. To the west of the site is Niantic Bay and to the east is Jordon Cove. Figure 2.4-1 shows the topography of the site, and Figure 2.3-1 shows the general topography of the Millstone area. As discussed in Section 2.4.5, the large radius, slow forward speed of translation, probable maximum hurricane (RL/ST PMH) was used to calculate the maximum still water level, or surge, and the design basis flood level (maximum combination of storm surge and wave runup). All safety related unit structures and equipment, except the circulating and service water pump house, are protected from flooding due to storm surge by the site grade of elevation +24 feet msl. Flood protection of the pump house and other safety related structures and facilities from hydrologically or hydrometeorologically induced flooding is discussed in Section 3.4.1.

2.4.1.2 Hydrosphere

The public water supplies within a 20 mile radius of the site are identified on Figure 2.4-2. The surface and groundwater supplies within a 20 mile radius are identified and their characteristics are listed in Table 2.4-1. This information was furnished by the Water Supplies Section, Bureau of Health Promotion and Disease Prevention of the Connecticut State Health Department. The nearest surface water supply is the New London Water Company's Lake Konomac, 6 miles north-northwest of the site. No surface drainage from the site could affect these reservoirs due to the distance involved, the topography, the expected groundwater gradient between the reservoir areas and the site, and the generally impervious nature of the overburden on and near the site.

The bedrock surface outcrops at the south end of Millstone Point and is generally covered with a layer of dense glacial till towards the north end. Groundwater flows across the site through the pervious outwash sands in a northeast-southwest direction towards Long Island Sound at approximately a 2-percent gradient, as shown on Figure 2.5.4-37. Some surface water collects in depressions in the marshy areas north of the site.

Section 2.4.13 describes the groundwater hydrology in the vicinity of the site.

An abandoned granite quarry is located on the southeast side of Millstone Point. Rock outcrops on the promontories with beach deposits located in the protected areas of the shoreline. Much of the southern portion of Millstone Point is protected from wave action by concrete seawalls adjacent to the intake structures of the three Millstone units.

Normal tides at Millstone Point are semidiurnal with a mean range of 2.7 feet and a spring range of 3.2 feet. Tides in excess of the mean high water occur on an average as follows: in excess of 3 feet about once a year, in excess of 2 feet about 5 times a year, and in excess of 1 foot about 98 times a year. Mean high water (mhw) at Millstone Point is 1.3 feet msl. Mean low water (mlw) is -1.4 feet msl.

Tidal current measurements were made at various locations in the vicinity of Millstone Point, by the Essex Marine Research Laboratory in 1965, and by the U. S. Coast and Geodetic Survey (USC&GS, now NOAA) in August and September of 1965. Figure 2.4-3 shows the location of the survey stations.

The results of the Essex Marine Laboratory tidal current survey (Figure 2.4-4), taken at the index station indicate an asymmetry between the flood and ebb tides, with the flood tide achieving a peak velocity of 1.75 fps and the ebb tide reaching a peak velocity of 1.48 fps. The USC&GS 1965 data are generally consistent with the data collected by the Essex Marine Laboratory.

Bottom profiles (Figure 2.4-5) were run by Essex Marine Laboratory from Station 1 through Station 2 to the shoreline, and from Station 4 to Station 3 to the shoreline, with a continuous recording fathometer. Using a mean velocity of 0.857 fps for the tidal cycle beginning 1 hour before low slack water on September 2, 1965 (obtained from the current survey) calculations show a mean tidal flow of 126,287 cfs in the Twotree Island Channel, and 79,186 cfs across the section running from Station 4 northeast toward the shore.

2.4.2 FLOODS

This section reviews the flood history in the vicinity of Millstone Point, flood design considerations, and the effects of local intense precipitation.

2.4.2.1 Flood History

The only sources of flooding that could affect Millstone 3 are direct rainfall and storm surge. Section 2.3.1 discusses historical rainstorms. Historical hurricanes and the resulting surges are described in this section.

Since Millstone Point is a peninsula projecting into Long Island Sound, it is subjected to tidal flooding from severe storms. The highest such flooding has resulted from the passage of hurricanes. The literature (NOAA 1968, U.S. Army Corps of Engineers 1965, Harris 1963, and Redfield et al., 1957) indicates that twelve severe hurricanes have crossed coastal southern New England since 1635 and that four of these storms occurred in the past 40 years.

These four are listed below along with the location where each storm center entered southern New England and its distance from Millstone Point. The tabulation also gives maximum flood tide levels recorded in the vicinity of Millstone Point.

Storm Center Flood Tide

Date of Hurricane	Inland Crossing	Distance from Millstone Point	Flood Tide Levels (msl in feet)
9/21/38	15 miles east of New Haven	20 miles west	9.7
9/14/44	Between Charlestown, RI, and Pt. Judith, RI	35 miles east	6.2
8/31/54	Vicinity of Millstone Point	Within vicinity	8.9
9/12/60	Vicinity of Millstone Point	Within vicinity	6.0

Figure 2.4-6 is a frequency plot of tidal flooding at New London, Connecticut, about 10 miles east of Millstone Point. This figure was based on information presented in Plate 1-6 of the U.S. Army Corps of Engineers report (1965). The plot is based on 25.5 years of records (July 1938 - December 1963) at a recording tide gage located at the State Pier in New London since July 1938 and 149 year record (1815- 1963) of high water marks. The continuous tide record was used to define the lower end of the frequency curve, and the record of high water marks was used to establish the upper portion of the curve. Because of the proximity of Millstone Point to New London and because of the similar exposure of the two areas to tidal flooding, the frequency plot is representative of Millstone Point tidal flood frequencies. This plot indicates that the 9.7-foot level recorded during the 1938 hurricane would have a recurrence interval of about 335 years and the 8.9-foot level reached in 1954 would have a recurrence interval of about 100 years.

2.4.2.2 Flood Design Considerations

The controlling event for flooding at the Millstone site is a storm surge resulting from the occurrence of a probable maximum hurricane (Section 2.4.5). As discussed in Section 2.4.5, the maximum still water level is +19.7 feet msl, and the associated wave runup elevation is +23.8 feet msl. All safety related unit structures and equipment, except the circulating and service water pumphouse, are protected from flooding due to storm surge by the site grade elevation for Unit 3 of +24.0 feet msl. The service water pumps and motors are located at elevation +14.5 feet msl inside watertight cubicles of the pumphouse. The walls of the cubicles are watertight to elevation +25.5 feet msl, protecting the pump motor control centers and associated electrical equipment from flooding due to wave action and storm surge. The front wall of the intake structure extends to elevation +43.0 feet msl; it is designed to withstand the forces of a standing wave or clapotis with a crest elevation of +41.2 feet msl. Section 3.4.1 gives further flood design considerations on storm surge and wave action.

The design basis flood levels for the Millstone site comply with Regulatory Guide 1.59, Revision 2, as follows:

1. The design basis flood levels comply with Regulatory Guide 1.59, Revision 2, Positions C.1.b, C.1.e, and C.4.

2. Regulatory Guide 1.59, Revision 2, Positions C.1.a, C.1.c, C.1.d, C.2.a, C.2.b, C.2.c, C.2.d, and C.3 are not applicable.

Refer to Section 1.8 for clarification to Position C.1.

No commitments for compliance are made or implied for the “to be issued” appendices.

2.4.2.3 Effect of Local Intense Precipitation

Hydrometeorological Report No. 33 (U.S. Weather Bureau 1956) was used to develop the design basis probable maximum precipitation (PMP) for the site. In addition, the most recent PMP guidance available on rainfall depth-duration relations, Hydrometeorological Reports No. 51 (Schreiner 1978) and No. 52 (Hansen 1982), collectively referred to as HMR-51/52, was used to determined the impact of this ultra- conservative PMP-induced site flooding on plant safety-related structures.

The all season envelope PMP for the site based on HMR-51/52 is tabulated below. PMP values for durations of 5 to 15 minutes for drainage basins of less than 1 square mile are applicable to the Millstone site.

Probable Maximum Precipitation

Duration	**Rainfall Depth for 1 mi^2 Area (inches)**	**Hydromet Report Number**
5 min	5.86	52
15 min	9.22	52
30 min	13.2	52
1 hr	17.4	52
6 hr	26.0	51

The storm drains are designed to pass, without flooding, a rainfall intensity of 6.5 iph for an unlimited duration.

A study was performed to determine the impact of the HMR-51/52 PMP intensity on the roof. Roof area and ponding level due to PMP for Category I structures are presented in Table 2.4-12. Results of the study show that roofs of safety related structures are capable of withstanding loads due to accumulation of rainwater (see Table 2.4-9). Scuppers are provided in parapet walls of the control, hydrogen recombiner, and containment enclosure buildings to preclude the possibility of a large depth of standing water remaining on the roof in the unlikely event that the roof drains were plugged. Details of scuppers are provided on Figure 2.4-34. Roof ventilators are weatherproof and are located above the level of maximum ponding on the roofs.

Covers of equipment removal hatches are located on curbs which are higher than the roof parapet walls with the exception of the hydrogen recombiner building, control building, and the circulating and service water pumphouse. The hydrogen recombiner building hatch is flush with the roof slab. The entire roof is covered with a waterproof sheet membrane. The membrane is covered with a 6 inch thick reinforced concrete wearing slab. No leakage is anticipated. The intake pumphouse and control building hatch cover seals remain structurally intact under hydrostatic loading, which is not capable of overcoming the dead weight of the concrete hatch covers acting on the seals. Details for sealing of the hatch covers are provided on Figures 2.4-35, 2.4-36, and 2.4-37.

The overflow lengths of the parapet wall on the roof used in PMP analysis for Category I structures are presented in Table 2.4-13.

It was estimated that the seal of the hatch cover on the control building roof would be under a maximum depth of 3 inches of water for a short duration, during the peak roof ponding due to a PMP event. To make the seal watertight, a continuous 0.5 inch thick by 4 inch neoprene pad is cemented to the sill angle, which is embedded along the perimeter of the hatch cover curb. The 0.5 inch thickness envelopes the permitted tolerance in the construction of the hatch cover and the curb.

Site ground elevation surrounding all buildings is elevation 24.0 feet msl with all safety related building entrances and ground level floors set at elevation 24.5 feet except the Demineralized Water Storage Tank (DWST) Block House and Refueling Water Storage Tank (RWST)/SIL Valve Enclosure. The entrance elevation for the DWST Block House is elevation 24.33 feet with ground level floor set at elevation 24.0 feet msl and the entrance and ground level floor for the RWST/SIL Valve Enclosure are set at elevation 24.33 feet msl. The yard area north of the control building and the waste disposal building is depressed below elevation 24.0 feet to create a swale to drain the PMP flood flow. The site was considered to be rendered impermeable due to saturation prior to the onset of the precipitation of highest intensity.

The site was divided into drainage basins according to the revised topography and plant layout as shown on Figure 2.4-7. Runoff hydrographs were developed using the U.S. Army Corps of Engineers HEC-1 flood hydrograph computer program. The surface area of buildings that were within the drainage basins were included in the runoff calculations. The following two conservative assumptions were made for this analysis: (1) no credit was taken for the site storm drainage system, and (2) zero infiltration rate was assumed for the analysis. Data for the drainage basins, runoff coefficients, and computed flows are presented in Table 2.4-10.

Modifications were made to the grading plan at the site boundary to prevent water in Basins A and B from flowing into Basins C and D where the safety related structures are located.

Flow from three Drainage Basins (C, C′ and D as shown on Figure 2.4-7) on site affects water levels at safety related structures. Basin C consists of the yard area north of the control building and waste disposal building. Basin C′ consists of the yard area north of Basin C as constricted by existing structures. Basin D consists of the yard area south of the containment building. Flood water from basin C flows west past the waste disposal building to the area north of the control building, and then over the roadway to the west of the site. Water from Basin C′ has been conservatively assumed to contribute totally to Basin C flows. Water from Basin D flows east between the containment building and the railroad tracks, through the Unit 2 area and on to the quarry southeast of the site.

The computed flows were then used to determine the water surface profile for each basin by utilizing the latest version of the U.S. Army Corps of Engineers HEC-2 Computer Program (Water Surface Profiles, Computer Program 723-X6-L202A). The swales and depressions that form drainage channels were divided into reaches to construct the model. Cross sections were taken to accurately describe the channel, site topography, and project features such as road crowns and railroad tracks. The locations of the cross sections are shown on Figure 2.4-7. Conservative values for Manning's coefficient were chosen as follows: lawn areas 0.05, paved areas 0.015, combination paved and gravel areas 0.020 and gravel covered areas 0.025. PMP runoff was proportioned into local incremental flows and then introduced at the appropriate cross sections.

The computed water surface elevations at the safety related structures are summarized in Table 2.4-11. In Drainage Basin C, the computed water surface elevation exceeds the door sill elevation of 24.5 feet at the auxiliary building. In Drainage Basin D, the computed water surface elevation exceeds the door sill elevation of 24.5 feet at the main steam valve, auxiliary, engineered safety features, fuel and hydrogen recombiner buildings. A detailed analysis considering the effects of doors A-24-5 and A-24-6 in Drainage Basin D show that the water will not exceed elevation 25 feet inside door A-24-5. A ramp and curb are installed inside auxiliary building door A-24-5. The curb has a top elevation of 25.0 feet to keep runoff from Drainage Basin D from entering the auxiliary building.

Results of a detailed analysis of the hydrogen recombiner and main steam valve buildings showed that the depth of any potential inleakage would be on the order of 0.16 feet which is substantially less than the base of any safety related equipment. Detailed analysis of the engineered safety features building showed that the depth of any potential inleakage would be in the order of 0.44 feet in the worst location which is substantially less than the base of any safety related equipment. Detailed analysis of the auxiliary building in Drainage Basin C and the fuel building in Drainage Basin D showed that any potential inleakage would be insignificant and would not affect any safety related equipment.

In Drainage Basin D, the computed water surface elevation 24.85 feet exceeds the entrance floor elevation of 24.33 feet at the DWST Block House and the RWST/SIL Valve Enclosure. The worst submergence level of 24.85 feet would not affect any safety related equipment in the DWST Block House and RWST/SIL Valve Enclosure.

Service building exterior door may allow a small amount of inleakage into the service building. This water may leak into the auxiliary building or control building. The total inleakage into the auxiliary building or control building would be insignificant and result in submergence levels much less than that used for the environmental design of mechanical and electrical equipment as identified in Section 3.11.

Since the intensity of winter PMP is only about half of the annual PMP (U.S. Weather Bureau 1956) and the snow accumulation on the road is plowed regularly, flooding at the site is not anticipated in the winter.

2.4.3 PROBABLE MAXIMUM FLOOD ON STREAMS AND RIVERS

There are no major rivers or streams in the vicinity of Millstone Point, nor are there any watercourses on the site. A number of small brooks flow into Jordan Cove, east of the site, and into the Niantic River and thence to Niantic Bay, west of the site. Any flooding of these brooks, even as a result of the probable maximum precipitation, would not significantly raise the water levels in Niantic Bay, Jordan Cove, or Long Island Sound in the vicinity of the site. Additionally, in each area, local topography precludes flooding of any portion of the site from the landward side.

2.4.4 POTENTIAL DAM FAILURES, SEISMICALLY INDUCED

Since there are no major rivers or streams in the vicinity of Millstone Point, the effects of potential dam failures, seismically induced, are not applicable.

2.4.5 PROBABLE MAXIMUM SURGE AND SEICHE FLOODING

2.4.5.1 Probable Maximum Winds and Associated Meteorological Parameters

The meteorological characteristics used to calculate the probable maximum storm surge at the Millstone Point site are those associated with the PMH as reported by the U.S. National Oceanic and Atmospheric Administration (NOAA) in their unpublished report HUR 7-97 (NOAA 1968). HUR 7-97 describes the PMH as "...a hypothetical hurricane having that combination of characteristics which will make it the most severe that can probably occur in the particular region involved." The hurricane should approach the point under study along a critical path and at an optimum rate of movement. The hurricane characteristics used in establishing the PMH include:

1. Central Pressure Index (CPI) - the minimum surface pressure in the eye of the hurricane

2. Radius of Maximum Wind (R) - the distance from the eye of the hurricane to the locus of maximum wind

3. Forward Speed (T) - the rate of forward movement of the hurricane center (eye)

4. Maximum Gradient Wind (V_{gx}) - the absolute highest wind speed in the belt of maximum winds

5. Peripheral Pressure (P_n) - the surface pressure at the outer limits of the hurricane where hurricane circulation ends

HUR 7-97 presents values for each of those characteristics for each degree of north latitude along the East Coast United States. Single values are presented for CPI and P and three values are given for both R and T. Since V_{gx} is dependent upon P_n, CPI, and R, three values are also given for this parameter. At the Millstone Point latitude (approximately 41 degrees north) the following PMH characteristics are recommended in HUR 7-97 (NOAA 1968).

1. CPI: 27.26 in Hg

2. R for small radius storm (RS): 8 nmi

   R for medium radius storm (RM): 24 nmi
   R for large radius storm (RL): 48 nmi

3. T for slow forward speed (ST): 15 knots

   T for high forward speed (HT): 51 knots
   T for high forward speed (HT): 51 knots

4. V_{gx} for RS: 131 mph (114 knots)

   V_{gx} for RM: 128 mph (111 knots)
   V_{gx} for RL: 124 mph (108 knots)

5. P: 30.56 in Hg

The PMH maximum gradient wind speeds are used for surge analysis only, design wind loads for structures can be found in Section 3.3.1.

2.4.5.2 Surge and Seiche Water Levels

Although frontal storms and squall lines cause tidal flooding in the Millstone Point area, by far the most severe flooding has resulted from hurricanes. For this reason, the PMH as defined in HUR 7-97 (NOAA 1968) was used to compute the design storm surge level at the site. The calculated total surge height or still water level includes the wind setup, the water level rise due to barometric pressure drop, the astronomical tide and forerunner or initial rise.

Calculation of the total surge height used a computerized bathystrophic storm surge model, which is based on procedures described in Freeman et al. (1957), Bodine (1971), Bretschneider et al. (1963), and Marinos et al. (1968). This theory was derived from the momentum and continuity equations with basic physical assumptions (Freeman et al., 1957, Bodine 1971). The model has been used to predict hurricane surge with good agreement with observed data (Bretschneider et al., 1963, Marinos et al., 1968). Use of this model requires that the storm be brought ashore from the edge of the continental shelf in a direction perpendicular to the general trend of the bottom contours. The surge is computed along the path of the locus of maximum winds as the storm moves onshore. In determining the maximum surge at Millstone Point, the locus of maximum winds is brought inshore along a track which passes just to the east of the eastern end of Long Island. This track produces the maximum surge heights at the mouth of Long Island Sound and consequently at Millstone Point.

Use of the bathystrophic storm surge program requires the input of several meteorological and physical parameters, including: the central pressure, the peripheral pressure, the maximum wind speed, the radius to maximum wind, the speed of translation, the initial rise, the astronomical tide, the bottom profile along the track of the maximum winds, the bottom friction coefficient, and the shape of the curve describing the relationship between the ratio of wind speed at any point to maximum surface wind speed and the ratio of the radius at any point to the radius to maximum wind. In addition, provision is made to enter a wind stress correction factor.

In general, the maximum surge and maximum wave need not be coincidental. For this reason, surge, wave heights, and corresponding runup at different times were considered. The maximum combination of the surge and runup on various plant structures were considered as the most severe flood level for the site.

Memorandum HUR 7-97 (NOAA 1968) gives three different values for both radius to maximum wind and speed of translation; therefore, it was necessary to compute nine different surge levels using all of the possible combinations of meteorological parameters. These calculations indicated that the large radius (RL) slow speed of translation (ST) storm yields the highest surge level at Millstone Point. The input parameters for this storm are as follows:

Central pressure	27.26 inches Hg
Peripheral pressure	30.56 inches Hg
Maximum gradient wind	124 mph (108 knots)
Radius to maximum wind	48 nmi
Speed of translation	15 knots
Astronomical tide (10 percent exceedance high tide)	2.4 feet above msl
Initial rise (Regulatory Guide 1.59, Table C.1)	1.0 feet
Bottom friction	0.0025
Wind stress coefficient factor	1.10
Bottom profile (Figure 2.4-8)	
Hurricane track (Figure 2.4-12)	

Surge analyses based on different types of hurricanes show that the large radius, slow forward speed hurricane produces the maximum stillwater level at the Millstone site.

The resulting maximum surge stillwater level is +19.7 feet msl. Additional surge data, including surge hydrographs for all three large radius storms, are shown on Figures 2.4-9 through 2.4-11.

2.4.5.3 Wave Action

Wave characteristics are dependent upon wind speed and duration, wind direction, fetch length, and water depth. Millstone Point is sheltered from the direct onslaught of open ocean waves by Long Island. Moreover, the unit itself is located on the western side of the Point and a considerable distance (about 2500 feet) inland from the southernmost tip. Thus, the topography of the Point itself protects the unit area from breaking waves during the period of peak tidal flooding when the winds are from the southeast quadrant.

For maximizing hurricane effects, the hurricane track was bent in order to have the maximum wind attack the site for the maximum possible time. The tracks are shown on Figures 2.4-12 through 2.4-14. Because of the location of the site, two possible methods of generating maximum waves, deep- and shallow-water waves, were considered.

2.4.5.3.1 Deep Water Waves

The first method was to generate deep-water waves offshore of the continental shelf and let them propagate over the shelf to Block Island Sound, finally reaching the Millstone location. Two independent analyses, one graphically by Wilson (1955, 1963) and the other computational by Bretschneider (1972) provide comparison for deep water waves.

Wilson Analysis

Wave forecasting in deep water depends on a number of empirical relationships involving the variables of significant wave height H, significant wave period T, wind velocity U, wind duration t, and length of the fetch F.

These relationships are as follows:

$$\frac{gH}{U^2} = 0.26 \tan h \left[\frac{1}{100} \left(\frac{gx}{U^2} \right)^{1/2} \right] \qquad (2.4.1)$$

$$\frac{c}{U} = 1.40 \tan h \left[\frac{4.36}{100} \left(\frac{gx}{U^2} \right)^{1/3} \right] \qquad (2.4.2)$$

where:

H = Wave height (ft)

U = Wind velocity (fps)

c = Deep water velocity of significant waves (fps)

x = Finite fetch over deep water (ft)

g = Acceleration due to gravity (ft/sec^2)

By using Equations 2.4-1 and 2.4-2 and the fact that the group velocity of the wave is half of its wave celerity, a H-t-F-T diagram covering the variables H, T, U, t, and F was constructed according to Wilson's graphical method. A transect along the forward direction on the hurricane wind field was then chosen, such that the wind components represent the maximum energy available for the wave generation. At this time, a space-time field of the wave generating wind component was constructed in conjunction with the hurricane forward velocity.

By adjusting the space-time field in the t-F quadrant of the H-t-F-T diagram, different significant wave heights and wave periods can be obtained for specific locations of the hurricane. This method was applied to the RL ST, RL MT, and RL HT probable maximum hurricanes, with the results given in Table 2.4-2. The low speed hurricane exhibited higher deep water waves than the medium or high speed hurricanes.

Special adaptation of the H-t-F-T diagram also gave information regarding time lags between surge levels and wave heights. This was accomplished by determining distances from the hurricane eye to the actual wave and noting that the hurricane travels at its translational velocity and the wave at its group velocity.

Bretschneider Analysis

The analysis by Bretschneider (1972) uses empirical data of 51 typical hurricanes to determine nondimensional, stationary deep water wave field models. The maximum significant wave height due to a stationary hurricane is as follows:

$$H_R = k'\sqrt{R\Delta P} \qquad \text{(2.4.3)}$$

where:

k' is determined from the 51 model hurricanes

H_R = Maximum significant wave height at R, stationary hurricane (ft)

R = Radius to maximum wind (nmi)

ΔP = Central pressure reduction from normal (in Hg)

For a hurricane moving forward at a speed equal to or less than the critical forward speed (V_{CR} = 16.3 exp $R\Delta P/200$), it can be shown that:

$$H'_R = \left[1 + \frac{2\Delta U}{U_R} + \left(\frac{\Delta U}{U_R}\right)^2\right] H_R \qquad (2.4.4)$$

$$\Delta U = 1/2\ V \cos\theta \qquad (2.4.5)$$

where:

H'_R = Maximum significant wave height (feet, corrected for forward speed of hurricane)

U_R = Maximum wind speed (knots)

V = Forward speed of hurricane (knots)

θ = Angle position of the radius measured counter-clockwise from its axis (degrees)

It was found that Bretschneider's estimate of hurricane waves produced by slow moving hurricanes was in agreement with the graphical solution of Wilson (Table 2.4-2). Bretschneider also provided formulation for calculating the critical wave speed. The medium and high-speed hurricanes were found to have forward speeds higher than the critical speed computed. Since Bretschneider's method included assumptions applying only to the slow moving storms, no comparison was possible with the waves generated by medium and high speed storms.

2.4.5.3.2 Shallow Water Waves

The second method considers shallow water wave generation. The geographic characteristics of Long Island Sound prevent deep-water waves from propagating through Long Island Sound. However, as hurricanes follow the track, moving over Long Island Sound and turning north-eastward as shown on Figures 2.4-12 through 2.4-14, wind generates waves within the Sound. As a wave grows in height and length, the attenuation of energy by bottom friction begins to hinder its growth. The wave attack on site thus depends on the complex interaction of shoaling, bottom friction, refraction, wind duration, and available fetch.

Energy loss due to bottom friction has been studied by Putnam and Johnson (1949), Bretschneider and Reid (1954), and Bretschneider (1954a). Combining the deep-water wave relationship given by Wilson (1963) and the shoaling and energy dissipation by friction Putnam and Johnson (1949), Bretschneider and Reid (1954), Bretschneider (1954a, b) used a numerical method to study shallow water wave generation.

Bretschneider's method (1954b) is extensively used in this study with a conservative friction coefficient of 0.01 as suggested by the U.S. Army Corps of Engineers, Shore Protection Manual (1977). However, instead of using a constant wind, a variable wind for generating the wave was taken to be the wind component along the specific direction of the hurricane.

Actual bottom topography along the specific direction was also used. The location and bottom topography of the three transects considered for Long Island Sound are shown on Figure 2.4-15. Wave heights generated by the slow, medium, and high speed PMH are shown in Tables 2.4-3 through 2.4-5.

2.4.5.3.3 Wave Shoaling

Changes in deep-water waves occur as they cross the continental shelf into intermediate water depths. The effects which must be included are the combined effects of bottom friction, the continued action of the wind, and the forward speed of the hurricane. All of these effects were taken into account by a computer program following the method developed by Harrison and Wilson (1964).

The above method also makes use of dissipation functions, introduced by Putnam and Johnson (1949), which obtain the reduction factor due to friction for any bottom slope, depth, initial wave height, or wave period. The continued action of the wind was taken into account by using Bretschneider's (1954a) determination of energy added to wind stress. The results of wave height reduction due to shoaling, with dissipation functions included, are shown in Table 2.4-2.

2.4.5.3.4 Wave Refraction

The process of refraction causes water waves to change direction when going from deep water to shallow water, because the inshore portion of the wave front travels at a lower velocity than does the portion in deep water. It is this change in orthogonal directions which causes the wave heights to be either magnified or reduced.

A program by Harrison and Wilson (1964) was adopted for the wave refraction study.

With the depth information on the constructed grid layout and the incident wave period and angle, the program constructed the wave rays inside the grid layout. In each ray construction step, a linear interpolation from wave celerities at four adjacent grid points was used. Wave refraction was considered to be significant for waves traveling through the Block Island Sound grid (along with shoaling) and the Millstone grid (Figure 2.4-16). The actual areas considered, along with refraction diagrams at various angles of approach, are shown on Figures 2.4-17 through 2.4-21. The resulting wave heights after shoaling and refraction are shown in Table 2.4-2.

2.4.5.3.5 Wave Runup

The wave data at three critical transects (Figures 2.4-22 through 2.4-25) was used to compute the elevation of maximum wave runup. Saville's method of composite slopes (U.S. Army Corps of Engineers 1977) was used, which relies on laboratory data to form curves relating the runup to wave steepness, structure type, and the depth at the structure toe. In order to obtain a maximum runup, the method of composite slopes was applied to several wave periods within the permissible range along with several controlling depths. The maximum runup for transects B and C, which occurs during the slow speed PMH, was calculated to be +23.8 feet msl and +21.2 feet msl, respectively.

2.4.5.3.6 Clapotis on Intake Structure

The water depth at the intake structure and the characteristics of the incident waves determine what type of waves would be formed at the intake, i.e., nonbreaking, breaking, or broken waves. Detailed analysis of incident waves showed only nonbreaking and broken waves are possible at the intake of Millstone 3. The bottom profile leading to the intake structure is shown on Figure 2.4-23.

Using the Miche-Rundgren (U. S. Army Corps of Engineers 1977) method, the maximum water level on the intake structure was calculated to be +41.2 feet msl. The maximum high water occurred for the slow speed PMH at the time of the peak surge of +19.7 feet msl and a wave height of 16.2 feet. Using this information, the maximum wave loading on the front of the intake structure was calculated and is shown on Figure 2.4-26.

2.4.5.4 Resonance

Resonance phenomena in a water body excited by incident waves from the open sea are associated with one or more of that body's natural periods. These natural periods vary with the size, shape, and depth of the water body. The extent of amplification at resonant period decreases with an increase in the order of harmonics considered. Therefore, in a resonant study, only the first few lower harmonics are of concern.

For the Millstone Point quarry in particular, neither the storm surge nor the waves associated with a PMH would cause the type of wave oscillations that are common in some harbors. The storm surge is a long wave whose period is far greater than the natural period of the quarry which is estimated to be about 1 minute. The net effect of the surge is to cause the water level in the quarry to vary slowly in accordance with the water level variations in the immediately adjacent areas of Long Island Sound.

During the peak surge period, general flooding of the Millstone Point area causes the quarry to become part of the open sea where resonance is not of concern. At a lower surge level, both before and after the peak surge period, the quarry is connected to Long Island Sound by the discharge channel which would allow waves to be transmitted in the quarry. However, because the incoming wave period would be in the order of 10 seconds, about one-sixth of the estimated natural period along the long axis of the quarry, there would be no significant amplification of the waves transmitted into the quarry. Moreover, the shape of the quarry is irregular and its boundary walls are not vertical resulting in scattering and imperfect reflection of waves and thereby greatly dampening the available wave energy.

Because the quarry is deep (about 100 feet), the wind fetch is short (about 1,400 feet), and there is an outlet from the quarry to the Sound, there would be no natural period seiching in the quarry due to variable hurricane winds.

2.4.5.5 Protective Structures

All safety related structures and equipment, except the circulating and service water pumphouse, are protected from flooding due to storm surge and wave action by the site grade elevation of +24 feet above msl. The effects of wave action on the pumphouse is the only topic discussed in this section, flood protection of the pumphouse is discussed in Sections 2.4.1 and 3.4.1.

The seaward wall of the intake structure is constructed of reinforced concrete designed to withstand the forces of a standing wave, or clapotis, with a maximum crest elevation of +41.2 feet msl. The resultant hydrostatic pressure distribution on the intake wall is shown on Figure 2.4-26.

To determine the maximum uplift pressure on the pumphouse floor, several combinations of surge level and coincident wave height for three different speed PMHs were examined. The maximum uplift pressure on the watertight cubicles within the pumphouse was generated by the maximum surge level of 19.7 feet msl and coincident wave height of 16.2 feet. The maximum net uplift pressure on the pumphouse floor with openings was generated by a surge level at the same level as the bottom of the pumphouse floor (11.5 feet msl) and a coincident wave height of 16.9 feet.

The calculated maximum uplift pressure on the watertight cubicles is 863 psf. The calculated maximum net uplift pressure on the pumphouse floor with openings is 557 psf. The pumphouse floor, including the watertight cubicles, is designed to withstand pressure of more than 863 psf.

The water level fluctuations within the pumphouse, resulting from storm surge and wave action, would be dampened by the energy lost in passage through the restricted openings in the trash racks, traveling screens, and operating deck. Internal water level fluctuations would be further attenuated because water must enter the structure through a submerged opening (elevation -7 to -30 feet) through which the pressure response factor would be less than unity.

Scour protection for the service water lines located behind the pumphouse is provided by a concrete retaining wall extending north from the west wall of the pumphouse.

Shoreline protection in the vicinity of the pumphouse to prevent beach erosion is discussed in Section 2.5.5.1.

2.4.6 PROBABLE MAXIMUM TSUNAMI FLOODING

The areas of the North American continent most susceptible to tsunamis are those bordering the Pacific Ocean and the Gulf of Mexico. Millstone Point is located on the North Atlantic coastline where there is an extremely low probability of tsunamis. Therefore, tsunamis are not considered to be credible natural phenomena which might affect the safety of the Millstone site.

2.4.7 ICE EFFECTS

There is no history of ice in Niantic Bay or ice jam formation in the area of the circulating and service water pumphouse. It is considered highly unlikely that ice would form or collect in a manner or amount sufficient to obstruct the flow to safety related pumps (Section 2.2.3).

A reinforced concrete curtain wall located at the front of the pumphouse and extending to -7.0 feet msl precludes floating or partially submerged ice from entering the pumphouse and damaging or blocking the bar racks.

Frazil ice formation takes place in the presence of supercooling, where turbulence is too great to allow surface ice to form, and can adhere to surfaces with a temperature equal to or less than the freezing point of water. However, at velocities of less than 2 fps, submerged frazil ice rises to the surface and form sheet ice (Bureau of Reclamation 1974). Since the water velocity in the area of the bar racks is approximately 1 fps, the possibility of submerged frazil ice adhering to the bar racks is considered unlikely.

2.4.8 COOLING WATER CANALS AND RESERVOIRS

There are no cooling water canals or reservoirs which would have any effect on safety related equipment.

2.4.9 CHANNEL DIVERSIONS

There are no channel diversions to the cooling water supply which would have any effect on safety related equipment.

2.4.10 FLOODING PROTECTION REQUIREMENTS

Section 3.4.1 discusses the flooding protection of safety related structures, and Section 2.4.2 gives a detailed discussion of the design criteria for site and roof drainage facilities.

Section 2.4.13 states that there is one Technical Requirements Manual item and one plant procedure that describe the requirements for protection of safety related equipment and facilities due to flooding.

2.4.11 LOW WATER CONSIDERATIONS

2.4.11.1 Low Flow in Rivers and Streams

Since Millstone 3 does not depend on either rivers or streams as a source of cooling water, this section is not applicable.

2.4.11.2 Low Water Resulting from Surges, Seiches, or Tsunamis

Probable minimum low water level at the Millstone 3 intake structure resulting from an occurrence of a PMH oriented so as to cause maximum depression of the water surface (setdown) at the site, is calculated to be -5.85 feet msl.

This estimate is based on a one-dimensional model with (U.S. Army Corp of Engineers 1977) with conservative assumptions regarding the hurricane track, wind field orientation, bottom profile, traverse line, and pressure effects. In addition, the model itself is inherently conservative because it does not consider return flow along the sides of the negative surge axis.

The large radius, slow speed of translation (LR/ST) PMH, with characteristics as specified in Section 2.4.5.1, is assumed to be the critical storm since the higher translational velocities of the high and medium speed of translation storms result in lesser offshore wind speeds on the backsides of those storms. The storm is assumed to approach along a track which is normal to the shoreline and which intersects the coast in western Rhode Island (Figure 2.4-27). The isovel pattern of the LR/ST PMH is assumed to be the overwater isovel pattern, (Figure 2.4-28) neglecting friction effects of overland traverse on the offshore part of the storm circulation. The wind field at Millstone results from the advection of this isovel pattern along the specified track and is shown on Figure 2.4-29. For the purpose of computing wind stress and resultant setdown, the offshore wind directions considered to apply are from 315 degrees clockwise through 045 degrees (with respect to true north). For the time period during which the winds are within this offshore direction, the average offshore wind speed is 82 mph. This wind speed is assumed to be applied along the traverse line (axis) of an outward moving surge under steady state conditions where the water surface level is balanced by the wind stress. A constant wind direction parallel to the surge traverse line is also assumed as a steady state condition.

The surge traverse and bottom profile lines assumed for the model (Figure 2.4-27) are conservative assumptions because the effects of Long Island are ignored and the surge is assumed to be directed into the open ocean; that is, a traverse line inside Long Island Sound would not produce as much setdown because the length of available fetch would be much shorter and bottom friction effects more pronounced due to shallower water.

The setdown at Millstone under the above assumptions was calculated for a wind speed of 82 mph. Figure 2.4-30 shows a plot of calculated setdown versus wind speed for a range of wind speeds from zero to 90 mph, added to the suggested 10-percent exceedence spring low tide level of -0.75 feet mlw. At 82 mph the probable minimum low water level is calculated to be -4.45 feet mlw or -5.85 feet msl.

The design low water level of the service water pumps is -8.0 feet msl, compared to a conservatively estimated -5.85 feet msl for probable minimum low water. Therefore, continuous operation of the service water pumps is ensured. The fire water pumps are supplied from two 250,000 gallon storage tanks connected to the public water system of the Town of Waterford. Probable minimum low water has no effect on these pumps.

2.4.11.3 Historical Low Water

Historical low tides at New London, Connecticut, from 1938 to 1974 are given in Table 2.4-6. The minimum tide level recorded at New London was about -4.8 feet msl on December 11, 1943.

2.4.11.4 Future Control

Consideration of future control of the cooling water source is unnecessary since the plant uses water from Niantic Bay. The use of water from the Bay by future users would not affect the cooling water supply because of the abundance of water available.

2.4.11.5 Plant Requirements

The ultimate heat sink consists of a single source of safety related cooling water, Long Island Sound. Long Island Sound contains sufficient volume to provide cooling for extended time periods (greater than 30 days) to permit safe shutdown of the unit. The minimum safety related cooling water flow required during accident conditions is provided in Table 9.2-1. Safety related plant water requirements for all modes of operation are given in Table 9.2-1.

During normal plant operation, cooling water is withdrawn from Long Island Sound and delivered by two of four available 15,000 gpm rated capacity service water pumps, enclosed in a Seismic Category I structure; the circulating and service water pumphouse (CSP). Figure 3.4-1 (sheets 3 and 4) shows the CSP (Section 3.4), configuration and minimum design operating water level. Each service water pump is designed to operate with a minimum submergence requirement of 4 feet.

2.4.11.6 Heat Sink Dependability Requirements

The ultimate heat sink for Millstone 3 is Long Island Sound. Sensible heat removed from both safety and non-safety related cooling systems during normal operation, shutdown, and accident conditions is discharged via the circulating and service water systems, through the quarry, and into Long Island Sound. Both the circulating and service water systems have as their source of water Niantic Bay, which is fed from Long Island Sound. The ultimate heat sink (Section 9.2.5) satisfies the requirements of Regulatory Guide 1.27.

Long Island Sound is capable of dissipating waste heat under all environmental and operating conditions. Table 2.4-7 lists the heat loads rejected under various operating modes.

The design low water level of elevation -8.0 feet msl for the service water pumps includes added conservatism to the calculated extreme low water level of elevation -5.85 feet msl (Section 2.4.11.2). The suction bells of the Millstone 3 circulating and service water pumps are located at elevation -19.5 feet msl and elevation -13.0 feet msl, respectively; well below the low water levels. Therefore, during all operating conditions, sea water is available to the safety related service water pumps. Table 9.2 1 gives the minimum cooling water flow required accident conditions for safety related service water loads. The circulating water system cooling water flow required during normal operating conditions is 912,000 gpm. Circulating water is not required during accident conditions.

The temperature extremes of the water in Niantic Bay and Long Island Sound are 80°F maximum and 33°F minimum (see Section 9.2.1.1). Long Island Sound and Niantic Bay can provide a 30 day supply of service water that does not exceed the design temperature, under any 30 day meteorological conditions that result in maximum evaporation.

The applicants have no knowledge of any history of significant ice formation in Niantic Bay. It is considered highly unlikely that ice would form or collect in a manner or amount sufficient to obstruct the flow to the service water and circulating water pumps (Sections 2.4.7 and 2.2.3). A reinforced concrete curtain wall located at the front of the pumphouse and extending down to elevation - 7.0 feet msl acts as an air seal and also prevents floating or partially submerged debris and ice from entering the pumphouse. Additionally, the flow velocity at the bar racks is low enough to cause frazil ice to rise to the surface and form sheet ice, such that there would not be blockage affecting the service water pumps.

Sedimentation that would affect the safety function of the service water pumps is considered unlikely. The suction bells of the circulating water pumps are at an elevation 6.5 feet lower than the suction bells of the service water pumps. The rated flow capacity of the circulating water pumps is approximately ten times larger than that of the service water pumps. Therefore, any sediment that might settle in the pump bays downstream of the traveling screens would be removed by suction through the circulating water pumps before it could block the inlets to the safety related service water pumps. In the event that significant sedimentation should deposit on the floor of the pumphouse bays, it would be removed by occasional dredging.

2.4.11.7 Dispersion, Dilution, and Travel Times of Accidental Releases of Liquid Effluents in Surface Waters

Dispersion characteristics and dilution capability of Niantic Bay and Long Island Sound for an accidental release through the circulating water discharge tunnel is the only case discussed here. Section 2.4.13 discusses the effects of contamination of groundwater, which subsequently flows into Long Island Sound.

Predictions of the dispersion and dilution of the accidental releases of liquid effluents in surface water are divided into two regions:

1. In the near-field, the dilution is due to momentum induced mixing and turbulence mixing created by the surface discharge jet from the quarry through the quarry cut into Long Island Sound.

2. In the far-field, the dilution is due to ambient tidal current in Niantic Bay and Long Island Sound.

It is assumed that no dilution occurred within the quarry. In the near-field at the edge of mixing zone, the dilution factor was estimated to be 3 (E. E. Adams 1999). In the far-field dilution factors were calculated using the two dimensional, vertically averaged numerical model as discussed in Regulatory Guide 1.113. The velocity field was computed from the following vertically integrated two-dimensional equations of mass and momentum conservation:

Mass:

$$\frac{\partial\eta}{\partial t} + \frac{\partial}{\partial x}[u(h+\eta)] + \frac{\partial}{\partial y}[v(h+\eta)] - \Upsilon = O \qquad (2.4.6)$$

Momentum:

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -g\frac{\partial n}{\partial x} - \frac{1}{\rho}\frac{\partial P_a}{\partial x} + fv + \frac{1}{\rho(h+\eta)}(\Gamma_{w,x} - \Gamma_{b,x}) \qquad (2.4.7)$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} = -g\frac{\partial n}{\partial y} - \frac{1}{\rho}\frac{\partial P_a}{\partial y} + fu + \frac{1}{\rho(h+\eta)}(\Gamma_{w,y} - \Gamma_{b,y}) \qquad (2.4.8)$$

where:

h = The wave height

h = The mean water depth

t = Time coordinate

u and v = Velocity components in the x and y directions, respectively

y = A source term which is defined as the discharge or intake rate per unit area at a specified grid point

g = Gravitational constant

P_a = Atmospheric pressure

f = 2Ω sin ψ = the Coriolis parameter

in which:

Ω = The angular velocity of the earth

ψ = The latitude

Γ_w and Γ_b = Shear stresses at the water surface and the bottom, respectively.

$$\Gamma_{b,x} = \rho g C^{-2} u(u^2 + v^2)1/2 \qquad (2.4.9)$$

$$\Gamma_{b,y} = \rho g C^{-2} v(u^2 + v^2)1/2 \qquad (2.4.10)$$

where:

C = The Chezy coefficient

Equations 2.4-6 and 2.4-7 represent a two-dimensional transient hydrodynamic mathematical model in a general form. The source term ϒ is included because it would simulate the intake and discharge flow effects on the ambient flow patterns. If the interested area is relatively small, P_a can be assumed to be constant, and if there is no source or sink in the area (ϒ = 0), then Equations 2.4-6 through 2.4-7 are those shown in page 1.113-15 of Regulatory Guide 1.113.

The numerical solution of Equations 2.4-6 through 2.4-8 was developed and a computer program was written. In using the computer program, a collection of square cells, with the height equal to the average water depth, is used to simulate Niantic Bay and the adjacent portion of Long Island Sound. A grid size of 1,000 by 1,000 feet was used. Figure 2.4-31 illustrates the area modeled by 280 cells. The solid line defines the closed boundary which was chosen to closely approximate the shoreline geometry from Black Point to Seaside Point. The dashed line defines the open boundary which extends through the open water of Long Island Sound. The model boundary also includes the Niantic River estuary.

The model used tidal level information from the 1974 hydrographic hydrological survey as input to obtain flow pattern predictions (NUSCo. 1975). Current data from the same survey were used for comparison and calibration. The bottom roughness (Manning's coefficient) was assumed to equal one of three values (0.02, 0.03, or 0.045) depending on the bathymetric conditions and the velocity profiles obtained. A phase lag of 10.5 minutes was used across the model region (east to west). With these inputs and refinements, the model predicted the flow field and tidal heights within the model region. A comparison of the predicted flow field velocities at points where current meter measurements were available was performed (NUSCo. 1975). Reasonably good agreement between current direction and magnitude existed between predicted and observed data.

The output of the model indicates that during the strength of flood the flow pattern shows a general westward circulation with maximum velocities of 2 fps in the Twotree Island Channel. The high slack stage occurs approximately 0.52 hour after high tide. The flow pattern at this stage shows the low velocities and mixed directions characterizing this period of tide reversal. The tidal current stage of the Niantic River estuary lags in time and still shows a moderate flooding current (NUSCo. 1975).

The strength of ebb develops about 4.05 hours after high tide and the flow pattern is from west to east. Finally, low slack water occurs and a general mixed flow pattern precedes a reversal direction. The tidal current stage of the Niantic River still lags the outer bay and shows an ebbing flow.

The general flow patterns are similar to those observed in past field surveys. They also indicate two phenomena recently noted in the summer 1973 survey data (NUSCo. 1975). First, there are no completely slack water conditions between the flood and ebb tides, a characteristic of rotary tidal current. Second, the time of lowest velocity does not always coincide with the high and low tide, as is observed in other bays along open coastlines, but rather exhibits a lag of from 1/2 to 1 hour usually (NUSCo. 1975).

The resulting velocity field then becomes the advective mechanism in the following vertically averaged conservation equation for the dissolved constituent concentration C (from Regulatory Guide 1.113):

$$\frac{\partial}{\partial t}(HC) + \frac{\partial}{\partial x}(uHC) + \frac{\partial}{\partial y}(vHC) = \frac{\partial}{\partial x}\left(HK_x\frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(HK_y\frac{\partial C}{\partial y}\right) - H\lambda C \qquad (2.4.11)$$

where:

H = Depth from water surface to bottom

K_x and K_y = Dispersion coefficients in the x and y directions, respectively

l = Decay coefficient

In the numerical computation, an initial concentration Co is arbitrarily assigned as one of the input data. The computer program computes the concentration, C(x,y), at every grid point in the interested area. The dilution factor, D, is given by:

$$D_f = \frac{C_o}{C(x, y)} \qquad (2.4.12)$$

The dispersion coefficients, k_x, k_y, used in the model described above were determined by using the thermal plume survey data obtained in July 1977. In the process of calibrating the model for a two-unit operation, a sensitivity analysis shows that using a dispersion coefficient of 450 sq ft/sec with a limiting depth of 18 feet, the model yields results compatible with those from the dye survey (Liang and Tsai 1979).

Principal users of Niantic Bay or Long Island Sound waters in the vicinity of the plant are recreational users. Table 2.4-8 summarizes areas of recreational water use and their corresponding dilution factors. To be conservative, no travel time from the accidental release point (quarry cut) to users was taken into consideration in calculating the concentrations of liquid contaminants.

The nearest industrial user of Long Island Sound water is the Pfizer Corporation located 5.5 miles east-northeast of Millstone Point. Normal or accidental releases from the site are not expected to affect this plant because of its distance from the site. No potential future users of Niantic Bay or Long Island Sound water are known at this time.

2.4.12 GROUNDWATER

2.4.12.1 Description and Onsite Use

Groundwater is not used as a source of plant water supply.

2.4.12.2 Sources

The Millstone site has several shallow wells near it, the nearest being about one-third of a mile from the station proper. None of these provides domestic drinking water, but one is used to water a nearby baseball field and to supply a drinking fountain at the field.

Three shallow wells (Figure 2.4-32) are located within 1.5 miles of the site; one nearly 1.5 miles to the north-northeast, one approximately 1 mile to the northeast, the third approximately 0.5 mile to the northwest.

Figure 2.4-2 identifies the public water supplies within a 20 mile radius of the site.

Groundwater conditions on Millstone Point have been documented in previous studies for Millstone 1 and 2, and have been observed by water level observations in borings drilled for the Millstone 3 site study in 1972 (Section 2.5.4.6).

Prior to development of the site as a nuclear power facility, there existed a granite quarry located approximately 1,200 feet south- southeast of the Millstone 3 area. Observations of the water levels in the granite quarry show that the water level in the quarry before the existing discharge channel opened it to the ocean, typically lay approximately 17 feet below the level of the adjacent Long Island Sound. It is significant that this quarry was worked for over 100 years (1830-1960) at distances of as little as 200 feet from the waters of Long Island Sound without experiencing notable inflows of water indicating that the permeability of the bedrock is very low.

Pressure tests (Table 2.5.4-16) were conducted in the vicinity of the quarry and in the containment area as part of the Millstone 3 site study. These tests indicate that the bedrock is generally massive with slight to moderate interconnected jointing. Geologic mapping of the site bedrock indicated that the bedrock is fresh, hard crystalline rock with tight, moderately spaced joints. Very little inflow of water was noticed entering the excavations through the bedrock. These observations also suggest that the permeability of the bedrock is very low, and that very little groundwater or seawater seeps through the site bedrock.

Both the basal till and the overlying ablation till are relatively impervious. The ablation till soils are more pervious than the basal tills and occasionally exhibit partial stratification, including sporadic sand lenses; accordingly, the upper portions of the soil transmit water more readily than the underlying dense basal tills. Groundwater levels appear to be subject to considerable seasonal fluctuations. In addition, borings taken prior to the 1972 Millstone 3 observations near the shoreline exhibited tidal fluctuations, suggesting that the occasional sand lenses can be quite permeable (Bechtel 1972).

Water levels measured in borings taken at the site in early 1972 indicate a groundwater piezometric surface with a gradient generally sloping from northeast to southwest (Figure 2.5.4-37).

Localized perched groundwater conditions probably exist because of the irregular distribution of ablation till materials of varying gradation and porosity. It is also likely that shallow, ponded water exists in localized bedrock troughs. The prevalence of bedrock outcrops to the north and northwest of the site indicate that bedrock acts as groundwater divide, isolating the soils of the tip of Millstone Point from soils further inland.

Since there is no plant use of groundwater, and the plant area is isolated from soils further inland, there is no effect on groundwater on the site or surrounding areas.

Groundwater recharge would primarily be due to infiltration of local precipitation, with probable migration to the waters of the immediately-adjacent Long Island Sound. As previously described, little groundwater is present in the crystalline bedrock, and virtually all of the groundwater movement is restricted to the soil overburden. Measurements taken during previous investigations (Goldsmith 1960) showed average influx rates into test pits of about 8 gph and concluded that both the ablation and basal tills are relatively impervious.

2.4.12.3 Accident Effects

Within a 5-mile radius of the Millstone 3 containment structure, public water supplies originate from ground sources, most of which are shallow wells and distant from the site. Three shallow wells shown on Figure 2.4-32 are located within 1.5 miles of the site. There are ridges in between the Millstone 3 location and the wells which are undoubtedly underlaid by rock. They create a drainage divide, the groundwater flowing to the east and west and to the south. Water or chemicals accidentally released during operation or accident conditions to the site surface would not reach these wells. Accidental waste discharges would not affect public groundwater supplies since the Niantic River and Niantic Bay lie west and northwest of the site while accidental spillage in the soil or rock column at the site while the Jordan Cove drainage basin is east of the site. Any accidental spillage in the soil or rock column at the site would be interrupted by these bodies of water and would prevent contamination of distant groundwater sources. Elevations exceeding those of the site and at-surface bedrock ridges preclude migration of contaminated groundwater to the north.

An investigation of possible diffusion in the groundwater was made, in case of an accidental liquid release of waste on the site outside the normal flow paths.

Liquid Release from Boron Recovery Tank

It is estimated that 80 percent of tank volume (120,000 gal) liquid would be discharged into the ground and eventually would reach the groundwater following the assumed tank failure. The location of the boron recovery tank is such that the bedrock and basal till overlaying the rock (both with very low permeability) have higher elevations to the south, east, and west of the location. The rock contours to the northwest of the boron recovery tank indicate a depression considered a channel through which the fluid might flow toward the trench for the circulating and service water pipelines. The granular backfill to be used in this trench is estimated to have a higher permeability than other surrounding soils (tills); hence, the trench offers the most probable path for discharging the boron recovery tank liquid to Niantic Bay. Under these conditions, the length of the possible flow path (Figure 2.4-33) is approximately 1,230 feet.

Once the boron recovery tank liquid reaches the groundwater, it is diluted by the groundwater through diffusion. In addition, the radioactive constituents in the liquid undergo radioactive decay. The filtering action and ion exchange action of the soil on particulates and solubles, respectively, in the discharged liquid are neglected.

The coefficients of permeability for each beach and outwash sand and the structural backfill have been determined using constant head and falling head tests. The permeabilities obtained during testing ranged between 1.2 x 10^{-4} to 2.7 x 10^{-3} cm/sec for the beach and outwash sand and between 1.6 x 10^{-4} to 4.0 x 10^{-4} cm/sec for structural backfill. The coefficients of permeability for the beach and outwash sand and the structural backfill are assumed equal 10^{-3} cm/sec.

Because the normal groundwater level at the location of the boron recovery tank is at elevation +22 feet and Niantic Bay is at Elevation 0 feet, the hydraulic gradient along the flow path is:

$$i = \frac{22}{1230} = 0.0179 \text{ or } 1.79\% \qquad (2.4.13)$$

The effective porosity, n_e, determined by porosity tests of soil samples from the site, equaled 0.1.

The seepage velocity in the groundwater is given by Darcy's Law:

$$u = \frac{k_i}{n_e} = \frac{3.28\text{x}10^{-5} \text{ x } 0.0179}{0.1} = 5.87\text{x}10^{-6}\text{ft/sec} \qquad (2.4.14)$$

The time for the discharged liquid to travel from the boron recovery tank to the point of discharge into Niantic Bay is given by:

$$t = \frac{D}{u} = \frac{1230}{5.87 x 10^{-6}} = 2.095 \text{ x } 10^{8} \text{ sec } = 6.64 \text{ yr} \tag{2.4.15}$$

The dispersion coefficients are related to the flow velocity by the dispersivity (Bredehoeft and Pinder 1973), i.e:

$$K_{x,\,y} = \alpha_{x,\,y} u \tag{2.4.16}$$

where:

$K_{x,y}$ = The horizontal dispersion coefficients; K_x is the component in the direction of the flow, K_y is in the direction perpendicular to the flow

$\alpha_{x,y}$ = The corresponding longitudinal transverse components of the dispersivity

u = Seepage velocity

Values are assigned to, based on a best fit between the results of a mathematical model and the field data for the Snake River Plain aquifer (Robertson 1974). The former is an analytical approach to the three dimensional dispersion problem which simulates the continuous release of a contaminant in a vertical line source. This calibration establishes a value for of 59 feet. Bredehoeft and Pinder (1973) suggest the relation:

$$\alpha_x = \frac{10}{3} \alpha_y \tag{2.4.17}$$

These results are generalized to other sites by assuming that, all other properties being equal, the property of an aquifer that fixes the dispersivity is the porosity, such that:

$$\alpha_y = \alpha_{ys} \left(\frac{n_{es}}{n_e} \right) \tag{2.4.18}$$

where:

α_y = Transverse dispersivity for the aquifer of interest

α_{ys} = Transverse dispersivity for Snake River aquifer

n_e = Effective porosity for the aquifer of interest

n_{es} = Effective porosity for Snake River aquifer

Because the local groundwater velocity (Equation 2.4.16) can be used to compute the horizontal dispersion coefficients, it is subsequently assumed that $K_z = k_y$.

As the liquid from the boron recovery tank reaches the groundwater, several factors contribute to its dispersion and dilution. These include advection, hydraulic dispersion, radioactive decay, and ion exchange. If the fluid flow is uniform, steady, and parallel to the x-axis, the hydraulic dispersion coefficients are homogeneous, anisotropic and orders of magnitude greater than the molecular diffusion coefficients, and the radioactive decay and sorption processes are not considered, the equation governing the distribution of contaminant is:

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} = K_x\frac{\partial^2 C}{\partial x^2} + K_y\frac{\partial^2 C}{\partial y^2} + K_z\frac{\partial^2 C}{\partial z^2} + \frac{M'}{n_e} \tag{2.4.19}$$

where:

C = Contaminant concentration

u = Seepage velocity

M' = Rate of release of mass per unit volume of aquifer

The solution of Equation 2.4.19 for an instantaneous volume source in an aquifer of finite depth is:

$$C=\frac{C_o}{4}\left\{\operatorname{erf}\frac{x-ut+l/_2}{(4K_xt)^{1/2}} - \operatorname{erf}\frac{x-ut-l/_2}{(4K_xt)^{1/2}}\right\}\cdot\left\{\operatorname{erf}\frac{y+b/_2}{(4K_yt)^{1/2}} - \operatorname{erf}\frac{y-b/_2}{(4K_yt)^{1/2}}\right\}\cdot$$
$$\left\{\frac{H_2-H_1}{H} + 2\sum_{n=1}^{\infty}\cos\left(\frac{n\pi z}{H}\right)\frac{1}{n\pi}\left(\sin\frac{n\pi H_2}{H} - \sin\frac{n\pi H_1}{H}\right)\cdot\exp\left[-\left(\frac{n\pi}{H}\right)^2K_zt\right]\right\} \tag{2.4.20}$$

where:

C_o = Initial contaminant concentration at source location

l, b = Source dimensions in the x and y direction, respectively

H_1, H_2 = Upper and lower surface of the volume source

H = Aquifer thickness

x, y, z = Coordinates in the longitudinal, transverse, and vertical direction, respectively

t = Time from initial release

When input data are substituted in Equation 2.4.9, the minimum dilution factor for the groundwater, C_o/C, equals 73.

The discharged liquid on reaching Niantic Bay is diluted further in that body of water. The method used to calculate the dilution in Niantic Bay and Long Island Sound is the same method as described in Section 2.4.12. The only difference is that the released point is in the intake area instead of the circulating water discharge tunnel. The dilution factor upon entering Niantic Bay at the Intake area is calculated to be 13,052 and at 1,000 feet from the point of discharge into Niantic Bay is calculated to be 32,151. One-thousand feet was chosen arbitrarily as the point to calculate the dilution factor in Niantic Bay so as to show the large dilution factor obtained in the bay.

2.4.12.4 Monitoring or Safeguard Requirements

Since the potential for groundwater contamination is minimal, as discussed in Sections 2.4.13.2 and 2.4.13.3, procedures and safeguards to protect groundwater users are not necessary.

2.4.12.5 Design Bases for Subsurface Hydrostatic Loading

There is no safety related permanent dewatering system for lowering groundwater levels for Millstone 3. Safety related structures are designed for water pressure and buoyancy forces applied from their respective foundation levels to the design piezometric surface levels, as shown in Figure 2.5.4-37 assuming saturated soil conditions to the water surface. Section 2.5.4.6 includes a discussion of groundwater conditions with respect to plant structure design and construction and Section 3.4 includes a discussion of flood design for Seismic Category I structures and components. Section 9.3.3 includes a description of the sump systems installed in the ESF Building for removal of groundwater inleakage collected in the porous concrete groundwater sump.

2.4.13 TECHNICAL SPECIFICATION AND EMERGENCY OPERATION REQUIREMENTS

In order to minimize the water associated impact of adverse hydrologically related events on safety related equipment and facilities, Millstone 3 has no related Technical Specification discussion. However, Technical Requirements Manual 3/4.7.6, Flood Protection, describes the measures required to provide flood protection for the service water pump cubicles.

The service water pumps are designed to operate at a low water level of elevation -8.0 feet msl, which is 3.2 feet lower than the historical low water level (Section 2.4.11.3) and are enclosed in a flood protected portion of the circulating and service water pumphouse (Sections 2.4.1.1 and 3.4.1). Other safety related structures and components are protected from flooding by the site grade of elevation 24.0 feet msl. AOP 3569 addresses safety measures to be taken in the case of severe weather conditions. These measures ensure that all watertight doors are in place and the pump cubicle sump drain lines are isolated and thus all safety-related structures and components are protected from flooding.

Section 2.4.2.3 states that there is no water associated impact in the safety related facilities, resulting from local rainfall as severe as the probable maximum. Therefore, no technical specifications or emergency operating procedures are required, except as discussed above for the pumphouse.

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TABLE 2.4–1 CONNECTICUT PUBLIC WATER SUPPLIES WITHIN 20 MILES OF MILLSTONE 3

CLICK HERE TO SEE TABLE 2.4-1

TABLE 2.4–2 MAXIMUM WAVE HEIGHTS GENERATED BY SLOW, MEDIUM, AND HIGH SPEED STORMS (DEEP-WATER FETCH)

CLICK HERE TO SEE TABLE 2.4-2

TABLE 2.4–3 MAXIMUM SHALLOW WATER WAVES (AFTER REFRACTION) SLOW SPEED PROBABLE MAXIMUM HURRICANE

CLICK HERE TO SEE TABLE 2.4-3

TABLE 2.4–4 MAXIMUM SHALLOW WATER WAVES (AFTER REFRACTION) MEDIUM SPEED PROBABLE MAXIMUM HURRICANE

CLICK HERE TO SEE TABLE 2.4-4

TABLE 2.4–5 MAXIMUM SHALLOW WATER WAVES (AFTER REFRACTION) HIGH SPEED PROBABLE MAXIMUM HURRICANE

CLICK HERE TO SEE TABLE 2.4-5

TABLE 2.4–6 LOWEST TIDES AT NEW LONDON, CONNECTICUT 1938-1974

CLICK HERE TO SEE TABLE 2.4-6

TABLE 2.4–7 CIRCULATING WATER SYSTEM AND SERVICE WATER SYSTEM HEAT LOADS

			LOCA Coincident with LOP		Loss of Power (LOP)	
	Normal Operating Condition (1) (10^6 Btu/hr)	Normal Unit Cooldown Condition (10^6 Btu/hr)	Minimum Engineered Safety Features (10^6 Btu/hr)	Normal Engineered Safety Features (10^6 Btu/hr)	Hot Shutdown (10^6 Btu/yr)	Cold Shutdown (10^6 Btu/yr)
Service Water System	178.97	(2)	(2)	(2)	(2)	(2)
Circulating Water System	8,200 (3)	0 (after RHR cooling commences)	0	0	0	0
TOTAL	8378.97	(2)	(2)	(2)	(2)	(2)

NOTES:

(1) These are maximum heat loads.

(2) See Table 9.2-2.

(3) An approximate value for operation with 1 to 5 inches of backpressure on the turbine.

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TABLE 2.4–8 DILUTION FACTORS AND TRAVEL TIME *

Usage Location	Dilution Factor	Travel Decay Time (hr)
Pleasure Beach	12.6	0.0
Harkness Memorial	36.0	0.0
Waterford State Park	36.0	0.0
Ocean Beach Park	21.0	0.0
Crescent Beach	40.0	0.0
Rocky Neck State Park	30.0	0.0
McCook Point	43.0	0.0
Edge of Initial Mixing Zone**	3.0	0.0
Far Field (7,000 ft south of discharge)	36.0	0.0

NOTES:

* For discharge from Millstone 2 and 3

** For Millstone 2 and 3 operation within 500 to 1,000 ft from the discharge point (quarry cut)

TABLE 2.4–9 CATEGORY I STRUCTURES - ROOF SURVEY

Structure	A* (ft)	B* (ft)	C* (ft)	D* (lb/ft^2)	Number and Size of Scruppers
Control Building	1.58		0.63	99	2 at 128 in^2 = 256 in^2
Auxiliary Building					
North	0.50			34	
South	0.50			42	
Fuel Building					
El 106'-0"	1.65			108	
El 101'-9"	1.67			109	
El 93'-10"	1.88			122	
El 61'-5"	1.15			88	
Main Steam Valve Building					
El 85'-11 1/4"	0.25			35	
El 71'-2"	0.25			73	
Engineering Safety Features Building					
El 56'-9"	0.75			47	
Containment Enclosure Building	2.06		0.83	118	8 at 128 in^2 = 1024 in^2
Circulating and Service Water Pumphouse (CSWP)					
El 39'-0"	1.98	1.31		87	
El 26'-0"	1.31			87	
Hydrogen Recombiner Building		0.92	57		2 at 90 in^2 = 180 in^2

NOTES:

A = Difference between drain low point and top of parapet.

B = Difference between drain low point and top of lowest roof curb.

C = Difference between drain low point and bottom of overflow scupper.

D = Maximum load (lb/ft^2) applied by maximum ponding (assume that roof drains are clogged); H_2O @ 4°C (62.4 pcf).

TABLE 2.4–9 CATEGORY I STRUCTURES - ROOF SURVEY

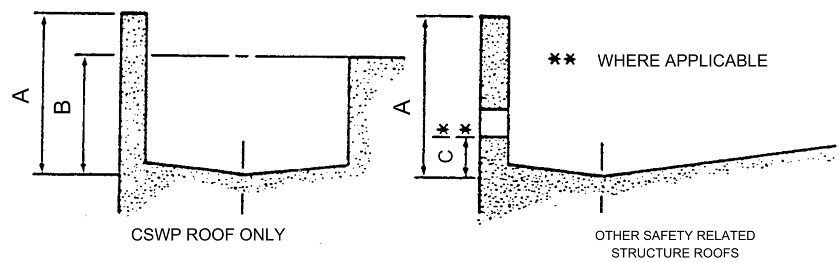

TABLE 2.4–10 INPUT DATA TO PROGRAM HEC-2 WATER SURFACE COMPUTATIONS

Drainage Basin	Surface Area (acre)	Concentration Time (minutes)	Computed Flow (cfs) at Down stream End of Drainage Basin
C & C[1] (2)	9.58	14.8	267
D	6.43	12.6	351

NOTES:

1. Drainage areas A and B are graded such that their flows do not contribute to the areas of safety related structures.

2. Drainage areas C and C[1] are conservatively combined to provide worst case water flows.

TABLE 2.4–11 COMPUTED WATER SURFACE ELEVATIONS AT SAFETY-RELATED STRUCTURES

Drainage Basin	Structure	Maximum W. S. Elevation at Doors to Structure (ft msl)
C	Auxiliary Building	24.85
C	Control Building	24.27
C	Emergency Generator Enclosure	24.27
D	Main Steam Valve Building	24.85
D	Hydrogen Recombiner Building	24.85
D	Auxiliary Building	24.85
D	Engineered Safety Features Building	24.85
D	Fuel Building	24.85
D	RWST/SIL Valve Enclosure	24.85
D	Demineralized Water Storage Tank Block House	24.85

TABLE 2.4–12 ROOF AREA AND PONDING LEVEL DUE TO PMP [1] CATEGORY I STRUCTURES

Structures	Plan Area of Roof [2] (ft^2)	Other Roof/Area Draining to this Structure's Roof [3] (Structure/Ft^2)	Total Area Considered in Flow off Roof (ft^2)	Peak Flow Q=CIA[4] (cfs)	Top Elevation of Parapet (ft, msl)	Peak Elevation of Water Surface [5] (ft, msl)	Elevation of Bottom Scupper (ft, msl)
Control Bldg.	5,916	Turbine Bldg. / 2,587	8,503	13.74	92'-4"	92'-5"	91'-5 1/2"
Auxiliary Bldg.							
North End	7,956	-----	7,956	12.86	94'-0" [6]	94'-1 1/2" [7]	-----
South End	7,912	Containment Encl. Structure /4,247 Fuel Bldg. / 286	12,445	20.11	93'-6" [6]	93'-10" [7]	-----
Fuel Bldg.							
El 106'-0"	2,912	Cont. Enc. Strct. / 956	3,868	6.25	107'-4"	107'-5"	-----
El 101'-9"	1,950	Fuel Bldg. / 443	2,393	3.87	103'-0"	103'-1"	-----
El 93'-10"	4,352	Liq. Wst. Bldg. / 72	5,514	8.91	94'-8"	94'-9"	-----
El 61'-5"	3,264	Fuel Bldg. / 3,942	7,846	12.68	56'-8 1/2"	56'-10 1/2"	-----
Main Steam Valve Bldg.							
El 85'-11 1/4"	2,900	Aux. Bldg. / 12,445 Cont. Encl. Strt. / 2,283	17,628	28.5	86'-2"	86'-8"	-----
El 71'-2"	928	Main. Stm. Valve / 17,628	18,556	30.0	71'-7 5/8"	72'-2"	-----
Eng. Safety Feat. Bldg.	6,931	Cont. Strt. Enc. / 5,628	12,559	20.3	57'-3"	57'-4"	-----
Cont. Strt. Encl.	18,252	-----	18,252	29.5	187'-0"	186'-10"	185-9"

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TABLE 2.4–12 ROOF AREA AND PONDING LEVEL DUE TO PMP [1] CATEGORY I STRUCTURES

Structures	Plan Area of Roof [2] (ft^2)	Other Roof/Area Draining to this Structure's Roof [3] (Structure/Ft^2)	Total Area Considered in Flow off Roof (ft^2)	Peak Flow Q=CIA[4] (cfs)	Top Elevation of Parapet (ft, msl)	Peak Elevation of Water Surface [5] (ft, msl)	Elevation of Bottom Scupper (ft, msl)
Hyd. Rec. Bldg.	2,104	Cont. Strt. Enc. / 1,327 ESF Bldg. / 598	4,029	6.5	51'-10"	51'-11"	-----
Circ. and SW Pumphouse							
El 39'-0"	10,126	----	10,126	16.4	40'-3 1/2"	40'-7"	-----
El 26'-0"	612	C&SW Pumphse / 840	1,452	2.4	27'-3 1/2"	27'-7"	-----

1. Based on HMR 51/52.
2. From SWEC Drawing No. 12179-EA-20A-1.
3. Effective area.
4. C = 1.0; i = 70.4 in./hr (peak 5 min. period); A = total runoff area flowing over parapet.
5. Assume entire length of parapet as weir.
6. Elevation of curb at low point.
7. Over curb at low point; all other flow on roof is sheet flow.

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TABLE 2.4–13 OVERFLOW LENGTH OF THE PARAPET WALL ON THE ROOF USED IN PMP ANALYSIS - CATEGORY I STRUCTURES

CLICK HERE TO SEE TABLE 2.4-13

2.5 GEOLOGY, SEISMOLOGY, AND GEOTECHNICAL ENGINEERING

This section provides information regarding seismic, geologic, and geotechnical characteristics of the site and the surrounding region.

The following companies and personnel performed tests on materials from the site:

1. American Drilling and Boring Company, Providence, Rhode Island, under the direction of Stone & Webster Engineering Corporation (S&W), drilled test borings, performed standard penetration tests, sampled soil, cored rock, performed pressure tests on selected holes, and installed piezometers.

2. Weston Geophysical Engineers, Incorporated, Westboro, Massachusetts, conducted cross-hole and down-hole surveys and refraction and reflection surveys to determine in situ seismic wave velocities and the varying depths to founding strata. S&W performed additional cross-hole surveys using an impact source.

3. Geotechnical Engineers, Inc., Winchester, Massachusetts, performed cyclic triaxial and resonant column tests on beach sands in the vicinity of the circulating and service water pumphouse.

4. Geochron Laboratories, Cambridge, Massachusetts, performed potassium-argon (K-Ar) dating to determine the age of rock and fault gouge samples.

5. Dr. R. T. Martin, Massachusetts Institute of Technology, Cambridge, Massachusetts, and Dr. R. C. Reynolds of Dartmouth College, Hanover, New Hampshire performed x-ray diffraction tests to determine the clay mineral composition of the fault gouge samples.

6. Dr. R. A. Wobus, Williams College, Williamstown, Massachusetts, performed petrographic analysis of thin sections from fault zones.

7. Dr. E. Ingerson, University of Texas, Austin, Texas, analyzed quartz crystals found in the fault zone to determine the conditions of formation.

8. Dr. D. W. Caldwell, Groton, Massachusetts, performed consulting services to determine the age of till at the Millstone site.

9. Dr. K. Tsutsumi, Tufts University, Medford, Massachusetts, performed unconfined compression strength tests on rock specimens taken from borings.

10. Dr. Robert F. Black, University of Connecticut, Storrs, Connecticut, performed consulting services regarding the age and origin of features found in site glacial deposits.

The information contained in this section was obtained from the following:

1. Review of published geologic literature and maps.
2. Detailed mapping of rock after the removal of overburden and the excavation of structures.
3. Interviews with authorities on regional geology.
4. Rock and soil borings.
5. Laboratory tests of representative soil and rock samples.
6. Interpretation of aerial photographs, Earth Resources Technology Satellite (ERTS) imagery, gravity, and aeromagnetic maps.
7. Geophysical surveys on the site.
8. Piezometer installations and groundwater monitoring.
9. Bedrock pressure testing (holding test and pressure flow test).
10. Age dating of rock samples.
11. Fluid inclusion studies.
12. Petrographic studies.
13. Blast monitoring.

The site is located on a low peninsula on the north shore of Long Island Sound and the east shore of the Niantic River. Bedrock is highest on the eastern portion of the site and dips to the west towards Long Island Sound. The reactor containment and most other Category I structures on the eastern side of the site are founded on bedrock, whereas the control, emergency generator, waste disposal enclosure, turbine building, are founded on dense basal till which overlies the rock. The circulating and service water pumphouse is also founded on bedrock. The bedrock surface falls off sharply from the main site area to approximately el -32 feet in the area of the pumphouse.

Section 2.5.1 presents the regional and site area geology and geologic history. A discussion of regional faulting and tectonics and their relationship to rock types at the site is discussed in detail.

Section 2.5.2 presents the regional seismicity and describes the selection of the site safe shutdown earthquake (SSE) of 0.17 g and the operating basis earthquake (OBE) of 0.09 g.

Section 2.5.3 describes the faulting encountered at the site during construction. A description of the origin and nature of the faults mapped at final excavation grades is included in this section.

Section 2.5.4 presents the results of geotechnical investigations and studies related to the stability of subsurface materials and plant structures. Field and laboratory investigations are described in detail, and stability and liquefaction analyses based on these studies are also included in this section, as well as maps and tables from the geological mapping program.

Section 2.5.5 presents the results of stability analyses on two safety related slopes at the site: the containment excavation and the shoreline slope.

Embankments or dams (Section 2.5.6) are not included in the plant design.

2.5.1 BASIC GEOLOGICAL AND SEISMIC INFORMATION

As shown on Figure 2.5.1-1 the site lies in the Seaboard Lowland section of the New England physiographic province. The site is located in a geologically complex region characterized by metamorphosed and folded rocks of Ordovician-Silurian age. This area has been affected by four orogenies: the Avalonian (575 million years ago m.y.a.), the Taconian (465-445 m.y.a.), the Acadian (400-370 m.y.a.), and the Alleghenian (230-260 m.y.a.). The surrounding region has also been affected by rifting ranging in age from Triassic to Jurassic. Since then the region has been stable, with the exception of epeirogenic uplift during Cretaceous and Tertiary times, and isostatic rebound, resulting from the removal of the weight of ice covering the region during Pleistocene time.

The site lies in an area of low seismic activity. Only 13 earthquakes of Intensity V, Modified Mercalli (MM) or greater, have been recorded within a distance of 50 miles of the site in more than 300 years. The nearest significant earthquake was at East Haddam, Connecticut, in 1791. Its epicenter was approximately 25 miles north of the site. Even though this earthquake is recorded in the Earthquake History of the United States (USCGS 1965) as having an intensity of VIII MM, detailed studies by Rev. Linehan, Director, Weston Geophysical Observatory, based on newspaper accounts and other records of the time, indicate that the intensity was no higher than VI to VII MM. Maximum intensity of ground motion experienced at the site in approximately 300 years of recorded history has not exceeded Intensity V MM, which would correspond to an acceleration of 0.02 to 0.03g.

Faults believed to be related to Triassic tectonics have been found in the excavation for Millstone 3. Potassium-argon methods of dating clay gouge found within the faults indicate that the last activity along these faults occurred approximately 142 m.y.a.; therefore, these faults are not capable features (NNECO. 1975, 1976, 1977, 1982). There is no capable fault at or near the site.

A thick layer of very dense basal till blankets the site. The bedrock surface is irregular and was glacially smoothed. Most major plant safety related structures are founded on hard, crystalline bedrock. The control building is founded on structural backfill overlying till and bedrock.

There has been no commercial mining in the area other than the now inactive granite quarry, located approximately 1,200 feet to the southeast of the Millstone 3 plant area. The soils and rock underlying the site are strong, stable materials that are not susceptible to loss of strength, subsidence, or other instabilities during earthquake motion. The gradation and the density of the till are such that liquefaction is precluded. The soils and rock underlying the site are of very low permeability. The groundwater table is highest in the northern part of the site and slopes gradually towards the shoreline. There are some isolated wells in the area; however, there is no industrial, domestic, or municipal use of groundwater from these wells.

2.5.1.1 REGIONAL GEOLOGY

New England is characterized by a series of intensely folded anticlinoria and synclinoria trending to the northeast. The geology of these folds has been made more complex by igneous activity, metamorphism, and faulting. Extensive glaciation has modified landforms and deposited or reworked most unconsolidated surficial deposits. The physiography, geological setting, stratigraphy, tectonics, and geologic history of the New England region are discussed in the sections that follow.

2.5.1.1.1 Regional Physiography and Geomorphology

The Millstone site is located in the Seaboard Lowland section of the New England physiographic province (Figure 2.5.1-1). The New England province is divided into five sections by Fenneman (1938): the Taconic, the Green Mountain, the White Mountain, the New England Upland, and the Seaboard Lowland. The Connecticut Valley Lowland is discussed by Fenneman (1938), but not considered as a separate province. Just southwest of Millstone Point along the coast of Connecticut lies the Coastal Plain province. These sections are not necessarily characterized by uniform geological terrain, but are defined primarily by similar topographic expression.
Section 2.5.1.2 discusses the local physiography and its significance to the site.

The Seaboard Lowland section is a smooth, low-lying belt extending from Connecticut north to New Brunswick. In Connecticut, the Lowland varies in width from 6 to 16 miles, and as it swings northward in Rhode Island and Massachusetts, it widens to approximately 50 miles in southeastern Massachusetts. The relatively low altitude of the seaboard section is not primarily due to a difference in rock resistance, though the parts underlain by the Carboniferous sediments are lower and flatter than the rest (Fenneman 1938). Along Long Island Sound, it is probable that a narrow zone was covered by Cretaceous formations of the coastal plain (Fenneman 1938). This zone has a steeper seaward slope than the upland and is considered by Fenneman (1938) to be part of the pre-Schooley peneplain. In the Millstone site area, this zone is characterized by glacial outwash and moraines with some swamp deposits.

The Taconic section, the westernmost subdivision of the New England province, extends from approximately 12 miles southeast of Poughkeepsie, New York, northward to approximately Rutland, Vermont. The zone is fairly narrow with a maximum width of about 25 miles, and the area is mostly mountainous. The mountains consist mainly of strongly metamorphosed sediments, now predominantly schists and slates.

The Green Mountain section borders the Taconic section to the northeast. This highland section extends from western Massachusetts into Canada. The Green Mountains are underlain by resistant crystalline rocks of Precambrian age.

The White Mountain section consists of a series of mountain ranges from the White Mountains of New Hampshire northeastward to the Katahdin group in Maine. This section is underlain mainly by metamorphosed sedimentary and volcanic rocks of Paleozoic age and igneous rocks of the White Mountain Plutonic-Volcanic series (Billings 1956).

The New England Upland section, the largest section of the New England physiographic province, extends from Canada to the “Highlands” area of southeastern New York and northern New Jersey. This section typically reflects underlying fold belts and has the appearance of a plateau dissected by narrow valleys and containing scattered monadnocks (Fenneman 1938). It was first believed that a single peneplain existed at one time and extended from Long Island

Sound to the Green Mountains. This peneplain ranged from sea level at the Sound to approximately 2,000 feet in the Green Mountain area (Fenneman 1938).

The exact origin of the peneplain is still questioned. Two hypotheses have been brought forth for the origin of the plateau: marine terracing and terracing by normal erosion (Fenneman 1938). Neither explanation is widely accepted, although a combination of the two seems more plausible.

The Connecticut Valley Lowland trends northerly through the New England Upland section from the Connecticut shore to just north of Greenfield, Massachusetts. The Lowland is underlain by sandstone, conglomerate, and shale, which is less resistant to weathering, and diabase which is more resistant. There is an abrupt change to crystalline rocks on both sides of the depression.

South of the New England Lowland section is the Atlantic Coastal Plain physiographic province. This section (Figure 2.5.1-1) encompasses Cape Cod, Long Island, southern New Jersey, and the offshore islands and shoals. In the site area, the Coastal Plain sediments are submerged by the Atlantic Ocean. These sediments are of late Cretaceous and Tertiary ages and thicken seaward. Figure 2.5.1-2 shows a distribution of pre-Pleistocene sediments off the New England coast. The basement is believed to be a continuation of that found underlying southern New England.

Glaciation has greatly changed much of New England. The rock outcrops have been rounded and smoothed and the valleys filled with glacial deposits. The rivers in many cases had to develop new channels after being dammed by glacial deposits.

Pleistocene glacial deposits are widespread throughout New England. End moraines occur along the southern margins and are prominent along Long Island, Block Island, Martha's Vineyard, Cape Cod, and in southern Rhode Island and Connecticut (Schafer and Hartshorne 1965). End moraines have been mapped in the site area by Flint (1975) and Goldsmith (1964) and are shown on the Site Surficial Map (Figure 2.5.1-3).

2.5.1.1.2 Regional Structure

The Millstone site area lies in the northern portion of the Appalachian Mountain system. The Appalachians extend from Alabama to Newfoundland as a series of ranges formed by a number of successive deformations during the Paleozoic era.

The northern Appalachians can be separated into a number of distinct geologic sections. The westernmost area, the foreland, is relatively undeformed. This area includes the Catskill Plateau, the Hudson-Champlain and the St. Lawrence Lowlands, and consists mainly of gently dipping, sedimentary rocks of Early Paleozoic age.

A narrow belt of deformed and metamorphosed lower Paleozoic carbonate rocks, east of the foreland, forms the northern extension of the Valley and Ridge province. These rocks are similar to those of the Catskill Plateau: however, they have undergone at least two deformations and have been broken by thrust faults and high-angle gravity faults.

Further eastward lie the Taconic Mountains which consist of allochthonous rocks of Cambrian and Ordovician ages. The Taconics are mainly sedimentary and metasedimentary rocks that have slid westward into place above middle Ordovician shales (Figures 2.5.1-4 and 2.5.1-5).

The New England section is a series of north-south anticlinoria and synclinoria that parallel the general trend of the Appalachian Mountain belt. They are, from west to east: the Green Mountain anticlinorium, the Connecticut-Gaspe synclinorium, the Bronson Hill anticlinorium, the Merrimack synclinorium, and the Rockingham anticlinorium, the Merrimack synclinorium, and the Rockingham anticlinorium. The Merrimack synclinorium in southeastern New England ends abruptly on the east along the Clinton-Newbury and Lake Char fault zones. East of the fault zone lies a belt of Precambrian and Lower and Middle Paleozoic igneous and metamorphic rocks of various lithologies. Figure 2.5.1-4 shows the major stratigraphic units associated with these structural belts and Figure 2.5.1-5 shows the structural units.

The Green Mountain anticlinorium is made up of a series of massifs that are intensely sheared and metamorphosed Paleozoic rocks with a Precambrian core. They are, from north to south: the Green Mountain, the Berkshire, and the Housatonic massifs.

The Hudson Highlands group of rocks including schists, gneisses, granites, and minor marbles of Precambrian age are exposed along much of the anticlinorium. This structural high is believed to separate the miogeosynclinal sequence on the west from the eugeosynclinal sequence on the east.

The eugeosynclinal sequence is generally considered as a homoclinal sequence, of intensely folded and sheared rocks of early Paleozoic age. In the trough of the Connecticut-Gaspe synclinorium is a series of domes surrounded by the entire synclinorial sequence. The synclinorium is a major tectonic unit that extends from Long Island Sound along the Connecticut River to the Gaspe Peninsula and into Newfoundland. The east limb is masked by the younger clastic sediments and basalt flows of the Connecticut Valley Triassic Basin.

The crest of the Bronson Hill anticlinorium coincides with an echelon series of Ordovician gneiss domes (Naylor 1968, Thompson et al., 1968). The metamorphosed sediments and volcanic rocks of Ordovician and Devonian ages are stratigraphically continuous with those of the Connecticut-Gaspe synclinorium. The gneiss domes are believed to have been the loci of volcanic islands within the eugeosynclinal trough during Early Paleozoic time (Naylor 1968, Thompson et al., 1968).

The Merrimack synclinorium shares its west limb with the Bronson Hill anticlinorium, which includes metamorphosed lower and middle Paleozoic clastic sediments. Metamorphism and plutonism have greatly confused the geology of the area. Metamorphic grade increases from north to south within the synclinorium. The synclinorium has been intruded by rocks belonging to the Devonian New Hampshire Plutonic series (Billings 1956, Page 1968, Foland et al., 1971). The southern extent of the Merrimack synclinorium is obscured by the Honey Hill fault and the local doming and refolding of the Ordovician rocks south of the Honey Hill fault.

In New Hampshire and Maine, the east limb of the Merrimack synclinorium is shared with the Rockingham anticlinorium (Billings 1956). This anticlinorium consists of lower and middle Paleozoic metamorphic units of primarily sedimentary origin.

The Merrimack synclinorium and the Rockingham anticlinorium end abruptly along the Clinton-Newbury fault zone. East of this fault and the Lake Char fault lies a belt of Precambrian and lower and middle Paleozoic igneous and metasedimentary rocks. Granites, granite gneisses, schists, and volcanic deposits are characteristic of this area. The Precambrian basement of southeastern New England is younger than that of the Green Mountains to the west (Naylor 1975). The geologic terrain in this southeastern New England belt is comparable to that of the Avalon Peninsula in Newfoundland (Rodgers 1972). A number of Late Paleozoic basins have been superimposed on these rocks: Boston, Norfolk, Woonsocket, North Scituate, and Narragansett Basins. The Narragansett Basin is slightly to moderately metamorphosed with a maximum staurolite grade in the southwest corner (Weston Observatory 1976). The Boston Basin is only slightly metamorphosed (Rodgers 1970).

Along the southern New England coast is an east-west belt of rocks extending eastward from the eastern edge of the Connecticut Valley Triassic Basin (Figure 2.5.1-4). In Connecticut, the strip is made up of complexly folded metasediments and a number of gneiss domes. The domes range in age from late Precambrian to early Paleozoic (Naylor 1968, Rodgers 1970). The Millstone site is located in this region adjacent to the Lyme Dome (Section 2.5.1.2). In Rhode Island, the strip consists of massive, relatively undeformed Late Pennsylvanian or Early Permian granites (Narragansett Pier and Westerly Granite) which intrude the Narragansett Basin deposits, and Precambrian gneisses.

Cretaceous and post-Cretaceous sediments have masked the seaward extension of the Appalachian structures to the south and east. Figure 2.5.1-2 shows the inferred distribution of the coastal plain material. Figure 2.5.1-5 shows what is considered to be the seaward thickening wedge of Cretaceous, Tertiary, and Quaternary sediments dipping to the southeast. These sediments unconformably overlie the pre-Cretaceous rock surface that dips seaward at a low angle. Recent work by Sheridan (1974) indicates that there are some very deep, possibly fault-bounded basins beneath the outer shelf and beyond, containing carbonates and evaporates of Jurassic-Triassic and Permo-Carboniferous age (Figure 2.5.1-6). A number of somewhat shallower Triassic and Permo-Carboniferous basins have been hypothesized in papers by Ballard and Uchupi (1972, 1975) (Figure 2.5.1-6). Table 2.5.1-1 gives the lithologies, ages, and thickness of the coastal plain sediments off the southern New England coast. Figure 2.5.1-2 shows the extent of the Cretaceous sediments and the unconformably overlying Tertiary sediments. A thin veneer of reworked glacial outwash and clastic material covers most of the shelf area (Hoskins 1967). Relief on the surface of the continental shelf of the Long Island, Block Island, and Rhode Island Sounds and in the Buzzards Bay area has been observed by seismic profiling. Tagg and Uchupi (1967) believe these irregularities to be caused by fluvial erosion and modified by glacial erosion and deposition.

Geophysical studies in the Gulf of Maine indicate that its tectonic history is similar to that of the New England coast. Late Paleozoic and Early Mesozoic basins are also believed to exist in this area (Ballard and Uchupi 1972, 1975). These structures are covered by differing amounts of post-

Jurassic deposits (Figure 2.5.1-2). Well defined unconformities beneath Georges Bank are inferred to separate the upper Cretaceous sediments from the Tertiary and lower Pleistocene sediments and the Tertiary-lower Pleistocene strata from the Pleistocene glacial deposits (Ballard and Oldale 1973). Moraine deposits cover much of the Gulf of Maine and Georges Bank area (Ballard and Oldale 1973). The topographic expression is believed by Ballard and Oldale (1973) to be due to the result of stream erosion during Tertiary and early Pleistocene time.

2.5.1.1.3 Regional Stratigraphy

The generalized regional geologic map (Figure 2.5.1-4) shows the distribution of significant rock types in the region surrounding the Millstone site. The regional geologic section (Figure 2.5.1-5) was taken trending east-west from the Appalachian Plateau in New York to the eastern edge of the Triassic sediments and then southeastward through the Millstone site to the Coastal Plain sediments.

The regional stratigraphic correlation chart (Figure 2.5.1-7) gives a number of stratigraphic columns with correlations between regions of similar latitude as well as correlations between regions of similar longitude. Therefore, correlations are given parallel to and across the regional trend. Figure 2.5.1-8 gives more detailed stratigraphic information for areas within the site region. A detailed description of the rock units shown on this chart is included as Tables 2.5.1-1 through 2.5.1-7.

2.5.1.1.4 Regional Tectonics

The Northern Appalachians have been affected by four major orogenies: the Avalonian, Taconian, Acadian, and possibly the Alleghenian. The Avalonian and the Alleghenian orogenies mainly affected the southeastern portions of New England. The first three of these orogenies have produced a complex series of anticlinoria and synclinoria that constitute the New England land mass. The prominent structural belts are the Green Mountain anticlinorium, the Connecticut Valley-Gaspe synclinorium, the Bronson Hill anticlinorium, the Merrimack synclinorium, and the Rockingham anticlinorium, all discussed in Section 2.5.1.1.2 and shown on Figure 2.5.1-6. These anticlinoria and synclinoria trend parallel to the Appalachian Mountain belt. Section 2.5.1.1.5 discusses the geologic history.

A detailed description of regional tectonics is included in this section, which forms the basis for the subdivision of New England into tectonic provinces (Section 2.5.2.2).

2.5.1.1.4.1 Domes and Basins

As mentioned in Section 2.5.1.1.2, gneiss domes are present in the Connecticut Valley synclinorium and the Bronson Hill anticlinorium.

These domes differ geologically because the gneiss cores of those in the synclinorium may consist partly of Precambrian basement from beneath the Paleozoic sequence, whereas, the core gneisses on the anticlinorium seem to be intrusions into the pre-Silurian part of the rock sequence (Rodgers 1970). The Lyme and Willimantic domes (Figure 2.5.1-5) lie east of the Bronson Hill anticlinorium. These domes are important to the geology of the Millstone site. Millstone is located just east of the Lyme dome. Both domes are overlain by an early Paleozoic sequence (Hebron Gneiss, Brimfield Schist, Tatnic Hill Formation, and Quinebaug Formation) and have a Precambrian-Cambrian core (Ivoryton Group, Plainfield Formation, and Sterling Plutonic Group) (Lundgren and Ebblin 1972).

The most prominent basins in the region are the Triassic basins of the Connecticut Valley and New York-New Jersey and Pennsylvania areas, and the Carboniferous basins of southeastern New England (Figure 2.5.1-6). Offshore basins have been located by geophysical methods south of New England and in the Gulf of Maine (Section 2.5.1.1.2).

2.5.1.1.4.2 Faulting

The effects of the different stages of mountain building are widespread throughout New England. The varying types of faults present in different sections have allowed a reconstruction of the geologic history and an increased understanding of the tectonic forces related to each orogeny. Characteristic crustal structures have been left by the Taconian and Acadian orogenies and later by the rifting during the Triassic-Jurassic period.

The area most affected by the Taconian orogeny is along the Hudson River from approximately Sudbury, Vermont, to the vicinity of Poughkeepsie, New York, and eastward into western Massachusetts. The region exhibits a number of gravity slices that slid off an uplifted block to the east during middle to late Ordovician time (Bird 1969).

A number of thrust faults are noticeable in New England. The Ammonoosuc fault in western New Hampshire (Figure 2.5.1-6) trends N25E (Rodgers 1970) and dips at approximately 38 degrees to the northwest. Silicified zones have been noted along the fault and the displacement has been estimated to be 7,000 feet (Billings 1956). The fault offsets the metamorphic isograds associated with the Acadian orogeny: however, it is intruded by granitic rocks associated with the White Mountain magma series (Billings 1956). Potassium-argon studies on biotite from the Conway Granite yield a radiometric age of 172 3 m.y.a. (Foland et al., 1971) indicating no movement along this fault since the granitic intrusion. Rodgers (1970) suggests that the Ammonoosuc may be a normal fault; however, Billings (1956) considers it a thrust fault.

Another major thrust fault system, the Lake Char-Honey Hill, lies in southern and eastern Connecticut. The Honey Hill, the east-west segment, extends from Chester near the Connecticut River eastward to south of Preston. The Lake Char section runs north-south from Lake Char in Massachusetts to Preston, Connecticut. The fault system is characterized by zones of cataclastic rocks up to 2,500 feet thick (Dixon and Lundgren 1968). The plane of the fault is an irregular, warped surface. The dip of the Honey Hill section is generally at low angles to the north with a maximum at 55 degrees in the Preston area; the Lake Char section dips westward at approximately 10 degrees (Dixon and Lundgren 1968). The Honey Hill part of the system is approximately 14 miles from the Millstone site.

The thrust fault activity along the Lake Char-Honey Hill system is thought to have begun in the middle to late Devonian and continued into the Permian period (170-225 m.y.a.). Movement on the Honey Hill fault may have begun during metamorphism as part of the eastward displacement of the recumbent Chester syncline, which is not cut by the fault (Lundgren 1963). The major movement on the fault plane was toward the southeast (Dixon and Lundgren 1968). Dixon and Lundgren (1968) believe that movement associated with the Lake Char-Honey Hill system comprised the last pre-Triassic activity in the area.

Recently, Lundgren and Ebblin (1972) have hypothesized that the thick zones of cataclastic rock are related to relative upward movement of basement at different places and at different times from late Devonian to Permian. This intense folding developed major cataclastic units in zones of high shear between mantling rock and basement complexes. Three different episodes of uplift brought about the present alignment of structure in southern Connecticut.

Rodgers (1970) indicates that late movements occurred sometime after Carboniferous, but before the late Triassic. The Honey Hill fault is cut by faulting believed to be related to Triassic rifting (Rodgers 1970, Goldsmith 1967c).

Further to the northeast in Massachusetts is another large thrust fault system, the Clinton-Newbury, paralleling the Bloody Bluff system. Skehan (1969, 1973), Castle et al. (1976), and Dixon (1976) have suggested that the Clinton-Newbury - Bloody Bluff system is a continuation of the Lake Char-Honey Hill system of Connecticut. The Clinton-Newbury -Bloody Bluff zones run northeasterly from south of Worcester to Newburyport and into the Gulf of Maine (Skehan 1969). Detailed mapping linking the Lake Char to the Bloody Bluff has yet to be done. Exposures in the Wachusett-Marlboro tunnel indicate that these faults dip to the northwest and are reverse in nature (Skehan 1968). The average direction of tectonic transport is to the east, similar to that of the Lake Char-Honey Hill fault. The dominant faulting is later than the metamorphism and is probably late Paleozoic to mid-Mesozoic (Skehan 1968). A prominent number of northerly trending, younger, high-angle faults have been observed throughout the New England area, some cutting the thrust faults associated with the Clinton-Newbury system.

The northern border of the Triassic Newark Basin is bounded by a series of closely spaced subparallel faults that commonly trend N30E to N50E and dip to the southeast. This Ramapo fault system has a complex history of movements dating back to late Precambrian (Ratcliffe 1971). Late Triassic rejuvenation of the old fracture system produced the Newark depositional basin. Normal faulting associated with the regional rifting and the deposition of the coarse conglomerates in the basin continued into the Jurassic (Ratcliffe 1971). Page et al. (1968) have reported recent seismic activity in the vicinity of the Ramapo, but there has been no movement detected at the surface.

The Triassic Connecticut Valley Basin extends from the Connecticut shore northward to the Massachusetts-Vermont border. The basin averages about 20 miles in width and exposes clastic sedimentary deposits interlayered with basalt flows and sills generally dipping to the east. At the eastern edge, the deposits are abruptly ended by a west dipping normal fault zone. It has been generally accepted that the Connecticut portion of the basin was formed by faulting that was contemporaneous with the deposition of the clastic sediments, and the fault zone of the east side brings into contact the Triassic sediments with the Paleozoic crystalline rocks to the east (Wheeler 1939, Sanders 1960). The northern part of the Triassic Basin may have had a slightly different origin. Bain (1932) indicates that sections of the eastern contact between the Triassic and the Paleozoic sediments are depositional contacts with no evidence of faulting. Faulting along the northern portion of the basin has been established in the Mineral Hill area of Montague, Massachusetts (NUSCO. 1974). This fault has been interpreted as a thrust fault, which was later reactivated with minor normal displacement. Potassium-argon radiometric dating of fault gouges found along this fault and other small faults in the region yielded dates between 140 and 180 m.y.a. (NUSCO. 1974). These dates reflect the movement related to the extension tectonics of the Jurassic-Triassic period.

A number of smaller faults are associated with the Carboniferous basins of eastern Massachusetts and eastern Rhode Island. Some of these faults bound the basin. Many of the faults associated with the Boston Basin are thrust faults. These are smaller splays off the large Bloody Bluff fault system previously mentioned (Nelson 1976). These faults were originally formed during the compressional forces associated with the Acadian orogeny. Movement along the faults is believed to be associated with the climax of the regional metamorphic event (Nelson 1976). Nelson (1976) indicates that another near-surface fault system is post-Pennsylvanian in age, and that this system may be related to the faulting of the Pennsylvanian rocks of Rhode Island.

The eastern margin of the Woonsocket and North Scituate Basins is bounded by high angle faults (Quinn and Oliver 1962). Although a short portion of the western boundary of the Narragansett Basin is a normal fault (Quinn 1971), silicification along this fault may indicate some association with Triassic activities (Rodgers 1970). Other small faults on the northeast edge of the Narragansett Basin bring Pennsylvanian sedimentary rocks in contact with older plutonic rocks. Geophysical studies by Ballard and Uchupi (1975) indicate a number of basins in the Gulf of Maine and the Georges Bank. These basins were postulated to be bounded by faults associated with the Triassic-Jurassic period. As shown on Figure 2.5.1-6, these authors suggest a Carboniferous basin extending offshore northeast of the Boston Basin. However, rock samples recovered from these areas by Ballard and Uchupi (1975) fail to support the existence of these geophysically-inferred basins.

Offshore geophysical studies by McMaster (1971) indicate a fault occurring southwest of Block Island. Recent work performed by Weston Geophysical Engineers, Inc., for New England Power Company (1976) and by the USGS (Needell and Lewis 1982) has indicated that this fault, named the New Shoreham fault, lies slightly east and extends further northward then originally indicated by McMaster (1971). It is a normal fault, striking approximately N30-50W and dipping at approximately 75 degrees to the northeast. The fault displaces sediments identified as Cretaceous; however, Pleistocene deposits are undisturbed. The nearest approach of the New Shoreham fault is approximately 21 miles southeast of Millstone Point (Figure 2.5.1 6).

Many faults have recently been investigated throughout New England. These investigations indicate that the last episode of movement was associated with Jurassic-Triassic tectonics. Lyons and Snellenburg (1971) have investigated three normal faults in New Hampshire. The study included the radiometric dating of the clay gouge generated during faulting. Radiometric testing performed on the illite portion of the clay gouge yielded ages between 157 and 164 m.y.a.

The Triassic Border fault was studied in detail in the Montague, Massachusetts area, and radiometric age determinations on clay gouge yielded dates between 140 and 180 m.y.a (NUSCO. 1974).

North-south trending high-angle faults have been analyzed in the Charlestown, Rhode Island area. Potassium-argon test results on the illite clay gouge indicated dates ranging from 169 to 226 m.y.a. (NEPCo. 1976).

High-angle, north-south trending normal faults uncovered in the excavation of Millstone 3 have also been investigated (NNECO 1975, 1976, 1977) and are discussed in greater detail in Section 2.5.3.2. Radiometric age determinations on clay gouge indicate dates ranging from 109 to 200 m.y.a.

High-angle normal faults are quite common in southern New England. Two of these faults, the Lantern Hill (Rodgers 1970) and the unnamed fault in the Uncasville quadrangle, (Goldsmith 1967c), cut the Honey Hill fault. The unnamed fault in Uncasville (Goldsmith 1967c) dies out approximately 10.5 miles northeast of Millstone Point. These faults are believed to be related to the rifting associated with the Trassic-Jurassic period because radiometric age dating indicates that the last activity along some of these faults occurred in that period. Rodgers (1975), Skehan (1975), and Goldsmith (1973) believe that the hydrothermal activity, typically silicification, along faults of this type represents the youngest known tectonically related event in southern New England.

2.5.1.1.4.3 Tectonic Summary

The structural pattern of New England (Figure 2.5.1-6) is characterized by strong north-northeast trends. The major anticlinoria and synclinoria, the alignment of domes and basins, the trend of the faulting, and the alignment of most of the granitic intrusions indicate a constant and pervasive tectonic force acting in the same orientation for a prolonged period of time.

Many of the features are the result of compressional forces acting throughout the region during much of the Paleozoic era. The area has undergone folding, igneous intrusion, refolding, and subsequently, thrust faulting.

The Mesozoic era was characterized by faulting and igneous activity differing from that of the Paleozoic era. Normal faulting associated with extensional forces is well developed in the southern New England area. The intrusion of diabase dikes and sills is also associated can be observed, physiographic and tonal. Tonal linear features may be due to a change in vegetation, whereas physiographic lineaments generally are due to topographic expression accentuated by erosion. These features are probably related to structural discontinuities, chiefly faults, shear zones, and joints (O'Leary et al., 1976).

2.5.1.1.4.4 Remote Sensing

Land Satellite (LANDSAT) photographs of Connecticut, Rhode Island, southern Massachusetts, and eastern New York were studied to identify linear features or lineaments. A lineament is defined as a mappable linear feature of a surface, with parts aligned in a rectilinear or slightly curvilinear relationship and which differs distinctly from the patterns of adjacent features and presumably reflects a subsurface phenomenon (O'Leary et al., 1976). Two types of lineaments can be observed, physiographic and tonal. Tonal linear features may be due to a change in vegetation, whereas physiographic lineaments generally are due to topographic expression accentuated by erosion. These features are probably related to structural discontinuities, chiefly faults, shear zones, and joints (O'Leary et al., 1976).

Figure 2.5.1-9 shows the LANDSAT photographs used for the study, and Figure 2.5.1-10 shows the lineaments greater than 10 miles long identified on the photographs. The explanation for the lineations shown on Figure 2.5.1-10 are given in Table 2.5.1-8. The linear features shown on Figure 2.5.1-10 are grouped into three categories:

1. Those coinciding with mapped faults
2. Those coinciding with mapped geologic contacts
3. Those which are not identifiable with either of the above, but associated with topographic expression

The lineaments shown on Figure 2.5.1-10 are, for the most part, due to differences in topography. These differences may be due entirely to the resistance to erosion of the varying rock units. The majority of the lineaments coincide with geologic contacts which have been accentuated by the erosion of rivers and streams. As can be seen on Figure 2.5.1-10 and listed in Table 2.5.1-8, planes of weakness within rock masses have also accounted for a number of the lineaments. Regional joint patterns and mapped faults are easily identifiable on the LANDSAT photographs. These often correspond to topographic lows due to the erosion of the broken and more easily weathered material.

2.5.1.1.4.5 Structural Significance of Geophysical Studies

Geophysical studies have aided in the interpretation of the geology of New England. The aeromagnetic and Bouguer gravity maps relating to regional geologic features are presented on Figures 2.5.1-11 and 2.5.1-12, respectively.

The aeromagnetic information shown on Figure 2.5.1-11 generally conforms to the regional geologic trends observed in New England.

A number of areas exhibit strong alignment or high intensity of magnetic character. The Lake Char-Honey Hill system in Connecticut and the Clinton-Newbury fault zone in Massachusetts are the most prominent lineations on the aeromagnetic map. The Cape Ann area, north of Boston, is characterized by its high magnetic intensity. This is caused by the combination of the high intensities related to the basic rock of the Salem Gabbrodiorite and the existence of a highly faulted and brecciated zone. The northwestern and southern boundaries of the Cape Ann area closely coincide with the Clinton-Newbury, the Bloody Bluff, and the Boston border faults

(Barosh and Pease 1974). The other obvious magnetic anomalies correspond to the plutons of the White Mountain series of New Hampshire and Maine.

Smaller, less striking anomalies occur in the site area, in the Cape Cod area, and in central Massachusetts just east of the Connecticut River Valley Triassic Basin. The anomaly in the Millstone area follows the folded pattern of the interlayed metasedimentary and metavolcanic rocks. The rock with very high susceptibilities apparently wraps around the structural features adjacent to the site (Lyme dome, Figures 2.5.1-13 and -14) and extends out into Long Island Sound (Barosh and Pease 1974). The anomalies on Cape Cod are probably due to large basic intrusive bodies (Barosh et al., 1974). The north-south trending anomaly east of the Triassic Basin in central Massachusetts is related to the presence of metavolcanic rocks of high magnetic susceptibility. Barosh and Pease (1974) indicate that the metavolcanic rocks to the south are less magnetically susceptible due to the effects of retrograde metamorphism and they are not noted on the aeromagnetic map.

Small isolated anomalies can be observed on the east side of the axis of the Green Mountain anticlinorium. A series of ultramafic bodies extending from Canada southward to Massachusetts (Skehan 1961) may be the cause of these anomalies.

Figure 2.5.1-12 shows the regional gravity in relation to the geologic structures of New England and the trend of the gravity anomalies corresponding to the differing structural alignment. The most prominent anomaly is along the axis of the Green Mountain anticlinorium. This gravity high appears to be caused by the relative uplift of a dense lower crust (Kane et al., 1972). In the eastern portion of New England, it is still apparent that the gravity anomalies follow the structural trend. This trend is sharply broken by the large negative anomaly encompassing the White Mountains of New Hampshire. Other locally pronounced anomalies are found throughout New England and are, for the most part, associated with igneous masses. The large anomaly on Cape Ann is probably due to mafic rock underlying the Cape Ann series.

2.5.1.1.5 Regional Geologic History

The Regional Geologic Map (Figure 2.5.1-4) shows the distribution and generalized age relationships of rocks in the New England area.

The geologic history of New England is complex because the region has been subject to several orogenies during the Precambrian and Paleozoic eras. The early and middle Paleozoic rocks represent geosynclinal sequences which have been deformed and recrystalized to varying degrees during the disturbances discussed below.

Younger, relatively unchanged rocks are found in the Carboniferous basins in southeastern New England and in the Triassic-Jurassic basins in south-central New England and New Jersey-Pennsylvania.

The youngest igneous activity in New England took place in the Mesozoic Era. The passive emplacement of the White Mountain series during the Jurassic and Cretaceous periods, and the slightly younger activity of the Monteregian Hills during the Cretaceous period, appear to be the last tectonic activity.

Precambrian

Differences have been recognized between the Precambrian rocks in the western part of New England and those of eastern New England. Basement rocks of western New England belong to the Grenville province. The older Precambrian rocks in this province include those in the core of the Adirondack Mountains and those of the Green Mountain, Berkshire, Housatonic, and Hudson Highlands massifs (Figure 2.5.1-6). Isachsen (1964) considers the Manhattan Prong to be Precambrian and is considered by Naylor (1975) to be part of the western basement. These rocks are characterized by high temperature, high pressure (granulite facies) metamorphism at 1,100 to 1,200 m.y.a. and may include units that formed significantly earlier (Naylor 1976). Rodgers (1968a) suggests that the eastern edge of the North American continent during the Cambrian and Early Ordovician periods coincided with the eastern edge of these massifs.

Precambrian rocks of eastern New England are believed to be associated with the Avalonian orogeny (Rodgers 1972). At Hoppin Hill, Massachusetts, the Dedham Granodiorite is unconformably overlain by lower Cambrian slate that is lithologically similar to sequences in Newfoundland (Skehan 1968). The eastern basement is considered to be a thick sequence of predominantly mafic volcanic rocks with intercalated metasedimentary rocks and granitic to gabbroic plutons lying underneath fossiliferous lower and middle Cambrian strata (Naylor 1976). Rubidium-strontium (Rb-Sr) whole-rock ages for the Hoppin Hill Granite, Northbridge and Milford Granite, and the Dedham Granodiorite date from 514 to 591 m.y.a. (Fairbairn et al., 1967). The eastern basement is nowhere characterized by granulite facies metamorphism and has not yielded zircon or rubidium-strontium whole-rock ages greater than 650 m.y.a. This basement represents a period of widespread volcanism and plutonism with peak activity between 600 and 650 m.y.a. (Naylor 1975). The eastern basement lies, for the most part, east of the Lake Char-Clinton Newbury fault system. Naylor (1976) considers the gneisses along the southeastern coast of Connecticut to be part of the eastern basement and not an eastward extension of the Bronson Hill sequence. The Millstone site lies in this sequence and it is discussed in greater detail in Section 2.5.1.2. Late Precambrian through early Devonian stratified sequences occupy most of the area between the eastern and western basements (Naylor 1975).

Early Paleozoic

Two bands of Cambrian rocks are observed in New England; one along the Hudson and Champlain Valleys extending northward to Quebec, and the other in scattered outcrops along the present-day coast (Theokritoff 1968). The western band was a sand-carbonate shelf sloping steeply eastward and grading into a basin of mud deposition. The eastern band consists mainly of mud deposits around nonvolcanic islands. During early and middle Cambrian, Pacific province faunas occupied sites on the shelf and adjacent parts of the basin, whereas Acado-Baltic faunas occupied sites around the island chains (Theokritoff 1968).

Sedimentation continued into the Ordovician period. In early middle Ordovician, much of both the platform carbonates and terrain to the east were folded and became emergent (Berry 1968).

Breaks in deposition are noted by unconformities throughout New England. The uplifts caused instabilities including the submarine gravity slides of the Taconics, the folding and emergence of land masses to the east, and the deposition of deltaic sediments westward from these lands (Berry 1968). The uplifts were the surface effects of the orogenic deformation at depth accompanied by low-grade metamorphism (Rodgers 1970). Also associated with these events, referred to as the Taconian orogeny, was the intrusion of plutons related to the Highlandcroft magma series (Berry 1968). During much of middle Ordovician time, a series of volcanoes and islands existed along the present day Bronson Hill anticlinorium. Much of eastern Connecticut is underlain by metasedimentary, metavolcanic, and plutonic rocks related to this volcanic-island chain.

Activity related to the Taconian orogeny occurred as a discontinuous series of disturbances between 450 to 500 m.y.a. with the area of maximum deformation located in western New England (Rodgers 1970).

Middle Paleozoic

During the Silurian period, those areas uplifted by the Taconian orogeny were gradually encroached upon and eventually covered (Boucot 1968). Volcanic rocks continued to be deposited along the Bronson Hill anticlinorium and volcanic activity became apparent along the Avalonian belt from southern New Brunswick through southeastern Maine to eastern Massachusetts (Rodgers 1970). A belt coinciding with the present-day Merrimack synclinorium was the locus of the thickest sequence of Silurian sediment in the New England region (Boucot 1968). Graywackes and thick argillaceous sandstones characterize this sequence.

Carbonate sequences reached a maximum in the earliest part of the Devonian period in western New England (Rodgers 1970, Boucot 1968). Clastic material was deposited upon this calcareous sequence as the land mass to the east expanded westward (Boucot 1968).

By middle Devonian, deposition had ceased throughout the region and the area then underwent its most severe deformation, metamorphism, and granitic intrusions (Rodgers 1970). The Acadian Orogeny is responsible for most of the folding in the rocks presently exposed through the region. The belt of maximum intensity of this activity extends southward from central Newfoundland to eastern Connecticut (Rodgers 1970). Faulting related to the Acadian Orogeny is widespread throughout the region. Disturbance of the regional metamorphic isograds indicates that folding and faulting continued after the peak of metamorphism (Thompson et al., 1968).

Late Paleozoic

The deposition of material from this period is concentrated in the southeastern part of the region. The Boston Basin of eastern Massachusetts and the Narragansett, Norfolk, Woonsocket, and Scituate Basins of Rhode Island and southeastern Massachusetts are the only remnants of sedimentation. Rocks in these basins consist generally of coarse clastic sediments of continental origin. The basins are controlled by faulting; the Boston Basin by high-angle reverse faulting (Nelson 1976) and the Narragansett by high-angle normal faulting (Weston Observatory 1976). Metamorphism has only slightly affected the Boston Basin, whereas the Narragansett Basin has, in the southwest portion, been metamorphosed to staurolite grade, with the grade of metamorphism decreasing to essentially none at the northern extent of the basin.

Deformation during the late Paleozoic is not widespread throughout New England. The Alleghenian orogeny has affected some areas of southern New England. The major manifestation of this orogeny is the granitic intrusion in southern Rhode Island and Connecticut. The gentle folding and the metamorphism of the Narragansett Basin sediments may also be attributed to the Alleghenian orogeny. Activity along the region's extensive system of thrust faults may have continued into the Permian period. A thermal disturbance yielding K-Ar dates of 230 to 260 m.y.a. has been observed in an area 60 to 80 miles wide extending northward from the southern Connecticut coast to southwestern Maine, the cause of which is still unknown (Zartman et al., 1970). The igneous activity in Rhode Island and Connecticut may account for the southern extent; however, Permian granitic intrusions are not observed further north. Granitic and pegmatitic intrusions related to the Westerly Granite intrude the Monson Gneiss at the Millstone site. Potassium-argon dating (NNECO. 1975) also indicates that the Monson Gneiss at the site has been affected by the thermal disturbance described by Zartman et al. (1970) (Section 2.5.1.2).

Mesozoic and Cenozoic

Toward the end of the Triassic period, a series of linear, generally fault-bounded troughs formed in which continental clastic sediments and volcanics accumulated. Two of these basins are apparent in this region: the Connecticut Valley Triassic Basin and the Newark-Delaware Basin (Figure 2.5.1-9). Similar basins beneath and beyond the continental shelf off the eastern and southern coasts of New England have been inferred by geophysical studies (Sheridan 1974, Ballard and Uchupi 1972 and 1975, Mayhew 1974). Dikes of Triassic-Jurassic age are common throughout the region. High-angle faulting related to the rifting is also widespread throughout southern New England (Section 2.5.1.1.4.2).

Igneous activity in the region continued with the intrusion of the White Mountain plutonic-volcanic series. These rocks are found from northern to southeastern New Hampshire, southern Maine, and east central Vermont. Age determinations indicate that activity associated with the White Mountain series began in the Triassic and continued into the early Cretaceous period, 216 to 112 m.y.a. (Foland et al., 1971, Armstrong and Stump 1971). This plutonism-volcanism represents the last known localized tectonic activity that has occurred in the region of the site. Further north, igneous activity continued with the intrusion of the Monteregian Hills plutonic rocks. The latest activity associated with the Monteregian Hills is approximately 100 m.y.a. (NUSCO. 1974).

The Appalachian Mountains have apparently undergone continuous erosion since late Paleozoic except in the areas of down-dropped Triassic fault blocks (Rodgers 1967). After Jurassic peneplanation of the Piedmont Plateau and what presently underlies the Coastal Plain, a broad area parallel to the coast was submerged. Material eroded from the exposed Piedmont was deposited in the coastal area in the form of a seaward thickening wedge. This wedge is dominantly Cretaceous in age (Figures 2.5.1-2 and 2.5.1-5), but includes some thin deposits of Tertiary age.

During the Pleistocene epoch, all of New England was covered with ice. Before glaciation began, the principal valleys, ridges, and hills had already been shaped by long-continued erosion and, except in detail, were similar to those of today (Flint 1975). The ice scoured the land leaving scattered deposits throughout the area and advancing to and beyond the southern New England coast. Glacial deposits are the sole rock type exposed on eastern Long Island, Cape Cod, and Nantucket. The ice began to retreat from the Connecticut coast approximately 15,000 years ago (Flint 1975). Temporary advances and retreats of the front of the glacier caused deposits of end moraines prominent throughout southern Connecticut and Rhode Island (Flint 1975). Pleistocene deposition on the submerged Coastal Plain is dominated by a complex series of sedimentary sequences separated by unconformities. These relationships are the result of fluvial and marine processes active during regressions and transgressions of the sea (Knott and Hoskins 1968).

2.5.1.2 SITE GEOLOGY

The Millstone site is located at the southern tip of Millstone Point in Waterford, Connecticut. The site is a low lying peninsula within the Seaboard Lowland section of the New England physiographic province. Its physiography is discussed in Section 2.5.1.2.1.

The Millstone area, like the rest of New England, was covered with glacial ice until approximately 15,000 years ago. The glaciers deposited a thick layer of glacial till and, as they receded, left end moraine and outwash deposits. The surficial geology of the area surrounding the Millstone site is shown on Figure 2.5.1-3.

The bedrock geology is characterized by extensive deformation, metamorphism, and intrusion by igneous bodies. The bedrock geology of the 5-mile radius is shown on Figure 2.5.1-13.

The geology of the eastern portion of Connecticut is made difficult to decipher by the complex folding and faulting of the Late Paleozoic era. The tectonic features of the eastern section of Connecticut are shown on Figure 2.5.1-14. As shown on this figure, the Millstone site lies approximately 30 miles east of the Triassic Border fault, and approximately 15 miles south of the Honey Hill fault. The area south of the Honey Hill fault is complexly folded. The site lies on the east limb of the recumbent Hunts Brook syncline which mantles the Lyme dome. The site location with relation to these structures is shown on Figure 2.5.1-14.

2.5.1.2.1 Site Physiography

The Seaboard Lowland section of the New England physiographic province narrows along the Connecticut coast, as shown by Figure 2.5.1-1. In the Millstone Point area, this section narrows to approximately 15 miles, bordered on the north by the New England Upland section and just south of the site by the Coastal Plain physiographic province.

The most striking topographic expression in the area is the north-south trending ridges and valleys. The area is drained by a number of brooks and also the Thames, Niantic, and the Connecticut Rivers, the latter approximately 8 miles west of the site.

Glacial deposits dominate the Seaboard Lowland province in the Millstone area. Till covers much of the bedrock surface on both hills and smaller valleys, showing that the bedrock had been sculptured, by weathering and rainwater runoff, essentially to its surface existing before glaciation occurred (Flint 1975). End moraine and glacial stream deposits are also prevalent throughout the region (Figure 2.5.1-3).

The Millstone site is located on a small peninsula near the mouth of the Niantic River. Wave action has eroded the blanket of till from the promontories of Millstone Point, exposing rock. The reworked material was deposited as beach sand in the protected areas. Eolian deposits are found in some locations, and tidal marshes and swampy areas are common.

Much of the plant area has been graded and backfilled during the construction of the three units of the power generating facilities now at Millstone Point.

There is no physiographic evidence indicative of actual or potential localized subsidence, mass wasting, or landslides in the vicinity of the site.

2.5.1.2.2 Local Stratigraphy

The site surficial and site bedrock maps are shown as Figures 2.5.1-3 and 2.5.1-13, respectively. These maps cover approximately the area within the 5-mile radius of the site. The age relationships and descriptions of the differing bedrock units found within this region are shown on Figure 2.5.1-13.

The site is underlain by the Monson gneiss of pre-Silurian age and the Westerly Granite of Pennsylvanian or younger age. The bedrock units shown on Figure 2.5.1-13 are dominated by metasedimentary and metavolcanic rocks of Cambrian or possibly Precambrian or Ordovician age. The metasedimentary and metavolcanic units have been intruded by several granitic masses, of which the Sterling Plutonic Group is the oldest. The granitic gneisses seem to have been emplaced at fairly deep levels in the crust, for they are associated with migmatites and are intimately intermingled with, and grade into, some associated metasedimentary and metavolcanic gneisses (Goldsmith and Dixon 1968). The Sterling gneiss units have not been noted stratigraphically above the Monson gneiss in the site area. The younger granitic intrusions are the nodular granites located in the Lyme dome and the Westerly Granite located along the coastline. These granites are believed to be Permian in age (Goldsmith 1967b).

The distribution of Quaternary surficial material is shown on Figure 2.5.1-3. This material includes such glacial deposits as glacial till, end moraine deposits, and stream deposits. Younger swamp, littoral, alluvial, and eolian deposits also occur.

2.5.1.2.3 Site Stratigraphy

The excavation for Millstone 3 has been extensively mapped. These maps are shown and described in Section 2.5.4.1. In the site area, the bedrock surface is very irregular and completely covered with glacial till. Construction activities from Millstone 1 and 2 disturbed the naturally deposited material in the site area which, for the most part, was replaced with artificial fill.

The Monson gneiss is the main rock found at the site, as shown on Figure 2.5.1-13. This rock is a biotite-quartz-andesine gneiss. Petrographic analyses indicate that the main constituents are: plagioclase (45 percent), quartz (35 percent), and biotite (15 percent). Sericite, garnet, apatite, epidote-clinozoisite, and zircon are also present (NNECo. 1975). The Monson gneiss is medium-grained, light gray with strong biotite foliation. A number of biotite segregation bands were observed throughout the excavation (Section 2.5.4).

The Monson gneiss is intruded by pegmatite and granite sills related to the Westerly Granite which was quarried on Millstone Point until 1960. The distinction between a granitic and a pegmatitic intrusion is a subtle one. Both intrusions are related to the same source and variable grain sizes are inherent in each. The Westerly Granite is considered to be a dike rock consisting of gray to pink, fine-to-medium-grained, equigranular granite composed of oligoclase, microcline, and quartz. The pegmatitic intrusions are similar in composition to the Westerly Granite intrusions except for their coarser grain size. Biotite, muscovite, and accessory minerals are also present in smaller percentages (Goldsmith 1967b, Lundgren 1967).

The entire bedrock surface at Millstone is covered by a layer of glacial till consisting of both basal and ablation tills. The basal till is a dense, unsorted soil material plastered and compacted into place by the weight and dynamic pressure of an actively moving glacier. The ablation till was deposited as the ice retreated. It is generally an unsorted material and, because it was subjected to a lighter load than the basal till, it is less dense.

The basal till consists of a mixture of cobble and boulder size rock fragments, gravel size material, sand, and some silt binder. The ablation till is irregularly stratified with lenses of sand and gravel and mixtures of cobbles, gravel, sand, and silts.

Glacial stream deposits are also present on Millstone Point (Figure 2.5.1-3), for the most part consisting of stratified sands with some silts and gravel.

Younger beach, swamp, and marsh deposits are also observed in the site area (Figure 2.5.1-3). The beach deposits are chiefly well sorted sand and pebbly gravel deposited by current and wave action.

2.5.1.2.4 Local Structural Geology

The Millstone site lies on the southeastern coast of Connecticut. The regional tectonic map (Figure 2.5.1-6) shows the location of the site with respect to the major structural features of New England. Figure 2.5.1-14 illustrates the generalized tectonic elements of eastern Connecticut and Figure 2.5.1-13 shows the structure within the 5-mile radius.

The tectonic map of eastern Connecticut (Figure 2.5.1-14) shows the major folds and faults that have affected the region. Three orogenies (Taconian, Acadian, Alleghenian) have structurally left their imprint on a series of complexly deformed rocks. As shown by the site bedrock geology map (Figure 2.5.1-13), the Lyme dome, Hunts Brook syncline, and two smaller anticlines lie within the site area. The larger structural features, such as the Bronson Hill anticlinorium, the Merrimack synclinorium, and the Lake Char-Honey Hill fault system, have been discussed in Sections 2.5.1.1.2 and 2.5.1.1.4.2 and are shown on Figure 2.5.1-6.

The structural trend south of Honey Hill is generally east-west, whereas, in the remaining portions of the state, the structural trends are north-south, paralleling the regional trend.

The north-south and east-west structures tend to meet in the Killingworth dome. This is not a simple dome and must have reached its present form and acquired its complicated internal structure in several stages (Lundgren and Thurrell 1973). Recumbent isoclinal folds are common throughout and the dome itself may consist of a series of antiforms and synforms.

The Lyme dome, east of the Killingworth dome (Figure 2.5.1-14), also appears to be a simple anticlinal structure; however, the dome is mantled by the folded isoclinal Hunts Brooks syncline. The extent of the dome is marked by the contact between the Mamacoke Formation, Monson gneiss, or the Brimfield schist with the Plainfield Formation (Figure 2.5.1-13). The broad internal structure of the dome is indicated by the pattern of the middle unit of the Plainfield Formation and the alaskite units (Sterling Plutonic Group) and by the foliation pattern (Lundgren 1967). Distribution of the stratigraphic units indicates that the dome is a northward plunging anticline. The Lyme dome lies just west of the Millstone site (Figure 2.5.1-13).

The Selden Neck dome, which parallels the Honey Hill fault, is the last major dome south of the fault. This dome is essentially an overturned, possibly recumbent, anticline having a folded axial surface that dips north or northwest (Lundgren 1966).

The Hunts Brook syncline, which separates the Selden Neck dome from the Lyme dome, is the last prominent fold south of the Honey Hill fault. The isoclinal syncline bends around the Lyme dome and the trace of the axial plane lies within the belt of the Brimfield schist and the Tatnic Hill Formation. The axial plane of the Hunts Brook syncline dips away from the Lyme dome; in the Millstone area, the syncline dips to the east with the site lying on the overturned limb.

The Hunts Brook syncline meets the Chester syncline in the Killingworth dome area. Lundgren (1966) has proposed two theories concerning the relationship between these two synclines. If the Hunts Brook syncline is a folded overturned syncline with a nearly horizontal axis, then this axis probably meets the axis of the Chester syncline at a right angle, implying that the Hunts Brook formed after or during the development of the recumbent Chester syncline. However, if the Hunts Brook syncline plunges steeply to the northwest, then it could merge with the Chester syncline beneath the Selden Neck dome (Lundgren 1966).

The Chester syncline is a recumbent isoclinal syncline trending north from the Killingworth dome region and exhibiting a complexly folded axial plane which parallels the Monson anticline until it reaches a point north of the Honey Hill fault which it parallels for some distance (Figure 2.5.1-14).

Two smaller anticlines are shown on Figure 2.5.1-13. Both are overturned isoclinal anticlines with their axial planes dipping to the northwest. The area is complexly folded and it appears that the two anticlines may actually be one.

Faulting is not conspicuous on quadrangle maps within the site area; however, faulting has played an important role in the geological history of southern Connecticut.

The Honey Hill fault (Section 2.5.1.1.4.2) lies approximately 15 miles north of the Millstone site. The closest mapped fault is approximately 10 miles northeast of the site in the Uncasville quadrangle (Figure 2.5.1-14). This fault trends north-south and is believed by Goldsmith (1973) to be a normal fault related to Triassic tectonics. The amount of displacement is unknown, but it is shown to cut the Honey Hill fault (Goldsmith 1967c). This faulting is thought to be related to the Lantern Hill fault further to the east due to its similar attitude. The Triassic Border fault lies approximately 30 miles west of the site (Figure 2.5.1-14).

A number of faults have been uncovered during the construction of Millstone 3 and are discussed in detail in Section 2.5.3.2.

2.5.1.2.4.1 Site Structural Geology

The Millstone site lies on the overturned eastern limb of the Hunts Brook syncline (Figure 2.5.1-13). The axial plane of the syncline in the site area dips to the east as shown on Section A-A of Figure 2.5.1-13. Detailed mapping of the excavation has yielded much information on the geology of Millstone Point (Sections 2.5.3.2 and 2.5.4.1).

The site is founded for the most part on the Monson gneiss which is part of a series of lower Paleozoic metavolcanic and metasedimentary rocks and granitic gneisses that underlie most of eastern Connecticut (Goldsmith and Dixon 1968). The Monson gneiss at the site area is light gray, medium grained, thinly layered with light feldspathic and dark biotite and hornblendic layers (Goldsmith 1976b). It consists of plagioglase (45 percent), quartz (35 percent), and biotite (15 percent) with accessories of garnet, apatite, epidote-clinozoisite, and zircon (NNECo. 1975). The foliation is a well defined alignment of biotite flakes. Figure 2.5.1-15 is a lower hemisphere plot showing the foliation readings taken from final grade mapping. The average foliation attitude for 344 points is N67W, 48NE. Segregation bands of biotite are apparent throughout the site.

The Monson gneiss has been intruded by a series of pegmatite and granite bodies. For the most part, these granitic intrusions are parallel to the foliation and believed to be related to the injection of the Westerly Granite (Goldsmith 1967b), which is a prominent intrusion throughout southeastern Connecticut and Rhode Island (Goldsmith 1967b).

Jointing is well developed at the site with the major joint set striking N03W and dipping 63NE. Figure 2.5.1-16 gives a contour diagram of poles to joint planes for the joints observed while mapping final grade. Minor joint sets have attitudes of N02W, 78SW; N69E, 74SE; and N48W, 07NE. The joints generally exhibit smooth, planar surfaces with a majority having a coating of chlorite and some showing iron oxide staining. Jointing at the site is discussed further in Sections 2.5.3.2.3. Slickensides were found in 241 locations. Figure 2.5.1-17 gives the contour plot of these data. The points are concentrated along the east-west axis, indicating that the major direction of displacement is east-west. The points also indicate the association of the slickensides with high angle planes, thus implying a minor readjustment of dip-slip type.

Eleven separate fault zones with numerous minor associated faults have been uncovered at the Millstone site. Section 2.5.3.2 discusses these faults in greater detail. All but one of the faults trend northerly and dip at high angles east or west. The other fault is a minor low angle thrust. Figure 2.5.1-18 shows the location of these faults. The faults are all incapable features with the last activity occurring approximately 142 m.y.a. Slickenside information and a section through fault 18 in the Millstone 2 and 3 condensate polishing facilities indicate that the faulting is of the normal type, with some oblique dip-slip movement.

2.5.1.2.5 Site Geological History

The geological history of southeastern Connecticut is obscured by the complex folding and metamorphism that the area has undergone. The Taconian, Acadian, and Alleghenian orogenies have affected the area to a varying extent (Goldsmith and Dixon 1968).

The ages of the rocks present in the site area are still in doubt. The Monson gneiss, the New London gneiss, the Mamacoke Formation, and the Plainfield Formation are pre-Silurian in age, and most probably the rocks range in age from late Precambrian or Cambrian to Ordovician, (Goldsmith 1976). The Brimfield schist, which lies unconformably beneath the Bolton Group, is similar to and can be traced into the Partridge Formation and the Ammonoosuc volcanics of Middle Ordovician age (Goldsmith and Dixon 1968). Two major plutonic rocks are present in the site area, the Sterling Plutonic Group and the Westerly Granite. The older Sterling Plutonic Group is believed to be Cambrian or older in southern Connecticut and does not occur stratigraphically above the Monson Gneiss around Millstone Point (Goldsmith and Dixon 1968). However, the Sterling Group is younger that the Monson gneiss, so the Sterling may be Ordovician or younger. The youngest rock type present in the site area is the Westerly Granite, which is regarded as Permian (Lundgren 1967). A granitic intrusion other than the Sterling Plutonic Group or Westerly Granite occurs in the Lyme dome. This nodular granite is believed to be older than the Westerly Granite and younger than the granitic intrusions of the Sterling Plutonic Group (Goldsmith 1967b).

The relationship of the rocks within the site area is shown on the stratigraphic chart for the surrounding area (Figure 2.5.1-7) and described in Tables 2.5.1-1 through 2.5.1-7. Figure 2.5.1-13 shows the distribution of the bedrock units.

The origin of the oldest rocks found in the site area, the Plainfield and the Mamacoke Formations, is obscure. These probably were originally quartz sandstone, limestone and dolostone, and shale (Lundgren 1966). The age of these rocks is still questioned, although it is believed that the rocks are of Cambrian age (Page 1976). The remaining rocks in the site region with the exception of the Nodular and Westerly Granites are probably Ordovician in age.

The Monson and New London gneisses are believed to be metamorphosed andesitic and dacitic volcanics and associated intrusions (Lundgren 1967). As mentioned in Section 2.5.1.1.5, the present day Bronson Hill anticlinorium was the location of a series of volcanoes and islands which served as a source area for much of the middle Ordovician period.

The Sterling Plutonic Group is present throughout much of the site area. The youngest unit it intrudes is the Monson gneiss. The age of the Sterling Group is still questioned. Radiometric dates for contiguous granitic gneisses in southern Connecticut suggest a Cambrian or older age (Goldsmith and Dixon 1968). However, the Monson gneiss, outside of the site area, has been dated as 472 m.y.a. ±15 (Brookins and Hurley 1965) and radiometric work by Zartman et al. (1965) implies that the Quinebaug Formation, correlated with the Monson, is middle Ordovician. The Sterling gneisses seem to have been emplaced at fairly deep levels in the crust, for they are associated with migmatites and are intimately intermingled with and grade into some associated metasedimentary and metavolcanic gneisses (Goldsmith and Dixon 1968). The Sterling Plutonic Group is widespread in Rhode Island, underlying most of the central portion of the state and considered to be late Precambrian or Cambrian in age.

Thus, the age relations are problematic and have not been resolved to date.

The Brimfield schist consisted originally of shale imbedded with minor amounts of quartz, sandstone, limestone, andesitic and basaltic pyroclastics, and manganese-bearing chert. The deposition of this pelitic unit represents a major change in the character of sedimentation, as volcanic rocks are of subordinate importance in the section above the base of the Brimfield and Tatnic Hill Formations (Lundgren 1964). The Brimfield and Tatnic Hill Formations may have been deposited as geographically separate facies of a single stratigraphic unit (Lundgren 1964). The Brimfield schist is the youngest pre-Pennsylvanian rock found within the site area.

Much of the deformation that occurred in the Millstone area has been attributed to the Acadian orogeny, which affected much of central and eastern New England. The initial stages in the formation of the complex structure now observed are the north-south trending recumbent isoclinal folds (Monson anticline and Chester syncline) which were formed in response to an east-west compression during early stages of post-Silurian metamorphism (Figure 2.5.1-14) (Lundgren 1964). Deformations continued with the development of the east-west trending anticlines and synclines, the Selden Neck dome and Hunts Brook syncline, respectively. Most of the major features of the map pattern in the rocks south of the Honey Hill fault are the combined result of the formation of the Lyme dome and the antiform at Chester. This uplift deformed the Hunts Brook syncline, the Selden Neck dome, and the Honey Hill fault, resulting in the present structural configuration.

Metamorphism accompanied the structural development mentioned above. Metamorphism of all the rocks produced assemblages characteristic of the upper amphibolite facies (Lundgren 1966). Lundgren (1964) believes the metamorphism took place when the rocks were deeply buried, probably at depths of 15 to 20 kilometers where the temperature was 550 to 650°C. Metamorphism presumably began during the Devonian period but may have continued into the Permian (Lundgren 1963).

The Honey Hill faulting also was initiated during the Acadian orogeny as part of the eastward displacement of the recumbent Chester syncline. Movement along the Honey Hill fault is believed to be southeasterly, continuing beyond the period of peak metamorphism (Dixon and Lundgren 1968).

Lundgren and Ebblin (1972) have proposed that the Honey Hill fault zone is related to the shearing between the Putnam Group and the underlying Ivoryton and Sterling Plutonic Groups during the folding and uplifts of the Acadian orogeny. Movement along the Honey Hill fault may have continued into the Permian period.

Following the highly active Acadian orogeny was a milder period of gentle folding, granitic intrusion, and localized thermal activity. The Alleghenian orogeny affected only the southeastern portion of New England, mainly Rhode Island and southeastern Connecticut. The main manifestation of the Alleghenian orogeny was the intrusion of the Narragansett Pier Granite and the Westerly Granite. The Pennsylvanian sediments of the Narragansett Basin of Rhode Island exhibit folding associated with this orogeny. The thermal activity is exhibited by a narrow band extending from southern Connecticut to southwestern Maine. These rocks yield potassium-argon dates of 230 to 260 m.y.a. The actual cause of this disturbance is still questioned although it could be attributed to contact metamorphism related to contemporaneous igneous activity, alteration associated with major faulting, regional metamorphism in late Paleozoic time, or burial followed by uplift and erosion (Zartman et al., 1970).

The Millstone site has been affected by thermal disturbance and granitic intrusion. Granitic intrusions parallel to the foliation of the Monson gneiss, folded and overturned during the Acadian orogeny, are widespread throughout the site area.

Potassium-argon dating of biotite from the gneiss and the granitic intrusions at the site yielded a range of ages from 208 to 273 m.y.a. (NNECo. 1975). At Millstone Point, the thermal disturbance could be attributed to contact metamorphism during emplacement of the Westerly Granite.

The most recently known expression of tectonic activity in the local area is faulting related to Triassic-Jurassic rifting. Small high angle faults and joints associated with the larger Triassic faults of the Triassic Basin (Figure 2.5.1-14) are common in the Clinton quadrangle to the west (Lundgren and Thurrell 1973) and in the Moodus and Colchester quadrangles to the north (Lundgren et al., 1971). Goldsmith (1967a) shows two small high-angle faults in the Uncasville quadrangle northeast of the site, which he believes to be related to the Triassic-Jurassic tectonics (Goldsmith 1973). No faults are shown adjacent to the site on the quadrangle maps. In the process of mapping the excavation at the Millstone site, eleven fault zones were uncovered (Section 2.5.3.2). Potassium-argon dating of clay gouge from some of these fault zones indicates that the last activity along these zones occurred about 142 m.y.a. Also associated with the Triassic-Jurassic periods are the deposits of arkosic clastic sediments in the Connecticut Basin, extrusive igneous activity, and related injection of basic dikes throughout southern New England. Hydrothermal activity, typically silicification, is commonly found along faults related to the Triassic-Jurassic tectonics. Rodgers (1975), Skehan (1975), and Goldsmith (1973) believe that the hydrothermal activity represents the youngest known tectonically related event in southern New England.

Recent study of dikes in southwestern Rhode Island and eastern Connecticut indicates that a few lamprophyre dikes may be as young as Cretaceous. Their relation to hydrothermal activity is not known.

Lundgren (1966) estimates an uplift of 15,000 to 20,000 feet occurred between the Permian and late Triassic periods. A long, continuous period of erosion followed, shaping principal valleys, ridges, and hills, similar to those of today (Flint 1975). Cretaceous and Tertiary sediments are present south of the site (Figure 2.5.1-2). The northernmost previous extent of these deposits is unknown. During Tertiary and Quaternary time, alternating periods of transgression and regression occurred along the coast of southern New England. The two major regressions took place during the Oligocene epoch and during the Pleistocene glaciation (Garrison 1970).

Evidence from outside the site area indicates that during the last million years or more, Connecticut was covered by continental glaciers at least twice, and possibly several times, however, evidence of only one glaciation is found locally (Flint 1975). The ice at its maximum reached its outer limit along a line on, or south of, what is now Long Island and culminated approximately 18,000 years ago (Flint 1975). Pollen studies and radiocarbon dates on samples taken in New London show that glaciation took place more than 13,000 years ago (Goldsmith 1960, 1962a). Caldwell (Appendix 2.5A), after visiting the Millstone site, indicated that the last deposition of till was approximately 18,000 years ago and that ice covered the area until about 14,000 years ago. The cumulative effect of the glaciation was to smooth, round off, and widen some of the valleys and to remove most of the pre-existing regolith (Flint 1975).

The Millstone area is covered with glacial till, end moraine deposits, and outwash sands as shown on Figure 2.5.1-3. The end moraines are common across Rhode Island and southern Connecticut. They were deposited when the recession of the glacial margin slowed or stopped for some period (Flint 1975).

Excavations along the discharge tunnel uncovered slumped and faulted ablation till and outwash deposits. These features were found to be quite common in the outwash and are believed to be related to penecontemporaneous soft sediment deformations, in some cases associated with melting out of buried ice blocks (NNECO. 1982).

Since the glacial period, the surficial geology has been most drastically changed by the rise in sea level, which reworked the glacial outwash and eroded till and rock promontories, then depositing this material on the beach to be reworked by the wind to form dunes.

2.5.1.2.6 Site Engineering Geology

All Category I structures at Millstone 3 are founded on rock, dense basal till, or compacted granular backfill. The properties of the subsurface materials are given in Section 2.5.4.2.

The country rock at the site is the Monson gneiss. This gneiss exhibits a well-developed foliation due to the alignment of biotite flakes. Segregation bands of biotite were also uncovered at the site. Figure 2.5.1-15 shows that the attitude of the foliation is quite consistent at N67E, 48NE. Jointing at the site is also very well-developed. The contour plot of the Lower Hemisphere projection (Figure 2.5.1-16) indicates one major joint set with three minor sets. The most prominent set has an average attitude of N03W, 63NE. The minor sets have attitudes of N02W, 78SW; N69E, 74SE; and N48W 07NE.

The combination of the weakness planes, joints, and foliation indicates that a potential for instability of rock slopes exists. This potential is explained in detail in Section 2.5.4.14.

The geology of the excavation is also described in Section 2.5.4.1. Maps showing the geology of the floors and walls of structure excavations accompany this description. During the mapping of the excavation, eleven fault zones were uncovered. The relationship between these faults is shown on Figure 2.5.1-18 and shown in greater detail on the geology maps associated with Section 2.5.4.1.

An old granite quarry is located in the Westerly Granite about 1,200 feet south-southeast of the plant area. This quarry was in operation as an open pit, unsupported excavation from 1830 to 1960. The rock is sound and self-supporting, and this excavation does not influence the stability of the site in any way. Neither the Westerly Granite nor the Monson gneiss are ore-bearing and there are no mining activities at present and none are anticipated in the future.

Both the basal and overlying ablation tills are relatively impervious. The only water flow through the gneiss noted during construction was along intersecting joints that extended upward to the surface. This flow was handled quite readily by sumps located throughout the excavation. Permanent sumps have been located around the structures to take care of this groundwater flow during the operation of the plant. The site groundwater conditions are covered in detail in Section 2.4.13 and the structure dewatering system is described in Section 3.8.5.1.

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TABLE 2.5.1–1 ROCK FORMATIONS OF THE COASTAL PLAIN OFF SOUTHERN NEW ENGLAND

CLICK HERE TO SEE TABLE 2.5.1-1

TABLE 2.5.1–2 ROCK FORMATIONS OF WESTERN CONNECTICUT

CLICK HERE TO SEE TABLE 2.5.1-2

TABLE 2.5.1–3 ROCK FORMATIONS OF EASTERN CONNECTICUT AND WESTERN RHODE ISLAND

CLICK HERE TO SEE TABLE 2.5.1-3

TABLE 2.5.1–4 ROCK FORMATIONS OF CENTRAL RHODE ISLAND (AND NOT INCLUDED IN PREVIOUS DESCRIPTIONS)

CLICK HERE TO SEE TABLE 2.5.1-4

TABLE 2.5.1–5 ROCK FORMATIONS IN NORTHERN AND EASTERN RHODE ISLAND AND SOUTHERN MASSACHUSETTS

CLICK HERE TO SEE TABLE 2.5.1-5

TABLE 2.5.1–6 ROCK FORMATIONS OF CENTRAL MASSACHUSETTS

CLICK HERE TO SEE TABLE 2.5.1-6

TABLE 2.5.1–7 EAST OF CLINTON-NEWBURY FAULT SYSTEM, EASTERN MASSACHUSETTS, AND NEW HAMPSHIRE

CLICK HERE TO SEE TABLE 2.5.1-7

TABLE 2.5.1–8 DESCRIPTIONS OF LINEAMENTS FROM LANDSAT PHOTOGRAPHS (SHOWN ON FIGURE 2.5.1-10)

CLICK HERE TO SEE TABLE 2.5.1-8

2.5.2 VIBRATORY GROUND MOTION

The site region is characterized by earthquakes of low to moderate intensity. During the past 300 years, only 13 earthquakes greater than or equal to Intensity V Modified Mercalli (MM) have been reported within 50 miles of the site. The site lies in the Southeastern New England-Maritime Tectonic Province. The largest earthquake in this province was an Intensity VI (MM) event which occurred in 1904 east of Eastport, Maine. Two moderate size earthquakes have occurred in the Moodus, Connecticut area, located in the adjacent New England Province, in 1568 (Intensity VII (MM)) and 1791 (Intensity VI-VII (MM)). The maximum earthquake potential at the site is assumed to be due to an earthquake of Intensity VII (MM) occurring close to the site. This corresponds to a peak ground acceleration of 0.10 g. The safe shutdown earthquake (SSE) has conservatively been specified as 0.17 g. The operating basis earthquake (OBE) has been specified as 0.09 g, which corresponds to approximately half the SSE.

2.5.2.1 SEISMICITY

Most of the information on earthquake activity in the northeastern United States is based on historical reports, old diaries, and newspaper accounts. These earthquakes are classified on the basis of intensity corresponding to the Modified Mercalli scale. This scale, developed in 1931 and described in Table 2.5.2-1, is based on observations of the effects of earthquakes and damage to structures. The instrumental monitoring of earthquakes began in the mid 1920s in the northeastern United States. Magnitude, a measure of earthquake energy, is determined from instrumental data. The number of seismographic stations has greatly increased in recent times. At present, Weston Observatory of Boston College, Lamont-Doherty Geological Observatory of Columbia University, Massachusetts Institute of Technology, University of Connecticut, Pennsylvania State University, and Delaware Geological Survey operate seismographic stations in the northeast and coordinate the publication of the Northeastern United States Seismic Network (NEUSSN) bulletin. Figure 2.5.2-1 shows the location of stations in this network and Table 2.5.2-2 lists the locations and other pertinent data for these stations. Historical reports of earthquakes and information obtained from instrumental coverage in recent years form the basis of this examination of the seismicity of the site region.

2.5.2.1.1 Completeness and Reliability of Earthquake Cataloging

Even though major historical catalogs carry entries dating back almost three centuries, the coverage of this period is not continuous. The completeness and reliability of the data are related to population distribution and, recently, to the seismograph network coverage. Therefore, accuracy of epicentral coordinates and the assigned maximum intensities must be evaluated carefully.

For the earlier historical events, epicenters were located closer to population centers due to the absence of reports from the true epicentral area. The intensity of an earthquake at a given location depends not only on accurate and complete human observations, but also on foundation conditions, design, type, and quality of building construction. Construction practices, particularly of chimneys in the earlier centuries, were certainly not those envisioned in the Modified Mercalli scale. Interpretation of historical damage reports, without consideration of construction practices or subsurface conditions, may result in erroneously high intensities.

Seismological information for the instrumental period (since 1900) must also be evaluated carefully. Seismic instrumentation began in the early 1900s in the United States and Canada with progressively improved quality of earthquake data. Epicentral locations based on felt reports were complemented and somewhat controlled by instrumental data. From the 1900s until the 1960s, only a few seismographs operated in the eastern United States. Most of these stations were part of the regional network operated by the Jesuit Seismological Association. In the early decades, numerous factors, such as the type of instrumental response, lack of accurate time control, awkward configuration, use of graphical methods, and limited knowledge of crustal velocities were potential sources of errors. These produced large uncertainties in the epicentral coordinates which, in many cases, amounted to tens of kilometers.

Since the 1960s, increased interest in understanding local seismicity has resulted in the implementation of dense seismographic networks. Seismic data in the northeastern United States are now gathered by NEUSSN and reported in its bulletin. NEUSSN reports earthquake hypocentral locations and magnitudes determined through the cooperation of several institutions. Although the coverage of this network is uneven, it is now capable of detecting and locating all earthquakes in New England of magnitude greater than or equal to 2.0 (Chiburis 1979; Sbar and Sykes 1977). Chiburis (1979) has recently examined the seismicity of New England based on recent earthquakes and has reevaluated the location and intensity of several earlier events.

2.5.2.1.2 Earthquake History

Studies of the earthquake history of the site region are based on the Chiburis (1979) catalog. Table 2.5.2-3 lists all earthquakes with intensity greater than or equal to IV (MM) within 200 miles of the site and all instrumentally located earthquakes regardless of magnitude. The table also lists the date, origin time, epicentral coordinates, epicentral intensity, magnitude, seismic moment, and a description of location. Except for the seismic moments, which were determined by Street and Turcotte (1977), all other information is from Chiburis (1979). The earthquakes listed in Table 2.5.2-3 and plotted on Figure 2.5.2-2 show that the site is located in an area of low to moderate seismicity.

The cumulative historical seismicity data (Figure 2.5.2-2) reveal the presence of several distinct areas of concentrated seismic activity. They are: Moodus, Connecticut; Narragansett Bay, Rhode Island; Cape Ann, Massachusetts; the area around Ossipee, New Hampshire; northern New York; southeastern New York; northeastern New Jersey; and the Hudson River Valley. These are discussed in terms of their location, areal extent, level of historical seismicity, and their tectonic framework as inferred from current research.

Activity in Southern New England

Areas of central Connecticut, near East Haddam and Moodus, and the region near Narragansett Bay in Rhode Island and southeastern Massachusetts have experienced a low level of activity.

The largest events for this region are the Intensity VII (MM) (1568), and the Intensity VI-VII (MM) (1574, 1791) East Haddam earthquakes. More recent activity is restricted to several lesser events ranging in magnitude to approximately 3.5.

Activity in Southeastern New York and Northeastern New Jersey

The seismic activity in southeastern New York, eastern Pennsylvania, and New Jersey is characterized by several repeated occurrences of Intensity VII (MM) earthquakes. Three of these events occurred near New York City in 1737, 1884, and 1927. Two others occurred in southwestern New Jersey in 1840 and 1871. Several Intensity VI events are also distributed throughout this area of low level activity.

Recent investigations by Page et al. (1968), Aggarwal and Sykes(1978), and Sbar and Sykes (1977) propose a spatial correlation of instrumentally recorded, small earthquakes with the Ramapo fault system, which extends in a northeasterly direction parallel to the Appalachian trend in this region. Available focal mechanism solutions for this area, by Aggarwal and Sykes (1978), suggest high angle reverse faulting along planes that parallel mapped or inferred segments of the northeast-trending Ramapo system.

White Mountains Plutons

The area of central New Hampshire and northeastern Massachusetts, including the Cape Ann area, once considered to be a segment of a continuous Boston-Ottawa seismic trend by Sbar and Sykes (1973), is presently interpreted as a separate seismic region. Recently, Sbar and Sykes (1977) have recognized the presence of a seismicity gap in Vermont and western New Hampshire.

Extensive regional investigations, geological and geophysical, conducted for the Preliminary Safety Analysis Report (PSAR) of Pilgrim Unit 2 (BECo 1976a), have stressed the individual entity of this seismic zone. The largest events to affect this region are the Intensity VIII (MM) Cape Ann earthquake of 1755 and three Intensity VII (MM) events, one near Cape Ann in 1727, and two near Ossipee, New Hampshire on December 20 and 24, 1940. Street and Turcotte (1977) suggest a magnitude of 5.4 for the Ossipee events, based on reanalysis of several seismograms. The larger earthquakes in the Ossipee and Cape Ann areas have been individually correlated to certain plutons of the White Mountains series in combination with anomalous country rock faulting in the Pilgrim Unit 2 PSAR (BECo 1976a), whereas the Nuclear Regulatory Commission has associated these earthquakes with a larger zone of weakness, and the United States Geological Survey, following Hadley and Devine (1974), has correlated the earthquakes with northeast-trending faults.

Recent activity in this region, including central New Hampshire and the Cape Ann area, appears to be low. Two events ranging in magnitude to just over 3.0 have been reported in the last decade.

Northern Coastal Zone

The seismicity of Maine, characterized by a maximum Intensity VI (MM), is spatially distributed in the central and west-central regions, the New Brunswick border area, and the Quebec border region near northern New Hampshire.

Two Intensity VI (MM) earthquakes, one located in the ocean off Portland in 1957 and the other near the Maine-Quebec border in 1973, are both assigned magnitudes of 4.8. For the 1973 event, Wetmiller (1975) determined an oblique strike-slip focal mechanism with nodal planes oriented NO4E and N37W.

Hudson River Valley

Few earthquake epicenters have been located in the Hudson River Valley. The largest of these earthquakes was Intensity VII (MM) near Lake George, New York, on April 20, 1931.

Although a number of large earthquakes (Intensity IX-XI (MM)) have occurred in the St. Lawrence River Valley, these earthquakes fall outside the 200-mile radius and, therefore, are discussed in Section 2.5.2.4 with relation to maximum earthquake potential at the site.

The cumulative historical seismicity data, carefully interpreted, can yield valuable information on the spatial and temporal distribution of larger and more significant earthquake events and the location of zones of concentrated activity. Four years of operation of the NEUSSN have produced a complete record of accurately located events of magnitude 1.8 to 2.0 and larger in the region. Sbar and Sykes (1977) and Chiburis (1979) have noted that the spatial distribution of this instrumental seismicity closely tracks the distribution of less accurately located historical events, thus reinforcing confidence that older events are fairly well located and that areas of seismic activity are relatively stationary.

2.5.2.1.3 Seismicity within 50 Miles of the Site

Earthquake activity within 50 miles of the site is listed in Table 2.5.2-4 and shown on Figure 2.5.2-3. There have been 50 earthquakes of intensity greater than or equal to Intensity IV (MM). Almost half of this earthquake activity has occurred in the Moodus-East Haddam area, about 25 miles northwest of the site. A temporary microearthquake network (five stations) has been installed in this area by Professor E. Chiburis of Weston Observatory to examine the nature and significance of this activity.

Large earthquakes have occurred in the Moodus area in 1568, with epicentral Intensity VII (MM), and on May 16, 1791, with Intensity VI-VII (MM) (Chiburis 1979). The earthquake of May 16, 1791, was felt over an area of 35,000 square miles extending from Boston to New York. Several aftershocks were reported for the next few days.

Since 1791, at least 40 earthquakes have been lightly felt in the East Haddam-Moodus area. A moderate earthquake took place in the same epicentral area on November 14, 1925 and, although it reportedly did some minor damage at Hartford and Windham, it was not strong enough to be recorded on seismographs in Cambridge, Massachusetts, or New York City. The last felt earthquake to occur in this general area took place on November 3, 1968 with an instrumentally determined epicenter about 19 miles northwest of the site. The earthquake had a maximum intensity of IV (MM) and was generally felt from Old Lyme, Connecticut, on the south to East Hartford on the north. The most recent earthquake in the Moodus area was of magnitude 2.2 in 1976.

Earthquake activity within 10 miles of the site has been limited to four very slight earthquakes with maximum intensities of Intensity III (MM). Two of these earthquakes occurred in New London on November 23, 1894 and August 9, 1935; one occurred in Groton on August 1, 1852; and the fourth was felt in Mystic, Moodus, and Norwich on September 20, 1938.

2.5.2.1.4 Earthquakes Felt at the Site

To determine the earthquake hazard at the site, it is necessary to examine how severely the site has been affected by large earthquakes in the past. This examination for Millstone 3 is based on available historical records. A discussion of these earthquakes follow.

June 11, 1638 (46.5°N, 72.5°W, Intensity IX (MM))

This earthquake, centered in the St. Lawrence River Valley, probably near Three Rivers, Quebec, was felt throughout New England with no damage reported except to chimneys at Plymouth and Salem, Massachusetts. Perley (1891) described the chimneys at Plymouth as follows: "The chimneys of the first houses here were built on the outside at the ends of the houses, with the tops rising just above the roof. They were massive piles of rough and uneven stones, generally some six feet square, besides being nearly perpendicular. Imperfectly built, without mortar except for filling, they readily yielded to the terrible shaking they received, and the tops of many of them fell off, striking on the house or on the ground." Felt (1899) reported that the shock was felt in Connecticut, Narragansett, Pascataquack, and surrounding areas. Based on available reports and the intensity attenuation characteristics of other earthquakes occurring in the vicinity of the St. Lawrence River Valley, the estimated maximum intensity of the earthquake at the site was IV-V (MM).

February 5, 1663 (47.6°N, 70.1°W, Intensity X (MM))

This earthquake was centered in the St. Lawrence River northeast of Quebec City and was felt over a 750,000-square-mile area of eastern North America, accompanied by landslides along the St. Maurice, Batiscan, and St. Lawrence Rivers. Other damage was confined to cracked chimneys and the like. Effects in New England were similar to those of the 1638 earthquake. Brigham (1871) reported that "on the shore of Massachusetts Bay, houses were shaken so that pewter fell from the shelves and the tops of several chimneys were broken." Based on available reports and intensity attenuation characteristics of other earthquakes occurring in the vicinity of the St. Lawrence River Valley, the estimated maximum intensity of this earthquake at the site was IV-V (MM).

November 9, 1727 (October 29, 1727 Old Calendar) (42.8 ±0.5°N, 70.55 ±0.1°W, Intensity VII (MM))

The epicenter of this earthquake was located off the coast of northeastern Massachusetts. Maximum damage in the intensity range of VI to VII (MM) occurred near the mouth of the Merrimack River where "no buildings were thrown down but parts of walls of several cellars fell in and the tops of many chimneys were shaken off" (Crowell, 1868). Slight damage equivalent to Intensity V (MM) consisting of cracked chimneys was noted as far north as Portsmouth, New Hampshire; as far west as Lowell, Massachusetts; and as far south as Boston, Massachusetts. The earthquake was felt over an estimated area of 75,000 square miles from the Kennebunk River in Maine to the Delaware River south of Philadelphia. The intensity distribution of this earthquake is shown on Figure 2.5.2-4. Based on available reports, the estimated maximum intensity of this earthquake at the site was IV (MM).

September 16, 1732 (45.5°N, 73.6°W, Intensity VIII (MM))

This earthquake was centered near Montreal where 300 homes were damaged and 7 people were killed. It was felt in Boston and throughout New England and possibly as far south as Maryland. Based on available reports and the intensity attenuation characteristics of other earthquakes occurring in the vicinity of the St. Lawrence River Valley, the estimated maximum intensity of this earthquake at the site was IV (MM).

December 18, 1737 (40.8°N, 74.1°W, Intensity VII (MM))

This earthquake appears quite similar to the earthquake of August 10, 1884, in that it was felt from Boston, Massachusetts, to New Castle, Delaware and the epicenter was located in the New York City area where some chimneys were thrown down and bells rang. Although the damage in the epicentral area appears similar, it is possible that the epicentral intensity of the 1737 earthquake may have been one intensity less (or Intensity VI (MM)) due to the difference in the construction quality over the 147-year interval between earthquakes. Based on available reports and a comparison of this earthquake with the 1884 earthquake, the probable intensity in the vicinity of the site was IV (MM) with an estimated maximum intensity of V (MM).

November 18, 1755 (42.7 ±0.1°N, 70.3 ±0.1°W, Intensity VIII (MM))

This earthquake had its epicenter off the Massachusetts coast, east of Cape Ann. It was felt over an estimated area of 300,000 square miles from the Chesapeake Bay in Maryland on the south to the Annapolis River in Nova Scotia on the north and from Lake George in New York on the west to approximately 200 miles east of Cape Ann (ship thought to have run aground). Most of the damage (Intensity VI (MM) or greater) from this earthquake occurred along the coast from the New Hampshire-Massachusetts line south to the Boston area. Some slight damage to chimneys (Intensity V (MM)) occurred as far north as Portland and Brunswick, Maine; as far south as Scituate, Massachusetts; and as far west as the Lowell, Massachusetts and Nashua, New Hampshire area. The intensity distribution for this earthquake is shown on Figure 2.5.2-5.

The only damage reported from the Connecticut River Valley was at Springfield, Massachusetts, where a vane atop a church was “bent to a right angle” (Winthrop 1757). Based on available reports, the estimated maximum intensity of this earthquake at the site was V-VI (MM).

May 16, 1791 (41.5°N, 72.5°W, Intensity VI-VII (MM))

The epicenter of this earthquake was located in the vicinity of East Haddam, Connecticut. This earthquake was felt over an area of 35,000 square miles extending from Boston to New York. Examination of the dates and times mentioned in the technical references suggests that a number of earthquakes occurred; the first and largest on May 16, 1791, at 8:00 pm, with a number of aftershocks during the next few days.

The only reports of damage were from the East Haddam area where stone walls and the tops of chimneys were thrown down and latched doors were thrown open. Linehan (1964) reports that a group of professors from Wesleyan University visited the East Haddam area in 1841 and was able to confirm these reports. However, contrary to the original reports, the professors found that only one large stone had been displaced (it was in a tenuous position to begin with) and that no fissures had opened in the earth.

Forty houses of pre-1791 construction were still occupied in the East Haddam-Middletown area as late as 1938. “A study of the houses in the East Haddam area shows that they were not of sturdy construction nor had deep foundations, yet none were structurally damaged in the 1791 earthquake. The fact that some stone walls or chimneys might have been damaged could be attributed to an earthquake of intensity not more than V (MM), as there was little brick used and the stones were glacial cobbles. Clay and fibers made up the morta” (Linehan 1964).

Previous reports of this earthquake placed the intensity at VIII (MM). However, Linehan (1964) concludes that the intensity of the seismic event which was felt in East Haddam on May 16, 1791 was no greater than V-VI (MM). If the disturbance was of Intensity VIII (MM), the damage would have been considerable in ordinary substantial buildings, with partial collapse, as defined by the MM scale. There is no record of any damage to buildings, even though most of these were poorly constructed. Therefore, the intensity of these earthquakes could have been no higher than VI-VII (MM).

Newspaper accounts indicate that the earthquake was strongly felt without any reported damage at Hartford or New Haven, Connecticut. The intensity distribution for this earthquake is shown on Figure 2.5.2-6. Based on Linehan's analysis of the earthquake's effects in the East Haddam-Moodus area and other available accounts, the estimated maximum intensity of the earthquake in the vicinity of the site was V (MM).

October 17, 1860 (47.5°N, 70.1°W, Intensity VII to IX (MM))

This earthquake had its epicenter in the St. Lawrence River Valley, northeast of Quebec City, and was felt over an area of 700,000 square miles extending as far south as Newark, New Jersey, and as far west as Auburn, New York and included most of New England. The earthquake was strongly felt in Maine, but no damage was reported there or elsewhere in New England. Based on available reports and the intensity attenuation characteristics of other earthquakes occurring in the vicinity of the St. Lawrence River Valley, the estimated maximum intensity of this earthquake at the site was IV (MM).

<u>October 20, 1870 (47.4°N, 70.5°W, Intensity IX (MM))</u>

This earthquake was centered near Baie-St. Paul, Quebec, and was felt over a 1,000,000 square-mile area of eastern Canada and the northeastern United States. The damage reported in the United States included some bricks thrown from chimneys in Lewiston, Maine and some window glass broken in Portland, Maine. In Springfield, three distinct periods of vibration were noticed with the longest estimated at 7 to 8 seconds; while at Hartford, a single shock lasting a minimum of 20 seconds was felt.

Based on available reports, the estimated maximum intensity of this earthquake at the site was IV (MM).

<u>August 10, 1884 (40.6°N, 70.4°W, Intensity VII (MM))</u>

This earthquake was felt over an estimated 70,000 square-mile area of the northeastern United States and had its epicentral location in the New York City area. The greatest damage occurred in Jamaica and Amityville on western Long Island, New York, where some walls were cracked, accounting for the epicentral intensity of VII (MM). The epicentral location is further evidenced by a moderate aftershock which took place on August 11, 1884, and was felt in a number of towns on western Long Island.

An analysis of this earthquake by Rockwood (1885) resulted in the isoseismal map shown on Figure 2.5.2-7. Rockwood's map was based on more than 215 observations, of which 30, all within Rockwood's Isoseismal IV, reported some damage such as fallen bricks and cracked plaster. As shown on the figure, the site is located within Rockwood's Isoseismal III.

In the southern Connecticut area, damage included some bricks shaken from chimneys and a few cracked walls at New Haven, and dishes thrown from shelves and broken at Bridgeport. The shock was strongly felt at Hartford, but no damage was reported.

In New London, the earthquake was felt by everyone and the water in the harbor was reportedly agitated. Reports also indicate a few instances of cracked and fallen plaster but no damage to chimneys (The Day 1884).

Based on Rockwood's data and other available reports, the estimated maximum intensity in the site area was V (MM).

<u>February 10, 1914 (45|N, 76.9°W, Intensity VII (MM), Magnitude 5.5)</u>

This earthquake had its epicenter about 25 miles west of Lanark, Ontario, and was felt over a 200,000 square-mile area including New England, New York State, and Pennsylvania. Some damage was reported in New York State with minor damage noted as far east as Albany. The earthquake was strongly felt throughout New England although no damage was reported. Intensities of III to IV (MM) were noted as far south as Boston, Hartford, and New Haven. Based on available reports of this earthquake, the estimated maximum intensity at the site was IV (MM).

<u>March 1, 1925 (47.6°N, 70.1°W, Intensity IX (MM), Magnitude 7.0)</u>

This earthquake, which had its epicenter in the St. Lawrence River Valley northeast of Quebec City, was felt over approximately 2,000,000 square miles of North America, extending as far south as Virginia and west to the Mississippi River. Important damage was confined to a narrow belt along the St. Lawrence River Valley. Isoseismals prepared by the Dominion Observatory of Canada and shown on Figure 2.5.2-8 indicate that most of New England experienced intensities of III and IV (MM), the exception being extreme northern Maine, which probably experienced an intensity of V to VI (MM). The shock was generally felt throughout Connecticut with a maximum intensity of IV (MM) in the site area.

<u>November 14, 1925 (41.5°N, 72.5°W, Intensity V to VI (MM))</u>

This earthquake was felt over an 850 square-mile area of central Connecticut. Minor damage was reported at Hartford where some plaster fell and at Windham where dishes fell from shelves. Newspaper reports indicated that the earthquake was strongly felt from the Haddam-Middletown area to Hartford.

Along the southern Connecticut coast, the earthquake was generally felt but no damage reported. Available reports indicate intensities of III to IV (MM) in the site area.

<u>December 20, and 24, 1940 (43.8 |N, 71.3 |W, Intensity VII (MM), Magnitude 5.8)</u>

The epicenters of these earthquakes were located near Lake Ossipee, New Hampshire. Damage of Intensity VII (MM) occurred at Tamsworth and Wonalancet, New Hampshire, while damage of Intensity VI (MM) was noted in a dozen localities in central New Hampshire and western Maine. The shocks were felt over a 150,000 square-mile area of the United States including all of New England, New York, and New Jersey. The earthquakes were noticeably felt in the vicinity of the site but no damage was reported.

The isoseismal map prepared by the Northeast Seismological Association, Figure 2.5.2-9, indicates that the intensity of these earthquakes in the vicinity of the site was IV (MM).

2.5.2.2 GEOLOGIC STRUCTURES AND TECTONIC ACTIVITY

The site region encompasses a large segment of the northern Appalachian region. This region has undergone at least four orogenies, Mesozoic rifting and igneous activity, epeirogenic uplift, and glaciation. The tectonics and geologic history are discussed in Section 2.5.1. Figure 2.5.2-2 shows the regional geologic structure and the locations of epicenters within the 200 mile radius of the site.

Portions of 10 tectonic provinces are located within this 200 mile radius (Figure 2.5.2-10). Three of the 10 -- the Southeastern New England-Maritime Province, the New England Province, and the White Mountains Plutonic Province -- comprise most of the area. The remaining provinces are: the Coastal Plain, the Blue Ridge and Piedmont, the Northern Valley and Ridge, the Appalachian Plateau, the Central Stable Region, the Grenville, and the Monteregian Plutonic Province. The provinces are delineated on the basis of the following criteria:

1. Style and degree of deformation

2. The age of orogenic, igneous, or tectonic activity

3. The age of the basement rocks

These provinces are shown on Figure 2.5.2-10.

Southeastern New England-Maritime Province

The site is located in the southwestern edge of the Southeastern New England-Maritime Province. The western boundary follows the Honey Hill Lake Char-fault system northward into Massachusetts. The rock fabric and structural trends are different than those of the New England Province to the west. The province is characterized by Late Precambrian basement rock overlain by mildly metamorphosed rocks of Carboniferous age. Unlike the remainder of New England, the effects of the Alleghenian orogeny are apparent within the province.

The Southeastern New England area is considered by Skehan (1973) to be a piece of the Paleo-African continental plate with the Clinton-Newbury fault zone being the collision boundary. Rodgers(1970) considers the rocks east of the Clinton-Newbury fault to be similar to those of the Avalon Peninsula of Newfoundland. The reopening of the Atlantic Ocean, which began in the Mesozoic, isolated the pieces of the African continent. Gravity and magnetic data also indicate that the province boundary represents a juncture between two discrete crustal blocks in near isostatic equilibrium.

Reverse faulting is prominent in the intensely faulted zone between the Clinton-Newbury and Lake Char faults and the Boston Border fault, although transcurrent or strike-slip components may exist. Northeastward along the Norumbega fault, the movement has been right lateral and may exceed several hundred kilometers. Skehan (1973) considers the area to be an ancient subduction zone, although all the elements have not been demonstrated. Certainly, large scale underthrusting has played a major role in the development of the province.

New England Province

Just west of the Southeastern New England-Maritime Province lies the New England Province, extending southward to 40⌋30'N latitude. The New England Province is structurally similar to the Piedmont. The region has been strongly affected by the Taconic and Acadian Orogenies, whereas the Blue Ridge and Piedmont Province and the Valley and Ridge Province to the south were affected by the Alleghenian orogeny. Grenville-age basement is exposed in the cores of the

Berkshire-Green Mountain anticlinorium and the Reading prong and shows evidence of involvement in the earlier Paleozoic deformations. As discussed in Section 2.5.1.1, the Precambrian basement disappears beneath the high grade metamorphic rocks of the Merrimack synclinorium to the east. The structural fabric of the province suggests a Paleozoic compressive stress directed from the east or southeast. The presence of the New Hampshire Plutonic series emplaced during the Acadian Orogeny aids in distinguishing the New England Province from the Southeastern New England-Maritime Province.

White Mountains Plutonic Province

The emplacement of magmas of the White Mountains Plutonic-Volcanic Series began in the Mesozoic and overprinted the Paleozoic effects. The series was intruded along a north-northwest trend extending offshore of Cape Ann, Massachusetts, into northern New Hampshire, Vermont, and southern Quebec, crossing the older structural grain of the Appalachians. Radiometric dating has shown that the igneous activity began in and continued sporadically throughout the Mesozoic Era (BECo 1976a). All the plutons are related in age, shape, magnetic signature, gross mineralogy, and mode of intrusion. The zone has been spatially correlated with a region of seismic activity in New Hampshire and Massachusetts.

This zone is defined to include all mapped occurrences of White Mountains Plutonic-Volcanic Series rocks and is extended offshore to include a group of magnetic anomalies similar to the onshore structures. It extends northwestward to include Mt. Ascutney in Vermont and northward to encompass Mt. Megantic in southern Quebec. Southeastward, it includes the Agamenticus complex and Cape Nedick pluton.

Monteregian Plutonic Province

This province, which represents an overprinting similar to the White Mountains intrusives, is composed mainly of alkaline, basic, and ultrabasic intrusives of Cretaceous age. They intrude early Paleozoic folded metasedimentary and undeformed sedimentary rocks of the New England Province. The trend of the plutonic belt cuts across the Paleozoic structural grain. The Cretaceous age, duration and mode of emplacement, size of plutons, extreme alkalic nature, contact relationships, and evidence of explosive activity distinguish the Monteregian plutons from the White Mountain Series. The zone is defined to include all known occurrences of Monteregian type rocks including several subsurface magnetic anomalies. It extends to the Oka Complex on the northwest and surrounds Mt. Shefford and Mt. Brome on the northeast. The zone includes the Cuttingsville stock near Rutland, Vermont, and all known alkalic dike occurrences in the Champlain Valley. It has also been the site of a moderate amount of seismic activity and includes the September 16, 1732, Intensity VIII (MM) event near Montreal.

Coastal Plain Province

The Atlantic Coast section of this province lies seaward of the Piedmont, New England, and Southeastern New England-Maritime Provinces. It is characterized by gently seaward-dipping, unconsolidated Jurassic, Cretaceous, and Tertiary sediments overlying Precambrian or Early

Paleozoic bedrock. Somewhere on the continental slope, or a little beyond, the continental basement rocks of the underlying Appalachian system give way to oceanic crust.

Tectonically, the province is characterized as a zone of subsidence, occurring mainly since the Jurassic and persisting through most of the Tertiary. Several arches and embayments exist in the basement rocks and serve to subdivide the Coastal Plain into distinct sedimentary basins, some of which contain between 10 and 12 km (32,800 and 39,400 ft) of sediments of Jurassic age and younger. Most of the deposits were placed in relatively shallow water indicating a progressive downwarping of the edge of the continent toward the oceanic floor.

Grenville Province

The Grenville Province borders the New England Province on the northwest and forms a belt 250 miles wide from Lake Huron to the Atlantic in Labrador. The rocks of the province are divided almost evenly between medium grade marbles, quartzites and gneisses, and higher grade gneisses and plutonic rocks of a slightly older series. An appendage of the Grenville Province occurs in New York State as the Adirondack uplift. Distinctive anorthosite bodies of the Adirondacks are included in the Grenville Province because they were deformed during the Grenville orogeny between 1.1 and 1.3 billion years ago. The Grenville Province appears to be an orogenic belt built against the stabilized older part of the shield and is more nearly comparable to the orogenic belts of the Paleozoic.

Lower Paleozoic platform rocks do exist in the Ottawa-Bonnecherre graben west of Logan's Line as a thin veneer on Grenville basement rocks. They represent a portion of the Central Stable Region which has been isolated by the uplift of the intervening Adirondacks. Their tectonic stability is related to the general stability of the underlying Grenville and, therefore, for simplicity, they are included in the Grenville Province.

Piedmont-Blue Ridge Province

The Piedmont-Blue Ridge Province is characterized by metamorphosed Precambrian and Early Paleozoic eugeosynclinal rocks which were deformed during the Taconic and Alleghenian orogenies and may have been recrystallized during the Acadian orogeny. It includes the Blue Ridge anticlinorium, a relatively narrow belt of folded and faulted upper Precambrian crystalline schists and gneisses which were thrust westward several kilometers over the rocks of the valley and ridge. Terrains of intrusive igneous rocks are notable in the Piedmont of Virginia and North Carolina. Long, narrow, graben structures filled with continental deposits of late Triassic age are superimposed intermittently on the crystallines from Pennsylvania to South Carolina. The effects that each orogeny had on the rocks in the Piedmont are not yet fully understood due to the lack of outcrop, lack of fossils, and the strong recrystallization.

The southern and eastern boundaries of the Piedmont are drawn at the present westward limit of Cretaceous Coastal Plain deposits. Piedmont geology certainly continues beneath the Coastal Plain for some distance but the line where Coastal Plain mobility becomes the dominant force is presently not well established. The northern boundary of the Piedmont with the New England Province is hidden beneath the Triassic Newark Basin.

Appalachian Plateau Province

The Appalachian Plateau Province borders the Central Stable Region on the east and on the south at its limit in New York. Geologically, the province is a broad, gentle, elongated basin whose youngest rocks are of probable Early Permian age. The basin forms the western part of the former Appalachian geosyncline with sediments thickening generally southeastward from the Cincinnati-Findlay arch. Grenville basement dips beneath the province in the same direction. The basement gradient steepens through central Ohio demarking the westernmost edge of Appalachian Plateau Province (USNRC 1977). Deformation of the province had its greatest development during the post-Early Permian Allegheny orogeny and resulted in gentle folding and uplift of the sedimentary pile with perhaps some decollement movements along weak units within the section. Mild epeirogenic movements have been the only tectonic events to affect the province since Late Paleozoic time.

Valley and Ridge Province

The Valley and Ridge Province lies east of the Appalachian Plateau except at the north end where the New England Province intervenes. The Valley and Ridge Province contains the major portions of the sediments which were deposited in the Appalachian geosyncline, of which it comprises the southeastern part. The province is characterized by unmetamorphosed Paleozoic sediments that were tightly folded and faulted during the Allegheny orogeny, about 250 million years ago.

Intense pressure exerted from the southeast folded the sediments into large synclines and anticlines, some strongly overturned to the northwest. Thrust faults were commonly developed, particularly south of Central Virginia. The Valley and Ridge Province has been divided into northern and southern sections based on the difference in structural styles. The northern section is dominated by folding, whereas the southern section is characterized by thrust faulting. In addition, the southern section has historically experienced a higher level of seismic activity while the northern section is nearly aseismic (USNRC 1977, USNRC 1978). The boundary between the two provinces is somewhat indistinct but is believed to occur between Roanoke and the James River in Central Virginia, roughly along latitude 37°-45' north. A striking change in the trend of Valley and Ridge structures also occurs at this line; the folds to the north trend about N25 E, whereas the faults to the south trend N70°E. The nature of the structural discontinuity is not known but may be related to basement transcurrent faulting (Cardwell, et al., 1968).

Central Stable Region

The Central Stable Region is the westernmost tectonic province of concern to the analysis contained herein. The province is bounded on the east by the Appalachian Plateau Province and the north and northeast by the Grenville Province and the New England Province. The Coastal Plain bounds the province on the south. The Central Stable Region extends westward to the east flank of the Rocky Mountains and includes a wide variety of morphology and structure. The province is made up of a foundation of Precambrian crystalline rock with a veneer of sedimentary cover which varies widely in thickness. It represents the craton or central stable area of the North American crustal plate. Deformation since the Precambrian has been restricted to the development of several broad basins, arches, domes, and similar features. Several of the basins contain in excess of 10,000 feet of strata, while some of the arches expose Precambrian rocks. Tectonic movements since the Paleozoic have been mostly a series of epeirogenic uplifts and downwarps followed by long periods of erosion. The eastern boundary of the province represents the western limit of effects from the Allegheny orogeny. The boundary follows the steepening of the basement contours as the gradient increases to form the Appalachian Basin.

2.5.2.3 CORRELATION OF EARTHQUAKE ACTIVITY WITH GEOLOGIC STRUCTURES OR TECTONIC PROVINCES

The relationship between earthquake locations and geologic structures is important in assessing earthquake hazard for a particular site. The absence of major spatial displacements through historical times that might be associated with tectonic activity in eastern United States makes the association of larger historical earthquakes with specific structures difficult. Only during the past 10 to 15 years have seismologists been able to determine earthquake locations with sufficient precision to relate them to geologic structures.

2.5.2.3.1 Correlation with Geologic Structures

White Mountain Plutons

The majority of the significant seismic activity in New England has been associated with the White Mountains Plutonic Province. The strong concentration of events in southern New Hampshire and northeastern Massachusetts has been spatially associated with plutons of the White Mountains (Figure 2.5.2-2). A detailed investigation of the White Mountains Plutons has indicated that the Ossipee, New Hampshire, earthquakes and the Cape Ann earthquake are associated with the plutons (BECo 1976a). The largest activity was located off Cape Ann in 1755. It was assigned Intensity VIII (MM). Also, there have been a number of Intensity VII (MM) events, two in Ossipee, New Hampshire in December 1940, and another located off Cape Ann in 1727.

Ramapo Fault

The Ramapo fault system, which bounds the Triassic-Jurassic Newark graben on its northwest side in northeastern New Jersey and southeastern New York, has been known for about 100 years and has been commonly presumed to be an inactive fault. Aggarwal and Sykes (1978) have observed a spatial correlation of some epicenters in southeastern New York with surface traces of faults in the area. A large majority of events lie on or very close (0.5 to 1.2 miles) to the faults. Furthermore, an examination of focal mechanism solutions shows that for each of the solutions, one of the nodal planes trends north to northeast, which is also the predominant trend of the faults in this area. The spatial correlation of one nodal plane with the trend of the mapped faults suggests that earthquakes in this area occur along pre-existing faults.

Considering both geology and seismicity, the Ramapo fault is not considered capable in accordance with the criteria for capable faults in 10 CFR 100, Appendix A. This was established by the Atomic Safety and Licensing Board (USNRC 1977) in 1977, after extensive hearings on the issue.

2.5.2.3.2 Correlation with Tectonic Provinces

As most earthquake activity in the site region cannot be correlated with geologic structures, it is assumed (in accordance with 10 CFR 100, Appendix A) that these earthquakes are associated with the tectonic provinces (Figure 2.5.2-10) in which they occur. A discussion of earthquake activity in various tectonic provinces follows.

Much of the seismicity of the Grenville Province is associated with the LaMalbaie seismic zone and the Monteregian Plutonic Zone, considered to be separate source areas and described below. The remaining activity is confined to a broad belt of epicenters extending from the Adirondack uplift northwestward into southwestern Quebec and eastern Ontario to the vicinity of Kirkland Lake. The largest historical events in this province were the 1944 Cornwall-Massena event of Intensity VIII (MM) and the 1935 Timiskaming, Quebec earthquake of magnitude 6.2 which had an epicentral intensity of VII (MM).

The Monteregian Plutonic Province overprints the older structural features of the Grenville and New England Provinces. Its seismicity includes the easternmost part of the prominent belt of epicenters which trends northwestward across the Grenville Province. The largest historical earthquake within the Monteregian Plutonic Province occurred at Montreal in 1732. Earlier catalogs have listed this event as Intensity IX (MM); however, recent evaluations of original accounts (Chiburis 1979; NYSE&G 1978) conclude that the epicentral intensity did not exceed VIII (MM).

The LaMalbaie Seismic Zone lies outside the 200-mile radius on the boundary between the Grenville Province and the New England Province. It occurs as a distinct concentration of epicenters extending northeast from Quebec City. The LaMalbaie Zone is the most important seismic source in the northeast in terms of energy released. Historically, numerous large earthquakes have occurred in this zone with intensities ranging from VII to X (MM). A conjunction of the Charlevoix meteoritic impact structure with the tectonic boundary between the Grenville Province and the Appalachian structures of the New England Province has been described by Leblanc and Buchbinder (1977) as a likely structural basis for the concentration of strain release in this zone.

The major seismicity of the New England Province is related to the White Mountains Plutonic Province described above. The remainder of the province is characterized by a band of activity which trends along the coast from northern New Jersey to eastern Connecticut. This area has experienced earthquakes up to Intensity VII (MM). These have occurred in 1737 and 1884 at New York City and 1791 at Haddam, Connecticut. Another diffuse pattern of epicenters of maximum Intensity VI (MM) occurs in coastal and central Maine. Minor microearthquake activity is also reported to originate along the Ramapo fault in New Jersey and New York (Aggarwal and Sykes 1978).

Earthquakes in 1568 and 1791 near East Haddam, Connecticut, are also part of the New England Province since these have not been associated with any specific geologic structures or faults. An investigation is currently in progress to study the Moodus “noises”. However the noises have not been associated with specific faults.

The Southeastern New England-Maritime Province is an area of low seismicity. Most of the activity in southeastern Massachusetts, offshore, and in eastern Maine has been lower than Intensity V (MM). The largest earthquake in this province was an Intensity VI (MM) event which occurred in 1904 east of Eastport, Maine.

The Atlantic Coastal Plain Province has experienced a number of minor earthquakes throughout the historic record. Exclusive of the Charleston, South Carolina area, the largest events have been of Intensity VII (MM). These occurred in 1871, 1884, and 1927 near the boundary with the New England and Piedmont Provinces in northern New Jersey and near New York City.

The Piedmont-Blue Ridge Province exhibits a fairly low level of seismicity throughout its length with diffuse areas of higher activity in central Virginia and western South Carolina. The largest historical earthquake in the province was of Intensity VII (MM). It occurred in central Virginia in 1875.

2.5.2.4 MAXIMUM EARTHQUAKE POTENTIAL

The maximum earthquake potential for the site is evaluated by utilizing maximum earthquakes associated with all nearby tectonic provinces and geologic structures. This analysis is made for two different sets of conditions. First, actual site intensities resulting from larger historical earthquakes are determined. Second, the maximum potential site intensities resulting from hypothetical events are calculated. These hypothetical events are specified as the largest known earthquakes in each adjoining tectonic province. Each is postulated to occur at the point where its province or structure most closely approaches the site.

2.5.2.4.1 Maximum Historical Site Intensity

A detailed analysis of large historical earthquakes in the northeastern United States indicates (Section 2.5.2.1.4) that four earthquakes have been felt with intensities of V (MM) or greater at the site. The 1755 Cape Ann earthquake caused damage corresponding to Intensity V-VI (MM) at towns near the site. The East Haddam-Moodus earthquake of 1791 was reportedly felt strongly but no damage resulted at such localities as Hartford and New London, indicating an intensity of approximately V (MM). A similar intensity value is indicated for the Millstone site. Data collected by Rockwood indicate that the 1884 earthquake, with an epicenter approximately in the New York City area, was felt at the site with a probable intensity of V (MM). Bricks were thrown from chimneys and a few walls were cracked at New Haven, and plaster was cracked and dislodged at New London. The 1737 earthquake with epicentral location also in the New York City area appears similar to the 1884 earthquake and may have been felt with an intensity of V at the site.

It is clear that these four earthquakes in the site region caused Intensity V or V-VI (MM) at the site. The epicentral intensity of these four earthquakes was either VII, VI-VII, or VIII (MM). In the site region, the 1755 Cape Ann earthquake was of highest intensity (VIII (MM)). Earthquakes larger than the 1755 Cape Ann, for example, have all occurred outside the site region in the LaMalbaie area of the St. Lawrence River Valley. Large earthquakes in this zone are estimated to have caused Intensity IV-V (MM) at the site. The 1886 Charleston earthquake of Intensity X

(MM) caused Intensities II-III (MM) at the site. Therefore, from historical data, it is concluded that the site experienced maximum intensity of V-VI (MM).

2.5.2.4.2 Maximum Earthquake Potential from Tectonic Province Approach

To account for the possibility of large errors in epicentral determination, especially for events occurring prior to 1950 and in the absence of capable faults, the largest known earthquake in each province was attenuated to the site from points of nearest approach of the tectonic province in which the earthquakes occurred, using the conservative attenuation relationship of Howell and Schultz (1975). Justification for this procedure is that individual epicenters are not properly located and, therefore, cannot be associated with specific structures.

The site is located in the Southeastern New England-Maritime Tectonic Province. The largest earthquake in this province was of Intensity VI (MM). The New England Tectonic Province is very near the site and several earthquakes of Intensity VII (MM) have occurred in this province (1568 and 1791 at Moodus and 1737 and 1884 at New York City). Assuming that these earthquakes occur at the nearest approach point of the New England Province to the site (20 km), intensity at the site would be VII (MM). The Coastal Plain Province is also close to the site (about 10 km). The 1927 earthquake near Asbury Park, New Jersey, was in the Coastal Plain Province and had an epicentral intensity of VII (MM). A similar earthquake in the Coastal Plain Province near the site would cause Intensity VII (MM) at the site. Only one earthquake of Intensity VIII (MM) is associated with any of the provinces or structures in the site region. This earthquake occurred near Cape Ann, Massachusetts, in the White Mountains Plutonic Province. Such an earthquake occurring in that province at a minimum distance from the site (170 km) would cause site intensity of V-VI (MM). In other tectonic provinces in the site region, the maximum intensity of earthquakes was VII (MM). Therefore, the effect of these earthquakes would be less than VII (MM).

In the eastern United States, earthquakes with intensities greater than VIII (MM) have occurred only in LaMalbaie, Quebec; Charleston, S.C.; and New Madrid, Missouri. Earthquake activity at these places is assumed to be associated with specific structures and, based on historical data, would not cause greater effects at the site than Intensity IV-V (MM). Therefore, the maximum earthquake potential at the site due to earthquakes occurring within 10 to 20 km of the site is Intensity VII (MM).

2.5.2.5 SEISMIC WAVE TRANSMISSION CHARACTERISTICS OF THE SITE

Properties of subsurface materials at the site are discussed in detail in Section 2.5.4. The compressional and shear wave velocities of in situ materials are tabulated in Section 2.5.4.4.3 and other properties of the in situ materials are described in Section 2.5.4.2. The groundwater conditions at the site are discussed in Section 2.5.4.6.

The safe shutdown earthquake (SSE) value of 0.17 g is applied to the bedrock surface. For structures founded on soils, the effect of the overburden on the earthquake motion has been considered in soil-structure interaction computations, as discussed in Section 3.7B.2.4.

2.5.2.6 SAFE SHUTDOWN EARTHQUAKE

As discussed in Section 2.5.2.4, the maximum earthquake potential at the site is an Intensity VII event occurring 10 to 20 km from the site. Murphy and O'Brien (1977) have published an analysis of acceleration-intensity correlations using a new worldwide data base and a variety of statistical models. Their correlation equation relating Intensity I (MM) and peak horizontal ground acceleration (A_h) is:

$$\log A_h = 0.25\ I + 0.25$$

where A_h is in cm/sec^2. For a Modified Mercalli Intensity VII earthquake, this equation gives an average horizontal component peak acceleration of 0.10 g. In order to be conservative in the Millstone 3 plant design, the SSE is specified as 0.17 g. The duration of strong ground motion associated with an Intensity VII earthquake is estimated at 6 seconds using an assumed threshold acceleration value of 0.05 g according to Bolt (1973).

2.5.2.7 OPERATING BASIS EARTHQUAKE

A study of the earthquake history of the site region has shown that the maximum historical intensity at the site has been V-VI (MM), corresponding to a peak horizontal ground acceleration of 0.05 g (Murphy and O'Brien 1977). In accordance with 10 CFR 100, Appendix A, the operating basis earthquake is taken to be at least one half of the SSE, or 0.09 g.

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TABLE 2.5.2–1 MODIFIED MERCALLI (MM) INTENSITY SCALE OF 1931

CLICK HERE TO SEE TABLE 2.5.2-1

TABLE 2.5.2–2 LIST OF OPERATING SEISMIC STATIONS

CLICK HERE TO SEE TABLE 2.5.2-2

TABLE 2.5.2–3 CHRONOLOGICAL CATALOG OF EARTHQUAKE ACTIVITY WITHIN 200 MILES OF THE SITE

CLICK HERE TO SEE TABLE 2.5.2-3

TABLE 2.5.2–4 LIST OF EARTHQUAKES WITHIN THE 50-MILE RADIUS

CLICK HERE TO SEE TABLE 2.5.2-4

2.5.3 SURFACE FAULTING

None of the published geology maps show faults in the vicinity of the site. Figure 2.5.1-13 shows a composite bedrock geologic map for the area surrounding the site. The closest mapped fault to the site is in the Uncasville quadrangle, 10.5 miles northeast of the Millstone site (Goldsmith 1967a). Faulting has also been observed in the Clinton quadrangle, approximately 17 miles west of the site, and in the Moodus and Colchester quadrangles, approximately 15 miles north of the site (Lundgren et al., 1971; Lundgren and Thurrell 1973). These faults are all believed to be high-angle faults related to extension tectonics of Late Triassic-Jurassic time (Lundgren et al., 1971; Lundgren and Thurrell 1973; Goldsmith 1973).

Sixty-two faults were found during the mapping of the rock excavation for Millstone 3 between July 1979 and July 1982. Forty of the faults have apparent displacements equal to or less than one foot with the remaining faults exhibiting apparent displacements greater than one foot. The extent of the areas mapped shows eleven separate fault zones with numerous minor associated faults. Figure 2.5.1-18 shows the general location of these faults. Table 2.5.3-1 lists the faults mapped at the site and provides a reference for those faults discussed in previous reports (NNECo. 1975; 1976; 1977; 1982).

Samples from the gouge zone of faults T-2, T-3, 1541, and 2819 were taken at final excavation grade in the containment structure and discharge tunnel excavations. Petrographic analyses, x-ray diffraction studies, and potassium-argon radiometric dating were performed on these samples. X-ray diffraction studies were performed on material from faults 1940, 2282, 2339, and 2781 which indicated that the material was not suitable for age dating. The results of these tests are discussed in detail in Section 2.5.3.2. Table 2.5.3-2 describes the samples and shows the tests performed. The analyses and tests show excellent agreement with previous studies performed at the site (NNECo. 1975; 1976; 1977).

2.5.3.1 GEOLOGIC CONDITIONS OF THE SITE

Section 2.5.1.2 discusses the stratigraphy, structural geology, and geologic history of the site area in detail. The bedrock geologic map and cross section of the site area and the tectonic setting of eastern Connecticut are shown on Figures 2.5.1-13 and 2.5.1-14, respectively.

2.5.3.2 EVIDENCE OF FAULT OFFSET

The published geologic maps which include the site area do not indicate the presence of faulting. A study of LANDSAT photographs (Figure 2.5.1-9) of southern New England identifies 72 lineaments greater than 10 miles long. None falls within the 5-mile radius of the site.
Figure 2.5.1-10 shows the lineaments and Section 2.5.1.1.4.4 discusses them.

A number of small faults were uncovered at the site during excavation and were mapped in detail. The larger faults were observed and mapped both at top of rock and at final excavation grade. One fault (508) (NNECo. 1975) was mapped at top of rock and not observed at final grade; others found at final grade were not observed at the rock surface. Figure 2.5.1-18 shows all of the faults uncovered during the mapping at the site. The larger faults exhibiting brecciated and silicified zones are identified by "T" on this figure and throughout this report. Figure 2.5.1-18 identifies the smaller faults by numbers.

Eleven fault zones (T-1, T-2, T-3, 18, 471-1541, 1599, 1940, 2250, 2282-2295, 2339-2347, and 2380) have been found in the main site area and pumphouse excavations. Figure 2.5.1-18 also shows the remaining ancillary faults. Two of the smaller faults, 508 and 368, terminate within the limits of the main site excavation. Fault 508 is the only fault that was mapped at top of rock that was not noted at final grade. The other faults extend beyond the boundary of the excavation at least in one direction. Fault 1541 in the auxiliary building was mapped as fault 461 in the containment excavation. Displacement along this fault dies out before intersecting the southwestern wall of the containment.

Most of the faults trend to the north and dip at high angles either to the east or to the west.
Table 2.5.3-1 lists their characteristics. Slickenside information (Figure 2.5.1-17) indicates that the sense of movement was in an east-west direction (dip slip). Slickenside information in the T-2, T-3, and 2339 fault zones indicates that the motion along the fault was oblique. Exposures of the faults (T-2, 18, and 1541) in the excavation walls indicate that they are normal (gravity) faults. Therefore, the oblique motion along the larger faults has a greater dip slip component.

Two of the larger faults, T-2 and T-3, were previously studied in detail immediately after their discovery during the mapping of the bedrock surface (NNECo. 1975). Figures 2.5.3-1 through 2.5.3-3 show the detailed maps of these faults at final excavation grade. Both faults are characterized by a zone of gouge, breccia, microbreccia, and cataclasite derived from the Monson Gneiss and igneous rocks which intrude the Monson Gneiss. Hydrothermal fluids have permeated the gouge zones of these faults. Free-growing crystalline quartz was found in the T-2 zone, and drusy quartz coated the fracture surfaces and vugs in the breccias and cataclasite of the T-3 fault zone. Drusy quartz was also found in open cavities adjacent to T-2.

The brecciated zone of T-2 varies in thickness from 4 to 6 inches. However, in some areas the zone widens to 1.5 feet, and in others narrows to a single, nearly clean fracture. For the most part, the breccia is partially to completely rehealed. The clay gouge varies in thickness along the fault zone although it rarely exceeds 1.0 inch. The T-3 brecciated zone is similar to that of T-2, except in dimensions. The fault zone varies in thickness from 6 inches to 2 feet, and the clay gouge typically forms a thin, 0.5 to 2 inch, continuous seam. It is occasionally found as a thin filling between brecciated blocks. Both zones are moderately to severely weathered with much of the area stained by iron oxide.

Fault T-2 trends N15W, dips at 70 degrees to the east, and is located on the eastern side of the containment excavation. The geologic maps of the walls of the containment and of the discharge tunnel, Figures 2.5.4-11 through 2.5.4-14 and 2.5.4-3 through 2.5.4-5, respectively, show a section across the fault in four locations. The largest fault at the site, T-3, lies on the western edge of the rock exposure in the excavation. T-3 strikes N28W and dips 70 degrees to the east.

Table 2.5.3-1 shows the apparent displacements of the faults in the horizontal plane and lists the calculated displacements, determined from the offset pegmatite veins and from slickenside information. The eastern blocks of T-3, T-2, 1599, and most of the faults in the pumphouse appear to be downthrown relative to the western block, whereas with faults T-1, 18, 461-1541, 368, 2251, and 2426, the western block appears to have been downthrown relative to the eastern block. A complex irregular pegmatitic intrusion has obscured the contacts in the vicinity of faults 2250 and 2282 making it impossible to determine the sense of development.

Fault 1940 shows low-angle thrust displacement of between 1.0 and 2.0 inches toward the northeast. The southwest dipping fault zone consists of a zone of weathered and fractured rock and clay varying from less than 1.0 inch to about 10 inches thick. The fault ends at joint 198 but is paralleled by a similar zone about 3 feet below it. This parallel zone crosses joint 198 but ends at fault T-2 in a southwesterly direction. Projection of 1940 updip places the intersection of the fault with the rock surface in the vicinity of the demineralized water storage tank. Geologic mapping of this area did not reveal the trace of the fault at the surface. Hydrothermal activity along the fault is evident by the presence of smectite clay in the gouge which is probably related to the same period of hydrothermal activity shown in the high angle faults at the site.

Four separate fault zones were uncovered in the pumphouse excavation (2250, 2282, 2330 plus 2347, and 2380) with smaller faults splaying from these zones, as shown by Figures 2.5.1-18 and 2.5.4-8. These faults are similar in trend, fault zone composition, and amount and type of displacement to those faults uncovered in the main excavation. The shear zones of the faults in the pumphouse were characterized by hydrothermal quartz. Clay gouge was generally restricted to very thin coatings on fracture surfaces.

Four other faults (2781, 2817, 2818, and 2819) were found in the discharge tunnel excavation and are included in Figure 2.5.1-18 and in Figures 2.5.4-19 through 2.5.4-22. A separate report has been submitted detailing the investigation of these faults (NNECo. 1982).

Fault 2781 dips 45 degrees to the west and shows reverse displacement of a biotite seam of 2.5 inches. Clay from the 0- to 4-inch thick fault zone was found unsuitable for age dating. Till and outwash directly overlying the fault was examined and found to be not disturbed. The largest fault uncovered in this portion of the discharge tunnel consists of three related faults, numbers 2817, 2818, and 2819. Offset of pegmatite veins up to 1.5 feet were observed across 2817 and 2818, whereas no continuity could be determined across 2819 in the width of the excavation. Fault gouge material from 2819 produced a K/Ar age date of 142 million 6 million years. The zone was filled with undisturbed drusy quartz and also showed no disruption of overlying stratified and unstratified glacial deposits. Faults 2894 and 2899 (NNECo. 1982) show 4-inch and 0.5-inch displacements, respectively, on very narrow fault zones. Displacements on both faults were observed to end within the excavation.

2.5.3.2.1 Petrographic Analysis

Six samples were taken from the T-2 and T-3 fault zones at final excavation grade to determine the geologic history of the faulting. Figures 2.5.3-1 through 2.5.3-3 show the location of these samples. Table 2.5.3-2 lists the samples and gives a general description of each.

Appendix 2.5B includes a report on the petrographic analyses performed by Dr. Reinhard A. Wobus of Williams College, Williamstown, Massachusetts. The work described herein supplements previous studies performed on these faults (NNECo. 1975) from samples taken at the bedrock surface.

Petrographic analyses of the samples indicate that the fault zones have undergone at least one period of deformation, and possibly more. The cataclasite samples (2F, 5F, 6F, 9F, and 11F) consist mainly of a very fine-grained matrix of subhedral quartz prisms. For the most part, these prisms exhibit no preferred orientation. Chlorite is also common in the matrix, along with some plumose muscovite. The remainder of the cataclasite is made up of quartz, plagioclase, and mica fragments. The fragments indicate that large pieces have undergone some deformation. The quartz crystals are highly strained and the plagioclase twin lamellae have been deformed. All of the larger fragments have been altered and chlorite is present between many of the crystals. Chlorite has replaced the plagioclase in many places, and, where it has not been replaced, the plagioclase has been altered to a highly-birefringent clay (Appendix 2.5B).

Sample 12F is a sample of the Monson Gneiss taken adjacent to the T-3 fault zone. Hand specimens of the gneiss appear to be sheared. The analysis indicates that quartz present in the thin section is very highly strained and that the plagioclase has been altered to highly birefringent clay. Wobus (Appendix 2.5B) classifies this as an altered biotite-quartz-andesine gneiss.

The petrographic analysis by Wobus (Appendix 2.5B) indicates that the material from the two different fault zones, T-2 and T-3, is similar. He has classified the material in the zones as hydrothermally altered and silicified cataclasite. Samples taken from the bedrock surface mapping also indicate the same results (NNECo. 1975).

The geologic history inferred from the petrographic study is as follows:

1. Formation of a breccia and cataclasite from faulting of Monson Gneiss and the pegmatites.

2. The injection of hydrothermal fluids producing a matrix of subhedral quartz, and altering the original breccia to produce a highly birefringent clay.

3. Fracturing and granulation of the crystallized quartz matrix.

4. Continuation of hydrothermal activity resulting in the development of chlorite and plumose muscovite in the cracks and fractures.

5. Weathering effects, varying with the degree of silicification.

2.5.3.2.2 Clay Mineralogy, Fluid Inclusion Analysis, and Radiometric Dating

Samples of the clay gouge in the fault zones were taken at final excavation grade. Table 2.5.3-2 lists these samples, their location, and the tests performed. Six samples were analyzed by x-ray diffraction and radiometrically dated using the potassium-argon (K/Ar) method. Five of the samples (7F, 10F, 13F, 14F, and 15F) were taken from the larger T-2 and T-3 fault zones. Sample 1F was taken from a small fault shown as 1541-461 on Figures 2.5.1-18 and 2.5.4-6. The locations of the samples taken from the T-2 and T-3 fault zones are shown on Figures 2.5.3-1 through 2.5.3-3, respectively.

The samples were analyzed to determine their composition by x-ray diffraction techniques prior to being radiometrically dated. Dr. R. T. Martin of the Massachusetts Institute of Technology, Cambridge, Massachusetts performed these analyses. His report is included as Appendix 2.5C. Prior studies made by Dr. Martin on clay gouge materials have been reported in detail in Geologic Mapping of the Bedrock Surface (NNECo. 1975) and Report on Small Fault in Warehouse 5 - Millstone 2 and Condensate Polishing Facility (NNECo. 1976).

The samples were comprised mainly of quartz and clay. Feldspar is noted in three of the samples (7F, 13F, and 14F); however, the amount is small enough to have no effect on the age determined by K/Ar methods. The clay portion of the gouge consists of smectite, chlorite, and illite.

The 1Md, 1M, and 2M polymorphs are the mica polymorphs (illite) of the clay size fraction. The relative amounts of the polymorphs are summarized below from Dr. Martin's report (Appendix 2.5C):

	1F	**7F**	**10F**	**13F**	**14F**	**15F**
2M	0	0.12	0	0	0	0
1M	0	0.13	0.42	0.22	0.20	0.42
1M	0.17	0.28	0.09	0.24	0.18	0

Complete loss of argon is possible as a result of intense cataclastic deformation (Sutter 1971). Lyons and Snellenburg (1971) have previously performed K/Ar dating of illite gouge and have indicated that the 1Md mica polymorphs are developed at the time of faulting and are authigenic. The 1Md polymorph is a low temperature mineral. Both the 1Md and the 1M polymorphs appear to be metastable, even at low temperatures (Velde 1965). With increasing temperature, the 1Md, 1M, 2M reaction takes place (Yoder and Eugster 1955). The temperature necessary for the initiation of the reaction from 1Md to 1M at low pressures is no greater than 250°C (Velde 1965).

Quartz crystals found in the brecciated zones of T-2 and T-3 at the bedrock surface were tested to determine their temperature of formation by Dr. Earl Ingerson of the University of Texas at Austin (NNECo. 1975). The temperature range for the hydrothermal formation of these quartz crystals is 118°C to 198°C. This information, together with Dr. Martin's analysis indicating the relative amounts of the mica polymorphs, infers that some of the 1Md polymorphs may have reverted to the 1M polymorph. Apparently, the hydrothermal activity was not intense enough or long enough to complete the reaction.

The 2M polymorph was noted in only one sample, 7F. Because it appears in only one sample, it seems unlikely that the 2M polymorph is caused by the completion of the reaction. The 2M polymorph is common in most igneous and metamorphic rocks (Velde 1965). Since both rock types are involved in the faulting at Millstone, the 2M polymorph in Sample 7F may be a contaminant from the country rock, and the date obtained may be slightly older than the actual faulting. Sample 7F yielded the oldest date of all samples of fault gouge tested from Millstone.

Geochron Laboratories, Cambridge, Massachusetts, dated the samples analyzed by Dr. Martin. The results of the potassium-argon testing performed by Geochron Laboratories on samples from final excavation grade are included in Appendix 2.5D and are summarized in Table 2.5.3-3. The samples ranged in age from 109 to 200 m.y.a. Three samples from T-3 (10F, 13F, and 15F) were analyzed and yielded dates of 182±7, 155±6, and 178±7 m.y.a. Dates of 200±7 and 165±6 m.y.a. were obtained on samples taken from T-2 (7F and 14F). Sample 1F was taken from a smaller fault, 1541. The age indicated by the K/Ar method for this sample was 109±5 m.y.a.

All of the samples tested yield results that are consistent with previous tests performed on samples from Millstone, with the exception of 1F. Table 2.5.3-3 lists the dates of samples previously tested at Millstone. These samples had a range of ages between 168 to 198 m.y.a. Excluding the date from Sample 1F, the average age of faulting from all tests performed on the clay gouge from the Millstone site is 176 m.y.a.

The date on Sample 1F is considerably lower than the other dates. Compared to the other samples taken at final grade, this sample had considerably smaller amounts of the illite fraction (Appendix 2.5C), and a higher ratio of smectite to illite. The smectite may have formed after the gouge material, due to weathering, hydration of the illite, or by hydrothermal alteration. The younger date may reflect the interference of the smectite portion of the sample. As mentioned in Section 2.5.3.2.1, hydrothermal alteration is quite prominent, and the fault zone has been influenced by weathering.

Five samples of gouge were taken from fault 1940 in the engineered safety features building and faults 2282 and 2339 in the Millstone 3 pumphouse. Dr. R. C. Reynolds of Dartmouth College analyzed the clay mineralogy of these samples. His reports are included as Appendix 2.5E.

Large amounts of smectite and little illite were present in the samples (B, C, and D) from fault 1940 which precluded K/Ar dating of the material. Samples P-1 and P-2, taken from faults 2282 and 2339, respectively, were composed mostly of kaolinite with a small percentage of montmorillinite (Appendix 2.5E). A trace of illite was noticed in sample P-2 but neither sample could be dated.

The form and quantity of the smectite present in the samples from fault 1940 does, however, indicate a probable hydrothermal origin for the material. The kaolinite from the faults in the pumphouse (P-1 and P-2) was found to have a crystalline structure, also indicative of a hydrothermal origin. The date of the last hydrothermal event, as indicated by the studies of faults, T-2 and T-3, is between 168 and 198 m.y.a.

Clay gouge samples from faults 2781 and 2819 (NNECo. 1982) in the discharge tunnel were also analyzed by Dr. R. C. Reynolds. His study indicated the material from fault 2781 was not suitable for age dating, as it comprised mostly original micas from the parent rock. The material from 2819 was found to contain sufficient authigenic illite and was suitable for age dating. It produced a K/Ar age date of 142 million +1-6 million years.

2.5.3.2.3 Conclusions

The K/Ar age dating, petrographic analysis, x-ray diffraction studies, soils mapping, and the detailed mapping of the fault zones indicate that the faults at the Millstone site are incapable features. The petrographic analysis shows that the cataclasite has been silicified and hydrothermally altered, and that the fractures and cracks have been filled with chlorite. Prismatic quartz crystals, drusy quartz, and the silicified cataclasite found in the fault zones would be fractured and/or granulated if any additional movement had occurred.

The radiometric age dates on the fault gouge indicate that the last activity along the faults occurred approximately 142 m.y.a. Silicified breccias, microbreccias, and cataclasites within the T-2 and T-3 zones indicate that earlier episodes of movement and silicification occurred. The presence of the 1M mica polymorph indicates that the unordered 1Md has undergone changes initiated by the heat associated with the introduction of hydrothermal fluids along the fault zones. The tabulation in Section 2.5.3.2.2 summarizes the relative amounts of polymorphs from the x-ray diffraction analysis reported in Appendix 2.5C. It was found that the clay gouge is comprised mainly of 1M and 1Md polymorphs. Therefore, the dates obtained by radiometric analysis indicate some hydrothermal heating of the clay gouge zone - the last activity along the faults.

The petrographic and radiometric studies are reinforced by the published geologic history of the region (Section 2.5.1.1.5) and of the site area (Section 2.5.1.2.4.1). Detailed mapping of the excavation showed that the most prominent joint set trends northerly and dips at high angles to the east or west, as shown on Figure 2.5.1-16. All of the smaller faults parallel the prominent jointing, indicating that the same tectonic forces were responsible for their formation. Slickenside information (Figure 2.5.1-17) and exposures in the excavation indicate that the major component of movement is down-dip. Regionally, a prominent northerly joint set exists. Many of these surfaces also exhibit slickensides (Lundgren et al., 1971; Lundgren and Thurrell 1973). West of the site, the Triassic-Jurassic Basin is bordered by a northerly trending, high angle fault (Rodgers 1970). The Clinton quadrangle to the west and the Moodus and Colchester quadrangles to the north of the site are cut by numerous high-angle faults related to the major Triassic faults to the west (Lundgren et al., 1971; Lundgren and Thurrell 1973). All available information indicates that the forces necessary to develop most of the jointing and faulting at Millstone Point are related to the extensional regime of the Juro-Triassic period. The compressional forces evident by faults 1940 and 2781 may have resulted from shear couples associated with the tensional forces or may have been the result of pre-Triassic tectonism during the Allegheny Orogeny. Hydrothermal activity along the faults represents the youngest known fault-related event in southern New England (Goldsmith 1973; Skehan 1975; Rodgers 1975).

Millstone Point, like much of New England, is covered by a layer of glacial till. The till has been observed to overlie several faults at the site. No disturbance of the till has been noted (NNECo, 1975, 1982). Caldwell (Appendix 2.5A) estimated the age of the till at the site to be approximately 18,000 years old. Flint (1975) estimates that the margin of the glacier had melted back to the line of the present Connecticut coast about 15,000 years ago.

Considering all the geologic data presented, it is concluded that the faults at the Millstone site are not capable. The last activity along them occurred approximately 142 m.y.a. This indicates that the faulting at the site is related to the Triassic-Jurassic rifting as stated in Section 2.5.1.1.4.2 or older events as in the case of fault 1940.

2.5.3.3 EARTHQUAKES ASSOCIATED WITH CAPABLE FAULTS

There is no evidence of capable faults within the 5-mile radius of the site. As stated in Section 2.5.2.3.1, the majority of the significant seismic activity has been associated with the White Mountain Plutonic Province. Some activity has been associated with the Ramapo fault system (Aggarwal and Sykes 1978); however, the fault is not considered capable (NRC 1977).

2.5.3.4 INVESTIGATION OF CAPABLE FAULTS

There are no capable faults within the site area. The faults uncovered in the excavation are discussed in Section 2.5.3.2.

2.5.3.5 CORRELATION OF EPICENTERS WITH CAPABLE FAULTS

As discussed in Section 2.5.2.3.2, there has been no spatial correlation between earthquakes and faults in the site region. Some correlation has been suggested with the Ramapo fault in New York and New Jersey. As discussed in Section 2.5.2.3.1, however, the Ramapo is not considered capable (NRC 1977).

2.5.3.6 DESCRIPTION OF CAPABLE FAULTS

There are no capable faults within 5 miles of the site.

2.5.3.7 ZONE REQUIRING DETAILED FAULTING INVESTIGATION

Eleven incapable fault zones have been uncovered during excavation at the site. These faults have been mapped in detail and are discussed in Section 2.5.3.2. Figure 2.5.4-6 shows the map of the floors of structures. There are no other zones requiring detailed investigation.

2.5.3.8 RESULTS OF FAULTING INVESTIGATION

There is no evidence of capable faulting within the 5-mile radius of the site. The faults at the site are related to the rifting associated with the Triassic-Jurassic Period or older, with the last activity occurring approximately 142 m.y.a.

2.5.3.9 REFERENCES FOR SECTION 2.5.3

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TABLE 2.5.3–1 LIST OF FAULTS

CLICK HERE TO SEE TABLE 2.5.3-1

TABLE 2.5.3–2 LIST OF SAMPLES

CLICK HERE TO SEE TABLE 2.5.3-2

TABLE 2.5.3–3 LIST OF K/AR AGE DETERMINATIONS OF FAULT GOUGE

CLICK HERE TO SEE TABLE 2.5.3-3

2.5.4 STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

The stability of the soil and rock underlying the Millstone Nuclear Power Station - Unit 3 foundations was evaluated using the results of detailed field and laboratory investigations, both prior to and during construction. The field investigations consisted of borings, standard penetration tests, piezometer installations, water pressure tests, geologic mapping, and seismic surveys to determine compressional and shear wave velocity. Laboratory testing was conducted to determine the physical properties of the soil and rock. A detailed listing of the site investigation program is included at the beginning of Section 2.5. Evaluations of the subsurface conditions, soil and rock properties, and results of stability analyses are presented herein. Analyses incorporate the vibratory ground motion associated with the safe shutdown earthquake (SSE) where appropriate.

2.5.4.1 GEOLOGIC FEATURES

The geologic setting and site structural geology of the Millstone 3 site is discussed in Sections 2.5.1.2 and 2.5.3, and the local geology is shown on the site bedrock geology map (Figure 2.5.1-13).

The rock surface, mapped prior to excavation, is fresh with few zones of weathering. The weathering is not excessive and occurs generally in highly jointed areas or along a fault zone. The top of rock has been glacially smoothed and eroded by outwash waters. Many of the joints have been filled with glacial till. In the southern portion of the main excavation in the discharge tunnel area, six low angle joints (394, 398, 424, 425, 577, 645) exhibiting slight displacement due to the wedging action of the glacial ice have been mapped. The location of these joints are shown on Figures 2.5.4-1 through 2.5.4-5.

No evidence of large stress concentrations developed during the rock excavation for Millstone 3. There was no observable stress relief in the form of popping rock, rock bursts, or notable rock movement. No significant problems were noted from rock stresses in the Millstone Point quarry (Dale and Gregory 1911; Dale 1923). However, Niles (1975-76) indicated that the thin webs of rock between closely spaced holes had popped while line drilling, and that the drills had become bound.

The close spacing of the drill holes and the binding of the drills were probably caused by the release of the residual stress in the rock mass.

Geologic Mapping During Construction

Final excavation grades and most of the top of rock were geologically mapped during excavation for the safety related structures. A summary report of the mapping of the bedrock surface and three subsequent reports concerning faults subsequently uncovered at the site have been submitted to the Nuclear Regulatory Commission (NRC) (NNECo. 1975, 1976, 1977, 1982). Results of site geologic mapping are discussed in Sections 2.5.1.2 and 2.5.3. Field sketches were prepared for the floors of structures at the scale of 1:120, and the walls and the major fault zones were prepared at a scale of 1:60. These scales have been reduced in this document for publication purposes. The geologic maps of final excavation grades of the safety related structures are shown on Figures 2.5.4-1 through 2.5.4-27. The identifying numbers adjacent to the joint lines, foliation symbols, and slickensides correspond to descriptions listed in Tables 2.5.4-1, 2.5.4-2, and 2.5.4-3, respectively.

The geologic maps of the containment and engineered safety features (ESF) building excavation walls are shown on Figures 2.5.4-10 through 2.5.4-14 and 2.5.4-18. Tables 2.5.4-4, 2.5.4-5, and 2.5.4-6 list the joint, foliation, and slickenside information for the containment and ESF buildings, respectively.

The excavation walls of the auxiliary building pipe tunnel pit and the north wall of the excavation are shown on Figures 2.5.4-15 through 2.5.4-17. The service water pipeline walls and discharge tunnel excavation floor and walls are shown on Figures 2.5.4-1 through 2.5.4-5 and 2.5.4-19 through 2.5.4-27. Lists of joint, foliation, and slickenside information are given in Tables 2.5.4-7, 2.5.4-8, and 2.5.4-9, respectively.

The igneous intrusions and biotite concentrations that cross the site are numbered for continuity and for distinguishing the different intrusions that cross discontinuities caused by faulting and elevation differences in the excavation.

The faults uncovered at the site are shown on Figures 2.5.4-6 and 2.5.4-19 and are listed in Table 2.5.3-1. The nature and age of the faults are discussed in detail in Section 2.5.3.2.

2.5.4.2 PROPERTIES OF SUBSURFACE MATERIALS

A series of investigations was conducted in the field and in the laboratory to determine the properties of the subsurface materials existing at the site and the compacted backfill materials processed from offsite sources. Materials underlying the site include beach sand, unclassified stream deposits, ablation till, basal till, and hard, crystalline bedrock of the Monson Gneiss formation. The field investigations included soil and rock borings, geologic mapping, piezometer installation and monitoring, water pressure testing of the bedrock, seismic refraction and reflection surveys, and cross-hole and up-hole seismic surveys. The field testing is described in detail in Section 2.5.4.3. The laboratory investigations included index property and gradation determinations of onsite soils, moisture-density relations, and direct shear testing of compacted backfill, shear modulus, and damping determination and cyclic and static triaxial testing of beach sands, unconfined compression testing of bedrock core samples, and joint and foliation friction determination for bedrock surfaces.

Laboratory testing of site soils and backfill source materials was conducted in the Stone & Webster Engineering Corporation (SWEC) Soils Laboratory. Field testing for backfill control during placement was conducted in the SWEC Field Quality Control Laboratory, located onsite. Compacted backfill test results are discussed in Section 2.5.4.5.2. Intact rock core specimens were tested for unconfined compressive strength and unit weight by Prof. K. Tsutsumi of Tufts University. Results of these tests are presented in Table 2.5.4-10. Direct shear tests along jointed and foliated rock surfaces on specimens selected from NX core samples were performed in the SWEC Soils Laboratory. A description of these tests is presented in Section 2.5.5.2 and data are tabulated in Table 2.5.4-11. Cyclic triaxial, resonant column, and small strain cyclic triaxial (E) tests were conducted by Geotechnical Engineers, Incorporated (GEI) on the beach sands adjacent to the pumphouse. The results of this study are presented in the GEI report, Appendix 2.5F. Consolidated undrained (CIU) tests were also performed on samples of the beach sands in the SWEC Soils Laboratory. The results of these tests are tabulated in Table 2.5.4-12 and Appendix 2.5G.

Overlying the bedrock at the Millstone site are five groups of soils. They are from youngest to oldest: artificial fill, beach deposits, unclassified stream deposits, ablation till, and basal till. Each of these is discussed in the following sections.

2.5.4.2.1 Artificial Fill

Artificial fill material is comprised of a mixture of till, waste rock materials excavated from the Millstone 1 and 2 sites, and some quarry waste. Consequently, it is a heterogeneous mixture. These fill materials were not placed in controlled thin-lift construction and are not a satisfactory foundation material for structures of any kind. All artificial fill has been excavated when encountered and no structures, pipelines, or electrical ducts are founded on this material.

2.5.4.2.2 Beach Deposits

The beach deposits are the youngest naturally occurring material in the site area. These are present for the most part only in the cove east of Bay Point, in the area of the circulating and service water pumphouse. For the most part they consist of uniform silty sand. The beach deposits are generally denser than the alluvium deposits due to wave action from Long Island Sound.

Static and cyclic triaxial and resonant column tests were performed on the beach deposits to investigate liquefaction potential and obtain shear strength parameters for slope stability analyses of the shoreline area. The results of these tests are tabulated in Table 3 of Appendix 2.5F. These analyses are discussed in Section 2.5.4.7, 2.5.4.8, and 2.5.5.2.

Composite plots of relative density and corrected blow count (N) vs effective overburden stress based on Gibbs-Holtz relations are presented on Figures 2.5.4-28 and 2.5.4-29, respectively. These plots show that the beach sand is a medium dense deposit with an average relative density of approximately 70 percent, with most points denser than 60 percent. Some points do plot lower, but these low density values are generally indicative of the looser, unsaturated sand near the ground surface.

No major plant structure, pipeline, or duct is founded on the beach deposits. This material was excavated and replaced with compacted select backfill under portions of the service water line, but remains in place along the shoreline, adjacent to the circulating and service water pumphouse.

2.5.4.2.3 Unclassified Stream Deposits

Unclassified glacial stream deposits west and southwest of Millstone 3 consist of sands with some silts and gravels. Thicknesses of the deposits vary, and exposed cuts reveal the sediment to be somewhat stratified. In general, the deposits are medium dense to dense cohesionless materials, with loose deposits occurring within limited zones above the basal till overlying bedrock. The extent of the unclassified stream deposits is shown on the site surficial geology map (Figure 2.5.1-3).

No major plant structure, pipeline, or duct is founded on unclassified stream deposits. Prior to installation of any foundations, all underlying loose deposits were removed to sound basal till or bedrock and replaced with compacted backfill, as discussed in Section 2.5.4.5.2.

2.5.4.2.4 Ablation Till

Ablation till overlies the dense basal till in the area where the major plant structures are located. This material consists of glacially transported debris which was deposited as the supporting and/or enclosing ice melted away from it. The ablation till has not been compacted by ice and is, therefore, less dense than the basal tills, but is still a strong, stable soil. Both the basal till and the overlying ablation till are relatively impervious. The ablation till is more pervious than the basal till because it is irregularly stratified with lenses of sand and gravel and mixtures of cobbles, gravels, sands, and silts.

Gradation analyses and moisture content determinations were conducted on split spoon samples of the ablation till. The gradation curves indicate that the ablation till is a silty sand, with typically 20 to 40 percent finer than the No. 200 sieve. The gradation curves are presented on Figure 2.5.4-30 plotted with the Lee & Fitton (1969) and Kishida (1969) gradation envelopes of soils most likely to liquefy during the earthquake. The ablation tills at the Millstone site are significantly more widely graded and coarser than the soils typified by these envelopes. The natural moisture content of the ablation till varies from 5 to 15 percent. Moisture content determinations from split spoon samples of various overburden materials at the site is presented in Table 2.5.4-13.

Approximately 500 feet of the circulating water discharge tunnel in the vicinity of Millstone stack is founded on crushed stone and concrete fill overlying ablation till. At all other structures, the ablation till was removed to sound basal till or bedrock and replaced with compacted backfill, if required, as discussed in Section 2.5.4.5.2.

2.5.4.2.5 Basal Till

Basal till overlies bedrock at the site area, varying in thickness from less than 5 feet in the pumphouse area on Niantic Bay to over 40 feet under the turbine building. The basal till is a very dense material of low permeability consisting of a widely graded mixture of cobble and boulder-size rock fragments, gravel-size material, sand, and some silt binder. The basal till was overridden and compacted by ice during the glacial period, accounting for its characteristic very dense state and high strength.

Gradation analyses and moisture content determinations were conducted on split spoon samples of the basal till. Although only the minus 1 inch portion of the basal till was tested, the gradation curves presented on Figure 2.5.4-30 show that the basal till consists of a widely graded silty sand

(SM) with 10 to 25 percent finer than the No. 200 sieve and a coefficient of uniformity (D_{60}/D_{10}) of approximately 80. The natural moisture content for the basal till, presented in Table 2.5.4-13, varies from 6 percent to 14 percent. A list of structures founded on basal till is presented in Table 2.5.4-14. A detailed discussion of the liquefaction potential of the basal till is presented in Section 2.5.4.8.2 and a discussion of the static stability of structures founded on basal till is included in Section 2.5.4.10.1.

Elastic constants have been determined by seismic cross-hole and up-hole surveys. Details of this study are presented in Section 2.5.4.4.3 and Appendix 2.5H. The average Young's modulus (E) determined for the basal till was 4 x 10^5 psi and the average shear modulus (G) determined was 1.4 x 10^5 psi. A Poisson's ratio of 0.44 has been calculated based on these values of E and G.

2.5.4.2.6 Monson Gneiss

The country rock at the site is the Monson Gneiss. At the site area, the Monson Gneiss is thinly layered with light feldspathic and dark biotitic and hornblendic layers. The foliation is well defined and exhibits a consistent northwest trend. Based on data accumulated during geologic mapping at the site during excavation, the average foliation attitude of the Monson Gneiss is N67W, 48NE, (N54W, 48NE grid north). A stereonet projection of the foliation is presented on Figure 2.5.1-15.

Jointing at the site is characterized by an average attitude of N03W, 63NE (N10E, 63SE). (All strikes are referenced to true north, which is 13.5 degrees east of grid north. Bearings in parentheses represent grid north.) Minor joint sets observed at the site are N02W, 78NW, (N11E, 78NW) and N69E, 74SE (N82E, 74SE). A low angle joint set oriented at N48W (N35W) dips 7 degrees northeast. A lower hemisphere stereonet plot of poles to the joint planes is shown on Figure 2.5.1-16 and a complete list of all measured joints and foliations is presented in Tables 2.5.4-1, 2.5.4-4, 2.5.4-7 and 2.5.4-2, 2.5.4-5, and 2.5.4-8, respectively. In general, the joints are linear and tight and exhibit smooth surfaces. A large number of the joints are coated with chlorite and many exhibit iron oxide staining.

Direct shear tests were performed on several joint and foliation surfaces. These tests indicate that the average residual shear stress for joint surfaces is 34.5 degrees, and the average residual shear stress for the foliation is equal to 32 degrees. Details of the testing program are presented in Appendix 2.5I.

Unconfined compression and density tests were performed on nine core samples of Monson Gneiss and two samples of Westerly Granite. The unconfined compressive strength of the Monson Gneiss varied from approximately 4,000 to 14,000 psi, with an average value of 10,000 psi. The unit weight of Monson Gneiss ranged from 161 to 168 pcf, with an average value of 165 pcf. The Westerly Granite was slightly stronger and less dense. The average unconfined compressive strength of the two samples was approximately 13,000 psi and the unit weight averaged 157 pcf. The results of the rock compression tests are tabulated in Table 2.5.4-10.

A geophysical survey was performed, consisting of measuring compressional “P” wave and transverse “S” wave velocities using both down-hole and cross-hole techniques. Average values for Young's modulus (E), shear modulus (G), and Poisson's ratio were conservatively determined to be 4 x 10^6 psi, 1.5 x 10^6 psi, and 0.33, respectively. The geophysical investigations are discussed in detail in Section 2.5.4.4.3 and Appendix 2.5H.

2.5.4.3 EXPLORATION

A total of 95 test borings, both vertical and inclined, were drilled in the rock and soil at the site. The boring locations are presented on Figures 2.5.4-31 and 2.5.4-32. Table 2.5.4-15 is a listing of all boring coordinates, ground elevations, top of rock elevations, and groundwater elevations at the time of drilling. Complete boring logs are presented in Appendix 2.5J. The logs describe the soil and rock types, the location, elevation, and type of samples recovered, the standard penetration test value (N), and the core recovery and rock quality designation (RQD) of the bedrock. Geologic profiles are presented on Figures 2.5.4-33 through 2.5.4-35 and the basal till surface contour map is presented as Figure 2.5.4-36.

The locations of boreholes in which water levels were taken are shown on Figure 2.5.4-37. Groundwater elevations were monitored in borings 301 to 310 prior to construction, and the groundwater fluctuations over a 2-year period for borings 303, 310, 311, 312, and 317 are shown graphically on Figure 2.5.4-38. These wells were disturbed during construction; therefore, there is no record reported in these wells subsequent to December 1973. Site groundwater conditions, based on regional data, site piezometers, and observations during construction, are discussed in detail in Sections 2.4.13 and 2.5.4.6.

Water pressure tests were performed in three borings to assess the degree of weathering and permeability of the bedrock. The results of the tests are presented in Table 2.5.4-16.

A seismic refraction survey to determine compression wave velocities and depths to various strata was performed by Weston Geophysical Engineers, Incorporated (WGEI) and is discussed in Section 2.5.4.4.1. The location of the seismic refraction lines and the seismic profiles are presented in Appendix 2.5K.

Seismic cross-hole and up-hole techniques were employed at the site in order to determine the values of dynamic moduli and Poisson's ratio for the ablation till, basal till, and bedrock. The results are tabulated and discussed in Section 2.5.4.4.3. The WGEI report on these tests is presented as Appendix 2.5H.

2.5.4.4 GEOPHYSICAL SURVEYS

Geophysical surveys were conducted to determine the nature and extent of subsurface materials at the site. The studies included a seismic refraction survey of the site in the vicinity of the major structures, an offshore seismic and bathymetric survey employing refraction and reflection techniques, and seismic cross-hole and down-hole surveys to determine compressional and shear wave velocities of subsurface materials.

2.5.4.4.1 Onshore Seismic Refraction Survey

A seismic refraction survey was performed by WGEI to investigate subsurface conditions at the site. The purpose of the study was to determine compression wave velocities and depths of subsurface materials, and to prepare a preliminary bedrock contour map of the site area.

Field procedures employed during the refraction survey are detailed in Appendix 2.5K.

The refraction survey identified three major strata at the site according to seismic velocity. The near surface overburden material, identified as ablation till and discussed in detail in Section 2.5.4.2.4, typically has a seismic velocity ranging from 1,500 to 2,000 fps, indicative of a medium dense to dense, unconsolidated material. The transition between saturated ablation till and moderately dense basal till corresponds to a zone with a seismic velocity between 5,000 and 5,600 fps. The very dense basal till, discussed in detail in Section 2.5.4.2.5, has a seismic velocity of approximately 6,700 fps. The thickness and extent of each of the overburden strata are shown on the subsurface profiles in Appendix 2.5K.

A sharp increase in the seismic velocity was observed at the bedrock surface, indicating the absence of any extensive zones of weathered rock. This was verified during excavation for structures. Typical seismic velocity values for the bedrock were approximately 12,000 fps, indicative of a hard, massive, unweathered rock type. The soundness of the rock has been verified from the logging of rock cores from boreholes and from geologic mapping. The rock contour map obtained from the seismic survey and shown on Sheet 3 of 8 in Appendix 2.5K agrees with the contour map of the bedrock surface shown on Figure 2.5.4-39, which is based on actual survey data of the rock surface measured during construction.

2.5.4.4.2 Offshore Seismic and Bathymetric Survey

A seismic and bathymetric survey was conducted by WGEI to contour the Long Island Sound bottom and the bedrock surface offshore from Millstone Point, in the vicinity of the intake and discharge structures, as shown on Figure 1 of Appendix 2.5L. Detailed profiling of the bedrock surface was obtained in some areas by means of continuous reflection techniques. Velocity values for the different materials were determined from a seismic refraction survey. These values were used in computing depths to the reflecting horizons and for identifying the type of overburden material and the quality of the bedrock.

The bedrock and bottom contour maps for the four areas surveyed are presented in Appendix 2.5L.

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 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:

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 elastic constants were determined from field seismic velocity measurements, based on low strain “P” wave and “S” wave velocity measurements from “explosive” and “impact” sources.

The values below are for low strain values from field generated tests and may not necessarily be used as design input. Final values used in design are calculated for individual structures.

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.

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 basal till. Isolated zones of softened till were excavated and replaced with fill concrete or compacted structural backfill. 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 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. 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 founded on soil. When soil was encountered as a founding material, all unsuitable overburden was removed to sound basal till. Where the invert elevation was higher than the excavated grade, compacted structural backfill was placed in thin lifts to the subgrade elevation of the pipe encasement. All compacted structural backfill was placed in accordance with procedures described in Section 2.5.4.5.2. Figure 2.5.4-52 (Geologic

Profile I-I") shows the extent of structural backfill placed beneath the service water intake lines between the turbine building and the circulating and service water pumphouse.

The locations of field density tests of structural backfill placed beneath the service water intake lines near the pumphouse, where the deposit of beach and outwash sand was removed above the basal till, are presented in Figure 2.5.4-53. Table 2.5.4-19 summarizes the results of the density tests in this area.

Rock in the containment area was blasted and excavated in segmented areas, each approximately 10 feet deep. Rock bolts, discussed in Section 2.5.4.12, were installed in the southwest sector of the excavation to prevent potential sliding failures along the foliation. In addition, intercept drains were installed into the southwest excavation face to reduce the hydrostatic pressure on the foliation and joint planes. No rock slides were noted during the time the excavation was in service. However, some areas were overbroken due to blasting and to subsequent scaling operations to remove loosened rock wedges. The overbreak areas were localized and generally limited in size to approximately 2 cubic yards and less. The surfaces of the wedges generally conformed to the predominant joint sets mapped at the site and discussed in Section 2.5.4.1. The nature and extent of overbreak experienced during site excavation is considered normal for bedrock of this type and does not indicate instability in the rock mass.

Various techniques were utilized when blasting near the perimeter of structures to limit overbreak and minimize damage to adjacent rock. The methods used include line drilling, cushion blasting, presplitting, and smooth wall blasting. The purpose of each of these techniques was to develop a shear plane along the perimeter of the excavation so that the excavated rock breaks cleanly from the face. In line drilling, the perimeter holes were closely spaced and left unloaded during the blast. Cushion blasting was used to blast a narrow berm left from a previous blast. A single row of closely spaced holes was drilled along the berm, lightly loaded, and fired simultaneously. Presplitting consisted of the firing of a single row of lightly loaded, closely spaced holes, prior to the primary blast. The purpose was to produce a crack along the line of presplit holes which the subsequent primary blast could break. Smooth wall blasting is similar to cushion blasting except that the lightly loaded perimeter holes were the last delay in the blast.

Controlled blasting techniques were used to limit the vibrations felt at Millstone 1 and 2 and to preclude any structural damage to concrete or bedrock near the blast. Peak particle velocity was measured for each blast, using Sprengnether 3 - component seismographs. No damage to any structure or component in the two operating units or the Millstone 3 construction site was observed as a result of the blasting.

The inflow of water into the excavation was controlled by means of pumping from local sumps. This was possible due to the low permeability of the soils and the tightness of the joints in the bedrock. Concrete working mats were poured on all foundation surfaces upon excavating each area in order to minimize the impact of construction activities on the undisturbed founding surfaces.

Some softening of the basal till in sections of the excavation was observed. The softening is attributable to the exposure of the till to the affects of weathering and construction traffic. When this condition was encountered, the softened material was hand-excavated to firm, dry till and replaced with either fill concrete or compacted structural backfill. In the control building excavation, softened till approximately 1 foot in thickness was hand-excavated to firm till and replaced with structural backfill. The extent of the softening was verified by excavating two test trenches into the till to a depth of 4 feet. No additional softened till was encountered below the softened surface layer. The groundwater level was maintained below the subgrade by pumping from sumps outside the structure, and no seepage infiltrated the excavation after removal of the softened till and placement of the structural backfill.

2.5.4.5.2 Backfill

Category I structures founded totally or partially on structural backfill include the control building and emergency generator enclosure building. In addition, sections of the service water line and some of the buried electrical ducts are founded on Category I structural backfill.

Material used for Category I structural backfill is predominantly obtained from glacial outwash deposits located at the Romanella Pit in North Stonington, Connecticut. Test data on borrow material from the Romanella Pit have been previously reported in July and November 1974 and are included in Appendix 2.5M. A small percentage is obtained from other borrow sources having similar geologic characteristics. A description of the borrow material from three alternate sources located in the towns of North Stonington, Preston, and Canterbury is included in a report submitted in June 1976 and is included herein as Appendix 2.5M.

All structural backfill is processed at the borrow pit by means of passing the soil through a screen, ensuring that the maximum particle size and gradation meet the backfill specification requirements. For Category I structural fill, the gradation limits are:

U.S. Standard Sieve Size	**Cumulative Percent Passing**
3 inches	100
3/4 inch	75 to 100
3/8 inch	65 to 90
No. 10	40 to 60
No. 40	15 to 35
No. 100	0 to 20
No. 200	0 to 15

Coefficient of Uniformity, $Cu = D_{60}/D_{10} \geq 10$.

All structural backfill was compacted to 95 percent of the maximum dry density determined from the Modified Proctor Test, ASTM D1557, Method D. Moisture content was maintained within 4 percent of optimum. Structural backfill for Category I structures was placed in loose lifts not exceeding 8 inches and uniformly compacted by heavy vibratory rollers.

A continuing program of testing, inspection, and documentation was in effect during construction to ensure satisfactory placement of backfill. Category I structural backfill was tested every 500 cubic yards for conformance to the specified gradation limits prior to being allowed into the construction area. In addition, the maximum density was determined by ASTM D1557, Method D, for every 500 cubic yards of fill placed. Field density tests, using ASTM D1556, were performed for each lift of fill, but not less than one test for every 500 cubic yards of fill placed.

Locations of field density tests under the emergency generator enclosure and control building are shown in Figure 2.5.4-54, and the test results are summarized in Table 2.5.4-20. Cross-sections showing generalized subsurface profiles beneath these two structures are presented in Figures 2.5.4-55 (Section J-J') and 2.5.4-56 (Section K-K').

Shear strength of compacted backfill materials was determined from drained direct shear tests on samples compacted to 95 percent of maximum dry (ATMS D1557) density. Samples tested in the direct shear box contained only the minus No. 4 portion of the sample. For consistency, the maximum density was also determined on the minus No. 4 portion of the sample. However, the maximum density of the minus 3/4-inch fraction was tested in the field, and it can be assumed that the maximum density of the minus No. 4 fraction would be less than the maximum density attainable at the site on the whole sample. Consequently, testing the minus No. 4 fraction results in values of shear strength more conservative than would be expected for the whole soil sample. A comparison of maximum densities for the minus No. 4 and minus 3/4-inch fractions for representative samples from the major borrow areas used for Category I structural backfill is presented below:

Backfill Source	**νd max (-3/4") (pcf)**	**νd max (-#4) RX (pcf)**	**ϕ @ 95% νd max (-#4) (deg)**	**ϕ @ 90% νd max (-#4) (deg)**
Romanella Pit (Sample “R”)	136.4	129.5	41.5	--
Preston Pit	138.8	131.0	35.0	34.6
No. Stonington Pit	148.0	136.1	37.9	34.0
Canterbury Pit	140.0	131.6	39.4	34.0
Hathaway Pit (Waterford)	129.7	121.1	39.1	--
Ledyard Pit (Soneco)	132.6	122.9	41.4	--

The maximum shear modulus and Young's modulus at static strain levels were calculated for the structural fill based on the Hardin and Richart (1963) equation for round-grained sands at very low strains:

$$G_{max} = \frac{2630\ (2.17 - e)^2}{1 + e}(\bar{\sigma}_o)^{1/2} \qquad (2.5.4\text{-}1)$$

where:

G_{max} = maximum shear modulus in psi

e = void ratio

σ_o = effective octahedral stress in psi

Void ratio was calculated assuming full saturation and a water content equal to 12 percent, which represents the water content at full saturation for a density of 95 percent of maximum, based on the moisture-density curve for Sample “R” in Appendix 2.5M. The octahedral stress was assumed to be equal to two-thirds of the effective overburden stress for a particular depth. The maximum shear modulus at a depth of 10 feet, which corresponds to the midpoint of the backfill layer beneath the emergency generator enclosure building, is 13,400 psi. A profile of G_{max} vs effective confining pressure is plotted on Figure 2.5.4-42.

A resonant column test was performed on a sample of the structural backfill compacted to 95 percent of a maximum dry density. The values of G_{max} plotted on Figure 2.5.4-42 obtained from this test are in agreement with the Hardin and Black (1968) equation. The low strain damping ratio was calculated to be 1.4 percent.

Young's modulus for static strain levels was obtained through an iterative process where a value of vertical strain was used to obtain a reduction factor for the G value. The value of E was calculated using the equation:

$$E = 2G(1+u) \qquad (2.5.4\text{-}2)$$

where:

u = Poisson's ratio

The strain level assumed was checked with the expected strain level caused by the structural loading, using the equation:

$$\varepsilon = \frac{\Delta\sigma_z}{E} \qquad (2.5.4\text{-}3)$$

where:

e = Vertical strain

$\Delta\sigma_z$ = Increase in vertical stress from structure load

E = Calculated value of Young's Modulus

For the emergency diesel generator enclosure building, the calculated vertical strain was approximately 10^{-3}, and Young's modulus at a depth of 10 feet was approximately 10,000 psi. The profile of E static vs effective confining pressure is also plotted on Figure 2.5.4-42.

Backfill placed behind concrete walls is described in Section 2.5.4.10.3.

2.5.4.5.3 Extent of Dredging

To facilitate the flow of water into the service and circulating water pumphouse, an intake channel has been dredged to the limits shown on Figure 2.5.4-41. Side and longitudinal slopes of the intake channel are designed at 10 and 5 percent, respectively. The beach slope varies from 20 to 10 percent and is protected with heavy armor, as discussed in Section 2.5.5.1.

Borings and laboratory testing in the beach area adjacent to the circulating and service water pumphouse indicate that the beach sands are generally moderately dense, with occasional thin zones of less dense material. Liquefaction analyses of these sands, discussed in Section 2.5.4.8.3.2, indicate that a general liquefaction of the sand adjacent to the pumphouse is highly unlikely. If the looser zones do liquefy, the extent of the failure would be strictly local and would not cause a massive soil movement into the dredged channel.

2.5.4.6 GROUNDWATER CONDITIONS

Groundwater observations have been documented in previous reports (Ebasco 1966; Bechtel Corporation 1969). Water level readings in borehole piezometers were taken for the Millstone 3 site study between 1971 and 1973. In addition, pressure testing of rock in three boreholes and during installation of rock anchors in the turbine and service buildings was conducted to determine the permeability of the rock mass. Also, temporary drains were installed in sections of the containment excavation face and the inflow of water into all excavations was observed throughout construction. These observations form the design bases for groundwater at the site, as discussed below.

2.5.4.6.1 Design Basis for Groundwater

Groundwater observations at the site prior to construction were made in piezometers installed in several borings. Listings of the water elevations and dates of reading are presented in Table 2.5.4-17. Three borings, 303, 310, and 311, were continually monitored over a 2-year period. A plot of elevation vs date for water levels in these boreholes is shown on Figure 2.5.4-38. As a result of these observations, a stabilized groundwater level contour map, based on the water levels measured in January 1972, shown on Figure 2.5.4-37, is used as the basis for determining hydrostatic loadings on structure foundations.

Localized perched groundwater conditions probably exist because of the irregular distribution of ablation till materials of varying gradation and porosity. It is also likely that shallow, ponded water exists in localized bedrock troughs. The prevalence of bedrock outcrops to the north and northwest of the site indicates that bedrock acts as a groundwater divide, isolating the soils of the tip of Millstone Point from soils further inland. Thus, groundwater recharge would primarily be due to absorption of local precipitation, with probable migration of the waters to the immediately adjacent Long Island Sound. Little groundwater is present in the crystalline bedrock, and virtually all of the groundwater movement is restricted to the soil overburden.

Measurements taken during previous investigations (Bechtel Corporation 1969) showed average influx rates into test pits of about 8 gallons per hour, and it was concluded that both the ablation and basal tills were relatively impervious. The ablation till soils are more pervious than the basal tills and occasionally exhibit partial stratification, including sporadic sand lenses. Thus, the upper portions of the soil transmits water more readily than the underlying dense basal tills.

All structures are designed for the groundwater levels shown in Table 2.5.4-14 which are based on groundwater contours plotted on Figure 2.5.4-37. No safety-related permanent dewatering system is required to lower groundwater levels. These groundwater contours represent average groundwater elevations of the site prior to the start of construction. A comparison of groundwater contours with the top of basal till contours on Figure 2.5.4-36 verifies that the primary medium for groundwater flow is the permeable surficial soil overlying the basal till. Recharge of the groundwater occurs mainly from precipitation infiltrating through the surficial soils, and flowing toward Long Island Sound and the outwash deposits above the till.

Construction of the plant results in large changes to the site geohydraulic conditions. Site grade has been lowered to a uniform elevation of +24 feet from the original site grade which varied from elevation 26 feet to 30 feet. The major plant structures are founded at approximately elevation 0 feet on blasted rock excavations and backfilled from subgrade level to the ground surface with fill materials of relatively high permeability. The backfilled zones under and around these structures and the circulating water intake pipelines provide a continuous hydraulic conduit for groundwater flow from the plant area to Long Island Sound. Therefore, the average water levels prior to construction are not necessarily representative of post-construction groundwater conditions. Design groundwater levels used in plant design are shown in Table 2.5.4-14.

A seepage diversion system, consisting of a series of underdrains and porous concrete, has been installed under and around several structures to minimize the amount of seepage into the basement of structures founded below the groundwater table. The quantity of seepage expected to be diverted through the system is small, due to the low permeability of the basal till and rock at the site. This system is not considered safety related because dewatering is not necessary to ensure the stability of any structure. However, enough leakage occurs to require pumping for equipment protection. The containment and all other Category I structures are protected from groundwater inflow by a waterproof membrane below the groundwater level. Water which penetrates or circumvents the membrane is diverted to the Engineered Safety Features Building porous concrete groundwater sump via the underdrains and porous concrete. The groundwater collected in this sump is removed during normal operation, post-LOCA and LNP conditions using a non safety-related pump (see Section 9.3.3 for details of this system.)

Water levels measured in borings taken at the site in early 1972 indicate a groundwater piezometric surface with a 3-percent gradient generally sloping from northeast to southwest, as shown on Figure 2.5.4-37.

As discussed in Section 2.4.5.2, Flood Design Considerations, the controlling event for flooding at the Millstone 3 site is a storm surge resulting from the occurrence of the probable maximum hurricane (PMH). The maximum stillwater level resulting from hurricane surge was calculated to be elevation 19.7 feet msl. As shown on Figure 2.4-9, the water level drops significantly with time, so that after 2 hours the flood level is at elevation 17 feet and after 6 hours the surge level subsides to elevation 10 feet. A continuous hydraulic connection would occur across the site from the main structure area to the shorefront through the backfill placed around structures and the backfill placed in the circulating water pipeline trench. It can be expected that the maximum groundwater level due to flooding would not exceed elevation 19.7 feet and would probably be less because of head losses in the soil. According to Figure 2.4-9, the water level drops to 17 feet after 2 hours.

The design groundwater levels for major safety-related structures shown on Table 2.5.4-14 are all equal to or greater than elevation 19 feet with the exception of the hydrogen recombiner building, which has a design groundwater level of 18 feet. However, founding grade is at elevation 20 feet for this structure, which is founded on concrete fill placed directly on bedrock. Design criteria for flood conditions are discussed in Section 3.4.

2.5.4.6.2 Groundwater Conditions During Construction

During construction, the inflow of water into the excavations was controlled by pumping from sumps located outside of the building lines adjacent to structures. Most flow through the overburden was transported through the sand lenses. All water-softened material was removed and replaced with a fill concrete working mat as described in Section 2.5.4.5.1. The rate of inflow was sufficiently low to allow enough time to pour the concrete working mat without further softening of the till.

Drainage pipes were installed in the southwest face of the containment excavation in order to relieve the hydrostatic pressure on the bedrock joint and foliation surfaces. Very little water was observed flowing through these pipes, indicating that the quantity of flow through the bedrock is small and that the permeability of the rock is low.

Water pressure tests were performed in three boreholes prior to construction. These tests indicated that the rock within the site area is generally massive with slight to moderate interconnected jointing. A summary of the water pressure test data from the boreholes is included in Table 2.5.4-16. Additional pressure tests were performed prior to installation of rock anchors in the turbine and service buildings. These tests further verified the low permeability of the rock mass.

These observations suggest that the permeability of the bedrock is extremely low, and that little or no groundwater or seawater is expected to seep through the fresh rock mass.

2.5.4.7 RESPONSE OF SOIL AND ROCK TO DYNAMIC LOADING

All Seismic Category I structures and associated piping are founded either on bedrock, basal till, or structural backfill. Portions of the circulating water discharge tunnel are founded on ablation till in the vicinity of the Millstone stack north of Millstone Unit 1. A listing of the founding strata for all Category I structures is included in Table 2.5.4-14.

Hard crystalline bedrock forms the basement complex of the area. The overlying dense basal till consists of a hard, compact soil which has been heavily preloaded by continental ice. Static and dynamic properties of the basal till and bedrock are discussed in Sections 2.5.4.2.5 and 2.5.4.2.6, respectively. Static and dynamic properties for the compacted structural backfill are discussed in Section 2.5.4.5.2.

The bedrock, basal till, ablation till, and structural backfill are stable materials under vibratory motion caused by the SSE. The basal till, ablation till, and structural backfill are not susceptible to liquefaction, as discussed in Section 2.5.4.8.

The soil-structure interaction analyses for Seismic Category I structures founded on soil were performed using the computer program PLAXLY-3. The nonlinear behavior of the subgrade was accounted for by use of the computer program SHAKE (LaPlante and Christian 1974) which was used to determine the strain-corrected soil properties. The subsurface material properties used in the SSI analysis are discussed in Section 2.5.4.7.1. The method of SSI analysis and the results are discussed in Section 3.7.2.4.

The response of buried piping to seismic loadings is discussed in Section 3.7.3.12.

The shorefront west of the circulating and service water pumphouse consists of a structural fill and beach and outwash and slope varying from 5H:1V to 10H:1V, protected by graded layers of armor stone. A plan showing the extent of the shoreline protection system is presented on Figure 2.5.4-41. A typical section is shown on Figure 2.5.5-1. Static and dynamic properties of the beach sands are discussed in Section 2.5.4.2.2 and documented in the reports in Appendix 2.5F and 2.5G. The liquefaction potential of the beach and outwash sand is discussed in Section 2.5.4.8. The stability of the shoreline slopes under static and dynamic loading is discussed in Section 2.5.5.2.

The service water intake pipes, between the circulating and service water pumphouse and the main plant area, are embedded in a rectangular concrete encasement. Soils encountered in the pipeline excavation include beach and outwash sands, unclassified stream deposits, and ablation till. These soils were removed under the pipeline to dense basal till and replaced with Category I structural backfill. The fill was placed at a 1:1 slope from the till surface to the base of the encasement and compacted to the requirements outlined in Section 2.5.4.5.2. The sides of the encasement were backfilled with nonstructural fill similar to the material used to backfill behind retaining walls and described in Section 2.5.4.10.3. The backfill was compacted to 90 percent of maximum dry density as determined by ASTM D1557, Method D.

2.5.4.7.1 Subsurface Material Properties Used in SSI Analysis

The subsurface profiles used in the soil-structure interaction analyses for the control building and the emergency generator enclosure (EGE) are idealized, horizontal profiles based on subsurface explorations conducted at the site and described in Section 2.5.4.3. Both of these structures are founded on dense basal till overlying bedrock. The computer program SHAKE was used to determine strain corrected values of shear modulus obtained from low strain values previously determined from field testing, laboratory testing, or empirical formulae based on laboratory test data. The program iterates to obtain values of modulus that are compatible with strain levels induced in a particular soil layer by a specific earthquake. The strain levels normally induced by earthquakes of magnitudes similar to the Millstone SSE are several orders of magnitude higher than the low strain levels achieved during laboratory or field testing, resulting in a reduction in shear modulus when these properties are corrected for strain and input into PLAXLY-3.

The soil-structure model used in the EGE analyses is shown on Figure 2.5.4-72. This idealized profile was selected to conservatively model the subsurface conditions under the EGE and in the free-field. The geologic profiles presented in Figures 2.5.4-55, 2.5.4-56, and 2.5.4-71 indicate that the rock surface slopes from approximately elevation 0 feet at the east end of the structure to at least elevation -10 feet at the west end. In the north-south direction, the sloping evacuation face between the control building and the south end of the EGE was backfilled with structural fill over the basal till. The extent of structural fill is shown on Section J-J (Figure 2.5.4-55) and Figure 2.5.4-54. Because the depth and extent of the structural fill under the EGE is limited, it was assumed that the model used in the SHAKE analysis is sufficiently conservative to account for local variations in the subgrade and their effect on structural response.

The soil properties input into the SHAKE calculation are listed in Table 2.5.4-21A for the free-field model and 2.5.4-21B for the structure-effects model. Three earthquake time histories, from the Taft, Helena and Parkfield earthquakes, were normalized to the site SSE peak acceleration value of.17g and input at bedrock. Shear modulus and damping iterations were performed within the SHAKE program in accordance with the curves marked “Resonant Column Test” on Figures 2.5.4-73 and 2.5.4-74. These curves were developed from empirical formulae and resonant column tests performed on samples of compacted structural fill from the Millstone site. These test results are presented on Figure 2.5.4-42. The tests show good correlation with curves present by Seed and Idriss in the SW-AJA report (1972).

The strain corrected values of shear modulus and damping in the free-field are presented in Table 2.5.4-21A. The mean value for each layer was calculated and used to represent the individual soil layer properties used in the PLAXLY model shown on Figures 3.7B-11 and 3.7B-12. The Millstone site artificial earthquake was input at bedrock and the soil was modeled as a finite element mesh. The use of SHAKE to perform shear modulus and damping iterations precludes the need to iterate in the PLAXLY model. A discussion of the soil-structure interaction analysis is presented in Section 3.7B2.4.

For the control building, the soil profile analyzed in SHAKE and used in the soil-structure interaction analysis was the section where rock was the deepest; i.e., top of rock at elevation -15 feet. Shear wave velocities were used to define soil stiffness. The low strain and strain-corrected soil properties for the free field case are listed in Table 2.5.4-22.

2.5.4.8 LIQUEFACTION POTENTIAL

The foundation materials beneath some of the Seismic Category I structures consist of limited depths of dense to very dense basal tills and/or compacted select granular backfill. These materials are not susceptible to liquefaction under earthquake motions as described in the following sections.

2.5.4.8.1 Structural Backfill

Based on studies of soils where liquefaction has been observed (Seed 1968, Lee and Fitton 1969, Kishida 1969), it is concluded that the structural backfill described in Section 2.5.4.5.2 in areas below the groundwater table is not susceptible to liquefaction, as discussed below.

1. A liquefiable soil is generally a uniform sand with a uniformity coefficient of not more than 10 (Kishida 1969). The structural backfill has a uniformity coefficient ranging from 25 to 50 (Figure 2.5.4-44).

2. A soil having a relative density of more than 75 percent is not likely to liquefy (Kishida 1966, 1969; Koizumi 1966; Lee and Seed 1967; Seed and Lee 1966). Accordingly, compaction criteria of the structural backfill given in Section 2.5.4.5.2 have been designed to yield a relative density higher than 75 percent.

3. According to the envelope of “most liquefiable soils” given by Lee and Fitton (1969), which also contains the envelope given by Kishida (1969), the average particle size, D, of the “most liquefiable soils” envelope is between 0.02 and 0.7 mm, whereas the corresponding particle size of the structural backfill used is larger than 1.0 mm (Figure 2.5.4-44).

It is concluded, therefore, that the structural backfill compacted as outlined in Section 2.5.4.5.2 is not susceptible to liquefaction during the SSE.

2.5.4.8.2 Basal Tills

Based on the regional geologic history, the basal tills are very dense deposits consisting of well graded materials ranging in size from boulders to clay (Section 2.5.1.2.3). Figure 2.5.4-30 shows gradation curves for the basal till specimens. These specimens were recovered by split spoon sampling with a 1 3/8-inch inside-diameter sampler. The gradation curves show that the till is well graded with a uniformity coefficient of about 80 and many particles larger than 3/8 inch. Larger particles present in the till (1 3/8+ inches) could not be recovered by the split spoon. The actual gradation curves for the samples would therefore be shifted to the left of those on the figures, resulting in a still wider graded soil than shown.

Envelopes of the most liquefiable soils are also shown in these figures. Lee and Fitton (1969) developed their envelope from cyclic triaxial tests in the laboratory. Kishida (1969) developed his envelope from sand deposits which liquefied in Japan. Kishida also notes that a criterion for “liquefiable soils” is that the uniformity coefficient is generally less than 10. The gradation curves for the basal till do not satisfy this criterion and are not enclosed within the envelopes developed by either Lee and Fitton or Kishida.

In conclusion, the well graded grain size characteristics and the high relative density of the basal tills preclude the possibility of liquefaction in terms of criteria developed by Kishida (1969) and Lee and Fitton (1969).

2.5.4.8.3 Beach and Glacial Outwash Sands

The circulating and service water pumphouse is located on the shorefront of Long Island Sound, approximately 200 feet west of the Millstone 2 intake structure. The pumphouse is founded on bedrock; however, the intake channel and adjacent slopes consist of beach and glacial outwash sand to approximately el -40 feet. Based on the results of grain size analyses of samples obtained from the pumphouse area, the beach and glacial outwash sands consist mostly of medium to fine and silty sand with a few layers of gravelly sand. High concentrations of mica are found throughout the sands in this area.

The grain size ranges for beach and outwash sands in the pumphouse area are shown on Figure 2.5.4-57. Envelopes of the most liquefiable soils are also shown on these figures.

The beach and outwash sands are saturated below sea level. Grain size analyses indicate that a liquefaction analysis of the sands should be performed to determine whether these sands could liquefy and slide into the intake channel, causing a potential blockage of the service water inlet pipes. The analyses described in Sections 2.5.4.8.3.1 and 2.5.4.8.3.2 show that the safety factor against liquefaction for the beach and glacial outwash sands is greater than 1.1 for the site SSE of.17g. Therefore, these sands would not liquefy as a result of the SSE.

2.5.4.8.3.1 Dynamic Response Analysis of Beach and Glacial Outwash Sands

The dynamic response analysis of the shorefront sand deposits has been evaluated to assess the potential amplification or deamplification of ground motions applied to the bedrock surface. This evaluation was made using the SHAKE (LaPlante and Christian 1974) computer program for analysis of the vertical transmission of horizontal shear stresses induced by the SSE through a layered system. This program treats the strain dependence of the shear modulus and damping ratio in an iterative manner.

A conservative, idealized profile was selected due to the variability of the rock surface and consisted of 40 feet of sand (the maximum sand thickness in the area) overlying 5 feet of basal till and bedrock. The sand layer was divided into four layers, each 10 feet thick, and the till was analyzed as a single layer. Groundwater level was established at 10 feet below the ground surface, and corresponds to the mean high water level in Niantic Bay. The shear moduli and damping ratios of the sand were obtained from tests discussed in Section 2.5.4.2.2 and described in detail in Appendix 2.5F. The variation of shear modulus (G) with depth was incorporated into the computer analysis by assigning increasing values of G to each layer of the profile. The shear modulus of the basal till and bedrock was determined from geophysical surveys described in Section 2.5.4.4.1.

The values of shear modulus (G) and damping (D) used in the SHAKE analysis for each layer are:

Layer	Depth (ft)	Soil Type	G_{max} (ksf)	D_{max} (%)
1	0-10	Sand	600	1.8
2	10-20	Sand	1,250	1.8
3	20-30	Sand	1,600	1.8
4	30-40	Sand	1,800	1.8
5	40-45	Till	2,500	1.8

The reduction of G_{max} with strain was performed through a series of iterations, based on the relationship

$$G = 1000K_2(\bar{\sigma}m)^{1/2} \quad (2.5.4\text{-}4)$$

where:

K_2 = a constant that varies with shear strain, developed from resonant column tests and plotted on Figure 2.5.4-45,

σm = the mean principal effective stress in psf, and

G = the shear modulus at a particular shear strain in psf.

The time history of the following earthquakes, normalized to the site SSE value of 0.17g, were input at the bedrock surface:

1. 1965 Olympia Earthquake (S86W component)

2. 1935 Helena Earthquake (west component)

3. 1971 San Fernando Earthquake (Pacoima Dam, N74W component)

This analysis indicated that the average maximum acceleration would be 0.27g at ground surface for the free-field case of the beach prior to construction of the shoreline slopes. The average shear stress induced by the earthquake, assumed to be 0.65 of the peak value, was calculated to vary from 107 psf at a depth of 5 feet to 410 psf at a depth of 42.5 feet for an effective strain level of less than 0.1 percent. Shear stresses vs depth are plotted on Figure 2.5.4-46.

2.5.4.8.3.2 Liquefaction Analysis of Beach and Glacial Outwash Sands

Procedures for liquefaction analyses, developed by Seed et al. (Seed and Lee 1966, Seed and Idriss 1967, 1971), require the following quantitative evaluations:

1. The magnitude of shear stresses induced at varying depths in the underlying sand due to earthquakes.

2. The resistance of the sands to liquefaction, which may be expressed as the cyclic shear stress necessary to cause "initial liquefaction" in the number of cycles estimated to occur in an earthquake of the intensity selected (also known as the significant number of cycles to cause liquefaction).

The resistance of a soil to liquefaction is expressed as a factor of safety, equal to the ratio of the shear strength available to resist liquefaction to the shear stresses induced by the earthquake.

The SSE at the site is based on an Intensity VI-VII earthquake which corresponds to a magnitude of approximately 5.3 using relationships developed by Gutenberg and Richter (1942). Based on Figure 2.5.4-58 from Seed, Idriss, et al. (1975), the irregular shear stress time history of the SSE can be represented by five equivalent cycles of loading.

The shear stresses induced by the SSE were calculated using the SHAKE program, assuming a maximum bedrock acceleration of 0.17g. A discussion of the analysis and results for the sand is included in Section 2.5.4.8.3.1.

The cyclic shear stress necessary to cause initial liquefaction, or the shear strength available to resist liquefaction, was determined from cyclic triaxial tests conducted on undisturbed samples from borings in the vicinity of the pumphouse. The testing program and results are described in detail in Appendix 2.5F.

The shear stress necessary to cause initial liquefaction in the field, τ_{res}, is calculated from the following equation:

$$\tau_{res} = \bar{\sigma}_v \left(\frac{\sigma_1 - \sigma_3}{2\bar{\sigma}_c}\right)_{cyc} C_r \qquad (2.5.4\text{-}5)$$

where:

σ_v= Vertical effective stress

$\left(\frac{\sigma_1 - \sigma_3}{2\bar{\sigma}_c}\right)_{cyc}$ = Cyclic stress ratio

C_r = Reduction factor to be applied to laboratory triaxial test data to obtain the stress conditions causing liquefaction in the field.

For the beach and glacial outwash sands at the site, the factor of safety was calculated at depths of 10, 15, 25, 35, and 40 feet below the ground surface. The cyclic stress ratio for a particular depth and vertical effective stress was determined from Figure 2.5.4-47, a plot of cyclic stress ratio vs confining pressure. This plot is based on test data from Figure 21 of Appendix 2.5F, assuming liquefaction occurs at a strain of 10 percent double amplitude.

The factors of safety for liquefaction, based on C_r equal to 0.60, are shown in Table 2.5.4-18. The minimum factor of safety calculated from laboratory tests is 1.25 at a depth of 40 feet. This factor of safety is sufficiently large considering the conservative assumptions included in the analysis.

An additional method of assessing liquefaction potential can be developed by comparing standard penetration resistance data from the vicinity of the pumphouse structure with standard penetration resistance data from sites which have been subjected to earthquakes. This method, described in detail below, also indicates there is no danger of liquefaction in the beach sands at the site.

An empirical approach relating standard penetration resistance data (N values) to liquefaction potential was proposed by Seed, Arango, and Chan (1975), who presented cyclic strengths based on empirical data from sites which did and did not experience liquefaction during earthquakes. Also included were data from large-scale shake table tests by DeAlba, Chan, and Seed (1975) which were corrected to account for effects of stress history and multidirectional shaking. Based on these data, Figure 6-1 of Seed et al. (1975) (included herein as Figure 2.5.4-48) presents lower bounds of the cyclic stress ratios causing liquefaction versus the standard penetration resistances of sands for magnitudes 5 to 6 and 7 to 7 1/2 earthquakes, corrected to an effective overburden pressure of 1 ton per square foot (N_1) based on the Gibbs and Holtz (1957) correlation of relative density of sands to blow count and effective stress. A plot of N_1 values vs effective stress used in this method is the SPT blow count for borings P1 through P8 and I2, I3, I8, I9, and I10 is included as Figures 2.5.4-28 and 2.5.4-29. The mean value of corrected blow count for these borings was calculated as 20.0, which corresponds to a cyclic stress ratio of 0.278 for a magnitude 5 to 6 earthquake, using Figure 2.5.4-48. When compared with the earthquake induced shear stresses obtained from the SHAKE analysis described in Section 2.5.4.7, the minimum factor of safety against liquefaction calculated by this method was 1.68 at a depth of 15 feet.

A very conservative factor of safety against liquefaction was also calculated using a cyclic stress ratio based on the mean corrected blow count less one standard deviation. An N_1 value of 13.1 was used to obtain a cyclic stress ratio of 0.185 from Figure 2.5.4-48. The minimum factor of safety calculated for the lower value of N_1 was 1.13 at a depth of 15 feet. This is considered acceptable, considering the fact that the mean value of N_1, less one standard deviation, is well below the mean value originally used by Seed et al. in determining the curves in Figure 2.5.4-48. An additional conservatism in the analysis is the use of the magnitude 6.0 relationship for determining the cyclic stress ratio. The SSE at the site is based on an Intensity VI-VII earthquake, which corresponds to a magnitude of approximately 5.3, using relationships developed by Gutenberg and Richter (1942).

The factor of safety against liquefaction at various depths for each analysis is presented on Figure 2.5.4-49. It can be concluded that liquefaction would not occur in the beach and glacial outwash sands adjacent to the circulating and service water pumphouse, and that the shorefront is stable against sliding failures due to liquefaction of the sand. The stability against sliding of the shorefront during the SSE is discussed in Section 2.5.5.2.

2.5.4.8.3.3 Liquefaction Analyses of Beach Area Sands using 2-Dimensional Dynamic Response Analysis

Liquefaction analyses performed on the sands at the shorefront and discussed in Sections 2.5.4.8.3.1 and 2.5.4.8.3.2 were based on the assumption that the subsurface conditions in this area could be modeled conservatively as a 40-foot deep uniform sand layer overlying 5 feet of basal till and bedrock. An additional analysis was performed in which the sloping bedrock and ground surfaces to the west of the circulating and service water pumphouse were incorporated into a 2-dimensional dynamic response model to determine earthquake-induced shear stresses. The section selected for the 2-dimensional dynamic response model is similar to the slope stability profile shown on Figure 2.5.5-4. The liquefaction potential of the saturated glacial outwash sands was determined by comparing the induced effective shear stresses calculated from the dynamic model with the dynamic shear strength of the sand available to resist initial liquefaction previously determined from corrected blowcount values obtained from standard penetration tests performed on beach area borings.

The computer program PLAXLY (Plane Strain Dynamic Finite Element Analysis of Soil-Structure Systems) was used to calculate earthquake-induced shear stresses within the soil profile. The initial value of low strain shear modulus and damping, total unit weight, and Poisson's ratio of the elements were assigned in accordance with the following table.

Soil Type	**Depth (ft)**	**G_{max} (ksf)**	**Damping (min)**	**Unit Wt (pcf)**	**Poisson's Ratio**
Outwash Sand	0-10	600	0.02	123	0.49
	10-20	1,250	0.02	123	0.49
	20-30	1,500	0.02	119	0.49
	30-40	1,800	0.02	119	0.49
Basal Till		20,160	0.02	145	0.40

Soil Type	Depth (ft)	G_{max} (ksf)	Damping (min)	Unit Wt (pcf)	Poisson's Ratio
Bedrock		216,000		165	0.40
Armor Stone	0-14	900		150	

Note: A Poisson's ratio of 0.25 was used for unsaturated sands.

The strain compatible shear moduli and damping ratios of the soil were determined through a series of iterations within the PLAXLY program. The time histories of the four earthquakes listed below were normalized to the site SSE peak acceleration of 0.17g and input at the rigid base of the model. These earthquake records were selected because they were recorded at rock sites or stiff soil sites and therefore would be expected to approximately match dynamic response at the Millstone site.

Taft S69E	1952 Kern County Earthquake
Helena N-S	1935 Montana Earthquake
Pacoima Dam S16F	1971 San Fernando Earthquake
Temblor N65W	Parkfield Earthquake

The profile used in the analysis is shown on Figure 2.5.4-75.

Liquefaction potential was calculated at each element for the six sections shown on this figure. The results of the PLAXLY analysis and the calculated values of safety factor against liquefaction are presented in Table 2.5.4-24.

The blowcount data used in Sections 1 to 5 were obtained from onshore borings in the shorefront area. The blowcount data from boring I21 was used to represent soil conditions in Section 6 because the borings indicate that the sands offshore are denser than the onshore sands. The dynamic shear strength of the sand was calculated by determining the corrected blowcount (N1) in accordance with methods established by Gibbs and Holtz (1957), in which the corrected blowcount data are corrected for an effective overburden stress of 1 tsf. The N1 values are plotted with vertical effective stress on Figures 2.5.4-28 and 2.5.4-29. The mean value of N1 was calculated from these data and used to determine the cyclic stress ratio to resist initial liquefaction from the Seed, et al, (1975) curve presented on Figure 2.5.4-48. The curve for Magnitude 6 earthquakes was used to obtain a nonliquefaction cyclic stress ratio of 0.27, which was used in the analyses performed on Sections 1 to 5. For Section 6, a mean N1 value of 28 was calculated and a stress ratio of 0.42 was used in the liquefaction analysis.

The earthquake-induced shear stresses were computed by averaging the peak shear stress values obtained for each of the four earthquakes at each element in the PLAXLY model. The effective shear stress was obtained by multiplying the average of the four peak values by a factor of two-thirds. Seed and Idriss (1971) recommend multiplying the absolute maximum shear stress value by a factor of 0.65 to obtain the equivalent uniform cyclic shear stress. This value was compared with the dynamic shear strength of the soil at each element to obtain the safety factor against liquefaction.

The results of the analyses, presented in Table 2.5.4-24, indicate that the safety factor for elements 1 to 5 are all greater than 1.25. Low safety factors were determined for Section 6, mainly because of the low vertical effective stress near the surface of the intake channel at elevation -29 feet. The effective stress increases to the west of this profile location as the side-slopes of the intake channel rise to meet the natural ocean bottom, making these low safety factors a local phenomenon limited to the intake channel only. The post-earthquake slope stability analysis presented in Section 2.5.5.2.1 was reanalyzed to consider the effect of liquefaction of the sand in the intake channel (Soil 7 on Figure 2.5.5-4) on stability of the shorefront slopes. The calculations show no change in the safety factor of the critical failure circle, indicating that the shorefront slopes would not fail in the event that the sand in the intake channel would liquefy.

It can be concluded from these analyses that liquefaction of the shorefront slopes would not occur and that liquefaction of the intake channel bottom would not affect the integrity of the shorefront slopes adjacent to the circulating and service water pumphouse or result in a condition that would make the service water system inoperable. The soil underlying the service water pipe encasement adjacent to the pumphouse is not susceptible to liquefaction.

Conservatively postulating that liquefaction could occur during the site SSE, a study was made to determine whether sliding of the slope into the intake channel would cause blockage of the service water intake pumps. Data from slides caused by liquefaction during the Alaskan Earthquake of 1964, (Seed, 1968) indicate that flow slides maintain a slope steeper than 5 percent. Assuming that the saturated sand overlying basal till adjacent to the pumphouse liquefies and flows toward the intake channel, with a final slope of 5 percent, then it can be shown that 7 feet of water remains available for suction below the pump intakes. Therefore, it can be concluded that even in the highly unlikely event that liquefaction of the glacial outwash sands were to occur, the plant would have an adequate supply of water available for cooling of safety-related systems.

2.5.4.8.4 Ablation Till

The circulating water discharge tunnel extends 1,700 feet from the main plant area to the Millstone quarry east of Millstone 1. For approximately 1,200 feet, the tunnel is founded on bedrock. However, in the vicinity of the ventilation stack north of Millstone 1, bedrock drops sharply to a trough. The maximum thickness of the overburden in this trough is approximately 60 feet. Borings 402 through 412 were drilled in this area to determine the subsurface conditions. A cross-section of the trough along the discharge tunnel is presented on Figure 2.5.4-51. The location of the section is shown on Figure 2.5.4-31. In this area, which extends for approximately 500 feet, the fill and alluvium overlying the ablation and basal tills were excavated and replaced with crushed stone and concrete fill to the base elevation of the discharge tunnel. Because the ablation till is a sandy material below the groundwater table, the liquefaction potential was analyzed. The analysis described in Section 2.5.4.8.4.1 shows that liquefaction of the ablation till is not possible under the site SSE. The structural fill and basal till have been shown to be nonliquefiable in Sections 2.5.4.8.1 and 2.5.4.8.2, respectively.

2.5.4.8.4.1 Dynamic Response Analysis of Ablation Till

The dynamic response of the ablation till has been evaluated to determine earthquake-induced shear stresses caused by ground motions applied at the bedrock surface and amplified through the soil profile. This evaluation was made using the computer program SHAKE, similar to the analysis in Section 2.5.4.8.3.1.

A horizontally stratified idealized soil profile was selected to model the subsurface conditions input into the SHAKE analysis for the discharge tunnel. This profile was based on soil strata encountered in boring 411, which encountered the deepest rock, and represents the most conservative profile in the study area. The generalized soil profile (Figure 2.5.4-50) used in the analysis of the tunnel consisted of 5 feet of structural fill, 13 feet of ablation till, and 22 feet of basal till. Groundwater level was established at 10 feet below the ground surface, elevation +4 feet, based upon the average groundwater levels measured in borings 407 and 411. (See Figure 2.5.4-31 for locations). The shear moduli values of the soils were obtained from cross-hole tests described in Section 2.5.4.4.3. The values of shear modulus (G) and damping (D) for low strain levels used in the SHAKE analysis for each layer are:

Layer	Elevation (ft)	Depth (ft)	Soil Type	Gmax (ksf)	Dmax (%)
1	+14 to -8	0-22	Discharge Tunnel	--	0.5
2	-8 to -13	22-27	Structural Fill	1.93×10^3	0.5
3	-13 to -26	27-40	Ablation Till	1.30×10^3	0.5
4	-26 to -48	40-62	Basal Till	2.0×10^4	0.5

The reduction of G_{max} with strain was performed through a series of iterations similar to the method described in Section 2.5.4.8.3.1 using the same earthquake records normalized to 0.17g.

This analysis indicated that the average maximum shear stress in the ablation till induced by the SSE, varied from 515 psf to 533 psf. The average shear stress is assumed to be 0.65 of the peak value.

2.5.4.8.4.2 Liquefaction Analysis of Ablation Till

Procedures used for liquefaction analysis of the ablation till were similar to the empirical approach described in Section 2.5.4.8.3.2.

Standard penetration resistance data (N_1 values) were related to liquefaction potential in accordance with methods developed by Seed, Arango, and Chan (1975) and DeAlba, Chan, and Seed (1975). N_1 values for the ablation till were obtained from borings taken at the discharge tunnel location (400 series) and samples of ablation till from the main plant borings (300 series).

The following table summarizes the results of the liquefaction analysis. It compares earthquake induced shear stresses calculated from SHAKE with shear strength values determined from average corrected blow count values and average N_1 values less one standard deviation (N_1-σ):

Midpoint of Layer Elevation (ft)	Induced Shear Stress (psf)	Mean N_1	Shear Strength (psf)	F.S.	N_1-σ	Shear Strength (psf)	F.S.
-15.2	515	28.7	1,079	2.10	15.5	578	1.12
-19.5	531	28.7	1,218	2.29	15.5	652	1.23
-23.9	533	28.7	1,357	2.60	15.5	726	1.36

It can be concluded, therefore, that the ablation till under the discharge tunnel is not susceptible to liquefaction, even considering the ultraconservative case of the shear strength calculated from the mean corrected blow count less one standard deviation.

2.5.4.9 EARTHQUAKE DESIGN BASIS

A safe shutdown earthquake of 0.17g and a 1/2 SSE value of 0.09g in the horizontal direction and two-thirds of these values in the vertical direction, input at the bedrock surface, have been used as the design bases for seismic loading at the site. The derivation of these values is described in Sections 2.5.2.6 and 2.5.2.7.

For structures founded on soils, amplification effects have been considered by means of a soil-structure interaction analysis using the computer program PLAXLY-3 described in detail in Section 3.7.2.4.

For the liquefaction analysis of the beach sands adjacent to the circulating and service water pumphouse, the SSE value of 0.17g was input at the bedrock surface, and the average amplified ground motion at the surface determined from the SHAKE program using three earthquake records and described in Section 2.5.4.8.3.1 was calculated to be 0.27g. Consequently, a value of 0.25g was conservatively used for the entire soil column as the average seismic loading of shoreline slopes in the stability analysis described in Section 2.5.5.2.

2.5.4.10 STATIC STABILITY

2.5.4.10.1 Bearing Capacity

Table 2.5.4-14 summarizes the bearing pressures for mats or individual spread footings founded on various foundation materials.

The selection of the bearing capacity values used in footing design were based on the bearing capacity formulae (Terzaghi and Peck 1967, Vesic 1975) for an estimated angle of internal friction for basal till equal to 40 degrees and for structural backfill equal to 34 degrees. The total unit weight for the till was assumed to be equal to 145 pcf and for the structural backfill, a total unit weight equal to 140 pcf was used. Test values reported in Section 2.5.4.5.2 showed a range of angles varying from 35 to 41.5 degrees for the structural fill compacted to 95 percent of the maximum modified Proctor density. Inputting the relevant soil parameters described above, and taking into account the effect of the groundwater table, the bearing capacity formula for square footings or mats on basal till reduces to:

$$q_{all} = 1.9\ D + 1.1\ B \qquad (2.5.4\text{-}6)$$

$$q_{all\ (max)} = 12\ ksf$$

For structural backfill:

$$q_{all} = 0.9\ D + 0.4\ B \qquad (2.5.4\text{-}7)$$

$$q_{all\ (max)} = 8\ ksf$$

where:

q_{all} = Allowable bearing capacity in ksf with a minimum safety factor = 3

D = Depth of embedment (feet)

B = Width of footing (feet)

Table 2.5.4-23, Bearing Capacity of Major Structures, presents a summary of the allowable bearing capacity for the material beneath each structure. In all cases, the factor of safety is greater than 3, which is the minimum required value.

Based on Teng (1962), the design bearing capacity of foundations on rock is commonly taken as 1/5 to 1/8 of the crushing strength (factor of safety of 5 to 8). A value of 200 ksf was selected for the maximum allowable bearing capacity of bedrock at the site. This corresponds to approximately 1/7 of the average unconfined compressive strength of approximately 1,440 ksf (10,000 psi) reported in Table 2.5.4-10. The 200 ksf value also corresponds to the presumptive surface bearing value given by the Connecticut Basic Building Code (1978) for massive crystalline rock, including granite and gneiss.

From Table 2.5.4-14, the maximum average foundation pressure for a structure on rock is 8 ksf. Thus, the factor of safety against a bearing capacity failure is much greater than 3 for all structures founded on rock.

2.5.4.10.2 Settlement of Structures

Rock and soil supported Seismic Category I structures experience only elastic displacements under the design loads. Analyses using linear elasticity principals, assuming rigid foundations, indicate that the vertical settlements of structures founded on rock are very small under the design loads, as shown by the summary included in Table 2.5.4-14.

The settlement of structures embedded in rock, such as the containment, was calculated using elastic solutions for circular rigid mats on a semi-infinite mass by Butterfield and Banjerjee (1971). The main steam valve, auxiliary, and engineered safety features buildings, founded on rock, were analyzed using equations for rigid rectangular mats on a semi-infinite mass developed by Whitman and Richart (1967). Structures founded totally or partly on soil, such as the control, emergency diesel generator enclosure, fuel, and waste disposal buildings, were analyzed using solutions obtained by Sovinc (1969) for rigid rectangles on a finite layer. The settlement of the underlying rock layer was also estimated using the Whitman and Richart equations.

Elastic properties of the rock and basal till are discussed in Section 2.5.4.4.3. The elastic modulus (E) for static strain levels was estimated equal to 10,000 psi, as discussed in Section 2.5.4.5.2.

Table 2.5.4-14 indicates that the maximum estimated settlement within any one structure occurs at the emergency generator enclosure building and is equal to 0.40 inch. Most of this settlement results from the conservative assumption that the south footing of the EGE is founded on 9 feet of structural fill. Maximum estimated differential settlement between adjacent structures occurs between the control building and the emergency generator enclosure building, and is equal to about 0.40 inch. The rate of these settlements would essentially be the same as the rate of loading because of elastic nature of the bearing material.

2.5.4.10.3 Lateral Earth Pressures

The magnitude and distribution of lateral earth pressures is a function of the allowable yielding of the wall, the backfill material characteristics, water pressure, surcharge loads from adjacent structures, and, for seismically designed structures, the earthquake loading. The concrete foundation walls were conservatively assumed to be rigid, unyielding walls. Therefore, the coefficient of earth pressure at rest, K_o, has been used in evaluating lateral loads on these walls. Compaction specifications prohibited the use of heavy vibratory compactors within 5 feet of all concrete structures. Light compactors were used when backfilling against structures in order to minimize residual lateral stresses in the fill due to the applied compactive effort. For the backfill at the site, a value of $K_o = 0.5$ was used.

Backfill placed behind walls consisted of well graded sands and gravels compacted to 90 percent of maximum density (ASTM D1557) to minimize the horizontal loads induced by high compactive stresses. Tests on similar soils, compacted to 90 percent of maximum dry density and reported in Section 2.5.2.5.2, resulted in friction angles in excess of 34 degrees.

Dynamic loadings include pressures due to the soil mass, water, and surcharge, accelerated in the vertical and horizontal directions. Methods of analysis are based on procedures proposed by Mononobe (1929), Okabe (1926), and Seed and Whitman (1970) and are graphically depicted on Figure 2.5.4-43.

2.5.4.11 DESIGN CRITERIA

The design criteria and minimum required factors of safety for bearing capacity, hydrostatic uplift (buoyancy), and sliding (against lateral pressures) are summarized below:

1. Bearing Capacity - Minimum factor of safety of 3 against bearing capacity failure for all loading combinations is used in foundation design (Seed and Idriss 1967, Terzaghi and Peck 1967).

2. Hydrostatic Uplift - The determination of the buoyant force, and the weight of the structures can be made relatively precisely. Therefore, a factor of safety against hydrostatic uplifting of 1.1 was determined to be adequate under the normal water levels shown on Figure 2.5.4-37, considering the dead load of the structure only. For high water level conditions, the dead load of the structure plus equipment load is at least 1.1 times the buoyant force of water.

3. Sliding - Either of two methods has been used to determine the factor of safety against sliding. One method considers that only frictional forces at the base resist sliding. A minimum factor of safety of 1.1 is required. The second method includes base friction and the resisting force due to passive earth pressure. For this method, a minimum factor of safety of 2.0 is required.

A discussion of the bearing capacity analysis is included in Section 2.5.4.10.1. The loads used for determining lateral pressures on structures are discussed in Section 2.5.4.10.3.

The design limits for the foundations of all Category I structures are discussed in the structural acceptance criteria in Section 3.8.5.5.

2.5.4.12 TECHNIQUES TO IMPROVE SUBSURFACE CONDITIONS

All Category I structures are founded on either high quality, intact rock, undisturbed basal till, or compacted, select granular fill. Therefore, no improvement of the founding material below any structure was required.

Rock dowels were installed around the periphery of the auxiliary building to provide stability during seismic loading. These dowels consist of 2 1/4-inch diameter, grade 60 steel bar with 10 mils of fusion bonded epoxy coating for double corrosion protection. The dowels were designed to act as a passive support system, with stressing occurring only during seismic loading. Six test dowels of varying lengths were loaded to the yield strength of the bar (240 kips) to verify design parameters.

Rock anchors were installed in the turbine building to provide resistance to overturning due to tornado loading. These anchors consisted of a 1 1/4-inch diameter, high strength steel bar sheathed in a corrugated PVC casing and fully grouted for double corrosion protection. Each anchor was proof loaded to 150 kips and then the load was reduced to 125 kips for 24 hours. The anchor was subsequently locked off at a permanent load of 25 kips and encased in the concrete foundation mat.

Rock anchors were installed in the service building to provide resistance to uplift loads due to buoyant forces and seismic forces. These anchors consisted of 1 3/8-in diameter, high strength steel bar sheathed in a corrugated PVC casing and fully grouted for double corrosion protection.

The ultimate strength of each anchor is 237 kips, with a working load equal to 60 percent of the ultimate strength, or 142 kips. Each anchor was tensioned to a test load of 168 kips and held at 150 kips for a 24 hour period. Two anchors were proof tested to 190 kips. The anchors were locked off at a load of 40 kips, which corresponds to the hydrostatic uplift component of the anchor design load. The remaining capacity of the anchor is mobilized during seismic loading.

Temporary rock bolts were installed in the southwest sector of the containment excavation face to prevent potential sliding failures along the foliation planes. These bolts consisted of Grade 60 steel, No. 11 reinforcing bars with a working load of 45 kips. Anchorage of the rock bolts was provided by Celtite polyester resin encapsulation.

Detailed geologic mapping of bedrock surfaces at the site, described in detail in Section 2.5.4.11, identified certain preferred joint surfaces that may cause potential sliding planes with the containment excavation face. As a result of these findings, a reinforced concrete ring beam was placed in the annular space between the excavation face and the containment exterior wall to stabilize the wedges. The slope stability analysis for the containment excavation is discussed in detail in Section 2.5.5.1. The structural analysis is discussed in Chapter 3.

2.5.4.13 STRUCTURE SETTLEMENT

Most of the Category I structures at the site are founded on sound bedrock. Predicted settlements listed in Table 2.5.4-14 for these structures are very small. Settlement predictions for structures founded on basal till or structural backfill indicate that the maximum expected settlement is less than 0.4 inch and that this settlement occurs over a relatively short period of time due to the elastic nature of the subsurface materials. Settlement has been monitored for the control, fuel, waste disposal, and emergency generator enclosure buildings during construction. A plan of the location of the settlement monitoring benchmark locations is shown on Figure 2.5.4-59. Plots of observed early settlement versus time for these structures are presented in Figures 2.5.4-60 through 2.5.4-64. The records show no significant movement of any structure, although some heave has occurred due to rebound from excavation. Settlement of these structures has been periodically measured, and it has been determined that there does not appear to be any significant movement in the monitoring points. Records of these measurements are being maintained, in accordance with Procedure No. SP-CE-223, as permanent plant records.

2.5.4.14 CONSTRUCTION NOTES

No significant problems were encountered during construction that required extensive redesign of structures. A small amount of basal till was excavated and replaced with structural backfill beneath the control building due to inflow of groundwater during excavation. This occurrence is discussed in detail in Section 2.5.4.5.1.

The concrete backfill in the annular space between the containment exterior wall and the excavation face was modified because of data obtained from the geologic mapping program. The concrete backfill was revised to be a reinforced concrete structural support to resist the potential failure of rock wedges subjected to seismic loading and maintain the isolation of the containment structure from external forces. This “ring beam” is discussed in detail in Sections 2.5.5.1 and 3.

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TABLE 2.5.4–1 LIST OF JOINTS - FINAL GRADE FLOORS OF STRUCTURES

CLICK HERE TO SEE TABLE 2.5.4-1

TABLE 2.5.4–2 LIST OF FOLIATIONS - FINAL GRADE FLOORS OF STRUCTURES

CLICK HERE TO SEE TABLE 2.5.4-2

TABLE 2.5.4–3 LIST OF SLICKENSIDES - FINAL GRADE FLOORS OF STRUCTURES

CLICK HERE TO SEE TABLE 2.5.4-3

TABLE 2.5.4–4 LIST OF JOINTS - FINAL GRADE CONTAINMENT AND ENGINEERED SAFETY FEATURES BUILDING WALLS

CLICK HERE TO SEE TABLE 2.5.4-4

TABLE 2.5.4–5 LIST OF FOLIATIONS - FINAL GRADE CONTAINMENT AND ENGINEERED SAFETY FEATURES BUILDING WALLS

CLICK HERE TO SEE TABLE 2.5.4-5

TABLE 2.5.4–6 LIST OF SLICKENSIDES - FINAL GRADE CONTAINMENT AND ENGINEERED SAFETY FEATURES BUILDING WALLS

CLICK HERE TO SEE TABLE 2.5.4-6

TABLE 2.5.4–7 LIST OF JOINTS - FINAL GRADE WALLS OF STRUCTURES

CLICK HERE TO SEE TABLE 2.5.4-7

TABLE 2.5.4–8 LIST OF FOLIATIONS - FINAL GRADE WALLS OF STRUCTURES

CLICK HERE TO SEE TABLE 2.5.4-8

TABLE 2.5.4–9 LIST OF SLICKENSIDES - FINAL GRADE WALLS OF STRUCTURES

CLICK HERE TO SEE TABLE 2.5.4-9

TABLE 2.5.4–10 ROCK COMPRESSION TEST RESULTS

CLICK HERE TO SEE TABLE 2.5.4-10

TABLE 2.5.4–11 DIRECT SHEAR TEST RESULTS FROM JOINT AND FOLIATING SURFACES

CLICK HERE TO SEE TABLE 2.5.4-11

TABLE 2.5.4–12 SUMMARY OF STATIC SOIL PROPERTIES FOR BEACH SANDS *

Boring No.	Sample	Depth (ft)	Elev (ft msl)	t (lb/cu ft)	Water Content (%)	d (lb/cu ft)	G_s	S_u (ksf)	f (deg)
P3	UP4A2	32.0	-18.65	117.2	32.9	88.2	2.75	1.9	33.3
P4	UP1A2	5.0	-01.13	114.9	29.8	88.5	2.76	1.6	41.9
P7	UP3A2	29.6	-25.80	116.3	32.9	87.5	2.77	2.2	35.2
P8	UP1A	12.0	-01.48	122.1	12.3	108.7	-	1.3	27.8

*. Table 3 in Appendix 2.5F gives data on dynamic properties.

MPS3 UFSAR

TABLE 2.5.4–13 NATURAL WATER CONTENTS OF SPLIT SPOON SAMPLES

CLICK HERE TO SEE TABLE 2.5.4-13

TABLE 2.5.4–14 FOUNDATION DATA FOR MAJOR STRUCTURES

Structure	Static Bearing Load (psf)	Founding Grade (ft)	Founding Material	Average Thickness Till (ft)	Average Thickness Structural Fill (ft)	Dimensions of Foundation (ft)	Design Groundwater Elevation (ft)	Maximum Calculated Static Settlement (in)
Containment	7,480	-38.7	Rock	-	-	158 diameter	21	0.04
Main Steam Valve	5,000	+9.0	Rock	-	-	70 x 60	19	0.01
Auxiliary	4,860	-0.5	Rock	-	-	177 x 102	23	0.02
Engineered Safety Features	3,050	-0.5	Rock	-	-	139 x 47	21	0.01
Control	3,810	-0.5	Till	0 to 10	-	120 x 103	19	0.02 to 0.03
Emergency Generator Enclosure (EGE)	3,070	+9.0	Till	10		10 Strip	19	0.01 to 0.4
Emergency Generator Oil Tank	1,230	+1.5	Till	10	4	65 x 32	19	less than 0.01
Emergency Generator Mats	1,500	+18.50	Structural Backfill	17	9.5	44 x 12	19	0.25
Refueling Water Storage Tank	4,000	+15.0	Rock	-	-	Octagon 64 inside diameter	-	less than 0.01

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TABLE 2.5.4–14 FOUNDATION DATA FOR MAJOR STRUCTURES

Structure	Static Bearing Load (psf)	Founding Grade (ft)	Founding Material	Average Thickness Till (ft)	Average Thickness Structural Fill (ft)	Dimensions of Foundation (ft)	Design Groundwater Elevation (ft)	Maximum Calculated Static Settlement (in)
Demineralized Water Storage Tank	4,000	+14.5	Rock	-	-	Octagon 40 inside diameter	-	less than 0.01
Fuel	4,500	+3.0	Rock	-	-	93 x 112	23	less than 0.01
Waste Disposal (Liquid)	4,500	+0.5	Till	2 to 8		114 x 48	23	0.02
Waste Disposal (Solid)	3,030	+19.5	Structural Backfill	23	7	114 x 38	23	0.25
Hydrogen Recombiner	4,490	+20.0	Concrete Fill	-	-	56 x 50	18	less than 0.01

<u>NOTE</u>: All foundations are structural mat except EGE which is strip footing and slab on grade.

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TABLE 2.5.4–15 LIST OF APPROXIMATE BORING LOCATIONS, GROUND ELEVATIONS, AND GROUNDWATER ELEVATIONS *

(SEE BOTH LOGS (APPENDIX 2.5J) FOR EXACT VALUES)
(Changes made to this table in 1997 correct transcription errors associated with the original submission.)

Boring No.	Site Coordinates		Surface Elevation (ft)	Depth Drilled (ft)	Top of Rock Elevation (ft)	Groundwater	
	North/South	East/West				Elevation (ft)	Date
301	N1562	E505	28.4	36.0	12.4	20.4	12-15-71
302	N1458	E421	28.2	75.0	15.7	17.7	12-22-71
303	N1635	E335	29.3	30.0	19.3	22.8	12-18-71
304	N1533	E371	28.5	75.0	14.5	19.5	12-21-71
305	N1448	E347	26.2	125.0	7.2	17.0	12-21-71
306	N1383	E346	24.1	75.0	10.6	12.6	12-15-71
307	N1558	E258	28.4	37.5	18.4	19.2	12-13-71
308	N1446	E267	24.8	75.0	14.8	18.0	12-17-71
309	N1632	E167	27.3	48.0	-0.7	17.3	12-13-71
310	N1433	E185	25.6	45.0	1.6	17.0	12-24-71
311	N1232	E213	20.9	50.0	-9.1	8.6	12-21-71
312	N1544	E123	25.9	65.0	-20.1	15.9	12-29-71
313	N1388	E113	22.7	66.5	-23.8	15.9	12-28-71
314	N1628	E062	24.9	53.0	-8.1	15.9	12-14-71
315	N1433	E076	23.3	63.0	-19.7	14.2	12-23-71
316	N1270	W010	15.6	53.0	-17.4	6.4	12-30-71

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TABLE 2.5.4–15 LIST OF APPROXIMATE BORING LOCATIONS, GROUND ELEVATIONS, AND GROUNDWATER ELEVATIONS * (CONTINUED)

(SEE BOTH LOGS (APPENDIX 2.5J) FOR EXACT VALUES)
(Changes made to this table in 1997 correct transcription errors associated with the original submission.)

Boring No.	Site Coordinates		Surface Elevation (ft)	Depth Drilled (ft)	Top of Rock Elevation (ft)	Groundwater	
	North/South	East/West				Elevation (ft)	Date
317	N1446	E322	25.3	74.5	15.8	16.6	12-27-71
318	N1415	E115	25.0	67.0	-22.5	16.3	01-12-72
319	N1708	E065	25.0	79.3	-10.2	16.6	11-11-72
320	N1705	E183	28.3	26.0	12.5	20.6	11-02-72
321	N1808	E174	27.6	71.1	-19.0	13.1	11-03-72
322	N1808	E264	30.3	35.0	6.3	22.2	10-31-72
323	N1708	E264	29.3	32.0	12.3	21.1	10-30-72
324	N1718	E364	30.1	51.3	-4.9	21.6	10-26-72
325	N1718	E476	30.1	47.0	-6.7	21.3	10-18-72
326	N1432	E476	27.0	85.3	17.9	16.5	10-10-72
327 *	N1510	E456	28.7	111.3	20.8	20.8	11-02-72
328 *	N1593	E384	29.1	144.3	10.5	16.4	10-12-72
329 *	N1520	E369	28.1	120.7	13.2	15.3	10-26-72
330 *	N1521	E309	28.2	106.0	19.4	20.8	11-15-72
331 *	N1460	E375	27.4	112.5	9.0	18.3	11-07-72
I-1	N1720	W980	18.1	31.5	7.6	6.6	12-31-71
I-2	N1520	W450	9.3	68.5	-38.2	1.3	01-14-72

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TABLE 2.5.4–15 LIST OF APPROXIMATE BORING LOCATIONS, GROUND ELEVATIONS, AND GROUNDWATER ELEVATIONS * (CONTINUED)

(SEE BOTH LOGS (APPENDIX 2.5J) FOR EXACT VALUES)
(Changes made to this table in 1997 correct transcription errors associated with the original submission.)

	Site Coordinates		Surface			Groundwater	
Boring No.	North/South	East/West	Elevation (ft)	Depth Drilled (ft)	Top of Rock Elevation (ft)	Elevation (ft)	Date
I-3	N1097	W370	0.6	48.4	-34.2	-1.2	11-17-72
I-4	N1260	W200	16.5	50.3	-9.0	1.1	11-15-72
I-5	N1470	W20	20.1	75.0	-22.9	7.8	11-08-72
I-6	N1529	W150	20.3	46.5	-11.2	6.3	09-10-73
I-7	N1388	W205	18.2	47.0	-13.9	3.2	09-06-73
I-8	N1257	W310	14.7	58.5	-28.8	0.6	09-07-73
I-8A	N1258	W307	14.8	18.0			
I-9	N1225	W538	7.4	55.5	-30.6		
I-10	N1148	W409	5.0	60.9	-40.9	1.7	09-10-73
I-10A	N1121	W368	5.4	19.2			
I-11	N1073	W279	7.1	60.0	-10.9	1.1	09-12-73
I-12	N0989	W171	9.0	29.0	-5.0	2.5	09-14-73
I-14	N1020	W485	-4.5	36.8	-41.3	Offshore	
I-15	N0948	W394	-4.6	51.8	-40.6	Offshore	
I-19A	N0837	W272	-12.0	22.4	-19.4	Offshore	
I-20	N0970	W692	-10.8	55.1	-52.9	Offshore	
I-21	N0902	W574	-11.0	61.0	-57.0	Offshore	

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TABLE 2.5.4–15 LIST OF APPROXIMATE BORING LOCATIONS, GROUND ELEVATIONS, AND GROUNDWATER ELEVATIONS * (CONTINUED)

(SEE BOTH LOGS (APPENDIX 2.5J) FOR EXACT VALUES)
(Changes made to this table in 1997 correct transcription errors associated with the original submission.)

Boring No.	Site Coordinates		Surface Elevation (ft)	Depth Drilled (ft)	Top of Rock Elevation (ft)	Groundwater	
	North/South	East/West				Elevation (ft)	Date
I-22	N0814	W433	-20.0	45.3	-56.3	Offshore	
I-23	N0836	W766	-14.1	22.5	-27.1	Offshore	
I-24	N0708	W679	-17.7	38.2	-40.9	Offshore	
DT-1	N0980	E580	15.1	44.5	-9.4	5.0	12-30-71
DT-2	N0250	E1040	9.8	150.0	1.8	3.3	01-11-72
DT-3	S0690	E1360	10.6	150.0	3.6	3.6	01-07-72
401	N1303	E487	21.9	35.3	0.2	12.2	06-04-74
402	N0950	E840	16.4	28.0	-0.1	8.9	06-04-74
403	N0710	E925	12.8	60.7	-33.7		
404	N0388	E924	11.7	36.2	-4.4		
405	N0301	E720	17.7	42.6	9.9	13.0	05-29-74
406	N800	E924	14.03	44.5	-20.5	6.03	04-30-80
407	N625	E924	14.94	65.0	-45.1	4.94	04-30-80
408	N788.12	E879.83	14.36	45.0	-29.1	-	-
409	N782.27	E870.02	14.54	39.0	-19.5	5.54	05-02-80
410	N775.21	E860.03	14.36	39.0	-19.6	-	-
411	N519.2	E922.6	13.94	64.5	-47.6	3.44	05-08-80

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TABLE 2.5.4–15 LIST OF APPROXIMATE BORING LOCATIONS, GROUND ELEVATIONS, AND GROUNDWATER ELEVATIONS * (CONTINUED)

(SEE BOTH LOGS (APPENDIX 2.5J) FOR EXACT VALUES)
(Changes made to this table in 1997 correct transcription errors associated with the original submission.)

	Site Coordinates		Surface			Groundwater	
Boring No.	North/South	East/West	Elevation (ft)	Depth Drilled (ft)	Top of Rock Elevation (ft)	Elevation (ft)	Date
402	N463.6	E921.2	13.34	57.0	-35.2	-	-
P-1	N1037	W313	1.4	28.7	-22.3		
P-2	N1109	W415	3.0	48.8	-41.0		
P-3	N1188	W383	13.4	58.6	-40.3		
P-4	N1046	W270	3.9	19.5	-10.6		
P-5	N1010	W218	5.6	16.0	-5.4		
P-6	N1068	W207	17.7	28.0	-5.3		
P-7	N1165	W495	3.8	43.0	-34.2		
P-8	N1315	W705	10.5	45.5	-30.0		
P-9	N1292	W825	7.2	12.5	-0.3		
P-10	N1254	W770	4.4	21.7	-12.3		
T-1	N1287	E428	21.1	31.5	-1.4		
T-2	N1234	E465	19.2	31.0	-3.3		
T-3	N1234	E428	19.8	38.0	-8.2		
T-4	N1159	E388	16.9	38.7	-16.8		
T-5	N1208	E308	17.9	36.0	-4.1		
T-6	N1250	E309	20.2	27.0	-1.8		

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TABLE 2.5.4–15 LIST OF APPROXIMATE BORING LOCATIONS, GROUND ELEVATIONS, AND GROUNDWATER ELEVATIONS * (CONTINUED)

(SEE BOTH LOGS (APPENDIX 2.5J) FOR EXACT VALUES)
(Changes made to this table in 1997 correct transcription errors associated with the original submission.)

	Site Coordinates		Surface			Groundwater	
Boring No.	North/South	East/West	Elevation (ft)	Depth Drilled (ft)	Top of Rock Elevation (ft)	Elevation (ft)	Date
T-7	N1186	E220	20.6	42.0	-7.4		
Q-1	N0097	E323	2.7	50.0	-36.3-42.8	Offshore	
Q-2	N0095	E294	3.3	55.0	-46.7	Offshore	
Q-3	N0009	E330	-5.0	33.0	-33.0	Offshore	
Q-4	N0002	E299	-5.8	42.0	-42.8	Offshore	
B-1	N1175	E061	19.3	34.5	-8.2		
B-2	N1172	E60.5	19.8	50.0	-25.2		
B-3	N1109	E152	14.8	33.5	-13.7		
B-4	N1059	E152	16.9	41.0	-17.6		
B-5	N1012	E120	16.6	21.5	0.5		
B-6	N1066	E061	17.0	21.0	2.5		

NOTE:

* 45 degree angle boring

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TABLE 2.5.4–16 SUMMARY OF WATER PRESSURE TEST DATA

CLICK HERE TO SEE TABLE 2.5.4-16

TABLE 2.5.4–17 GROUNDWATER OBSERVATIONS

CLICK HERE TO SEE TABLE 2.5.4-17

TABLE 2.5.4–18 FACTORS OF SAFETY AGAINST LIQUEFACTION OF BEACH SANDS

CLICK HERE TO SEE TABLE 2.5.4-18

TABLE 2.5.4–19 IN-PLACE DENSITY TEST RESULTS ON CATEGORY I STRUCTURAL BACKFILL BENEATH THE SERVICE WATER INTAKE PIPE ENCASEMENT

CLICK HERE TO SEE TABLE 2.5.4-19

TABLE 2.5.4–20 IN-PLACE DENSITY TEST RESULTS AT CONTROL AND EMERGENCY GENERATOR ENCLOSURE BUILDINGS

CLICK HERE TO SEE TABLE 2.5.4-20

TABLE 2.5.4–21A EMERGENCY GENERATOR ENCLOSURE - FREE FIELD SOIL PROPERTIES FROM SHAKE ANALYSIS

						Taft		Helena		Parkfield	
Layer	Top of Layer Elevation (ft)	Soil Type	γ^t (pcf)	G_{max} (psi)	$G\gamma^{(1)}$ (psi)	$G^{(2)}$ (ksf)	$D^{(3)}$	$G^{(2)}$ (ksf)	$D^{(3)}$	$G^{(2)}$ (ksf)	$D^{(3)}$
1	24	Fill	143	$1.2 \text{ X } 10^4$	3810	613	.087	457	.140	576	.101
2	15	Fill	143	$1.63 \text{ X } 10^4$	5324	778	.104	825	.116	697	.120
3 (4)	10	Basal till	145	1.4×10^5	1.28×10^5	18,800	.014	18,715	.014	17,968	.019
4	0	Basal till	145	1.4×10^5	1.20×10^5	17,850	.018	17,249	.022	16,913	.024
5	-10	Basal till	145	1.4×10^5	1.12×10^5	16,981	.022	16,077	.025	15,470	.029
6	-20	Bedrock	-	1.5×10^6	-						

NOTE:

1. Gg = The average of the G's for the 3 earthquakes.
2. G = Strain corrected shear modulus (ksf).
3. D = Strain corrected damping ratio.
4. The structure is founded on the basal till at the top of Layer 3. Soil stiffness was modeled using shear modulus.

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TABLE 2.5.4–21B EMERGENCY GENERATOR ENCLOSURE - SOIL PROPERTIES WITH STRUCTURE EFFECTS FROM SHAKE ANALYSIS

CLICK HERE TO SEE TABLE 2.5.4-21B

TABLE 2.5.4–22 EMERGENCY GENERATOR ENCLOSURE - SOIL PROPERTIES WITH STRUCTURE EFFECTS FROM SHAKE ANALYSIS

CLICK HERE TO SEE TABLE 2.5.4-22

TABLE 2.5.4–23 BEARING CAPACITY OF MAJOR STRUCTURES

Structure	Approximate Dimensions of Contact Area (ft)	Approximate Foundation Depth (ft)	Approximate Foundation Static Load (ksf)	Ultimate Bearing Capacity (ksf)	Allowable [1] Bearing Capacity (ksf)	Factor of Safety
Containment	158 diam	62.7	7.48	-	200	> 26
Main Steam Valve	70 x 60	15.0	5	-	200	> 40
Auxiliary	177 x 102	24.5	4.86	-	200	> 41
Engineered Safety Features	139 x 47	24.5	3.05	-	200	> 65
Control	120 x 103	24.5	3.81	488	12	> 128
Emergency Generator Enclosure	10 strip	15.0	3.07	128	12	> 41
Emergency Generator Oil Tank	65 x 32	22.5	1.23	102	8	> 83
Refueling Water Storage Tank	Octagon 64 I.D.	9.0	4	-	200	> 50
Demineralized Water Storage Tank	Octagon 40 I.D.	9.5	4	-	200	> 50
Fuel	93 x 112	21.0	4.5	-	200	> 44
Waste Disposal (Liquid)	114 x 48	23.5	4.5	288	12	> 64
Hydrogen Recombiner	56 x 50	4.0	4.49	-	200	> 44
Discharge Tunnel	17 wide	32.5 to 22.5	3.59	56 [2]	8	15
Circulating Water Pumphouse	142 x 84	46.0	4.55	-	200	> 44

NOTES:

1. See FSAR Section 2.5.4.10
2. Bearing capacity determined for structure on concrete fill over ablation till

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TABLE 2.5.4–24 RESULTS OF TWO-DIMENSIONAL LIQUEFACTION ANALYSIS OF BEACH AREA SANDS

CLICK HERE TO SEE TABLE 2.5.4-24

2.5.5 STABILITY OF SLOPES

The topography in the plant area is generally flat with the final grade at el +24 feet in the major plant area. Detailed analyses were performed to determine static and dynamic stability of two man-made slopes at the site. The beach and outwash sand and armor stone slope at the shoreline, adjacent to the pumphouse, was analyzed using circular failure surfaces according to methods developed by Bishop (1955) and incorporated in the LEASE II (SWEC 1977) computer program. The analysis showed that the slope (Figure 2.5.5-1) was safe under an average amplified seismic loading of 0.25g and under static conditions.

The vertical rock cut excavated for the containment structure, (Figure 2.5.5-2) was analyzed by assuming failure planes developed along fully continuous joint and foliation surfaces. Methods developed by Hendron et al. (1971) and incorporated into the computer program SWARS-2P (SWEC 1974b) were used to analyze slope stability of this rock cut under both static and dynamic loading conditions. It was determined that the stability of these slopes was inadequate to maintain isolation of the containment structure walls from the external load applied by the rock wedges. As a result, a continuous structural hoop or ring beam was constructed in the annular space between the containment walls and the rock face. The purpose of this ring beam is to transfer any rock loading from the less stable areas where potential failure wedges may form to the more stable areas elsewhere around the containment, maintaining isolation of the rock loads from the containment exterior walls. Section 3.8.1.1 discusses the details of the ring beam design.

2.5.5.1 SLOPE CHARACTERISTICS

2.5.5.1.1 Shoreline Slope

A plan of the shoreline in the vicinity of the Millstone 3 pumphouse is shown on Figure 2.5.4-41. To the east of the pumphouse, a reinforced concrete seawall with post-tensioned rock anchors has been built between the pumphouse and the Millstone 2 intake structure to retain the earth and protect the structures from wave action. On the west side of the pumphouse, extending in a northerly direction, is a reinforced concrete retaining wall keyed into rock. The purpose of this wall is to protect the circulating and service water lines from being undermined due to wave action on the adjoining slope. To the west of the pumphouse, a variable slope has been cut in the beach and outwash sand to provide for a transition from the offshore intake channel at el -32 feet to the pumphouse area site grade at el +14 feet. The slope varies from five horizontal to one vertical immediately adjacent to the pumphouse, to ten horizontal to one vertical near Bay Point, the western extent of the beach. Compacted backfill was placed in areas where additional fill was required to meet these grade requirements.

A multilayer stone armor zone was placed on the slope for protection against wave action during the probable maximum hurricane. The maximum significant wave height of 13 feet was used to design the slope protection system. The techniques used are described in the U.S. Army Shore Protection Manual (USA CERC 1975).

The armor layer is designed as a 2-layer system. The weight of stone was obtained from the equation:

$$W = \frac{W_r H^3}{K_D (S_r - 1)^3 \cot \theta}$$

where:

W_r = unit weight of the stone = 160 pcf

H = design wave height = 13 ft

S_r = specific gravity of rock with respect to seawater = 2.5

q = angle of slope = 5:1 = 11.3°

K_D = stability coefficient = 3.5 (assuming 2 layers of randomly placed rough angular quarrystone, a breaking wave, and a structure trunk with 0 to 5 percent armor layer damage).

An individual stone weight of 6,000 pounds was obtained for the primary armor stone cover layer. A range of 0.75W to 1.25W was allowed in specifications. Stone sizes, based on cubic shapes, ranged from 3.0 to 3.6 feet.

The thickness of the 2 armor layers was calculated as 7.7 feet. A minimum still water level of elevation -3 feet was assumed in calculating the bottom of the primary armor layer at elevation -16 feet. A secondary rock protection layer, referred to as Type B material, was calculated to be 500 pound stone. Two layers of secondary protection, varying in size from 300 pounds to 700 pounds with 75 percent greater than 500 pounds, with a minimum thickness of 3.6 feet, were determined as necessary underlayment for the primary armor stone layer. This secondary layer was placed on a continuous filter fabric layer.

The in situ beach sands and compacted fill layers are overlain by filter fabric, which prevents migration of finer materials into the rock protection layers. Figure 2.5.5-1 shows a detailed cross-section of the slope protection system. Stone for the slope protection was obtained from bedrock previously blasted during excavation at the site and from offsite sources.

Borings P1 through P10 and I1 through I12 were drilled onshore in the vicinity of the pumphouse. The P-series of borings included undisturbed sampling of the saturated beach sands using the Osterberg sampler. The location of these borings is shown on Figure 2.5.4-31. A geologic profile across this area is shown on Figure 2.5.4-35. The depth of sand along the beach varies from zero at Bay Point and the area just west of the Millstone 2 intake structure, where exposed rock is evident, to a maximum of approximately 40 feet in the vicinity of the Millstone 3 pumphouse. The beach and outwash sand deposits overlie a thin layer of basal till, generally less than 5 feet thick which covers the bedrock. The relative density of the beach sand determined from the Gibbs-Holtz correlation of blow count data averages approximately 70 percent. The data points are plotted on Figure 2.5.4-28. No extensive or continuous loose zones were detected in these borings.

2.5.5.1.2 Containment Rock Cut

The reactor containment building is founded on bedrock at approximately el -39 feet. Top of rock varies from approximately el 0 feet to el 20 feet, as shown on the bedrock surface contour map (Figure 2.5.4-39). The excavation walls are vertical, with a 9-inch bench at el -17 feet. The excavation of bedrock for the containment is described in detail in Section 2.5.4.5.1.

As a result of detailed geologic mapping of the bedrock surface during construction, described in Section 2.5.4.1.1, additional preferred joint sets were noted beyond those previously reported in the local geological literature (Goldsmith 1967). These joint sets have been interpreted from the stereonet projection plots for top of bedrock mapping previously reported (NNECo. 1975) and plotted from final excavation grade data on Figure 2.5.1-16. Cross sections through the critical wedges are shown on Figure 2.5.5-2.

The assumption that failure surfaces develop in the bedrock along joint and foliation surfaces is very conservative. For this to occur, joint and foliation surfaces must be at least as long as the horizontal projection of the wedge failure surfaces and must extend from the rock surface to a minimum elevation of -27 feet, which corresponds to the top of the containment mat. There is no firm evidence that this situation does occur around the containment structure, particularly with respect to the minor joint sets. However, for the purposes of analysis, the joint and foliation planes are modeled as flat, smooth continuous surfaces.

Direct shear tests were conducted on samples of both foliation and joints to determine the frictional values for each plane. A direct shear device capable of developing the low normal forces representative of field conditions and sensitive enough to measure the shear force was used to test NX core samples of rock from the borings previously taken in the vicinity of the containment structure. A description of the samples tested is shown in Table 1 of Appendix 2.5I. The peak and residual θ values are plotted on Figure 2 of Appendix 2.5I. For analysis, a friction angle θ of 32 degrees was used for the foliation, θ equals 34 degrees for the predominant joint set of N04E and θ equals 37 degrees for the minor joint sets. These values do not take into account the added strength of the asperities, which was significant for the higher normal stresses.

2.5.5.2 DESIGN CRITERIA AND ANALYSIS

2.5.5.2.1 Shoreline Slope

A computer program, LEASE II (Limiting Equilibrium Analysis of Slopes and Embankments) (SWEC 1977), was used to analyze the stability of the shoreline slope. This program, part of ICES (Integrated Civil Engineering System--VI M3, dated November 1969), is accepted and widely used by soil mechanics and foundation engineers for analyzing slope stability problems. This version is an update of an earlier version and provides for making dynamic analyses. LEASE II is presently being run on an IBM-370 Operating System, Model 165 at the SWEC Computer Center.

LEASE II calculates three different factors of safety. The methods of analysis include the simplified Bishop method of slices, the Fellenius method of slices, and the Rankine wedge method. The simplified Bishop method of analysis was used to compute factors of safety of the slopes. It has been shown by Whitman and Bailey (1967) and Whitman and Moore (1963) that the answers obtained using the simplified Bishop method are more correct than other methods. Whitman and Bailey indicate that the error involved in the simplified Bishop method is usually less than 5 percent and, therefore, recommend it be used for slope stability analyses.

The shoreline slope shown on Figure 2.5.4-41 was analyzed for static, dynamic, and post-earthquake conditions. The slope to the west of the circulation and service water pumphouse is bowl-shaped. It is 5H to 1V at the steepest portion and decreases to 10H to 1V adjacent to the intake channel. Conservative assumptions were made in constructing the analytical model for the slope stability analysis. The end constraints of three dimensional geometry were ignored and the entire slope was assumed to be 5H:1V. A section through the modeled slope together with a summary of the results of the slope stability analysis is presented on Figure 2.5.5-1. Factors of safety are defined as the available shear resistance along a postulated failure surface divided by the maximum driving forces along that surface.

Figure 2.5.4-37 shows a groundwater gradient from the main plant area toward Long Island Sound. Groundwater levels in boring 316, which is approximately 250 feet from the pumphouse, varied between elevations 6.4 and 8 feet. Water levels of elevation +6 feet onshore and -6 feet offshore were conservatively selected to maximize the destabilizing forces in the analysis. These levels represent approximately four times the normal tidal range, and elevation +6 feet corresponds to an appropriate flood tide level at the site.

Soil strength properties used in the stability analysis were selected on the basis of standard penetration tests and of cyclic triaxial and consolidated undrained (CIU) triaxial tests on undisturbed samples, as reported in Appendixes 2.5G and 2.5F, respectively. The effect of possible pore pressure buildup in the beach and outwash sands was accounted for in the stability analysis for the post-earthquake conditions.

A static slope stability analysis was conducted using the assumptions described above together with strengths for the various slope materials as shown on Figure 2.5.5-1. The effective internal friction angles assigned to the beach and glacial outwash sand were selected on the basis of standard penetration tests and of the CIU triaxial tests on undisturbed samples. The CIU tests (see Appendix 2.5G and Figure 2.5.5-5) revealed effective internal friction angles of 33 to more than 40 degrees for the samples tested. For internal friction, an angle of 34 degrees was used in the analysis. The minimum factor of safety against slope failure for the static case is 2.9, which is adequate. The dynamic slope stability during the SSE was evaluated by using a pseudo-static approach and undrained shear strengths of the soils. Input horizontal and vertical accelerations of 0.25g and 0.17g were based on the average amplified accelerations described in Sections 2.5.4.8.3.1 and 2.5.4.9. Acceleration directions were selected to maximize instability.

Undrained strength parameters for the beach and glacial outwash sands were derived based on undrained triaxial compression test results reported in Appendix 2.5G. Stress paths and data from these tests indicate that during undrained loading the average A parameter at maximum obliquity was 0.13. The values of A ranged from +0.33 to -0.16. An A parameter equal to 0.5 and an internal friction angle of 34° were used to derive the undrained strengths of the beach and glacial outwash sands. These values are considered to be conservative based on the in situ density and loading conditions. The derived undrained strengths which are modeled as cohesion and a friction angle of zero are shown on Figure 2.5.5-1. The undrained strength is calculated as at the mid-level of each layer.

Results of the pseudo-dynamic stability analysis indicate that the minimum factor of safety against slope failure is 0.9 for the assumed conditions. This result is very conservative because of the assumptions made about slope geometry and end effects. An additional analysis was performed on this slope considering only the horizontal component of seismic loading, and a safety factor of 1.16 was calculated for the same failure circle.

Due to the low factor of safety obtained, an analysis was performed to estimate the deformations which could theoretically occur along the postulated failure surface during earthquake loading. The analysis is based on an approach presented by Newmark (1965) using the computer program SIDES (Seismically Induced Displacement of Embankments and Slopes, SWEC, 1979) which calculates the cumulative mono-directional sliding displacement of a rigid body shaken by an earthquake. An input earthquake accelerogram is represented by a maximum 12,000 point time history of acceleration. No motion is assumed to occur within the slope until the strength of the soil is exceeded; i.e., the limiting acceleration producing a safety factor of 1.0 is exceeded. Analytical equations governing rigid solution are then solved incrementally on the assumption that the input acceleration varies linearly from point to point, and that the displacements are cumulative throughout the duration of the earthquake. Each of the three earthquakes used to compute the dynamic response of the soil were used (Section 2.5.4.8.3). Their time histories were scaled to the appropriate average amplified accelerations (i.e., vertical acceleration of 0.17g and horizontal acceleration of 0.25g) described above. Results from each of these earthquakes indicate maximum cumulative slope movements less than 0.1 inch. The limiting horizontal and vertical acceleration used were 0.2g and 0.12g, respectively. These results indicate that if there is any movement of the slope during the SSE, the movement would be negligible. There would be no adverse effect to any safety related system component or structures.

A post-earthquake stability analysis was performed to quantify the effect of pore pressure generated by the earthquake. The magnitude of pore pressure buildup was estimated from results of cyclic triaxial tests (Appendix 2.5F) considering such factors as the number of equivalent cycles, cyclic shear stress levels, confining pressures, material density, and gradation. The pore pressure buildup for 5 cycles of loading on samples which most closely represent the in situ condition and dynamic loading was between 40 and 60 percent of the effective confining pressure. An estimated pore pressure buildup of 50 percent was used to evaluate the post-earthquake slope stability. Therefore, the soil properties are the same as in the static case but the pore pressures are increased during the LEASE analysis. Results of the post-earthquake analyses reveal that the minimum factor of safety against slope failure is 1.4. This is considered acceptable. The analysis of slope stability indicates that the shoreline slope is stable under static, dynamic, and post-earthquake conditions.

In addition to the above analysis, where the shorefront slope was considered to consist of a uniform deposit of outwash sand to el -40 feet, the actual subsurface conditions were modeled to determine whether a more critical cross-section existed due to sloping bedrock conditions at the shorefront. The actual soil profiled in this area is shown on Figure 2.5.4-52. This condition was modeled for LEASE and a static slope stability analysis was performed using both the simplified Bishop circular failure method and the Morgenstern-Price wedge failure method. The profile of the sloping rock condition used in the slope stability analysis showing soil properties and slope geometry is shown on Figure 2.5.5-4.

The minimum safety factor for static loading conditions is 3.2 for a circular arc failure surface. This compares to a safety factor of 2.9 for the circular failure surface in the analysis for a uniform depth of sand to el -40 feet indicating that the sloping rock profile is less critical than the uniform sand profile. Also, the dynamic analysis for the sloping rock profile is less critical than the uniform sand profile because the magnitude of the dynamic forces is reduced due to less amplification through the stiffer till and because of the shallower depth to bedrock. The minimum safety factor for dynamic loading conditions is comparable with the uniform sand profile when similar dynamic forces are assumed.

Morgenstern-Price wedge failure analyses were also performed to further investigate the sloping rock profile. Safety factors for static loading conditions of 4.14 for shallow wedge and 3.54 for deeper wedge failure surfaces were calculated. These safety factors against slope failure are higher than the circular arc safety factor of 3.2 and confirm the inherent conservatism of the circular arc failure analysis.

Liquefaction of the shoreline slopes was also investigated. The analyses (Section 2.5.4.8.3) show that the beach sands would not liquefy when subjected to the SSE.

2.5.5.2.2 Containment Rock Cut

Two computer programs have been developed to evaluate field data and compute the stability of rock slopes. JTPLOT(ST-212) (SWEC 1974a) is used to reduce data from joint and foliation surveys and to prepare contoured stereographic plots, such as those on Figures 2.5.1-15 and 2.5.1-16. SWARS-2P (SWEC 1974b) is used to analyze the stability of tetrahedral rock wedges formed by the intersections of joint and foliations surfaces with the vertical excavation face. The data are input in geological notation and are converted internally to the format required for rock mechanics calculations. All possible combinations of joints are automatically considered. Effects of seismic loads, rock bolts, surcharges, point loads, and several types of piezometric loads are included in the analysis. In designing a restraining hoop or ring beam, the forces required to stabilize the sliding wedges are input into the program as hypothetical rock bolts, with the load distributed across the projected vertical area of the rock wedge. A minimum safety factor of 1.1 was considered acceptable for determining required stabilizing forces.

In the analysis, the surcharge loading from adjacent structures was accelerated in the vertical direction, and soil surcharge was accelerated both vertically and horizontally. Water pressure was not applied to the rock wedge surfaces, on the assumption that the differential head acts directly on the containment wall. However, the buoyant weight of the rock was used to account for the presence of groundwater. This assumption is considered conservative because the buoyant weight effectively reduces the resistive forces. Wedges smaller than 100 cubic feet were disregarded, on the assumption that these wedges were formed by the intersection of two high angle joint sets, and were probably removed during blasting and scaling operations.

Figure 2.5.5-6 shows the plan view of potential failure wedges that could develop on the west side of the containment excavation. Geologic mapping of this area (see Figure 2.5.4-6) does not exhibit a high density of fractures that could produce these wedges. Figure 2.5.5-7 is a photograph showing the rock surface commonly found in the area of the main steam valve building.

The forces applied by the rock wedges on the ring beam are shown on Figure 2.5.5-3. The maximum forces act in the southwest quadrant, due to the effect of the weaker foliation planes which dip into the excavation face in this area. Other areas of instability can be attributed to the high dip angles of the jointing, which are inherently unstable when subjected to seismic and surcharge loadings. The design of the structural support, or ring beam, which transfers this load around the excavation, maintaining the isolation of containment structure from these external loads, is discussed in detail in Section 3.8.1.1.

2.5.5.3 LOGS OF BORINGS

All boring logs are included in Appendix 2.5J. No borings were taken in borrow areas for materials used onsite.

2.5.5.4 COMPACTED FILL

Structural backfill used to raise the shoreline slopes to final design lines meets the requirements outlined in Section 2.5.4.5.2.

2.5.5.5 REFERENCES FOR SECTION 2.5.5

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2.5.5.1-5 Stone & Webster Engineering Corporation (SWEC), 1974a. Stereographic Projection of Joints (JTPLOT). Computer Program ST-212. SWEC, Boston, Mass.

2.5.5.1-6 Stone & Webster Engineering Corporation (SWEC), 1974b. Analytical Method for Analysis of Stability of Rock Slopes; SWARS-2P. Computer Program ST-214. SWEC, Boston, Mass.

2.5.5.1-7 Stone & Webster Engineering Corporation (SWEC), 1977. Limiting Equilibrium Analysis on Soil Engineering, LEASE II. Computer Program GS-018. SWEC, Boston, Mass.

2.5.5.1-8 Stone & Webster Engineering Corporation (SWEC), 1979. Seismically Induced Displacements of Embankments and Slopes, Sides. Computer Program GT-009. SWEC, Boston, Mass.

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2.5.5.1-10 Whitman, R.V. and Bailey, W.A., 1967. Use of Computers for Slope Stability Analyses. Journal of Soil Mechanics and Foundations Division, ASCE. Vol 93, SM4.

2.5.5.1-11 Whitman, R.V. and Moore, P.J., 1963. Thoughts Concerning the Mechanics of Slope Stability Analyses. Proceedings, Second Pan American Conference on Soil Mechanics and Foundation Engineering.

2.5.6 EMBANKMENTS AND DAMS

No embankments or dams have been constructed at the Millstone site.

APPENDIX 2.5A– AGE OF TILL AT MILLSTONE POINT

D.W. Caldwell, PhD

AGE OF TILL AT MILLSTONE POINT, CONNECTICUT

D. W. Caldwell, Ph.d.

Till at Millstone Point

The till exposures at Millstone are inadequate for the purpose of establishing their time of deposition. The best exposures exist along an embankment some 200 feet long and from 10 to 15 feet high just to the west of the switchyard northeast of the plant. Part of this exposure has about 5 feet of artificial fill, covered by six inches of concrete. Beneath the fill, a grey, compact, clay - rich till is exposed. This till has few large stones and the matrix is closely jointed. At the northern end of the embankment, the till is less compact and less jointed. The complete exposure is inadequate to determine the relationship between the two exposures of till, that is, whether one till definitely underlies the other or whether a single till simply changes in its texture and compactness from one exposure to another.

Because of the rarity of two-till exposures in New England, it is most probable that a single body of till, changing in its physical character from one place to the next, exists at the Millstone site. A small likelihood exists that there are two separate bodies of till at Millstone, a fact which can only be established by further and more extensive excavation.

Two-till Problem in New England

At several localities in southern New England there is evidence of two tills, believed to be of different ages (Schafer and Hartshorn, 1965; Pessl and Schafer, 1968). The older till is usually compact, contains much silt and clay and has closely spaced jointing. Oxidation in the older till ranges to depths of 10 or more feet. Drumlins are generally composed of the older till.

The younger till is generally less compact, is sandier and does not contain numerous joints or foliated structures. Oxidation is less than 3 feet and is usually absent altogether.

Age of Older Till

At three localities in New England organic material beneath the lower till has been dated. At New Sharon, Maine, wood embedded in weathered sand, lying between two tills, has a radiocarbon age of more than 44,000 years B.P. (W-910; Caldwell, 1959). Wood at the base of an exposure of till in Wallingford, Connecticut, has been dated as more than 40,000 years B.P. (Y-451). Peat overlain by drumlin sediments in Worcester, Massachusetts, has been dated as more than 38,000 years B.P. (W-647, L-380). All of these listed C-14 ages of the older till are (or were at the time of analysis) beyond the range of carbon-14 analysis, although they are probably post-Sangamon in age, that is, less than about 100,000 years old. Without deposits of organic material at other till localities in New England, it is not possible to relate them to these three till sites where dating has been possible.

Age of the Younger Till

The emplacement of the younger till is more firmly established than that of the older till, but neither has been dated as completely and as consistently as they have been in the mid-west.

The last (Wisconsin) ice sheet covered all of New England and its terminal position is marked by the moraines on Long Island (Ronkonkoma moraine) and the Islands (Nantucket moraine on Martha's Vineyard and Nantucket). The advance of this ice sheet is dated by organic material, older than the advance, incorporated in till at Harvard, Massachusetts (21,200 ±1,000 years B.P.; W-544), and shells in drift on outer Cape Cod (20,700 ±2,000 years B.P.). On Martha's Vineyard plant material in clay (15,300 ±800 years B.P.; W-1187) is overlain by till from a slight readvance of the ice margin.

The Martha's Vineyard moraine can be traced by underwater topography to Block Island and to Long Island and the Ronkonkoma moraine, about 50 miles south of Millstone Point. The chart (Fig. 1) presents the spatial and temporal relationship of the advance of the Wisconsin ice over the Millstone area about 18,000 years ago. This is the approximate age of the upper part of the till at Millstone (assuming there are two tills) or all the till (assuming there is but one till).

The retreat of the Wisconsin ice from its terminus at the Ronkonkoma - Block Island moraine is dated by numerous C-14 ages of organic material overlying the upper till. At Rogers Lake, Lyme, Connecticut, basal peat overlying last till is 14,240 ±240 years B.P. (Y-950/51). Other dates of similar material in Connecticut and Massachusetts are consistent with the Rogers Lake date.

Flint (1953, 1958) describes a short readvance of the ice to Middletown, Connecticut, "before, but probably not long before, about 13,000 years ago." Following this readvance the ice melted rapidly up the Connecticut River Valley and Glacial Lake Hitchcock was formed in the valley by a rock dam at Rocky Hill, Connecticut, north of Middletown. This lake was drained between 10,710 and 10,650 years B.P. (Y-253 and Y-251; Flint, 1956).

Conclusions

The last till deposition at Millstone Point occurred about 18,000 years ago. The area remained ice - covered until about 14,000 years ago. If older till exists at Millstone, it may be equivalent to the pre-Wisconsin-post-Sangamon till deposited more than 40,000 years ago. A more complete exposure of the Millstone till would be required in order to establish the presence or absence of two tills at the site.

References for Appendix 2.5A

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APPENDIX 2.5B– PETROGRAPHIC REPORTS, FINAL GRADE

CLICK HERE TO SEE APPENDIX 2.5B

APPENDIX 2.5C– MINERALOGICAL ANALYSIS OF MILLSTONE FAULT GOUGE SAMPLES

CLICK HERE TO SEE APPENDIX 2.5C

APPENDIX 2.5D– POTASSIUM - ARGON AGE DETERMINATION

CLICK HERE TO SEE APPENDIX 2.5D

APPENDIX 2.5E– SEPARATION OF < 2µ FRACTION AND CLAY ANALYSIS OF SAMPLES B, C, D (ESF BUILDING) AND P-1 AND P-2 (PUMPHOUSE)

CLICK HERE TO SEE APPENDIX 2.5E

APPENDIX 2.5F– DYNAMIC SOIL TESTING ON BEACH SANDS

CLICK HERE TO SEE APPENDIX 2.5F

APPENDIX 2.5G– CONSOLIDATED UNDRAINED TESTS ON BEACH SANDS

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APPENDIX 2.5H– SEISMIC VELOCITY MEASUREMENTS

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APPENDIX 2.5I– DIRECT SHEAR TESTS ON NATURAL ROCK JOINTS

CLICK HERE TO SEE APPENDIX 2.5I

APPENDIX 2.5J– BORING LOGS

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APPENDIX 2.5K– SEISMIC SURVEY

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APPENDIX 2.5L– SEISMIC AND BATHYMETRIC SURVEY

CLICK HERE TO SEE APPENDIX 2.5L

APPENDIX 2.5M– LABORATORY TEST PROGRAM FOR PROPOSED ADDITIONAL STRUCTURAL BACKFILL SOURCES

CLICK HERE TO SEE APPENDIX 2.5M

APPENDIX 2.5B

PETROGRAPHIC REPORTS
FINAL GRADE

December 1975

R. A. Wobus
Associate Professor of Geology
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Williamstown, Massachusetts

WILLIAMS COLLEGE WILLIAMSTOWN, MASSACHUSETTS 01267

DEPARTMENT OF GEOLOGY
(413) 597-2221

December 11, 1975

Mr. F. S. Vetere, Geotechnical Division
Stone & Webster Engineering Co.
245 Summer Street
Boston, Massachusetts 02107

Dear Mr. Vetere:

Enclosed are petrographic reports for the six additional samples from Millstone which I received on November 25. I am returning the thin sections and a roll of photomicrographs (undeveloped) via Jack MacFadyen, who is going to your office today; the samples will be mailed under separate cover.

Sample locations were not provided with the sections, but one sample (12F) seems to have escaped the cataclasis, silicification, and severe alteration which the others have experienced. There is only slight variety among the other samples; all appear to be former cataclastic rocks in which the fragments have been altered to or replaced by chlorite and sericite, and in which the matrix has been silicified by the crystallization (from hydrothermal solution?) of prismatic quartz. (These events could have occurred during the same episode of hydrothermal activity, though chlorite appeared to fill fractures in matrix quartz in some samples.) A younger, though minor, cataclastic event resulted in the fragmenting of earlier hydrothermal quartz and in the formation of thin (1-3 mm) shear zones through the matrix (see especially 5F).

Staining of hand specimens for K-feldspar revealed very minor amounts only in 6F and 12F, and x-ray diffraction scans indicated nothing besides the minerals observed in thin section.

I hope these reports will be helpful; please call if there are any questions. I will be on sabbatical leave but in residence at the college during the first two months of 1976 if you have any other samples to be examined.

Sincerely,

R. A. Wobus
Associate Professor of
Geology

RAW:al

Photomicrographs - Millstone Samples

(Film = KM-135-20, ASA 25, color slides)

Photo No.	Sample No.	Magnification	Polarizers	Subject
1	2F	35x	unxd	Partly chloritized fragments
2	2F	35x	unxd	Partly chloritized fragments
3	2F	35x	xd	Partly chloritized fragments
4	2F	35x	xd	1 1/2 mm fragment of strained quartz, with thin quartz overgrowth(rim)
5	5F	35x	unxd	2 mm fragment which contains prismatic quartz similar to that in the matrix
6	5F	35x	xd	2 mm fragment which contains prismatic quartz similar to that in the matrix
7	5F	35x	xd	Bent twin lamellae and internal granulation within 3 cm fragment
8	5F	35x	xd	Thin zone of shearing in which matrix quartz has been pulverized
9	6F	35x	unxd	Chloritization and sericitization of fractured fragment
10	6F	35x	xd	Chloritization and sericitization of fractured fragment
11	6F	100x	xd	Plumose muscovite at pulverized margin of fragment
12	6F	35x	xd	Matrix quartz (subhedral, unoriented)
13	9F	35x	unxd	Chlorite platelets in fractures
14	9F	35x	xd	Chlorite platelets in fractures
15	9F	35x	xd	Fragments of undulose anhedral quartz in matrix of subhedral oriented quartz
16	9F	35x	unxd	Extensive sericitization of matrix; 1 mm fragment in center may be piece of earlier cataclasite
17	11F	35x	unxd	Altered micas and strained quartz within largest fragment

Photo No.	Sample No.	Magnification	Polarizers	Subject
18	11F	35x	xd	Altered micas and strained quartz within largest fragment
19	11F	35x	unxd	2 mm fragment (of earlier cataclasite?) nearly "assimilated" by matrix
20	11F	35x	xd	2 mm fragment (of earlier cataclasite?) nearly "assimilated" by matrix
21	11F	35x	xd	Matrix - a mosaic of subhedral quartz (many basal sections)
22	12F	35x	unxd	Altered biotite and plagioclase
23(?)	12F	35x	xd	Altered biotite and plagioclase

2F - Millstone

Hand specimen

Gray, very fine-grained, highly altered and silicified rock with small angular fragments (< 3 mm) and several irregular vugs up to 2-3 cm long which are partly filled with greenish clay. Entire sample is coated with clays, and one surface contains fine-grained calcite. No planar or linear structures are visible; a few thin (1-2 mm) zones of more intense shearing cut the sample.

Thin section

Fragments (approx. 10%)

Angular, unoriented fragments are mostly of altered and chloritized plagioclase of at least two compositions: albite-oligoclase ($\sim An_{10}$) with a 12° extinction angle and positive sign, and andesine (An_{30-35}) with a 15° extinction angle and negative sign. Some of the plagioclase has been almost entirely replaced by chlorite. A few fragments are of strained quartz; two show thin quartz overgrowths around earlier angular grains. A few feldspar (?) fragments are so highly altered to clays that they almost merge with the matrix; others show distinct albite twinning which has been bent or offset.

Matrix ($\sim$ 90%)

Very fine-grained unoriented subhedral quartz prisms, generally unstrained but somewhat corroded along the edges. Highly birefringent flakes (sericite?) are also abundant and are essentially unoriented; a few plumose aggregates of sericite or muscovite are present adjacent to some of the fragments.

Interpretation

A fragmental rock (cataclasite) which has undergone extensive alteration (particularly to sericite), chloritization, and silicification. The corroded nature of the matrix quartz suggests that hydrothermal alteration continued after the crystallization of the quartz. No pervasive cataclastic deformation has affected this sample since the hydrothermal event, however.

Name

SILICIFIED AND ALTERED CATACLASITE

5F - Millstone

Hand specimen: Dark gray, very fine-grained groundmass with white and dark green, angular to subrounded fragments up to 3 cm in length. The largest fragment shows signs of interior crushing, and the dark matrix has been squeezed into fractures around its margin. No preferred orientation of fragments or matrix is visible. Thin (< 3 mm thick) zones of shearing cut parts of the sample. Clays, and locally calcite, coat the surface of the hand specimen.

Thin section

Fragments (~ 30% of section)

The largest (3cm) is of medium-grained, unoriented sodic andesine (~ An_{35}) and quartz; it shows considerable internal granulation and deformation of the plagioclase twin lamellae. Other fragments are composed of strained quartz, quartz and plagioclase, or quartz and chlorite; a few are dominantly replaced by or altered to chlorite. Several fragments are composed of the same kind of hydrothermal(?) quartz found in the matrix; good basal and prismatic sections of tiny quartz crystals are present in these fragments.

Matrix (70%)

Fine-grained subhedral quartz, especially as prismatic sections with two perpendicular preferred orientations. Chlorite is present between the quartz grains, and it partially rims some of the fragments. One euhedral grain of apatite is conspicuous. The matrix has been pulverized within a 2-3 mm wide shear zone that runs the length of the thin section; even the subhedral quartz has been granulated within this zone.

Interpretation

Fragments were produced by cataclasis, as indicated by their angular nature and the degree of their internal granulation and twin-lamellae deformation. Subsequent hydrothermal fluids produced the subhedral quartz of the matrix and caused the alteration and chloritization of many fragments; chlorite was also deposited interstitially between the prismatic quartz grains of the matrix. It is significant that some of the fragments in this section contain the subhedral prismatic (hydrothermal) quartz usually associated with the matrix of the Millstone samples; this would suggest a younger period of cataclasis, which occurred since the formation of hydrothermal quartz in older shear zones. The thin pulverized zone within this sample is further evidence of a younger cataclastic event.

Name

CHLORITIZED AND SILICIFIED CATACLASITE

6-F Millstone

Hand specimen

On cut surface, this is a light gray, very fine-grained silica-rich rock with subangular quartzo-feldspathic and chloritic fragments less than 5 mm long. There is no orientation of the fragments or of the quartzose matrix. The sample is encrusted with tiny drusy quartz crystals on one surface, with limonite-stained clay on another side, and with gray calcareous clays on the two remaining sides. A pinkish coloration of the clay on one surface is of uncertain origin.

Thin section

Fragments (approx. 30% of section)

Subangular, unoriented fragments composed of undulose quartz, minor orthoclase, and sodic plagioclase (biaxial positive, maximum extinction angle $\sim$ 12°, R.I. < quartz = albite-oligoclase, An_{10}). Most grains are fractured, some fragments are partly disaggregated, and plagioclase twin lamellae are commonly bent or offset. Alteration of feldspar to highly birefringent clay is moderate, though it is pervasive at the granulated margins between a few grains. Plumose muscovite appears to have formed locally within these clays. Chlorite occupies fractures in grains in one portion of the section; one fragment looks like a piece of cataclastic rock (cataclasite).

Matrix ($\sim$ 70%)

Fine-grained, subhedral to anhedral quartz grains, mostly elongate (prismatic) sections in a variety of orientations. The matrix differs from that in other sections (11F, 9F, 5F) in having more irregular quartz grains which are less oriented, less interstitial chlorite, and more interstitial clay. Plumose muscovite occurs locally in the matrix as well as in the fragments; it was observed only in one other section (2F). A few thin, late fractures are filled with anhedral quartz and clays (sometimes with plumose muscovite growing across the fracture).

Interpretation

Originally a cataclastic rock in which the matrix has been silicified; hydrothermal (?) alteration has created highly birefringent clays, from which plumose muscovite has locally crystallized at a late stage. Chlorite is another late mineral, filling fractures in some fragments, though it is not nearly as common in this section as in others.

Name

SILICIFIED AND ALTERED CATACLASITE

9F - Millstone

Hand specimen: Mottled white and greenish -gray, very fine-grained altered and silicified fault gouge(?), with angular quartzose fragments up to several cm in diameter. Parts of this sample are very friable.

Thin section

Fragments (∿ 50% of section)

Angular to subrounded; average size 1-2 mm in diameter; no preferred orientation. Most are of highly strained polycrystalline quartz, locally with plagioclase (oligoclase?) being replaced by quartz; some show internal crushing and marginal granulation. A few fragments, originally more micaceous (schists?), have been altered to muscovite, chlorite, clays, and opaques. The remaining fragments contain angular, non-oriented grains of undulose quartz in a dense, clay-rich matrix; they are perhaps pieces of an earlier cataclasite.

Matrix (∿ 50%)

Dominantly fine-grained hydrothermal (?) quartz, in tiny subhedral grains preferentially oriented in two directions which are at right angles to one another. Chlorite is the other common matrix mineral, occurring between fragments and rimming some, as well as in late fractures that cut even the matrix quartz. Chlorite commonly forms circular or hexagonal platelets.

Interpretation

Quartzose and micaceous fragments have been crushed and altered in a cataclastic zone which has since become silicified. Chlorite was added (hydrothermally?) during or after silicification. A few late fracture and granulation zones also contain chlorite.

Name

CHLORITIZED AND SILICIFIED CATACLASITE

11F - Millstone

Hand specimen: Greenish-gray, very fine-grained quartzose cataclastic rock with a few unoriented darker green, angular to lensoidal fragments ranging from 1/4 - 2 cm long. Sample is partly coated with clay which is locally limonite-stained.

Thin section

Fragments (∿ 20% of section)

Dark green or brownish under uncrossed polarizers; generally subangular and completely unoriented, with many as small as 1-2 mm. The largest fragment is 1x2 cm and is composed of medium-grained, highly strained (undulose) quartz and oriented micas (all formerly biotite?), which have been altered to a dense mixture of muscovite and sericite, chlorite, allophane (?), and opaques. Accessory garnet and apatite are also present, and the fragment is surrounded by a 1 mm "reaction rim" of darker clays.

Other fragments are dominantly clays with minor quartz; a few appear to be finer-grained cataclasites, with angular fragments in a clay-rich matrix. Some fragments seem to have been disaggregated so that they seem to merge with the quartz-rich matrix described below. Two fragments have been reduced to isolated hexagonal platelets of chlorite, separated by matrix quartz.

Matrix (80%)

A mosaic of fine-grained subhedral, weakly undulose quartz. No preferred orientation is visible; both basal and prismatic sections are common. Crystal boundaries are not nearly as distinct as those in the martix of other silicified samples from Millstone.

Interpretation

The fragments have been hydrothermally altered to a variety of clays; many were originally micaceous schists or gneisses judging from their texture. The matrix appears to be hydrothermal quartz, far less strained than the anhedral quartz of the fragments. The fragmental texture of the rock indicates that it was probably a cataclastic rock before silicification.

Name

HYDROTHERMALLY ALTERED AND SILICIFIED CATACLASITE

12F - Millstone

Hand specimen: Mottled white and black, medium-grained biotite-quartz-feldspar rock; could be granitic or a weakly foliated quartzo-feldspathic gneiss. Feldspars seem quite altered, and much of the sample's surface is covered by clays.

Thin section

Mineralogy	Estimated %	
PLAGIOCLASE	50	Biaxial (+); maximum extinction angle 20-25°, R.I. > quartz; composition $\sim An_{40}$ = andesine. Distinct, undistorted polysynthetic twinning; moderate alteration to highly birefringent clays.
QUARTZ	35	Anhedral, very highly strained, with undulose and "patchy" extinction.
ALTERED BIOTITE	8	Subhedral flakes, weakly oriented, mostly altered to chlorite and opaques.
ORTHOCLASE	3	Biaxial (-), no twinning; moderately altered.
MUSCOVITE	2	Secondary (?) - mostly at grain boundaries.
OPAQUES	2	Angular grains.

Texture

Medium-grained xenomorphic granular; very weak biotite alignment. Considerable alteration of biotite and feldspars. Quartz is highly strained, but there are no other signs of deformation.

Name

ALTERED BIOTITE QUARTZ DIORITE (OR BIOTITE-QUARTZ-ANDESINE GNEISS)

APPENDIX 2.5C

MINERALOGICAL ANALYSIS OF MILLSTONE FAULT GOUGE SAMPLES

MINERALOGICAL ANALYSIS OF MILLSTONE FAULT GOUGE SAMPLES

Six samples labeled 1F, 7F, 10F, 13F, 14F, and 15F were supplied by Mr. Leo Martin of Stone & Webster Engineering Corporation for mineralogical investigation. The two major objectives of the mineral analyses were: 1) to ascertain if the samples contain sufficient 1Md mica and an absence of feldspar for possible age dating, and 2) to provide a documented sample for dating. The analyses were carried out as set forth in the author's letter to Mr. R. D Thomas of Stone & Webster, dated 25 August 1975. The laboratory work was done during November-December 1975 by the author with laboratory assistance from E. H. Martin.

The as received samples were crushed to pass a No. 4 sieve. After crushing, the soil was thoroughly mixed. A 20 gm subsample was separated by repetively halving in a sample splitter. The 20 gm subsample was ground to pass a No. 35 sieve, thoroughly mixed, and again subsampled via the sample splitter to obtain a representative 3 g sample that was ground to pass a No. 200 sieve (<74μ). This 3 gm subsample was designated whole soil.

Random powder mounts of the whole soil were prepared and examined by x-ray diffraction, XRD, using CuKα radiation at 40 kV and 20 ma Goniometer speed was 1°2θ per minute and the chart speed gave 2°2θ per inch of chart. The 2θ range examined for the whole soil powder mounts was 4 through 40 (d = 22-2.25A). The XRD data indicated abundant clay minerals and quartz in all samples. XRD data on samples 7F, 13F, and 14F clearly showed the presence of feldspar minerals. Siderite was present in samples 10F, 13F, and 15F. Based upon these results, the decision was made to proceed with the size fractionation and XRD analysis of the clay fraction.

The crushed soil was again mixed and a 160 gram sample taken for size fractionation. The 160 g sample was added to 400 ml distilled water and mixed in a Waring blender for 20 minutes after which the contents were transferred to a 4.5 liter bottle diluted to 4.0 liters and thoroughly mixed by hand shaking. Adjusting the pH to 10 caused strong flocculation in all suspensions. All slurries except 15F appeared to be well dispersed between pH 7 and 8. Slurry from sample 15F never was completely dispersed, probably because of siderite. Pretreatment of the soil to remove siderite was not done because of the unknown effect such pretreatment may have on the age dating. The suspension was allowed to temper 48 hours. Sedimentation for size fractionation was started by hand shaking each bottle to resuspend the soil particles. The top 10 cm was siphoned off after 7.5 hours of settling at a temperature of 23±0.5°C. Distilled water was added to bring the volume of the bottles back to 4.0 liters and the next day a second separation was made and combined with the clay slurry from the first day.

The size separation is based on Stoke's law settling. The equation used to calculate the equivalent spherical diameter (D) was:

$$D = \frac{18\eta H}{g(\rho_s - \rho_u)t}$$

D = spherical diameter in cm
η = water viscosity, 9.38 x 10^{-3} at 23°C
H = depth in cm, 10
g = gravity, 980.4
ρ_s = specific gravity of settling particles 2.75 for most clays
ρ_u = specific gravity of water, 1.0
t = time, 7.5 x 3,600 sec

which gives 1.9µ for the equivalent spherical diameter of the clay fractionated from the soil samples.

The clay slurry was flocculated using a small amount of $CaCl_2$. After settling 24 hours, the clear supernatant fluid was siphoned off and the suspension centrifuged to remove more water. Distilled water was added to the centrifuge tubes, the clay resuspended and again centrifuged. The second addition of distilled water left clay suspended after 2 hours of centrifugation at 2,000 rpm. This was taken to indicate that all excess salt had been removed. Each suspension was mixed and a representative portion taken to be used for the preparation of oriented aggregate mounts. The oriented aggregate mounts were used as part of the XRD clay mineral analysis. After air drying, each clay sample was crushed to pass a No. 35 sieve, thoroughly mixed and quartered to yield a 2 g subsample that was further crushed to pass a No. 200 sieve.

The 2 g clay powder sample was used for random powder mounts in the XRD clay mineral analysis. Further, the 2 g clay powder sample was given to Mr. Martin for age dating ensuring that the age dating was on identical material used for mineral analysis.

Qualitatively, the XRD traces for clay size samples were dominated by smectite, chlorite, and illite in all but sample 1F where illite was not detected. Samples 1F and 15F gave XRD spacing greater than 25A so that illite may be one of the components of the interstratified material in sample 1F.

The chlorite phase in all but sample 1F gave a sharp integral series of basal reflections. From the combination of basal spacing and heat stability it would appear that the chlorite in samples 7F and 14F is very similar. The chlorite basal spacings of samples 10F, 13F, and 15F are similar but the thermal stability of the chlorite in sample 13F is very low while samples 10F and 15F have higher thermal stability of chlorite than samples 7F and 14F. Thermal stability of chlorite in sample 15F was considerably higher than in sample 10F. The chlorite in sample 1F was initially identified as kaolinite because of the high basal spacing and absence of a 144A peak; however, the very high thermal stability precludes the mineral being kaolinite. The chlorite in sample 1F is distinct from the chlorite present in the other samples.

The smectite phase gave a very poor integral series indicative of random interstratification most likely with illite. The nature of the regular stratification suggested by the large spacing in samples 1F and 15F has not been determined; however, the possibility of organic material interlayering is suggested. Sample 1F after heating to 500°C for one hour was black. Treatment of a new subsample with H_2O_2 to remove organic matter followed by Mg saturation did not eliminate the large d spacing for glycerol and 100°C treatments but the large spacing disappeared after heat treatment to 300°C. After one hour at 550°C, the H_2O_2 treated 1F clay was still grey.

All clay size samples have a small percentage of quartz and samples 7F, 10F, and 15F still contain siderite. Sample 13F contains a trace of fledspar but from the weak reflections it is not possible to conclusively identify the feldspar species.

The relative smectite content of the clay samples shown in Table 1, used the amplitude of the 17.7A peak from glycerol treated Wye montmorillonite as reference. Clearly, the smectite in this suite of samples gives a more intense basal spacing than Wye montmorillonite. These data illustrate a frequent hinderance to quantification of XRD data. Nevertheless, the relative numbers show the variation in smectite content within the group of samples examined. Similar arguments apply to the relative amount of chlorite shown in Table 1.

The polymorphic varieties in the illite or clay size mica has special meaning to the mineralogical analysis of these samples because of K/Ar age dating to be done. All polymorphic varieties of illite have many common XRD features. Yoder and Euster established criteria for distinguishing the various polymorphic varieties. Briefly summarized these criteria are:

- 2M - d values at 3.00, 2.87, and 2.80A
- 1M - d values at 3.66, 3.07, and 2.69A
- 1Md - none of the identifying peaks of 2M or 1M but a general clay mica XRD pattern

It is important to note that the 1Md polymorph is identified only in the negative sense, that neither 2M or 1M are identified.

As a reference to verify line positions for polymorphic variety identification, XRD data on a sample of very pure 2M muscovite was collected. Comparison of the amplitudes of the three diagnostic 2M mica peaks in sample 7F to the corresponding peak amplitudes from pure 2M muscovite was used to estimate the amount of 2M mica in sample 7F. Because no reference sample of 1M mica was available, the relative mount of 1M polymorph in the samples was estimated relative to sample 30-7A from R. D. Thomas which was assumed, somewhat arbitrarily, to contain only 1M polymorph; also, the 1M mica in the other samples is the same as in sample 30-7A.

Since 1M polymorph is clearly present in all samples and in addition, sample 7F contains 2M polymorph, one can say nothing about the presence or absence of 1Md polymorph. One possible solution to the dilemma is to make use of the K_2O content.

Define: 2M mica as containing 12 percent K_2O
1M mica as containing 10 percent K_2O
1Md mica as containing 6 percent K_2O

This completely arbitrary assignment of K_2O content to the different polymorphs is done for the sole purpose of illustrating a possible method for estimation of 1Md. The proportion of 1M and 2M polymorph in each sample was made from the XRD data alone. With the above definition of K_2O content in the different polymorphs, the proportion of K_2O present in 2M and 1M polymorphs of each clay sample can be determined. The total K_2O content for 2M and 1M polymorph is now subtracted from the measured K_2O content of the samples and any excess K_2O ascribed to 1Md polymorph. Results from this analysis of the six samples and using K_2O content data supplied by Mr. Martin are given in Table 2.

The amount of clay in the whole soil (see Table 3) was estimated from the relative amplitude of the major clay mineral prism reflection at 4.4A in the XRD data from the whole soil relative to the 4.4A peak in the clay size fraction. Quartz estimation was based on the 4.2A peak because the 3.3A quartz peak was severely masked by the strong mica third order basal peak.

R. Terrence Martin

Table 1. Crystalline Phases Present in the Clay Size Fraction (<1.9μ)

Mineral	Sample Number (Relative Amount)					
	1F	7F	10F	13F	14F	15F
Smectite	1.72	1.60	1.08	0.94	2.00	0.46
Chlorite	0.95	0.80	0.35	0.14	0.25	0.39
Illite	0.17	0.53	0.51	0.46	0.38	0.42
Interstratified	++	0	0	0	0	+
Quartz	0.05	0.07	0.03	0.05	0.10	0.03
Siderite	0	0.02	0.02	0	0	0.04
Feldspar	0	0	0	<0.02	0	0

Table 2. Approximate Amount of Mica Polymorphs in Clay Size Fraction (<1.9μ)

Polymorph	Sample Number (Relative Amount)					
	1F	7F	10F	13F	14F	15F
2M	0	0.12	0	0	0	0
1M	0	0.13	0.42	0.22	0.20	0.42
1Md	0.17	0.28	0.09	0.24	0.18	0
$\%K_2O$	1.01	4.41	4.75	3.65	3.11	4.24

Table 3. Crystalline Phases Present in Whole Soil

Mineral	Sample Number (Relative Amount)					
	1F	7F	10F	13F	14F	15F
Total Clay	0.65	0.60	0.65	0.90	0.75	0.60
Quartz	0.55	0.55	0.35	0.15	0.50	0.55
Siderite	0	0.01	0.15	0.06	0	0.11
Feldspar	0	0.05	0	0.05	0.03	0

NOTE:

For all tables: + means phase present
0 means phase not detected

APPENDIX 2.5D

POTASSIUM-ARGON AGE DETERMINATION

Geochron Laboratories Division
Kruger Enterprises, Inc.
Cambridge, Massachusetts

KRUEGER ENTERPRISES, INC.
GEOCHRON LABORATORIES DIVISION
24 BLACKSTONE STREET • CAMBRIDGE, MA. 02139 • (617)-876-3691

POTASSIUM–ARGON AGE DETERMINATION **REPORT OF ANALYTICAL WORK**

Our Sample No. M-3456

Date Received: 9 December 1975

Your Reference: 1F P.O. 2199.073-480-3
J.O. 12179

Date Reported: 19 December 1975

Submitted by:
Leo Martin
Stone & Webster Engineering
P.O. Box 2325
Boston, Mass. 02107

Sample Description & Locality: Clay mineral concentrate, 1F, less than 1.9 microns.

Material Analyzed: Analyzed as received.

Ar^{40*}/K^{40} = .006575 AGE = 109 ± 5 M.Y.

Argon Analyses:

Ar^{40*}, ppm.	Ar^{40*}/ Total Ar^{40}	Ave. Ar^{40*}, ppm.
.008398	.137	.008134
.007870	.220	

Potassium Analyses:

% K	Ave. %K	K^{40}, ppm
1.021	1.014	1.237
1.007		

Constants Used:

$\lambda_\beta = 4.72 \times 10^{-10}$/ year

$\lambda_e = 0.585 \times 10^{-10}$/ year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$AGE = \frac{1}{\lambda_e + \lambda_\beta} \ln\left[\frac{\lambda_\beta + \lambda_e}{\lambda_e} \times \frac{Ar^{40*}}{K^{40}} + 1\right]$$

Note: Ar^{40*} refers to radiogenic Ar^{40}.
M.Y. refers to millions of years.

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POTASSIUM-ARGON AGE DETERMINATION | **REPORT OF ANALYTICAL WORK**

Our Sample No. M-3457

Date Received: 9 December 1975

Your Reference: 7F P.O. 2199.073-480-3
J.O. 12179

Date Reported: 19 December 1975

Submitted by:
Leo Martin
Stone & Webster Engineering
P.O. Box 2325
Boston, Mass. 02107

Sample Description & Locality: Clay mineral concentrate, 7F, less than 1.9 microns.

Material Analyzed: Analyzed as received.

Ar^{40*}/K^{40} = .01237 AGE = 200 ± 7 M.Y.

Argon Analyses:

Ar^{40*}, ppm.	Ar^{40*}/ Total Ar^{40}	Ave. Ar^{40*}, ppm.
.06642	.628	.06661
.06679	.708	

Potassium Analyses:

% K	Ave. %K	K^{40}, ppm
4.420	4.412	5.383
4.405		

Constants Used:

$\lambda_\beta = 4.72 \times 10^{-10}$/ year

$\lambda_e = 0.585 \times 10^{-10}$/ year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$AGE = \frac{1}{\lambda_e + \lambda_\beta} \ln\left[\frac{\lambda_\beta + \lambda_e}{\lambda_e} \times \frac{Ar^{40*}}{K^{40}} + 1\right]$$

Note: Ar^{40*} refers to radiogenic Ar^{40}.
M.Y. refers to millions of years.

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POTASSIUM-ARGON AGE DETERMINATION | **REPORT OF ANALYTICAL WORK**

Our Sample No. M-3458

Date Received: 9 December 1975

Your Reference: 10F P.O. 2199.073-480-3
J.O. 12179

Date Reported: 19 December 1975

Submitted by:
Leo Martin
Stone & Webster Engineering
P.O. Box 2325
Boston, Mass. 02107

Sample Description & Locality: Clay mineral concentrate, 10F, less than 1.9 microns.

Material Analyzed: Analyzed as received.

Ar^{40*}/K^{40} = .01116 AGE = 182 ± 7 M.Y.

Argon Analyses:

Ar^{40*}, ppm.	Ar^{40*}/ Total Ar^{40}	Ave. Ar^{40*}, ppm.
.06456	.689	.06473
.06489	.726	

Potassium Analyses:

% K	Ave. %K	K^{40}, ppm
4.734	4.752	5.798
4.771		

Constants Used:

$\lambda_\beta = 4.72 \times 10^{-10}$/ year

$\lambda_e = 0.585 \times 10^{-10}$/ year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$AGE = \frac{1}{\lambda_e + \lambda_\beta} \ln\left[\frac{\lambda_\beta + \lambda_e}{\lambda_e} \times \frac{Ar^{40*}}{K^{40}} + 1\right]$$

Note: Ar^{40*} refers to radiogenic Ar^{40}.
M.Y. refers to millions of years.

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POTASSIUM-ARGON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. M-3459 — **Date Received:** 9 December 1975

Your Reference: 13F P.O. 2199.073-480-3
J.O. 12179 — **Date Reported:** 19 December 1975

Submitted by:
Leo Martin
Stone & Webster Engineering
P.O. Box 2325
Boston, Mass. 02107

Sample Description & Locality: Clay mineral concentrate, 13F, less than 1.9 microns.

Material Analyzed: Analyzed as received.

Ar^{40*}/K^{40} = .009429 — AGE = 155 ± 6 M.Y.

Argon Analyses:

Ar^{40*}, ppm.	Ar^{40*}/ Total Ar^{40}	Ave. Ar^{40*}, ppm.
.04239	.622	.04194
.04149	.656	

Potassium Analyses:

% K	Ave. %K	K^{40}, ppm
3.617	3.646	4.448
3.675		

Constants Used:

$\lambda_\beta = 4.72 \times 10^{-10}$/ year

$\lambda_e = 0.585 \times 10^{-10}$/ year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$AGE = \frac{1}{\lambda_e + \lambda_\beta} \ln\left[\frac{\lambda_\beta + \lambda_e}{\lambda_e} \times \frac{Ar^{40*}}{K^{40}} + 1\right]$$

Note: Ar^{40*} refers to radiogenic Ar^{40}.
M.Y. refers to millions of years.

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POTASSIUM-ARGON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. M-3460

Date Received: 9 December 1975

Your Reference: 14F P.O. 2199.073-480-3
J.O. 12179

Date Reported: 19 December 1975

Submitted by:
Leo Martin
Stone & Webster Engineering
P.O. Box 2325
Boston, Mass. 02107

Sample Description & Locality: Clay mineral concentrate, 14F, less than 1.9 microns.

Material Analyzed: Analyzed as received.

Ar^{40*}/K^{40} = .01011 AGE = 165 ± 6 M.Y.

Argon Analyses:

Ar^{40*}, ppm.	Ar^{40*}/ Total Ar^{40}	Ave. Ar^{40*}, ppm.
.03884	.505	.03839
.03793	.522	

Potassium Analyses:

% K	Ave. %K	K^{40}, ppm
3.112	3.111	3.795
3.110		

Constants Used:

$\lambda_\beta = 4.72 \times 10^{-10}$/ year

$\lambda_e = 0.585 \times 10^{-10}$/ year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$AGE = \frac{1}{\lambda_e + \lambda_\beta} \ln\left[\frac{\lambda_\beta + \lambda_e}{\lambda_e} \times \frac{Ar^{40*}}{K^{40}} + 1\right]$$

Note: Ar^{40*} refers to radiogenic Ar^{40}.
M.Y. refers to millions of years.

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POTASSIUM-ARGON AGE DETERMINATION | **REPORT OF ANALYTICAL WORK**

Our Sample No. M-3461 | **Date Received:** 9 December 1975

Your Reference: 15F P.O. 2199.073-480-3 J.O. 12179 | **Date Reported:** 19 December 1975

Submitted by:
Leo Martin
Stone & Webster Engineering
P.O. Box 2325
Boston, Mass. 02107

Sample Description & Locality: Clay mineral concentrate, 15F, less than 1.9 microns.

Material Analyzed: Analyzed as received.

Ar^{40*}/K^{40} = .01095 AGE = 178 ± 7 M.Y.

Argon Analyses:

Ar^{40*}, ppm.	Ar^{40*}/ Total Ar^{40}	Ave. Ar^{40*}, ppm.
.05717	.634	.05671
.05624	.678	

Potassium Analyses:

% K	Ave. %K	K^{40}, ppm
4.237	4.245	5.179
4.254		

Constants Used:

$\lambda_\beta = 4.72 \times 10^{-10}$/ year

$\lambda_e = 0.585 \times 10^{-10}$/ year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$AGE = \frac{1}{\lambda_e + \lambda_\beta} \ln\left[\frac{\lambda_\beta + \lambda_e}{\lambda_e} \times \frac{Ar^{40*}}{K^{40}} + 1\right]$$

Note: Ar^{40*} refers to radiogenic Ar^{40}.
M.Y. refers to millions of years.

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POTASSIUM–ARGON AGE DETERMINATION **REPORT OF ANALYTICAL WORK**

Our Sample No. M-3509 **Date Received:** 19 March 1976

Your Reference: C-1 J.O. 12179 **Date Reported:** 26 March 1976

P.O. 2199.073-480-5

Submitted by: Leo Martin
Stone & Webster Engineering Corp.
P. O. Box 2325
Boston, Mass. 02107

Sample Description & Locality: Clay sample C-1.

Material Analyzed: Prepared clay sample, analyzed as received.

Ar^{40*}/K^{40} = .01029 AGE = 168 ± 9 M.Y.

Argon Analyses:

Ar^{40*}, ppm.	Ar^{40*}/ Total Ar^{40}	Ave. Ar^{40*}, ppm.
.004495	.057	.004983
.005471	.037	

Potassium Analyses:

% K	Ave. %K	K^{40}, ppm
.391	.397	.484
.403		

Constants Used:

$\lambda_\beta = 4.72 \times 10^{-10}$/ year

$\lambda_e = 0.585 \times 10^{-10}$/ year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$AGE = \frac{1}{\lambda_e + \lambda_\beta} \ln \left[\frac{\lambda_\beta + \lambda_e}{\lambda_e} \times \frac{Ar^{40*}}{K^{40}} + 1 \right]$$

Note: Ar^{40*} refers to radiogenic Ar^{40}.
M.Y. refers to millions of years.

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POTASSIUM-ARGON AGE DETERMINATION | **REPORT OF ANALYTICAL WORK**

Our Sample No. M-3510

Date Received: 19 March 1976

Your Reference: C-2 J.O. 12179
P.O. 2199.073-480-5

Date Reported: 26 March 1976

Submitted by:
Leo Martin
Stone & Webster Engineering Corp.
P. O. Box 2325
Boston, Mass. 02107

Sample Description & Locality: Clay sample C-2.

Material Analyzed: Prepared clay sample, analyzed as received.

Ar^{40*}/K^{40} = .01184 **AGE =** 192 ± 9 **M.Y.**

Argon Analyses:

Ar^{40*}, ppm.	Ar^{40*}/ Total Ar^{40}	Ave. Ar^{40*}, ppm.
.008829	.106	.008766
.008703	.089	

Potassium Analyses:

% K	Ave. %K	K^{40}, ppm
.598	.607	.740
.616		

Constants Used:

$\lambda_\beta = 4.72 \times 10^{-10}$/ year

$\lambda_e = 0.585 \times 10^{-10}$/ year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$AGE = \frac{1}{\lambda_e + \lambda_\beta} \ln \left[\frac{\lambda_\beta + \lambda_e}{\lambda_e} \times \frac{Ar^{40*}}{K^{40}} + 1 \right]$$

Note: Ar^{40*} refers to radiogenic Ar^{40}.
M.Y. refers to millions of years.

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POTASSIUM–ARGON AGE DETERMINATION | **REPORT OF ANALYTICAL WORK**

Our Sample No. M-3511

Date Received: 19 March 1976

Your Reference: C-3 J.O. 12179
P.O. 2199.073-430-5

Date Reported: 26 March 1976

Submitted by:
Leo Martin
Stone & Webster Engineering Corp.
P. O. Box 2325
Boston, Mass. 02107

Sample Description & Locality: Clay sample C-3.

Material Analyzed: Prepared clay sample, analyzed as received.

Ar^{40*}/K^{40} = .01222 AGE = 198 ± 9 M.Y.

Argon Analyses:

Ar^{40*}, ppm.	Ar^{40*}/ Total Ar^{40}	Ave. Ar^{40*}, ppm.
.01165	.082	.01173
.01181	.070	

(Note: A third analysis gave .00900 ppm Ar^{40*} but the atmospheric argon content of that fusion was triple that of the reported analyses and the data was rejected.

Potassium Analyses:

% K	Ave. %K	K^{40}, ppm
.790	.787	.960
.784		

Constants Used:

$\lambda_\beta = 4.72 \times 10^{-10}$/ year

$\lambda_e = 0.585 \times 10^{-10}$/ year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$AGE = \frac{1}{\lambda_e + \lambda_\beta} \ln\left[\frac{\lambda_\beta + \lambda_e}{\lambda_e} \times \frac{Ar^{40*}}{K^{40}} + 1\right]$$

Note: Ar^{40*} refers to radiogenic Ar^{40}.
M.Y. refers to millions of years.

KRUEGER ENTERPRISES, INC.
GEOCHRON LABORATORIES DIVISION

24 BLACKSTONE STREET • CAMBRIDGE, MA. 02139 • (617)-876-3691

POTASSIUM–ARGON AGE DETERMINATION | **REPORT OF ANALYTICAL WORK**

Our Sample No. M-3512 | **Date Received:** 19 March 1976

Your Reference: C-4 | J.O. 12179 | P.O. 2199.073-480-5 | **Date Reported:** 26 March 1976

Submitted by:

Leo Martin
Stone & Webster Engineering Corp.
P. O. Box 2325
Boston, Mass. 02107

Sample Description & Locality: Clay sample C-4.

Material Analyzed: Prepared clay sample, analyzed as received.

Ar^{40*}/K^{40} = .01110 | AGE = 181 ± 10 M.Y.

Argon Analyses:

Ar^{40*}, ppm.	Ar^{40*}/ Total Ar^{40}	Ave. Ar^{40*}, ppm.
.004012	.042	.004151
.004290	.032	

Potassium Analyses:

% K	Ave. %K	K^{40}, ppm
.307	.306	.373
.306		

Constants Used:

$\lambda_\beta = 4.72 \times 10^{-10}$/ year

$\lambda_e = 0.585 \times 10^{-10}$/ year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$AGE = \frac{1}{\lambda_e + \lambda_\beta} \ln\left[\frac{\lambda_\beta + \lambda_e}{\lambda_e} \times \frac{Ar^{40*}}{K^{40}} + 1\right]$$

Note: Ar^{40*} refers to radiogenic Ar^{40}.
M.Y. refers to millions of years.

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POTASSIUM–ARGON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

PRIORITY SAMPLE

Our Sample No. M-6233 — **Date Received:** 6/4/82

Your Reference: P.O.#2199.073-480 — **Date Reported:** 6/7/82

Submitted by: Frank S. Vetere
Stone & Webster Engineering Corp.
P.O. Box 2325
Boston, MA 02107

Sample Description & Locality: Sample A, less than 2 micron fault gouge, Millstone Nuclear Power Station - Unit 3.

Material Analyzed: clay sample, analysed as received.

Ar^{40*}/K^{40} = .008608 — AGE = 142 +/- 6 M.Y.

Argon Analyses:

Ar^{40*}, ppm.	Ar^{40*}/ Total Ar^{40}	Ave. Ar^{40*}, ppm.
.02139	.752	.02133
.02127	.728	

Potassium Analyses:

% K	Ave. %K	K^{40}, ppm
2.051	2.031	2.478
2.011		

Constants Used:

$\lambda_\beta = 4.72 \times 10^{-10}$/ year

$\lambda_e = 0.585 \times 10^{-10}$/ year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$AGE = \frac{1}{\lambda_e + \lambda_\beta} \ln\left[\frac{\lambda_\beta + \lambda_e}{\lambda_e} \times \frac{Ar^{40*}}{K^{40}} + 1\right]$$

Note: Ar^{40*} refers to radiogenic Ar^{40}.
M.Y. refers to millions of years.

APPENDIX 2.5E

SEPARATION OF $<2\mu$ FRACTION AND CLAY ANALYSIS OF SAMPLES B, C, D (ESF BUILDING) AND P-1 AND P-2 (PUMPHOUSE)

June 1979

Robert C. Reynolds, Jr.
Professor of Geology
Dartmouth College
Hanover, New Hampshire

Dartmouth College HANOVER · NEW HAMPSHIRE · 03755

Department of Earth Sciences · TEL. (603) 646-2373

January 8, 1980

Mr. R. Hike
Stone and Webster Engineering Corp.
P.O. Box 2325
Boston, Mass. 02107

Dear Mr. Hike:

I have examined samples of P-1 and P-2, fault gauge J.O. 12179, and find that they contain insufficient illite for dating purposes. The samples were fractionated into three size ranges in an attempt to eliminate kaolinite and smectite interference, but the procedure was unsuccessful. The data are shown in the table below:

< 0.5μ	P-1	<u>smectite</u> - kaolinite
< 0.5μ	P-2	<u>smectite</u> - kaolinite - illite (trace)
< 2.0μ	P-1	<u>kaolinite</u> - smectite
< 2.0μ	P-2	<u>kaolinite</u> - smectite - illite (trace)
< 5μ	P-1	<u>kaolinite</u> - smectite (trace)
< 5μ	P-2	<u>kaolinite</u> - smectite (trace)

Underlined names mean that the mineral is dominant. Trace means that the mineral's strongest peak is <5% of the intensity of the strongest peak of the dominant mineral.

As the data show, P-1 contains no apparent illite, and P-2 contains only trace amounts.

The kaolinite in both samples is very well crystallized as evidenced by its concentration in the fine silt fraction and the very sharp (narrow) character of its diffraction peaks. Such kaolinites are usually hydrothermal. The sedimentary varieties, formed by weathering, give more diffuse diffraction patterns. Hydrothermal kaolinites are usually taken as evidence of acidic solutions. More alkaline solutions are apt to form montmorillonite or illite.

The original job called for clay identification, illite polymorph analysis, and separation of illite for dating purposes. The price was $170 per sample. Because the timeconsuming step of separating illite was not done, I request payment of $50/sample, or a total of $100. The samples are returned under separate cover.

Sincerely,

Robert C. Reynolds, Jr.
Professor of Geology

RCR/sgo

Separation of < 2μ Fraction and Clay
Analysis of Samples B, C, and D
Job Order No. 12179

CONCLUSIONS

Sample C is unsuitable for age determinations related to fault movement because it contains abundant feldspar and in addition, the mica may not be syngenetic with faulting. Sample B is unsuitable because it is essentially pure smectite. Sample D is marginally suitable; it contains abundant smectite with some mica (illite?).

All three samples contain abundant smectite whose crystallinity suggests that it formed by hydrothermal alteration along the fault.

PROCEDURE

Three samples, labeled B, C, and D were received from Stone and Webster Engineering Corp. These were treated according to the following scheme except for variations noted below:

1. Soak bulk sample for 1 hour in distilled water.
2. Stir suspension with electric stirrer.
3. If clay flocculates, decant and add fresh water until clay is apparently dispersed.
4. Add 0.01 N sodium pyrophosphate to promote dispersion.
5. Stir, settle 10 minutes to remove sand and silt, and transfer the supernatant to centrifuge cups.
6. Centrifuge for 10 minutes at 450 rpm (size 2 International centrifuge) to extract < 2μ material.
7. Flocculate with dilute HCl and rewash with centrifuge to concentrate the clay in a smaller volume.

8. Extract alliquot of suspension, pipette onto glass slide, and oven dry at 105°C for clay analysis.

9. Flocculate the remainder of the suspension with dilute HCl, centrifuge, and dry the sediment at 105°C. Grind to a powder in an alundum mortar.

10. Pack alliquot of dry powder in recessed aluminum sample holder for polytype analysis.

11. Run X-ray pattern of glass slide over the range of 50 to 2° 2θ (CuKα radiation). Interpret the clay pattern.

12. Solvate the slide with ethylene glycol (vapor method) at 60°C and reanalyze by X-ray diffraction to detect smectites if present.

13. X-ray the dry powder over the angular range 50 to 2°2θ (CuKα).

14. Run diffraction pattern calibration check on diffractometer using "permaquartz" slab. Step scan over the $10\bar{1}0$ to ascertain that is within ± 0.02°2θ of the nominal value of 26.664°2θ (CuKα radiation). (Parrish, W., 1948, Philips Lab. Inc. Tech. Rept. No. 17.)

Sample D contained much smectite and some illite. It was saturated with Na to remove exchangeable K by suspending it in 1N NaCl and centrifuging to remove the supernatant; the procedure was repeated three times and the sample was washed to dispersion by repeated centrifugation from distilled water. Sample B consists of essentially pure smectite, so no randomly oriented diffraction pattern was prepared for this sample.

RESULTS

Sample C consists of mica, smectite, quartz, and feldspar. The mica 002 is very weak compared to the 001, thus the mica is probably a trioctahedral species such as biotite or phlogopite. Such materials are most likely derived from igneous and/or metamorphic lithologies and thus are probably not authigenic to the fault gouge. This finding, plus the abundant feldspar lines present, makes this sample unsuitable for radiometric age measurement if that measurement is used to date the time of last fault movement. An age would probably relict the age of the wall rock.

Sample D is mostly smectite with some ($\sim$10%) illite. The abundance of illite is so low that $hk\ell$ reflections could not be observed on the randomly oriented dry powder. Consequently, the mica polytype is unknown and unknowable. This material could probably be used for an age measurement of fault movement, but the resulting age would be subject to some uncertainty of meaning.

Sample B is essentially pure smectite with just a suggestion of trace amounts of mica. It was judged unsuitable for age measurement and its $< 2\mu$ fraction was discarded.

Samples C and D were used to completion. The $< 2\mu$ powder provided to Stone and Webster is the total $< 2\mu$ material from these samples. Sample B, bulk material as received, will be returned.

DISCUSSION

All three samples contain well crystallized smectite. In fact, the $< 2\mu$ fraction of Sample B is almost as pure as many of the A.P.I. standard bentonites such as the Clayspur, Santa Rita, and Belle Fourche. The diffraction pattern of the glycol-solvated oriented film shows intense, sharp 00ℓ reflections. Sample D is rich in similar material and Sample C contains some of it.

Smectites are commonly formed by hydrothermal activity (Grim and Güven, 1978, p. 131; Takeshi, 1978, p. 221). Other origins include pedogenic weathering of mica and after-burial alteration of volcanic ash beds. The latter is inappropriate here, and smectites formed by weathering produce diffuse, weak diffraction patterns that are unlike the ones observed from these samples. The conclusion seems certain that the smectites in samples B, C, and D were formed by hydrothermal alteration of fault gouge at some time during or after faulting.

REFERENCES

Grim, R.E., and Güven, N. (1978) Bentonites: Geology, Mineralogy, Properties, and Uses. Elsevier Press.

Takeshi, H. in Sudo, T., and Shimoda, S. (1978) Clays and Clay Minerals of Japan. Elsevier Press.

RC Reynolds Jr

Robert C. Reynolds, Jr.
Professor of Geology
Dartmouth College
Hanover, NH 03755

APPENDIX 2.5F

DYNAMIC SOIL TESTING
ON BEACH SANDS

Geotechnical Engineers Inc.
Winchester, Massachusetts

Report

on

LABORATORY SOIL TESTING
MILLSTONE NUCLEAR STATION

Submitted to

STONE & WEBSTER ENGINEERING CORP.
Boston, Massachusetts

by

GEOTECHNICAL ENGINEERS INC.
1017 Main Street
Winchester, Massachusetts 01890

Project 75244
Sept. 5, 1975

Gonzalo Castro

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1. INTRODUCTION

1.1 PURPOSE

The purpose of this report is to present the results of laboratory tests performed on undisturbed silty sand samples from the site of Millstone Nuclear Power Station, Unit 3, in Waterford, Connecticut. The testing was done in order to evaluate the dynamic response characteristics of the subsoils in the area of the circulating and service water pump house.

1.2 SCOPE

A total of nine 3-in.-diameter, fixed-piston samples from seven borings were delivered to Geotechnical Engineers Inc. by Stone & Webster Engineering Corporation on June 13, 1975. Based on the condition of the tube and of the soil in the tube, seven samples were chosen for cyclic triaxial testing. All samples were described and the testing program consisted of:

- 6 Cyclic Triaxial ($C\bar{R}$) Tests
- 2 Resonant Column (RC) Tests
- 1 Small Strain Cyclic Triaxial (E) Test
- 11 Grain Size Distribution Determinations
- 3 Specific Gravity Determinations

1.3 AUTHORIZATION

The work reported herein was authorized by Stone & Webster Engineering Corp. under purchase order No. 2199.082-521, for Stone & Webster Job Order No. 12179.

2. OUTLINE OF GENERAL TESTING PROCEDURE

2.1 CONTROL OF THE LENGTH OF THE SAMPLES

Stone & Webster personnel transported the samples from the field to the Geotechnical Engineers Inc. laboratory in Winchester, Massachusetts where the samples were handled at all times in an upright position. The distance from the top of the tube to the top of the sample was measured in the laboratory prior to testing for comparison with the same measurement made in the field by Stone & Webster personnel after the sample came out of the borehole. Compaction of the sample during handling would have resulted in an increase in the measured distance. Table 1 lists the measured distances and the apparent sample compression or expansion.

Samples UP3 and UP4 from boring P-3 were not measured in the field so it was not possible to determine apparent sample compression. Samples UP1 from boring P-4, UP2 from boring P-7 and UP1 from boring P-8 all showed apparent sample expansion of from 1.6 to 5.6 cm. The apparent sample expansion may be due to measurement inaccuracy, or from movement of the sample in the tube if during transportation from the field to the laboratory the sample was placed in a horizontal position. These samples were used for resonant column and cyclic load tests. The results of these tests would underestimate the strength of the soil if the apparent expansion were real and not the result of error in measurement. Sample UP1 from boring P-10 had an apparent sample compression of 3.0 cm and was not used for triaxial testing. A difference of a fraction of a centimeter was considered likely to be the result of measurement error due to an uneven end of the sample, loss of soil during removal of the wax seal, or to the measuring stick indenting the soil.

2.2 EXTRUSION OF SAMPLES FROM THE TUBES

Before the samples were cut and extruded the wax-sealed plastic caps and wax seals at the top and bottom of the sample were removed. The cutting edge diameter of the tube was measured and nicks or dents in the tube were noted in the individual sample descriptions (Appendix A). All the tubes but P-7, UP1C had cutting edge diameters ranging from 98.2% to 99.0% of the inside diameter. The cutting edge diameter of tube P-7, UP1 could not be accurately measured because of the damage suffered by the cutting edge during sampling. Due to the limited number of samples available this sample was used for testing.

A section of the tube about 7 to 8 in. long was cut with a tube cutter while maintaining the tube in an upright position. The pressure applied by the tube cutter was kept to a minimum to avoid deforming the tube. The tube and sample were weighed. To prevent sample disturbance during extrusion a bevel tool was used to bend out and smooth the sharp edges of the tube where it was cut. The sections of a given tube were designated A, B, and C starting from the top.

The sample was trimmed in the tube to a length of about 17.0 cm. A porous disc was placed at the bottom of the sample before extrusion if additional support after extrusion and during transfer to the triaxial cell was required. The specimen was then extruded vertically into a membrane stretched by vacuum on a membrane stretcher. After weighing, the specimen was placed in the triaxial cell. A vacuum of about 27 inches Hg was applied[1)] to prevent disturbance of the specimen while measuring the specimen and during assembly of the cell.

[1)] No vacuum was used on the E-test specimen. For Test RC-2 a vacuum of only 10 inches Hg was applied to the specimen.

3. SAMPLE DESCRIPTIONS AND INDEX TESTS

3.1 SAMPLE DESCRIPTIONS

After completion of each cyclic triaxial test, the specimen was carefully removed from the cell. The specimen was then sliced longitudinally and described. The sample descriptions for each section extruded are presented in Appendix A.

The samples tested were generally a brown micaceous silty medium to fine sand, except sample P-7 UP1C (used for test CR-6) which was a slightly silty coarse to fine sand. All specimens contained layers of fine sand or silty fine sand, or more micaceous sand, from 1 mm to 2 cm thick, except samples P-7 UP1C and P-8 UP1C. Sample P-7 UP1C had no apparent stratification and contained some gravel particles up to 1.5 cm in diameter. Sample P-8 UP1C was a layered silty fine to medium sand, with layers of stiff brown silty clay from 1 mm to 5.0 cm thick and one layer of clean orange-brown medium to fine sand, 2 cm thick, at the top of the specimen. Relative density determinations were not performed because of the stratification observed in the samples.

3.2 UNIT WEIGHTS AND WATER CONTENTS

The unit weight of each extruded sample section was determined both in the tube and in the triaxial cell. The length and weight of a sample section was first determined in the tube. All trimmings were retained together with any soil which remained in the tube after extrusion of the section. The trimmings were then oven dried and weighed.

After extrusion and before placement in the triaxial cell, the sample was weighed while in the membrane stretcher. With the specimen in the cell and under a vacuum, the dimensions were determined. After completion of the triaxial test and sample description, the sample was oven dried and weighed. This weight was used to determine the initial dry unit weight and water content of the triaxial specimen. The dry weight of the sample was added to the dry weight of the trimmings to determine the dry unit weight and water content in the tube. The dry unit weights and water contents ranged from 86.4 to 107.5 pcf and 20.1 to 33.7%, respectively. All unit weight and water content determinations are listed in Table 2.

3.3 GRAIN SIZE TESTS

After each sample specimen had been oven dried a sieve analysis was performed on soil from the zone or zones of maximum deformation. In the case of the resonant column tests and the E test, where only small strains developed, a sieve analysis was performed on a representative sample of the entire specimen. The grain-size distribution curves for each specimen are shown in Figs. 1 to 11.

3.4 SPECIFIC GRAVITY TESTS

After the specimens used for the resonant column tests and E test were oven dried, a representative sample of each specimen was used for specific gravity determinations. The following values of specific gravity were obtained:

Boring	Sample	Specific Gravity
P-3	UP4B	2.75
P-4	UP1B	2.76
P-7	UP3B	2.77

The relatively high values of specific gravity can be attributed to the presence of appreciable amounts of muscovite and biotite, which have specific gravities from 2.8 to 3.1.

4. CYCLIC CONSOLIDATED-UNDRAINED TRIAXIAL ($C\bar{R}$) TESTS

4.1 PROCEDURE

The specimens were placed in the triaxial cell as described in Section 2. After the cell was assembled a small confining pressure of 0.5 kg/cm^2 was applied. Water was admitted to the specimen until the vacuum applied prior to assembling the cell was dissipated. The specimens were consolidated isotropically at effective confining pressures of 0.50 kg/cm^2 or 1.0 kg/cm^2, which were selected to be approximately equal to the effective overburden pressure acting on the soil in the ground. To investigate the influence of the confining pressure on the test results, test $C\bar{R}$-9 and $C\bar{R}$-6 were consolidated at lower and higher confining pressures, respectively, than their in-situ condition. Back pressures in the order of 14.0 kg/cm^2 were used to ensure saturation of the specimens, which was checked by determining the B value. The specimen was considered saturated if the B value was 0.95 or higher.

After saturation the drainage valves were closed. A cyclic load, approximately symmetrical in extension and compression was applied at a frequency of about one cycle every 2 to 3 seconds until axial extension failure or 10% double amplitude strain occurred. A continuous record was made of the axial load, axial deformation, and pore pressure. A typical example of a portion of such a record is shown in Fig. 12.

4.2 RESULTS

Table 3 presents a summary of the results of all $C\bar{R}$ tests. Included are the number of cycles to reach momentarily $\bar{\sigma}_3 \simeq 0$ for the first time, to reach double amplitude strains of 2.5%, 5%, and 10%, and to reach axial extension failure, and the double amplitude strain at the cycle immediately preceding axial extension failure.

The individual test results of all $C\bar{R}$ tests are presented in Figs. 13 to 18 by the following plots of cyclic number versus:

Peak deviator stress in compression and extension.

Peak axial strain in compression and extension and double amplitude strain.

Induced pore pressure at the end of each cycle.

Figs. 19 to 24 are summary plots of the cyclic deviator stress ratio and the cyclic deviator stress versus the number of cycles to reach 2.5%, 5%, and 10% double amplitude strain. Because only two specimens reached axial extension failure, no summary plot was made of cyclic deviator stress versus number of cycles to reach axial extension failure. Plots of cyclic deviator stress and cyclic stress ratio to reach double amplitude strains of 2.5%, 5%, and 10% in five to ten cycles versus effective consolidation pressure for each soil type (Items 11 and 12 in Section 3.4 of Stone & Webster Scope of Work 2199.082-521) were not possible due to the limited number of tests performed.

4.3 COMMENTS

When the axial deformation of the specimens during the C$\bar{R}$ tests became large enough to be visible, it was observed that the axial strain would be concentrated in one or two zones of the specimen. The zones of excessive axial deformation could be identified by necking or bulging during extension and compression, respectively. In two tests (C$\bar{R}$-1 and C$\bar{R}$-8) the specimens failed in extension by necking.

Two zones of concentration of deformation were noted in tests C$\bar{R}$-4 and C$\bar{R}$-5. The specimen in test C$\bar{R}$-4 necked one-third of the way from the top and bottom in zones of silty fine sand. The specimen in test C$\bar{R}$-5 developed maximum deformation in layers of silty fine to medium sand above and below a 4-cm layer of stiff brown sandy silty clay, in the top one-third of the specimen.

The vacuum applied to each C$\bar{R}$ test specimen to prevent disturbance during measurement of the specimen and assembly of the triaxial cell may have influenced slightly the C$\bar{R}$ test results. The vacuum, about 27 inches of mercury, in effect preconsolidated each of the specimens to about 0.93 kg/cm^2.

The pore pressure was measured by means of an electric transducer connected to the top and bottom of the specimen. Under the relatively rapid loading applied in the C$\bar{R}$ tests there is not enough time for the pore pressure to equalize along the sample, except perhaps in the cleaner sands. Thus, in some C$\bar{R}$ tests there is not enough time for the pore pressure to equalize along the sample, except perhaps in the cleaner sands. Thus, in some C$\bar{R}$ tests the recorded pore pressure probably did not represent the pore pressure in the most highly strained zone of the specimen.

The induced pore pressure was plotted versus the cycle number for each $\bar{C}R$ test (Figs. 13 to 18). The pore pressure was determined by reading the maximum induced pore pressure recorded in each cycle. The maximum induced pore pressure occurs when the axial load on the specimen is zero, that is when the load changes from extension to compression. The number of cycles to reach $\bar{\sigma}_3 \simeq 0$ for each $\bar{C}R$ test is presented in Table 3. In three of the six $\bar{C}R$ tests the induced pore pressure became very close to but did not reach the effective consolidation pressure. In those cases ($\bar{C}R$-1, $\bar{C}R$-4, and $\bar{C}R$-9) the number of cycles to reach $\bar{\sigma}_3 \simeq 0$ listed in Table 3 was determined by choosing the cycle in which the induced pore pressure became very close to the effective consolidation pressure and then continued to approach the effective consolidation pressure asymptotically.

5. SHEAR MODULUS DETERMINATIONS

Two types of tests were performed to determine the shear modulus of the soil, namely resonant column tests for shear strain amplitude of about 3×10^{-6} mm/mm to 10^{-4} mm/mm and cyclic triaxial (E) tests for shear strain amplitude of 10^{-4} mm/mm to 10^{-3} mm/mm. Two resonant column tests and one E test were performed.

5.1 PROCEDURE - RESONANT COLUMN TEST

The specimens were removed from the tubes as described in Section 2, placed in the resonant column cell, and subjected to a vacuum as indicated in Table 2 while assembling the cell. The specimens were then back-pressure saturated before beginning the shear modulus determinations.

The shear modulus was determined as a function of single amplitude shear strain for a sequence of effective confining pressures. Torsional vibrations were applied to the "free" end of the sample through four permanent magnets attached to the top cap of the sample and moving inside four fixed coils to which a sinusoidally varying voltage was applied. The moving magnets applied a cyclic torque to the "free" end of the specimen and the frequency of the torque forcing the sample vibrations was increased until resonance was reached. The amplitude of specimen vibration was monitored using an accelerometer attached to the top cap. Resonance was detected when the voltage output of the accelerometer reached a maximum. The corresponding frequency was measured using an oscilloscope.

The single amplitude shear strain was calculated as a function of frequency, accelerometer output and specimen dimensions. The shear strain amplitudes reported occur along the outer perimeter of the specimen where they are a maximum.

The shear modulus was computed from the shear wave velocity according to the formula:

$$G = E Vs^2$$

where

G = shear modulus
E = mass density of specimen
Vs = shear wave velocity

Damping determinations at resonance involved simultaneously switching off the input voltage to the coils and photographing the decaying trace of the accelerometer output on the oscilloscope. The damping ratios were then computed as a function of the peak-to-peak amplitude of the accelerometer output voltage as measured from the photographs.

A schematic of the equipment arrangement is shown in Fig. 28.

5.2 PROCEDURE - E TEST

The specimen was consolidated and saturated in the same manner as the CR test specimens. In contrast to the resonant column test specimens, no vacuum was applied to the sample while assembling the cell.

The elastic modulus was determined as a function of axial strain in the range of 10^{-4} to 10^{-3} mm/mm for a series of effective confining pressures. Several series of different repeated compressive deviator stresses were applied to the specimen for four to six load repetitions each. Using an X-Y recorder, a record of axial deformation and load was obtained from which the elastic modulus and damping values were obtained. After each determination, the drainage valves were opened to allow the induced pore pressure to dissipate. At the completion of the modulus determinations for a given effective confining pressure, the cell pressure was raised and the specimen consolidated to the next higher effective confining pressure for the next series of determinations. For the purposes of presenting the data, the elastic modulus and axial strain values from the E test were converted to shear modulus and shear strain, respectively, using a Poisson's Ratio of 0.5.

5.3 RESULTS

The data obtained from the two resonant column tests and the E test are combined in Figs. 25 and 27 to show the relationship between shear modulus and damping ratio, respectively, versus shear strain for the full range of shear strains tested. The relationship between the maximum shear modulus versus the effective consolidation pressure is shown in Fig. 26.

As stated previously, a vacuum was applied to the resonant column test specimens to facilitate the assembly of the cell prior to applying an initial cell pressure of 0.5 kg/cm^2.

For RC-1 a vacuum of 27 inches of mercury (0.93 kg/cm^2) was used while for RC-2, a vacuum of 10 inches of mercury (0.3 kg/cm^2) was used. Upon the application of cell pressure of 0.5 kg/cm^2, the specimens were consolidated to 1.4 and 0.8 kg/cm^2 for RC-1 and RC-2, respectively. After release of the vacuum the effective consolidation pressure was reduced to the value of the cell pressure (0.5 kg/cm^2). This may partially explain the higher values of shear modulus obtained from RC-1 as compared to RC-2 at the effective confining pressure of 0.5 kg/cm^2 (see Fig. 25).

The data obtained show the following general trends:

1) A decrease in shear modulus with increasing shear strain.

2) An increase in shear modulus with increasing effective confining pressure.

3) An increase in damping ratio with increasing shear strain.

4) A slight decrease in damping ratio at a given level of strain for increasing effective confining pressure.

TABLE 1 - CONTROL OF LENGTH OF TUBE SAMPLES
MILLSTONE NUCLEAR POWER STATION

Boring No.	Sample No.	Distance From Top of Tube to Top of Sample		Apparent Sample Compression (b) - (a) cm
		Field Measurement (a) cm	Lab Measurement (b) cm	
P-3	UP 3	-[1)]	55.6	-
P-3	UP 4	-[1)]	20.1	-
P-4	UP 1	30.5	24.9	-5.6
P-7	UP 1	49.5	49.3	-0.2
P-7	UP 2	31.8	30.2	-1.6
P-7	UP 3	22.9	22.7	-0.2
P-8	UP 1	43.2	41.2	-2.0
P-10	UP 1	54.6	57.6	+3.0

Note: 1) Measurement not taken in the field.

Geotechnical Engineers Inc.

Project 75244
August 12, 1975

TABLE 2 - UNIT WEIGHTS AND WATER CONTENTS OF UNDISTURBED SAMPLES
MILLSTONE NUCLEAR POWER STATION

Boring No.	Sample No.	Depth	Sample Section				Triaxial Specimen				
			Section	Wet Unit Weight	Water Content	Dry Unit Weight	Test No.	Dry Unit Weights, pcf			
								Initial[1)]	After Consol. to $\bar{\sigma}_c$, kg/cm^2		
		ft		pcf	%	pcf			0.5	1.0	2.0
P-3	UP3	27.0	C	123.1	25.3	98.3	C$\bar{R}$-8	99.4	99.4	-	-
P-3	UP4	32.0	B C	115.5 118.6	33.7 29.3	86.4 91.7	RC-1 C$\bar{R}$-1	86.4 89.4	86.4 -	86.7 90.3	- -
P-4	UP1	5.0	B C	- 118.4	- 29.9	86.5 91.1	RC-2 No test	85.5 -	86.5 -	87.1 -	88.3 0
P-7	UP1	12.0	C	127.1	20.1	105.8	C$\bar{R}$-6	107.5	-	108.6	-
P-7	UP2	19.5	B C	117.7 118.6	32.0 29.9	87.4 91.8	C$\bar{R}$-9 No test	88.4 -	90.0 -	- -	- -
P-7	UP3	21.5	B C	118.0 120.8	33.7 28.3	88.3 91.1	E-1 C$\bar{R}$-4	88.5 91.3	89.3 -	90.6 92.0	91.5 -
P-8	UP1	24.4	C	123.4	22.7	100.5	C$\bar{R}$-5	100.5	100.5	-	-

Note: 1) All CR test specimens and RC-1 test specimen were subjected to a vacuum of 28 in. Hg (~0.9 kg/cm^2) while assembling the cell. RC-2 test specimen was subjected to a vacuum of 10 in. Hg (~0.3 kg/cm^2) while assembling the cell. E-1 test specimen was not subjected to a vacuum.

Geotechnical Engineers Inc.

Project 75244
August 15, 1975

TABLE 3 - CYCLIC CONSOLIDATED - UNDRAINED TRIAXIAL $\bar{CR}$ TESTS
MILLSTONE NUCLEAR POWER STATION

Boring No.	Sample and Section No.	Test No.	Depth ft	Elevation (MLW) ft	Initial Water Content w_i %	Initial Dry Unit Weight γ_{di} pcf	Dry Unit Wt. After Consolidation γ_{dc} pcf	Effective Consolidation Pressure $\bar{\sigma}_c$ kg/cm^2	Cyclic Deviator Stress 1) $(\sigma_1 - \sigma_3)_{cy}$ kg/cm^2	$\frac{(\sigma_1 - \sigma_3)_{cy}}{2\bar{\sigma}_c}$	Number of Cycles to Reach: $\bar{\sigma}_3 \simeq 0$ 2)	Double Amp. Strain ϵ_c Equal to 2.5%	Double Amp. Strain ϵ_c Equal to 5.0%	Double Amp. Strain ϵ_c Equal to 10%	Axial Extension Failure	Double Amplitude Strain ϵ_c in Cycle Preceding Axial Extension Failure
P-3	UP3C	$\bar{CR}$-8	27.0	-13.65	25.3	99.4	99.4	0.50	.32	.32	66	15	22	38	100	21.6
P-3	UP4C	$\bar{CR}$-1	32.0	-18.65	29.3	89.4	90.3	1.0	.62	.31	5	1	1	5	17	17.6
P-7	UP1C	$\bar{CR}$-6	12.0	- 8.18	20.1	107.5	108.6	1.0	.56	.28	7	2	4	9	- 3)	- 3)
P-7	UP2B	$\bar{CR}$-9	19.5	-15.68	32.0	84.4	90.0	0.50	.41	.41	20	5	14	28	- 4)	- 4)
P-7	UP3C	$\bar{CR}$-4	29.5	-25.68	28.3	91.3	92.0	1.0	.63	.32	10	2	5	11	- 5)	- 5)
P-8	UP1C	$\bar{CR}$-5	12.0	- 1.48	22.7	100.5	100.5	0.50	.24	.24	83	87	130	288	- 6)	- 6)

Notes: 1) $(\sigma_1 - \sigma_3)_{cy}$ is an average of extension and compressive stresses for cycles up to 15% Double Amplitude Strain.

2) In several tests $\bar{\sigma}_3$ did not reach 0. In those cases the cycle was chosen in which the induced pore pressure became very close to the effective consolidation pressure and then leveled off or continued to approach the effective consolidation pressure assymptotically. See text and individual test results (Figures 13 to 18) for more details.

3) Axial extension failure not achieved. Test stopped after cycle No. 13 with Double Amplitude Strain = 13.5%.

4) Axial extension failure not achieved. Test stopped after cycle No. 37 with Double Amplitude Strain = 14.2%.

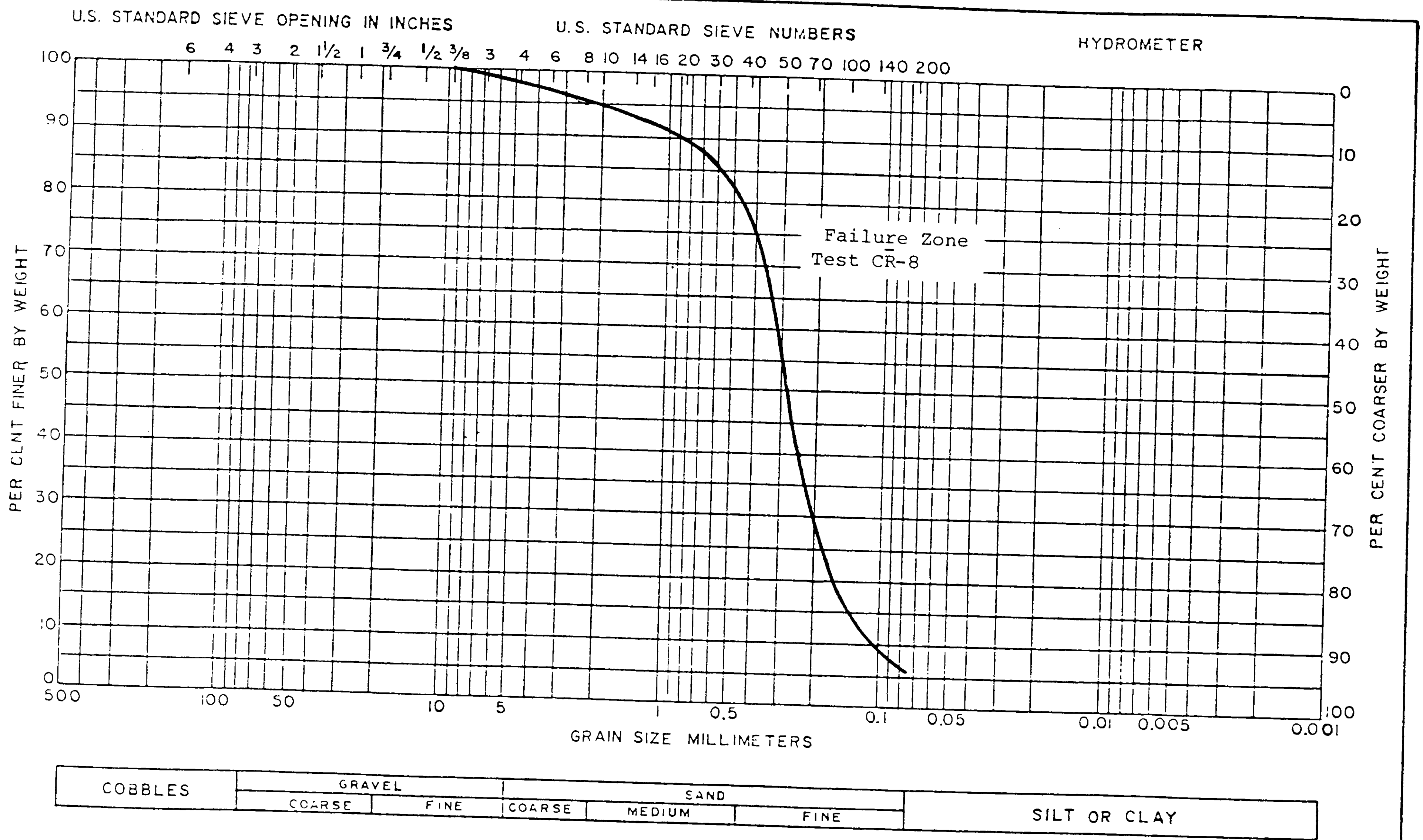
5) Axial extension failure not achieved. Test stopped after cycle No. 16 with Double Amplitude Strain = 14.7%.

6) Axial extension failure not achieved. Test stopped after cycle No. 360 with Double Amplitude Strain = 10.5%.

Geotechnical Engineers Inc.

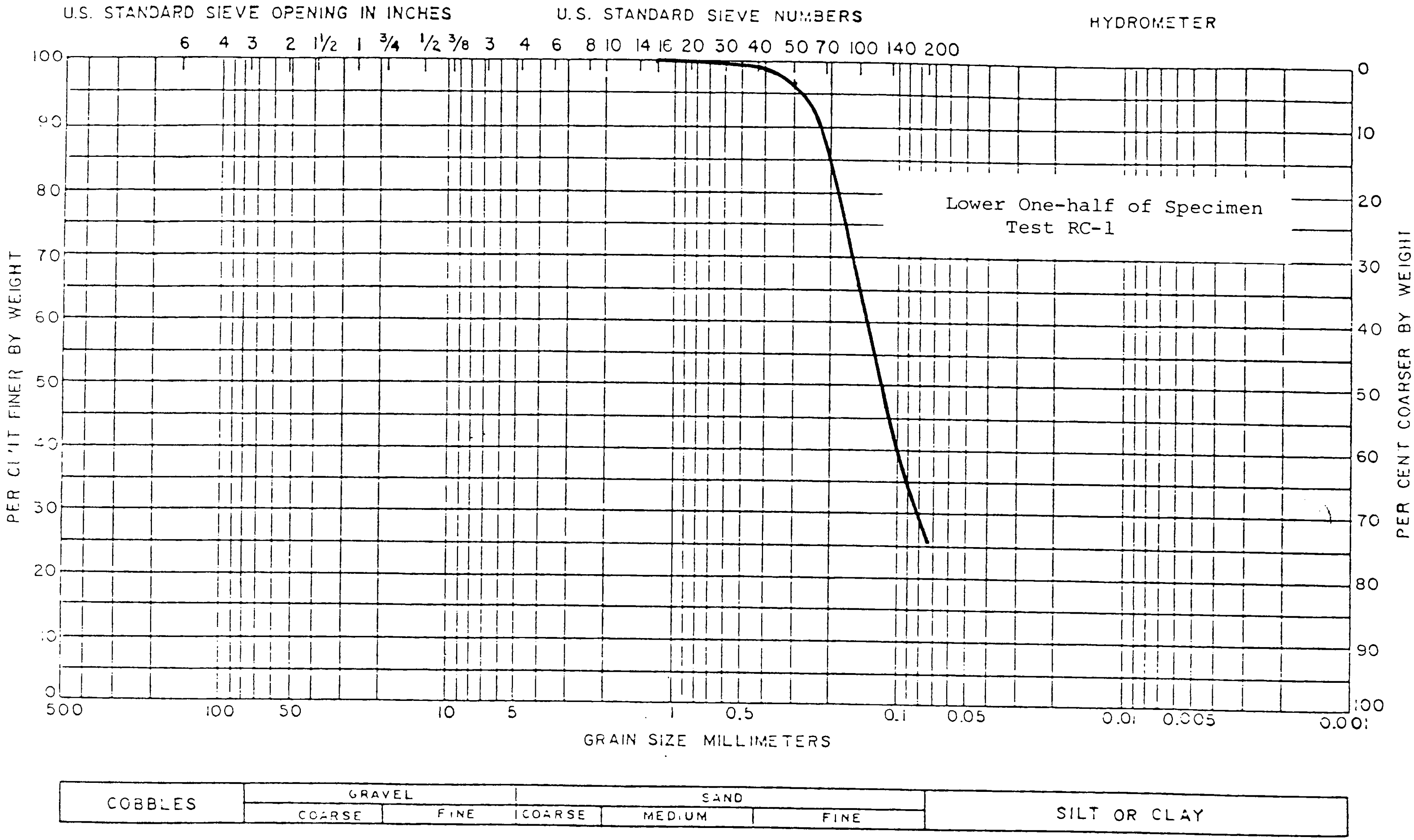
Project 75244
August 11, 1975

Lab 4-3 rev 0 28 May 74



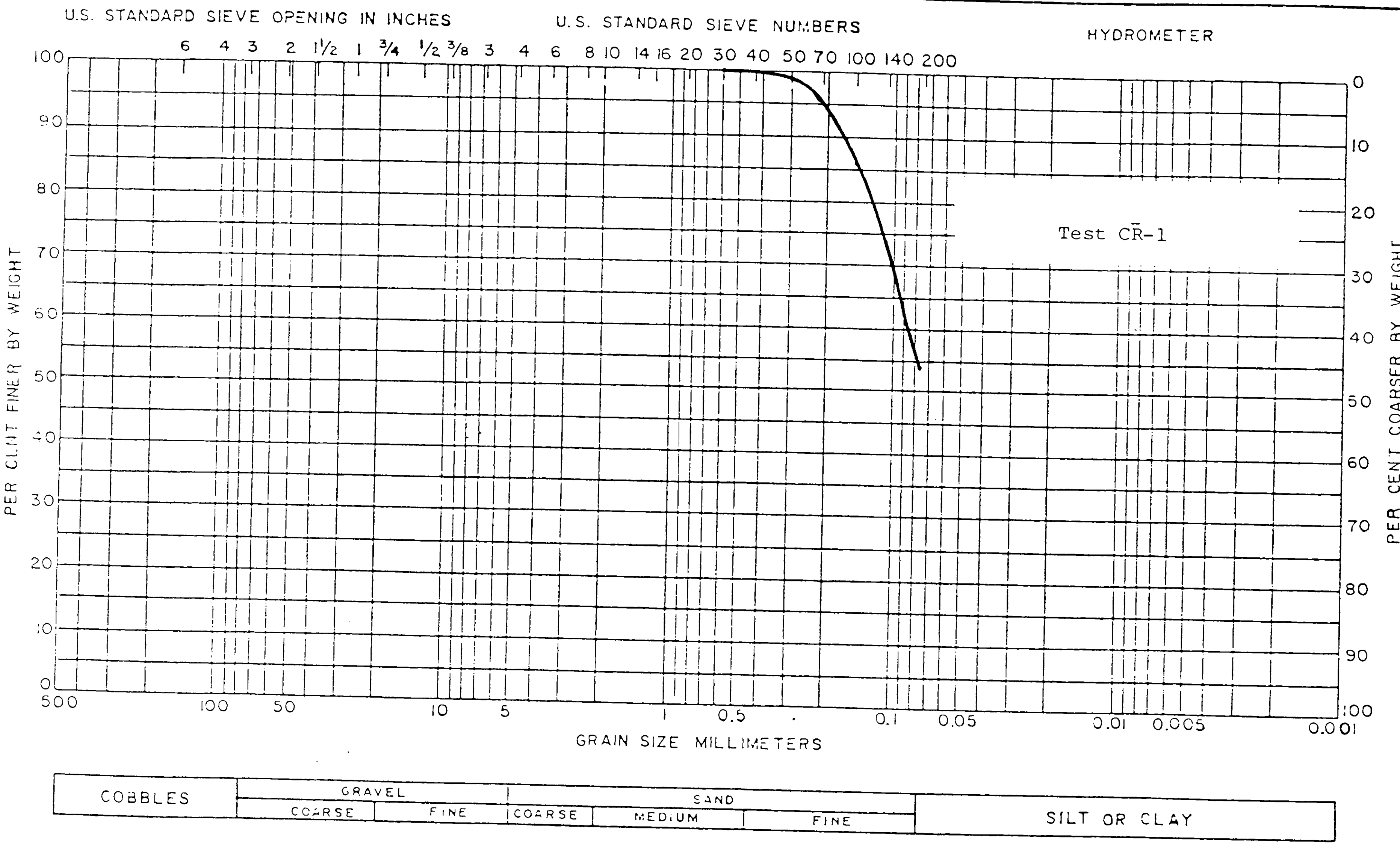
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	GRAIN SIZE CURVE Boring P-3 Sample UP3C
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 1

Lab 4-3 rev 0 28 May 74



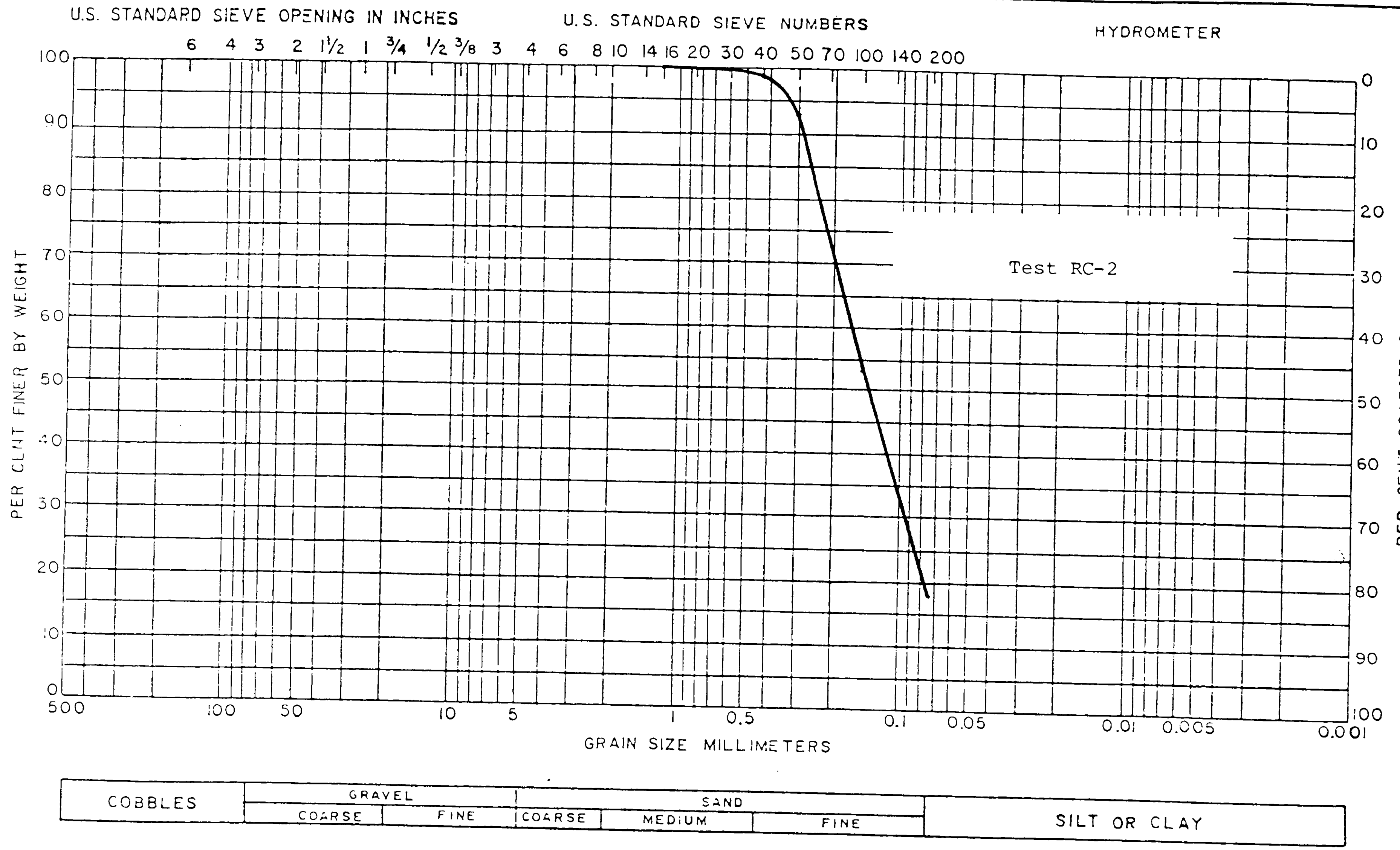
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	GRAIN SIZE CURVE Boring P-3 Sample UP4B
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 2

Lab-4-3 rev 0 28 May 74



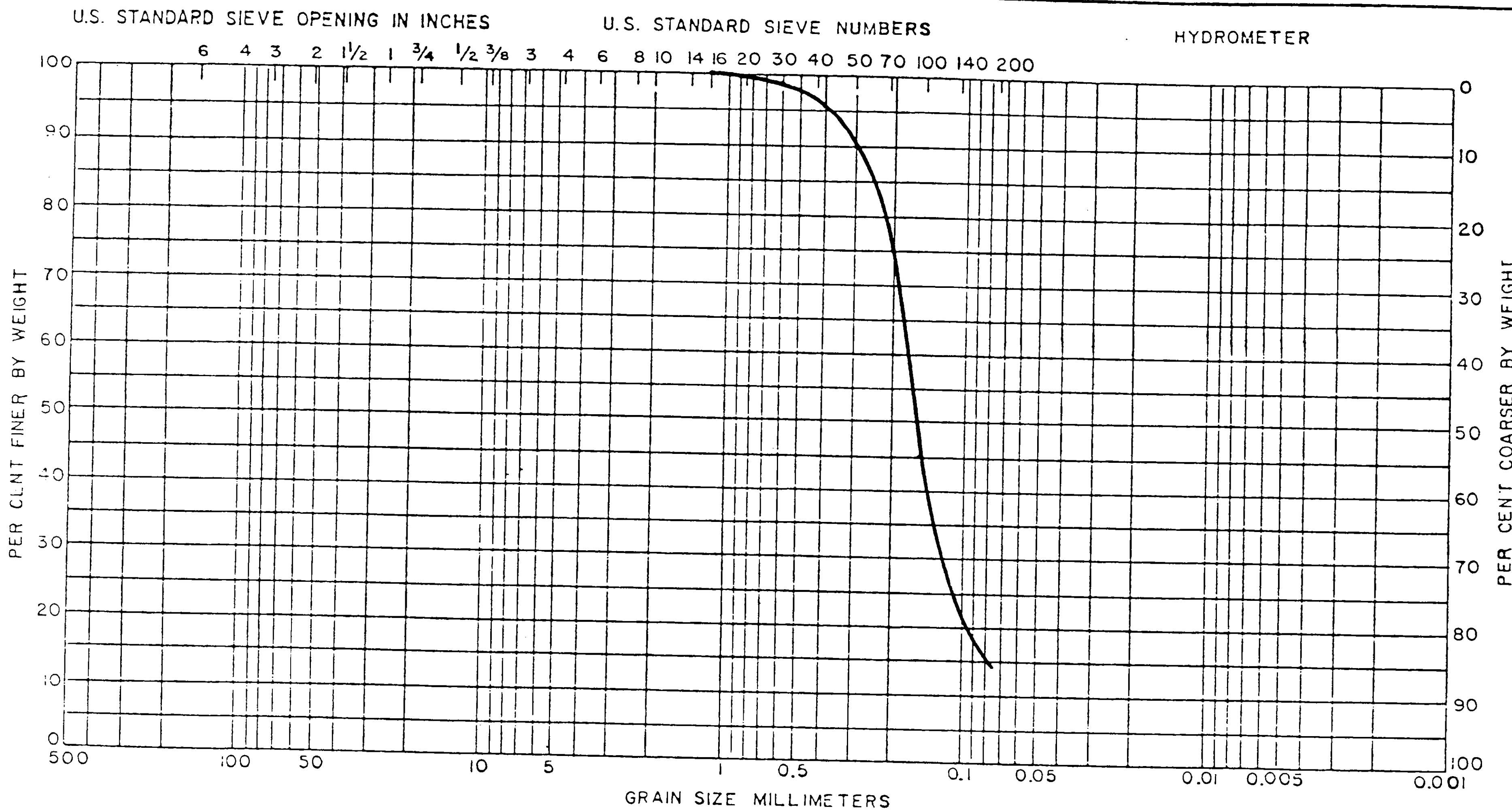
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	GRAIN SIZE CURVE Boring P-3 Sample UP4C
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 3

Lab 4-3 rev 0 28 May 74



Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	GRAIN SIZE CURVE Boring P-4 Sample UP1B
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 4

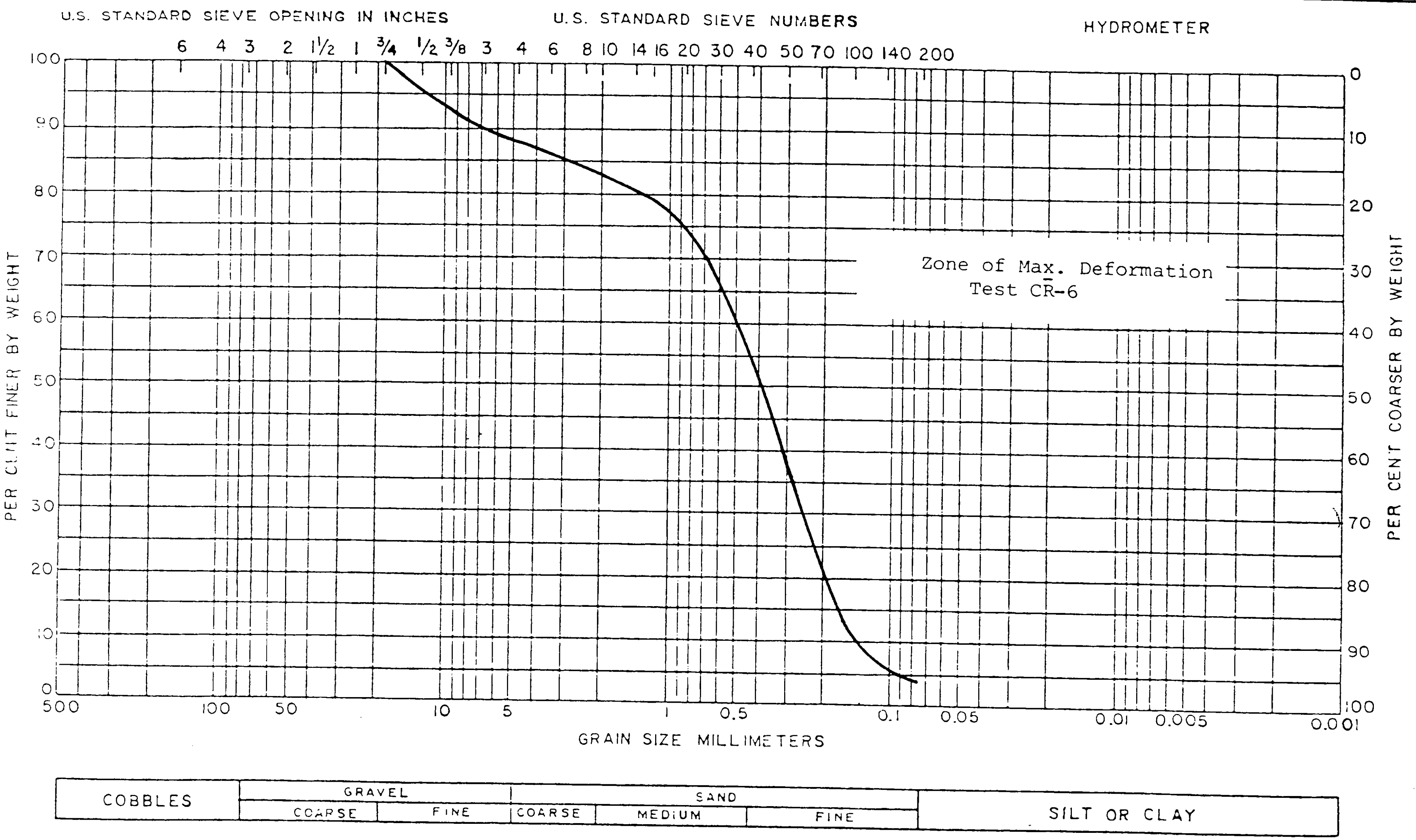
Lab 4-3 rev 0 28 May 74



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

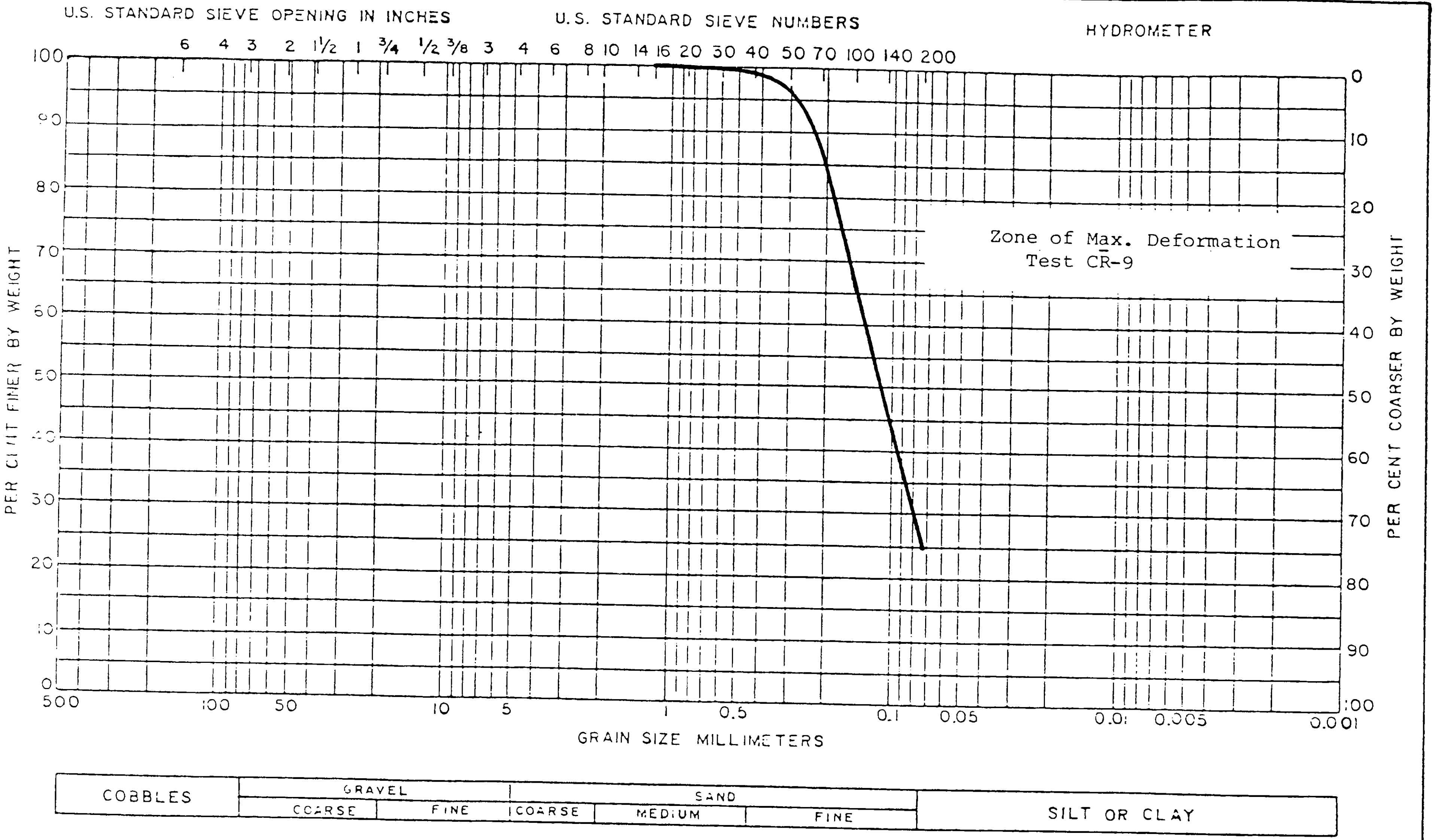
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	GRAIN SIZE CURVE Boring P-4 Sample UP1C
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 5

Lab 4-3 rev 0 28 May 74

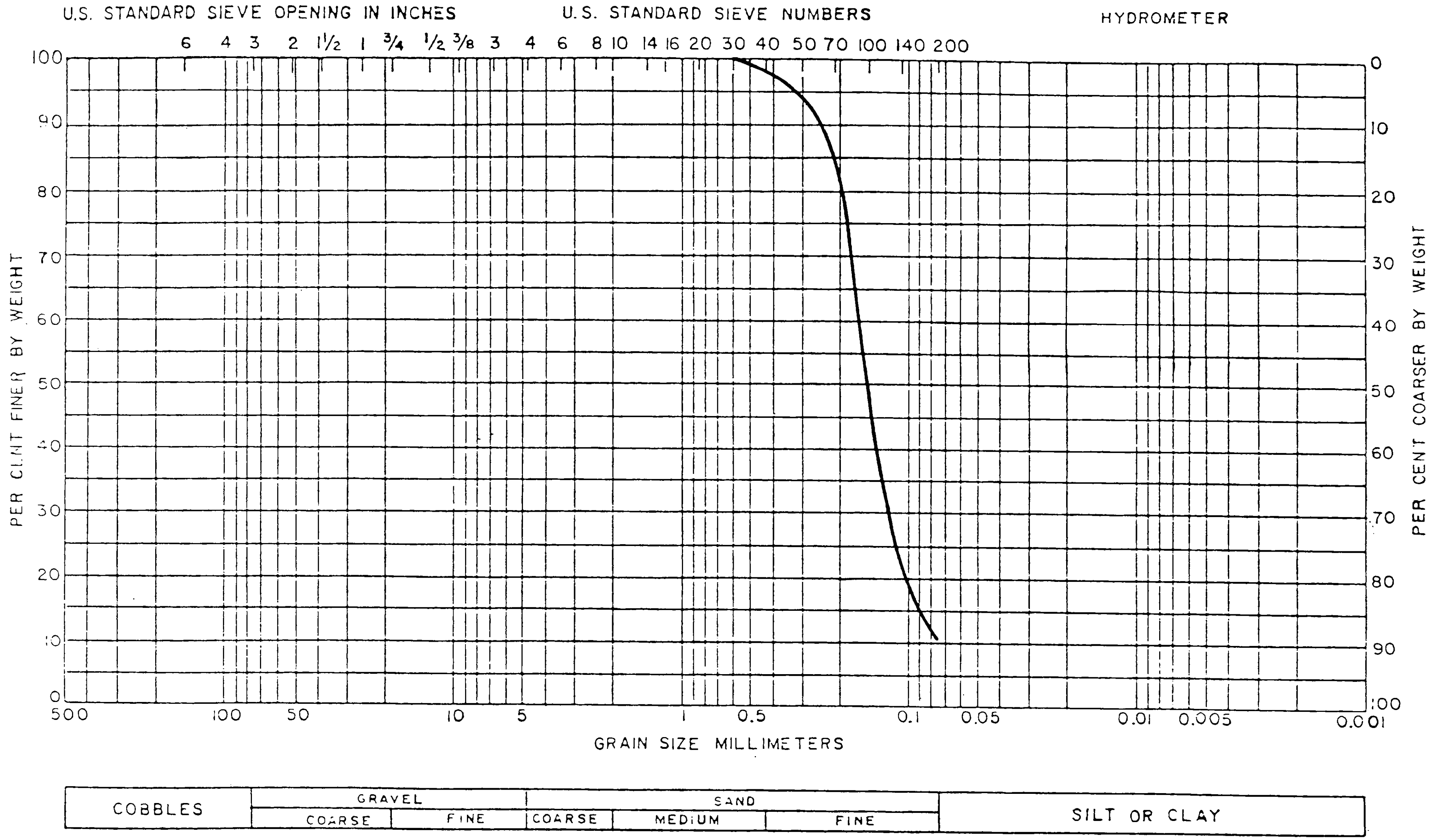


Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	GRAIN SIZE CURVE Boring P-7 Sample UP1C
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 6

Lab 4-3 rev 0 28 May 74

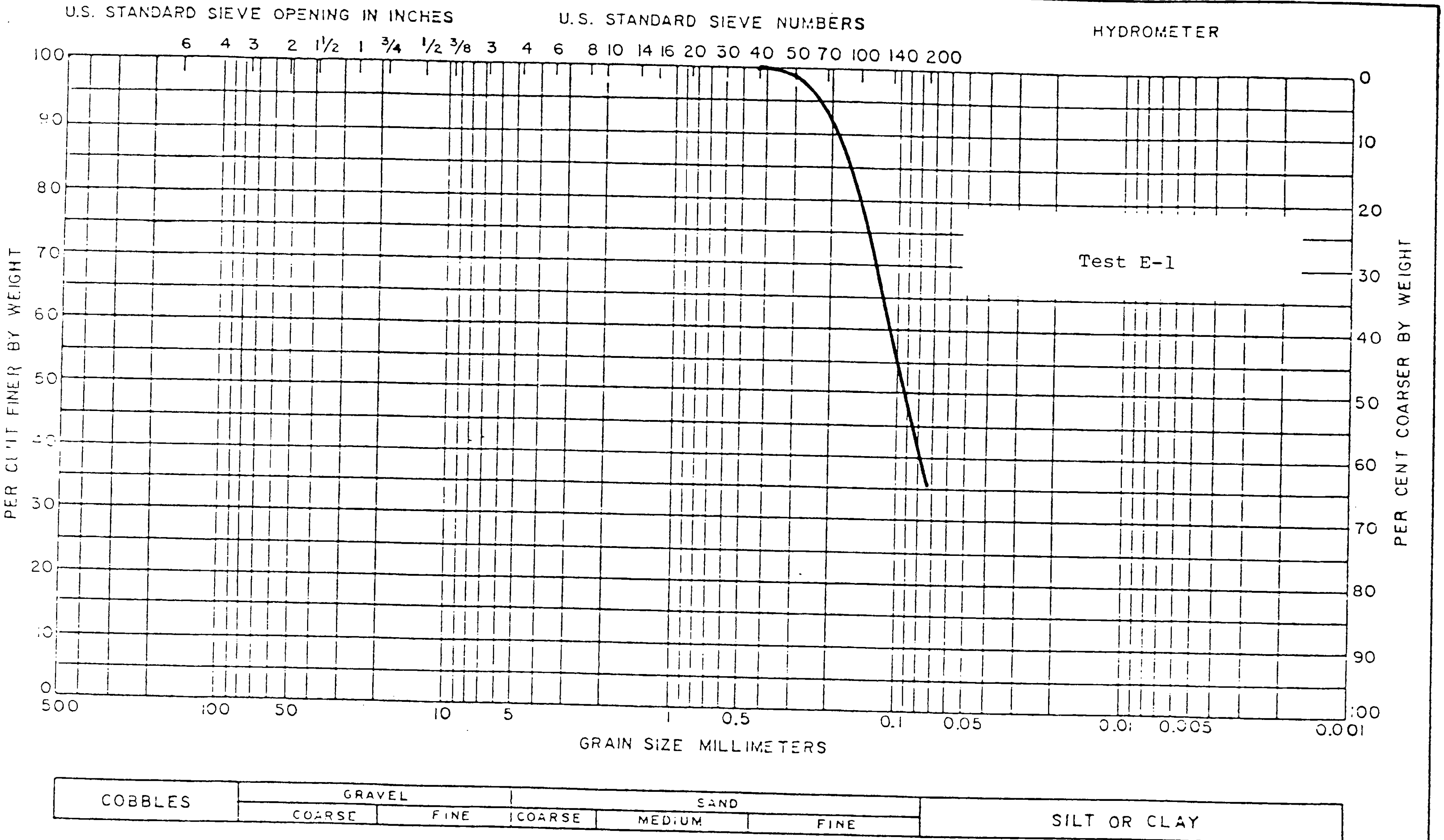


Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	GRAIN SIZE CURVE Boring P-7 Sample UP2B
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 7

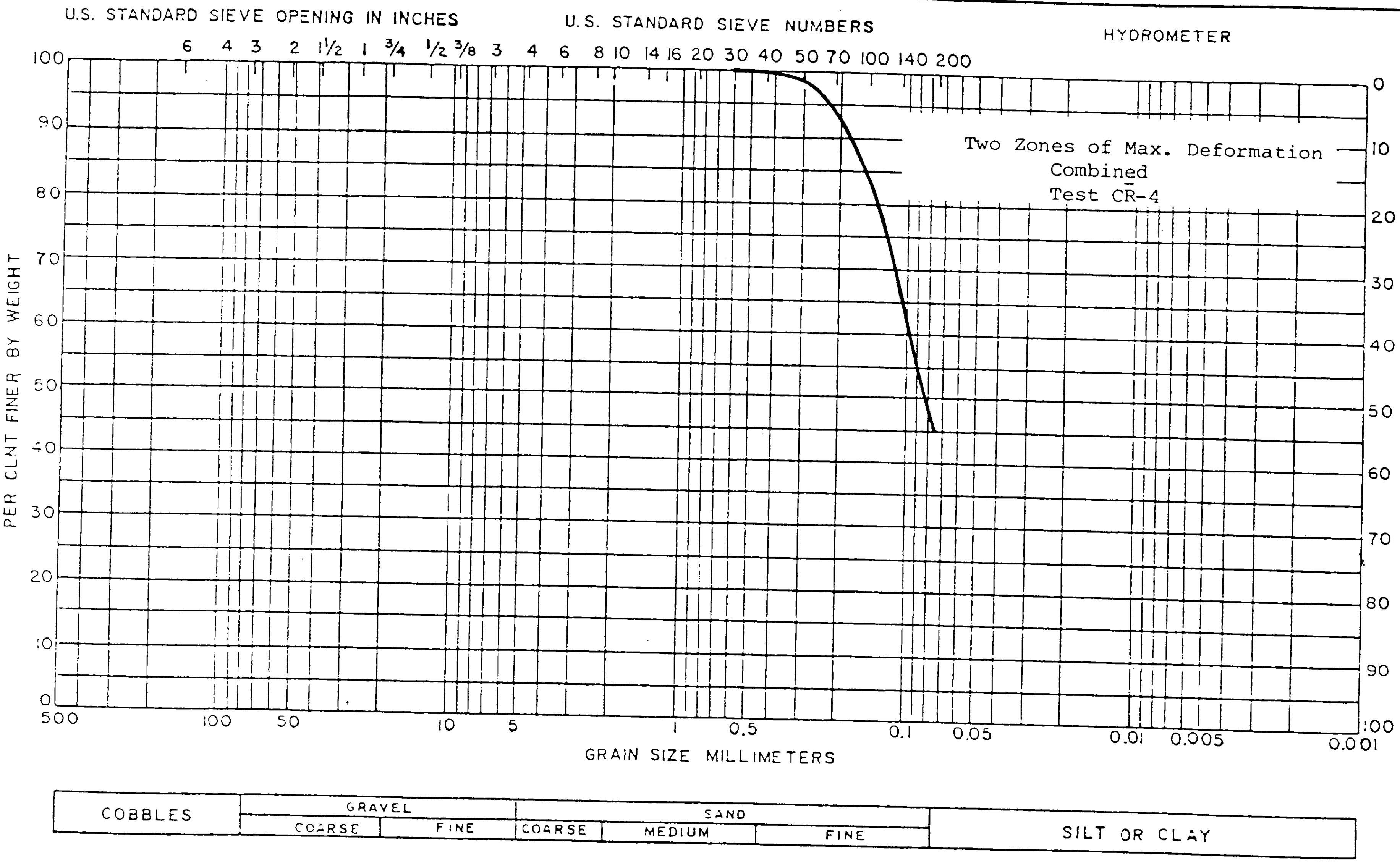


Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	GRAIN SIZE CURVE Boring P-7 Sample UP2C
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 8

Lab 4-3 rev 0 28 May 74

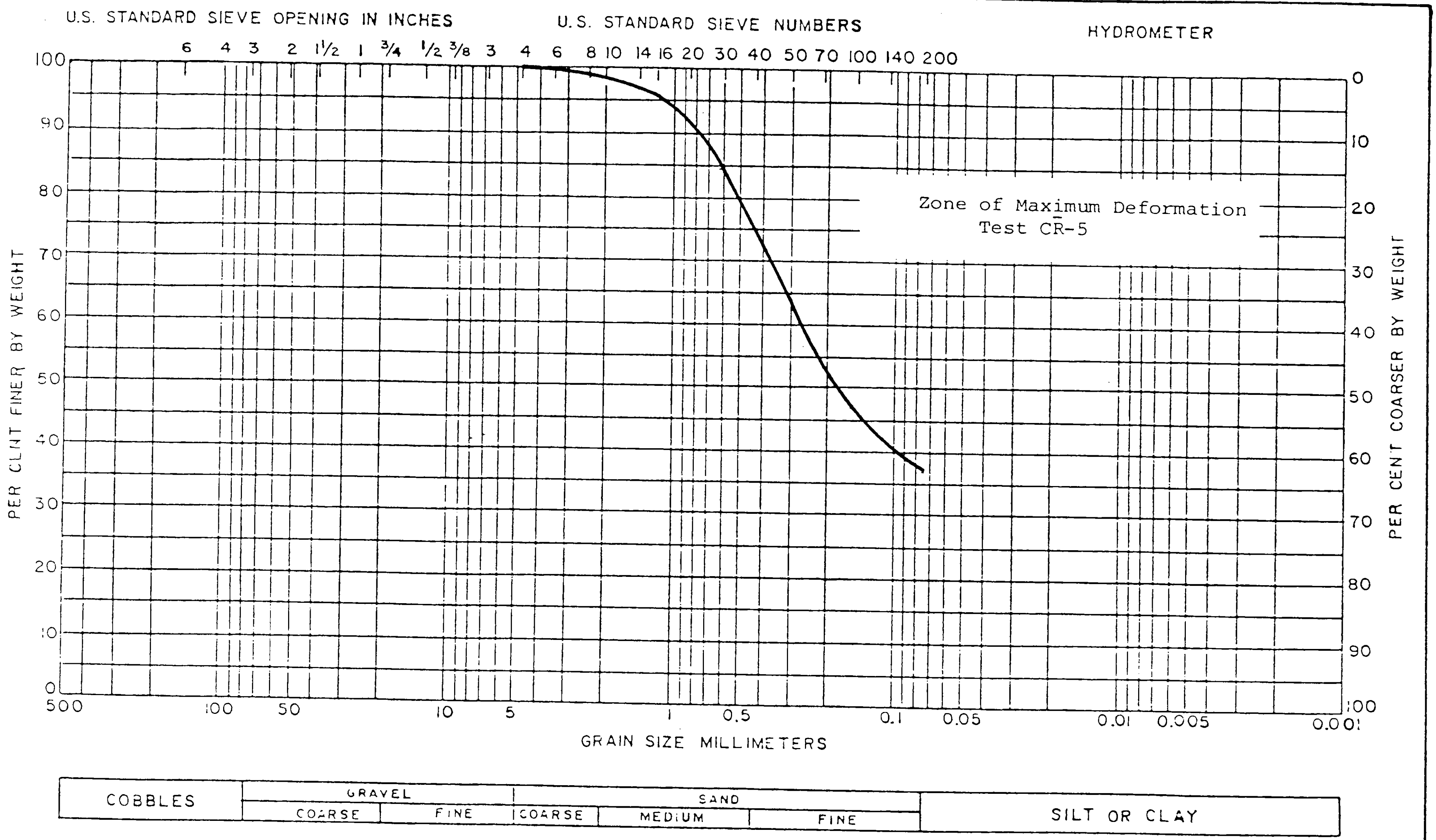


Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	GRAIN SIZE CURVE Boring P-7 Sample UP3B
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 9

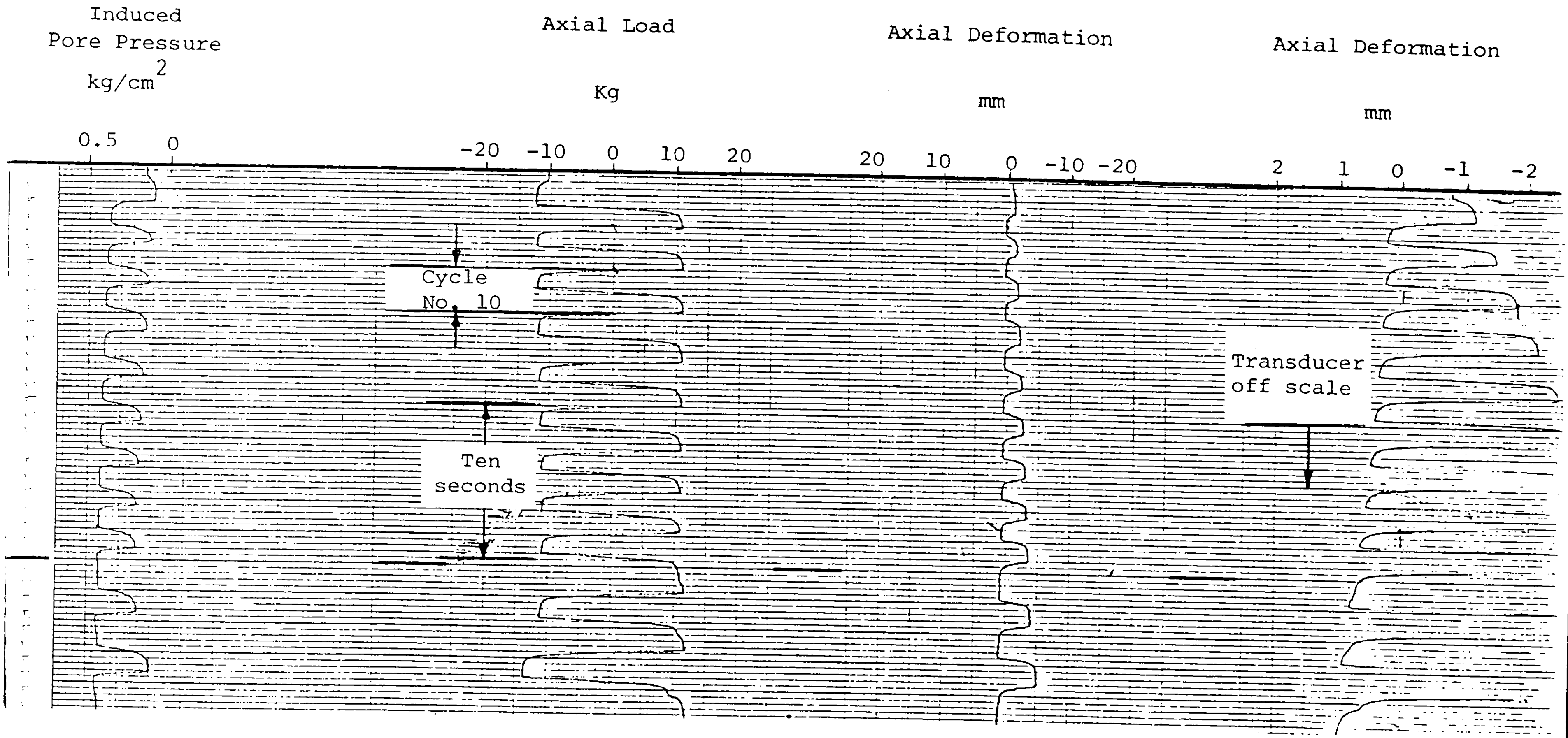


Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	GRAIN SIZE CURVE Boring P-7 Sample UP3C
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 10

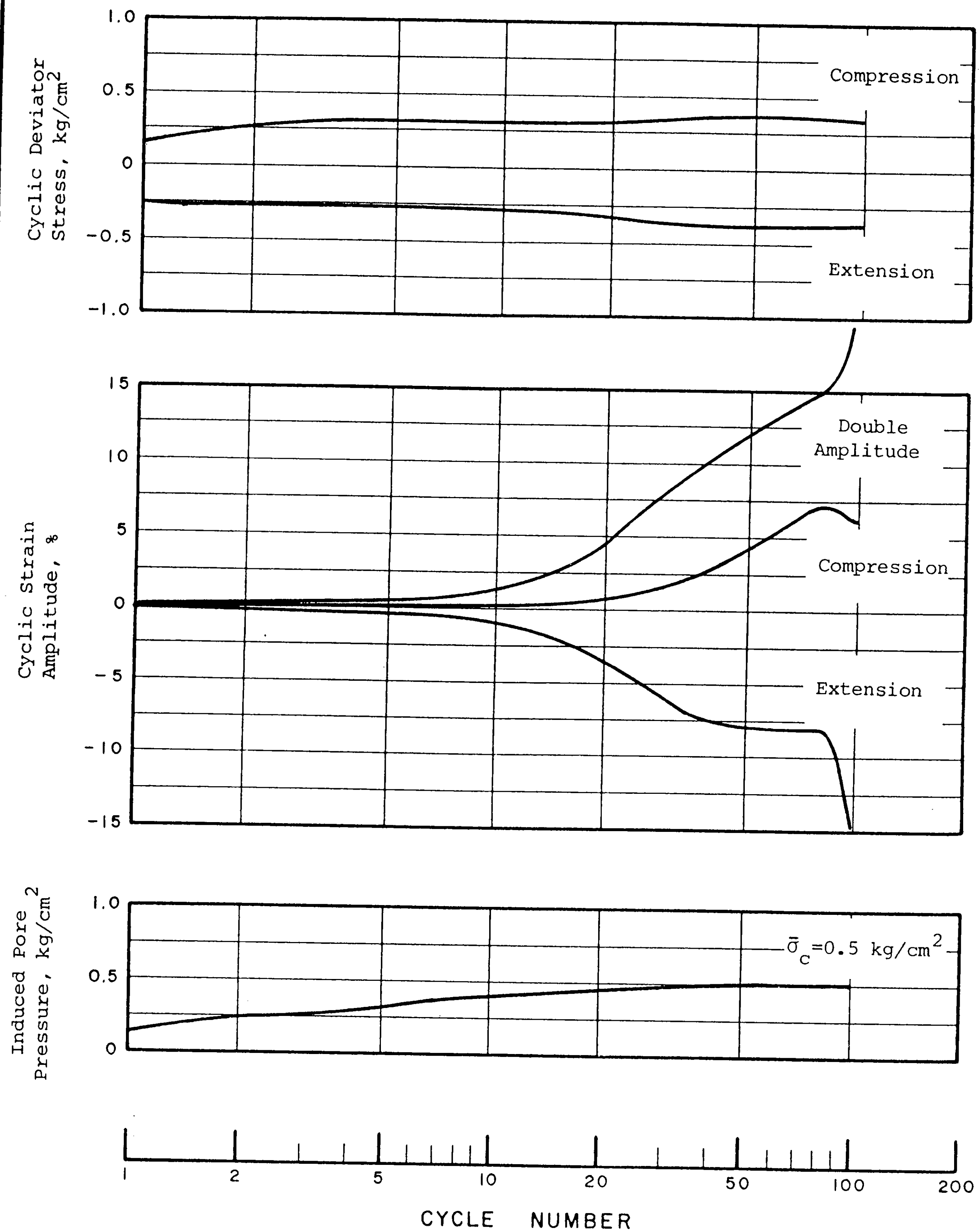
Lab 4-3 rev 0 28 May 74



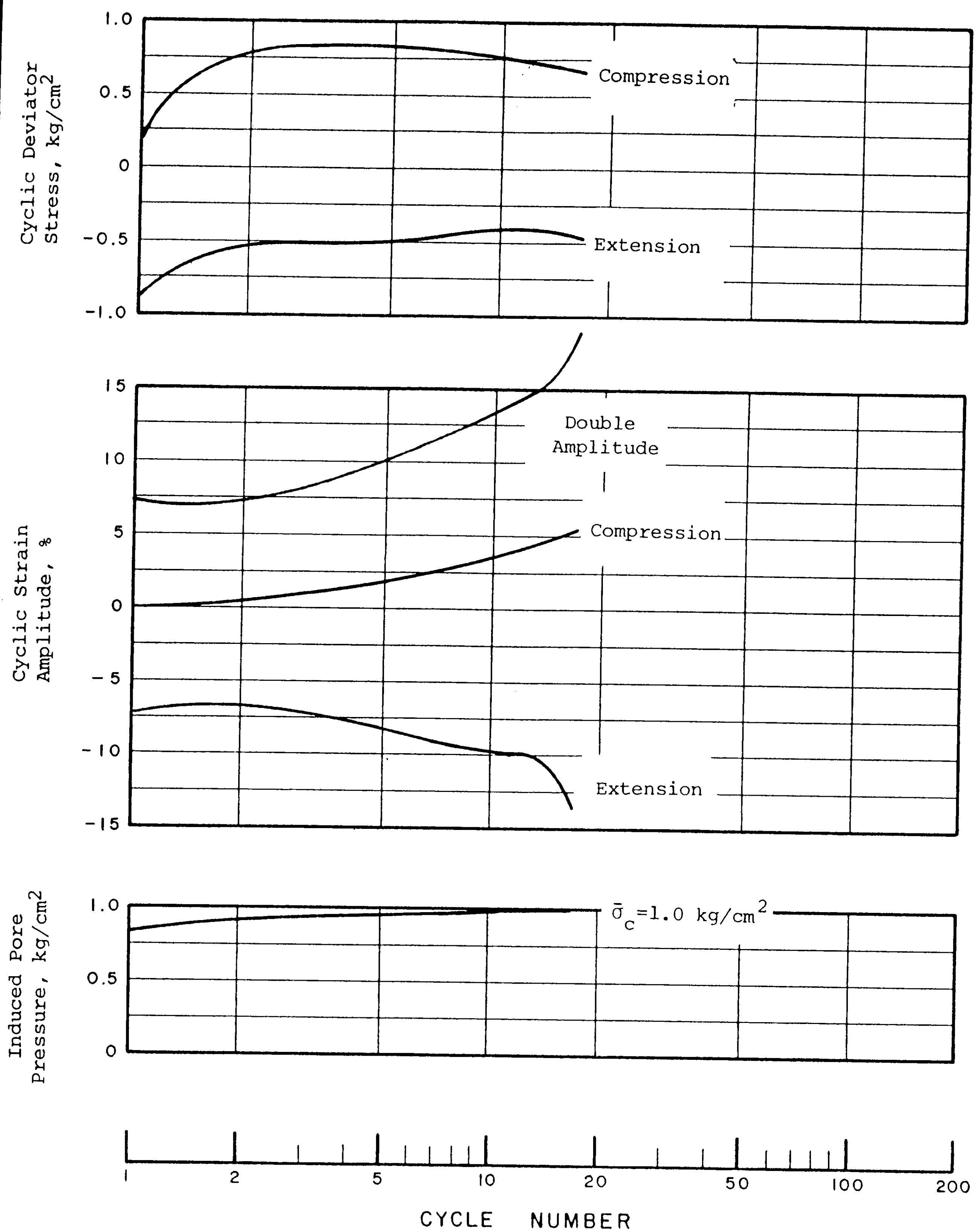
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	GRAIN SIZE CURVE Boring P-8 Sample UP1C
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 11



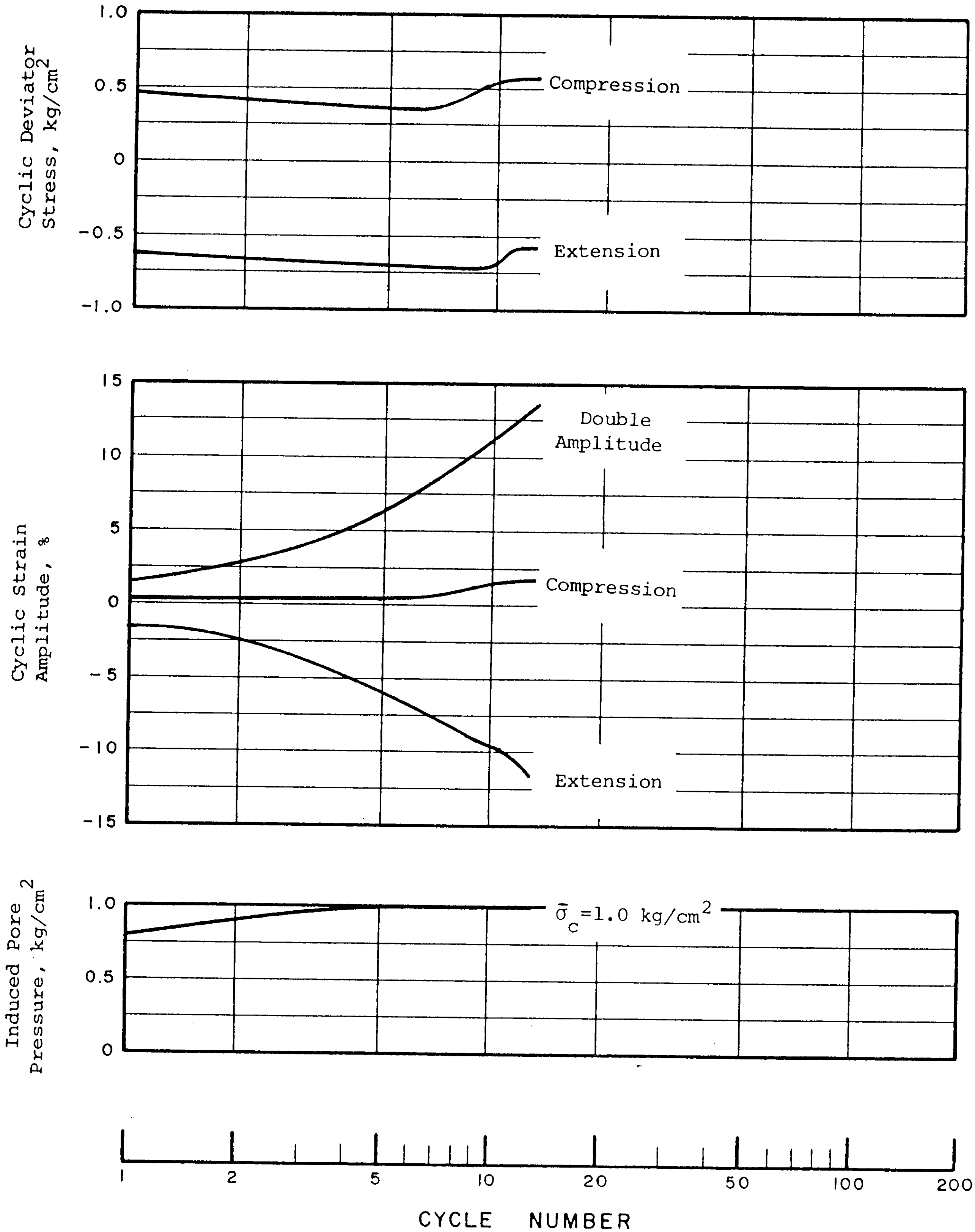
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	TYPICAL CYCLIC LOAD TEST RECORD Test CR-8 (Partial Record)
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 12



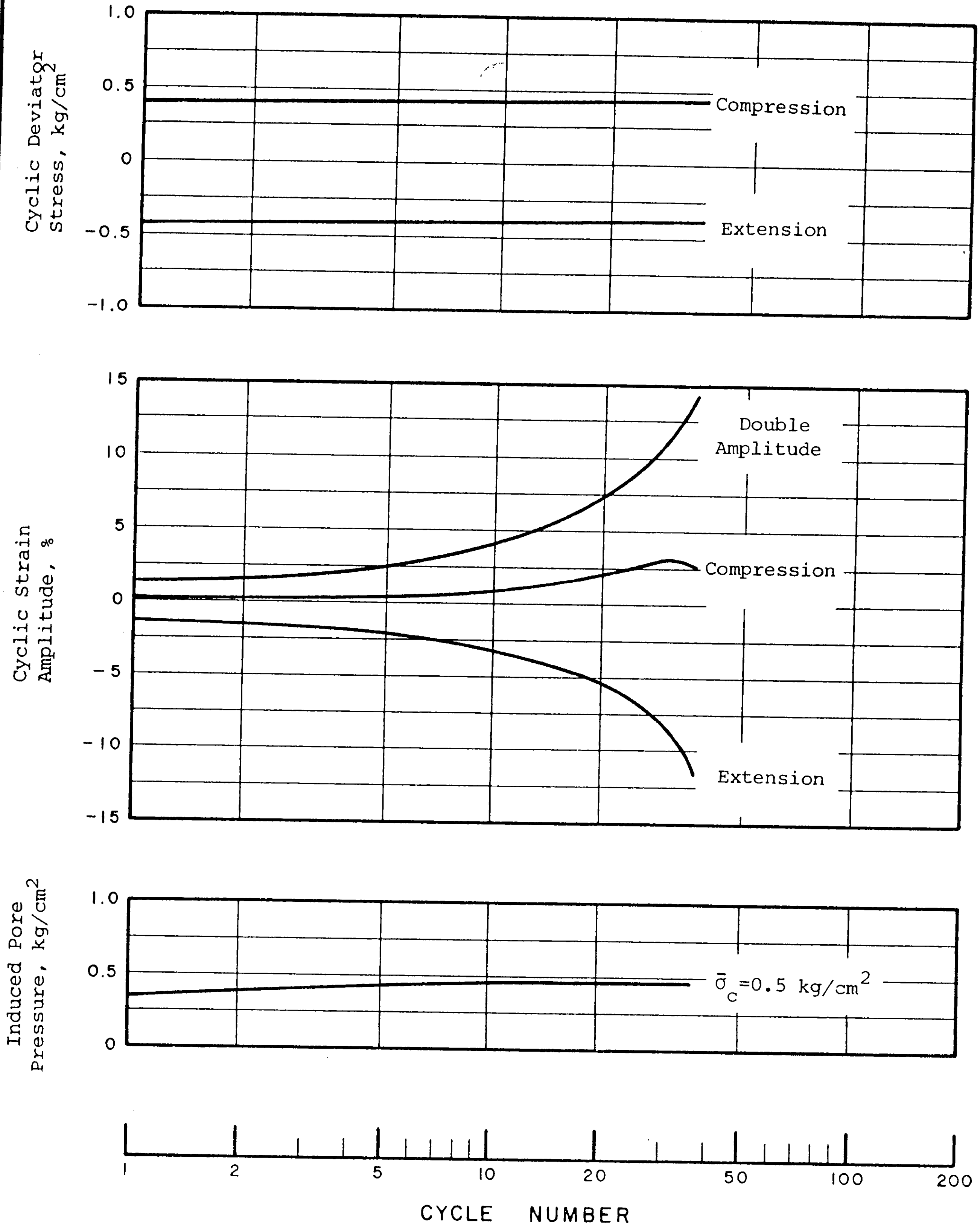
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TEST INDIVIDUAL RESULTS Boring P-3, Sample UP3C Test No. C$\bar{R}$-8
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 13



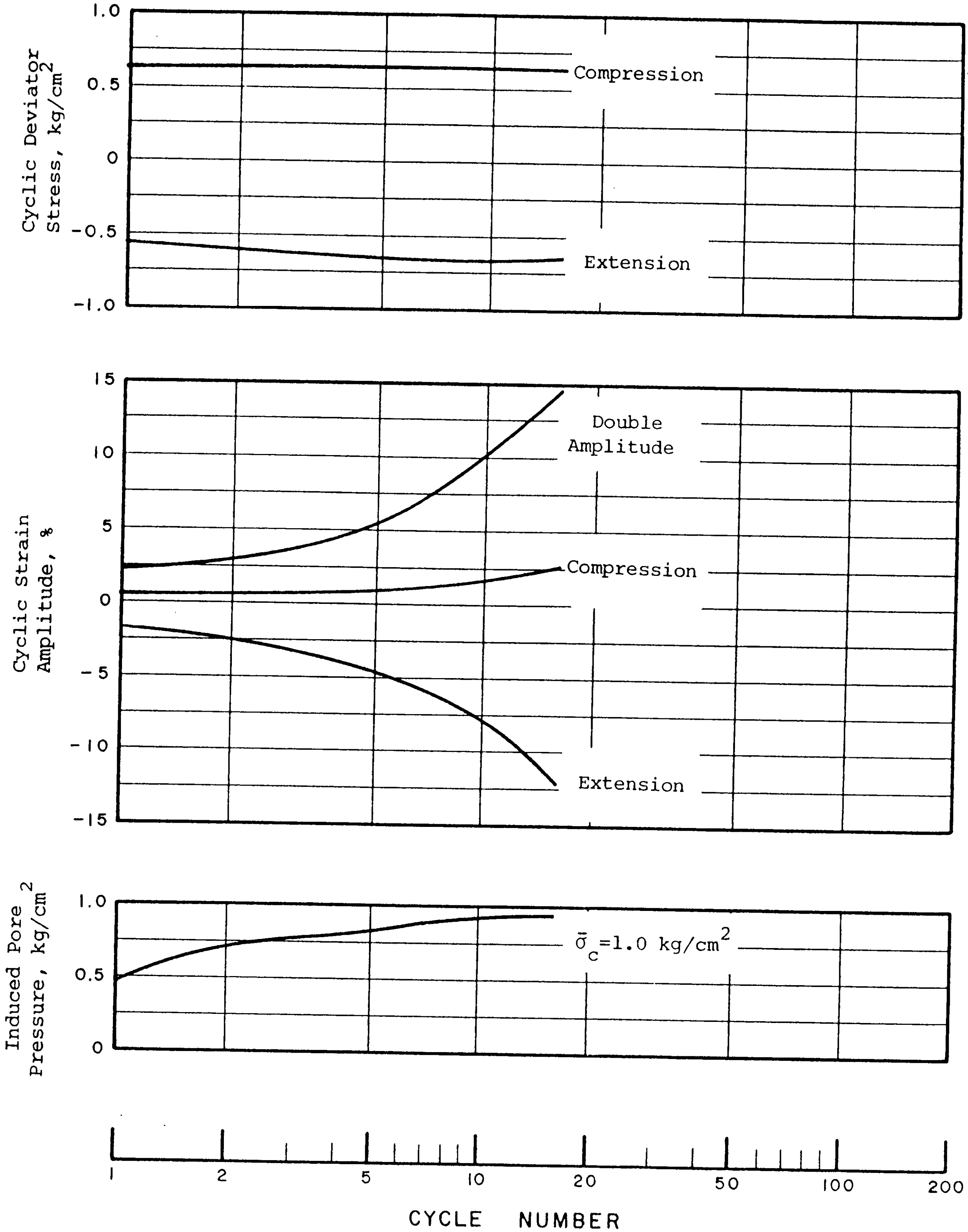
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TEST INDIVIDUAL RESULTS Boring P-3, Sample UP4C Test No. CR̄-1
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 14



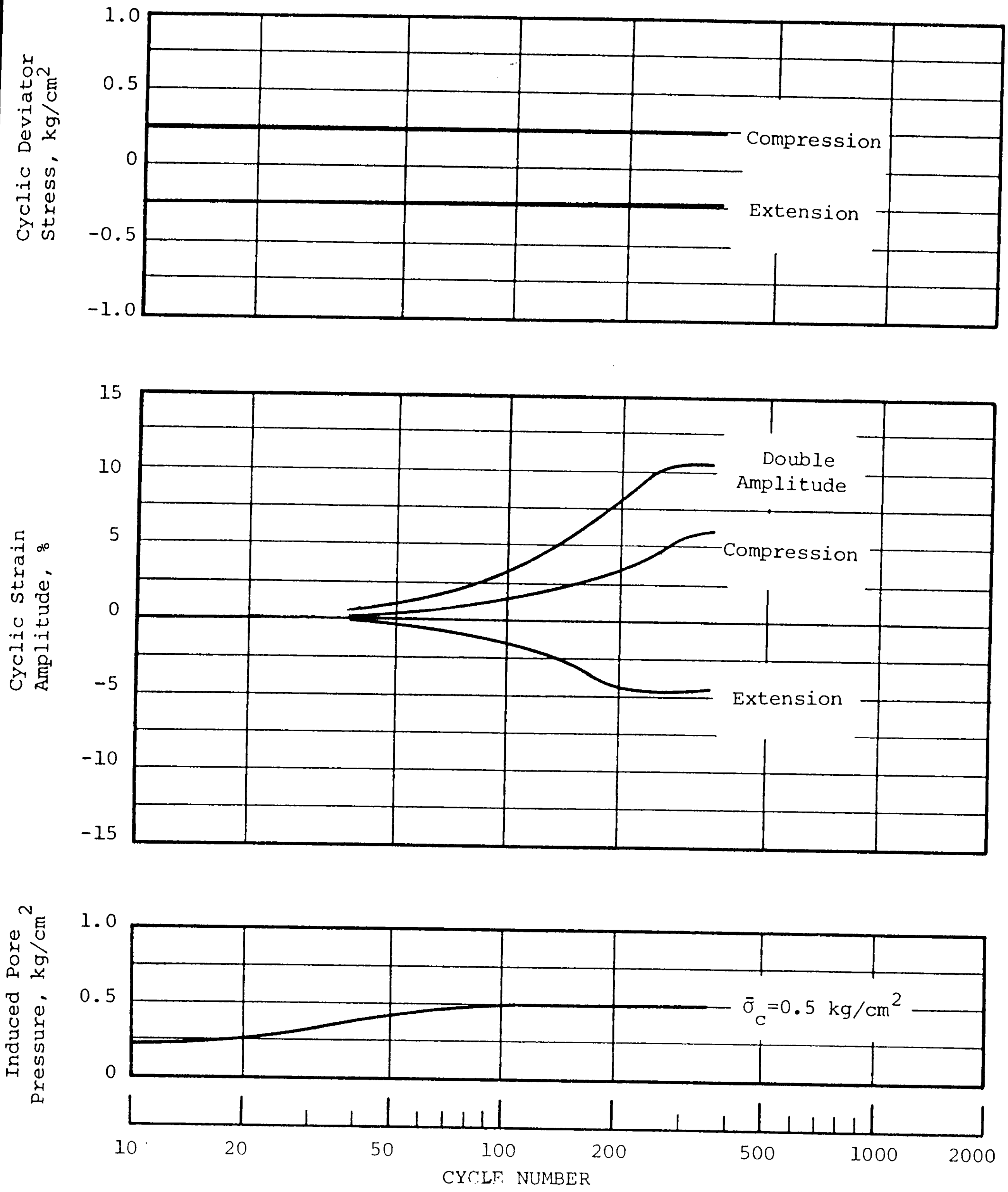
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TEST INDIVIDUAL RESULTS Boring P-7, Sample UP1C Test No. CR̄-6
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 15



Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TEST INDIVIDUAL RESULTS Boring P-7, Sample UP2B Test No. CR̄-9
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 16

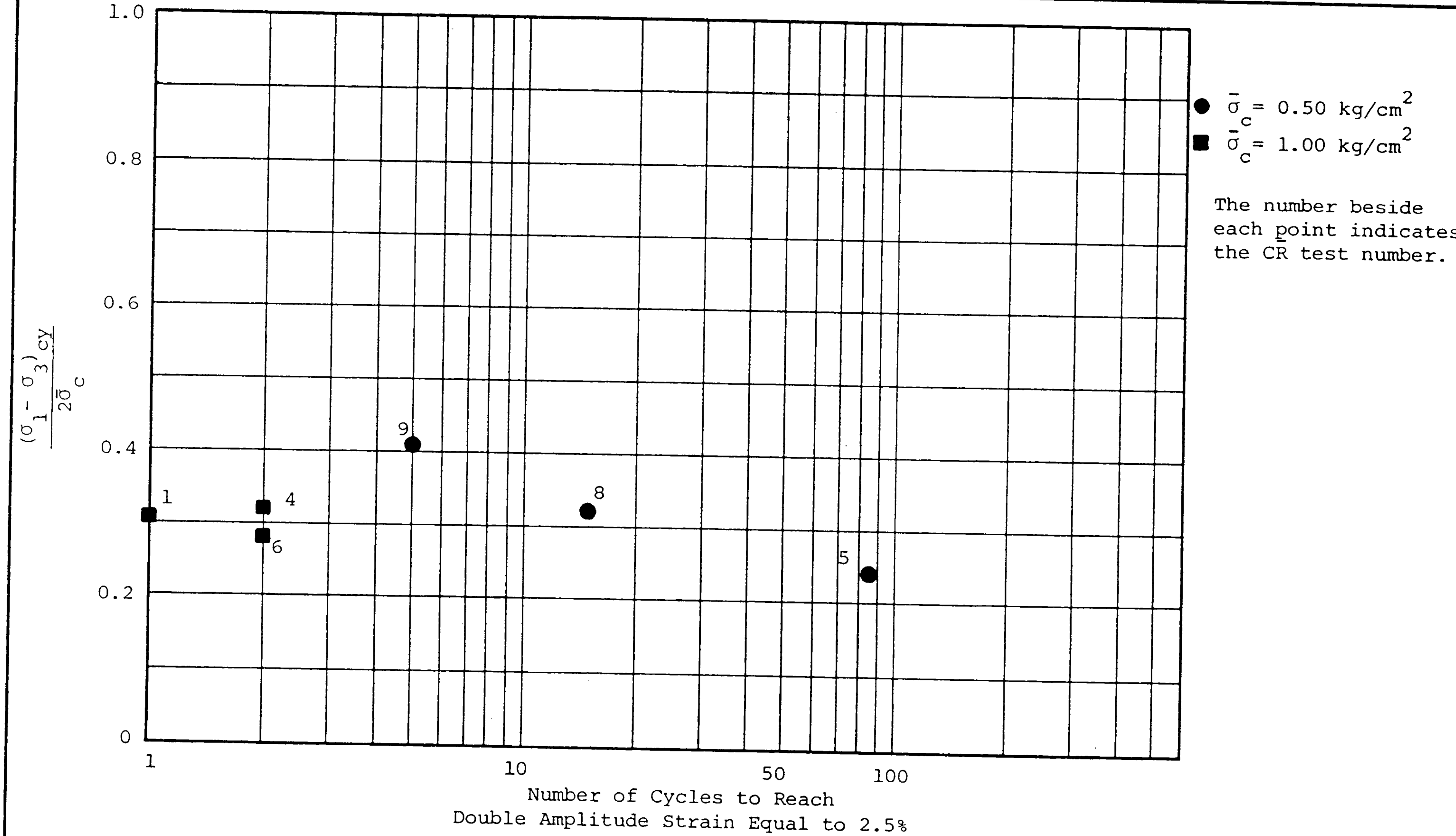


Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TEST INDIVIDUAL RESULTS Boring P-7, Sample UP3C Test No. CR̄-4
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 17

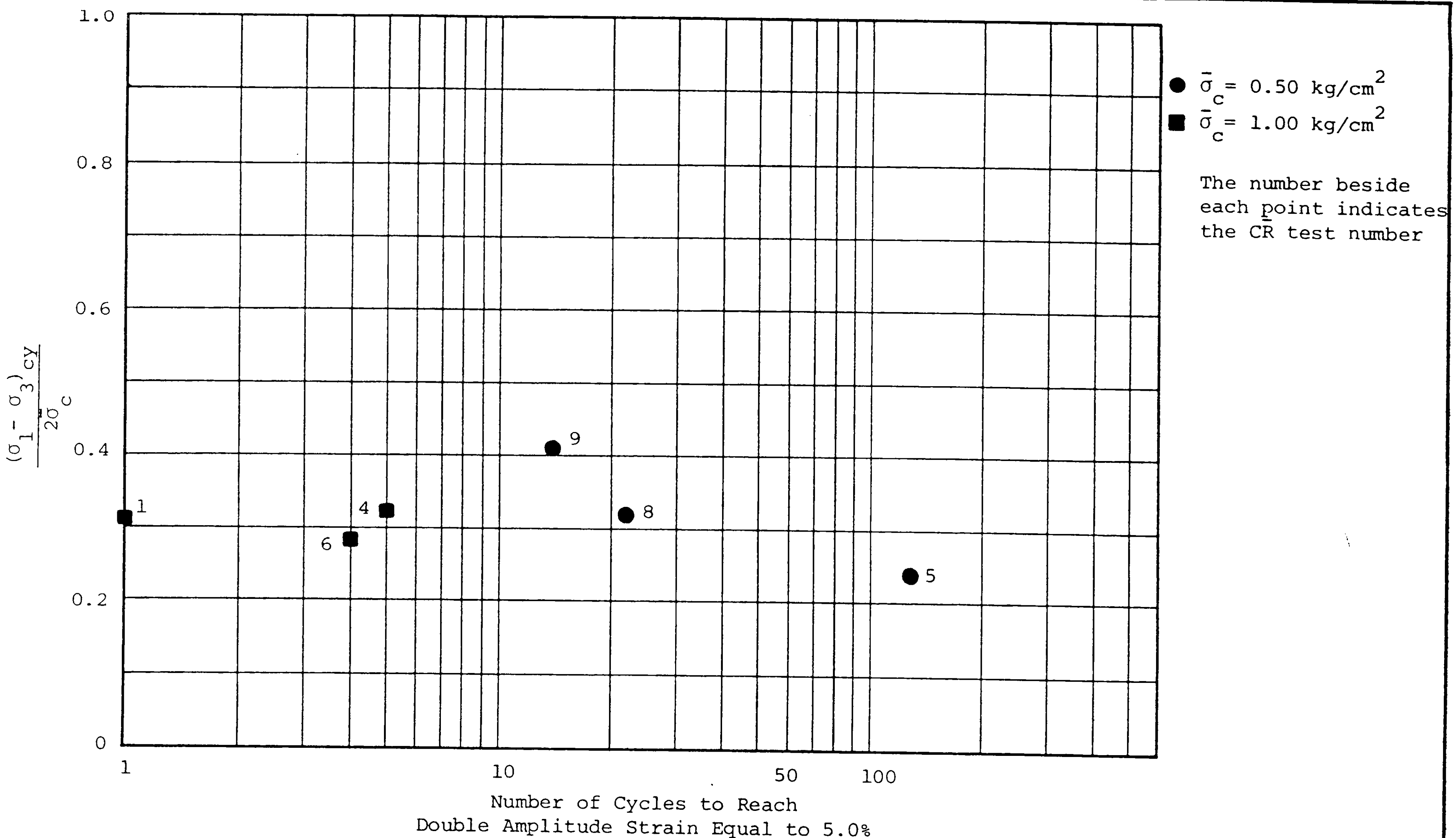


NOTE: Plot started at cycle 10. After cycle 1 Induced Pore Pressure was 0.16 kg/cm^2. Cyclic Strain Amplitude was not measured until cycle 38. At cycle 38 the Double Amplitude Strain was less than 0.5%.

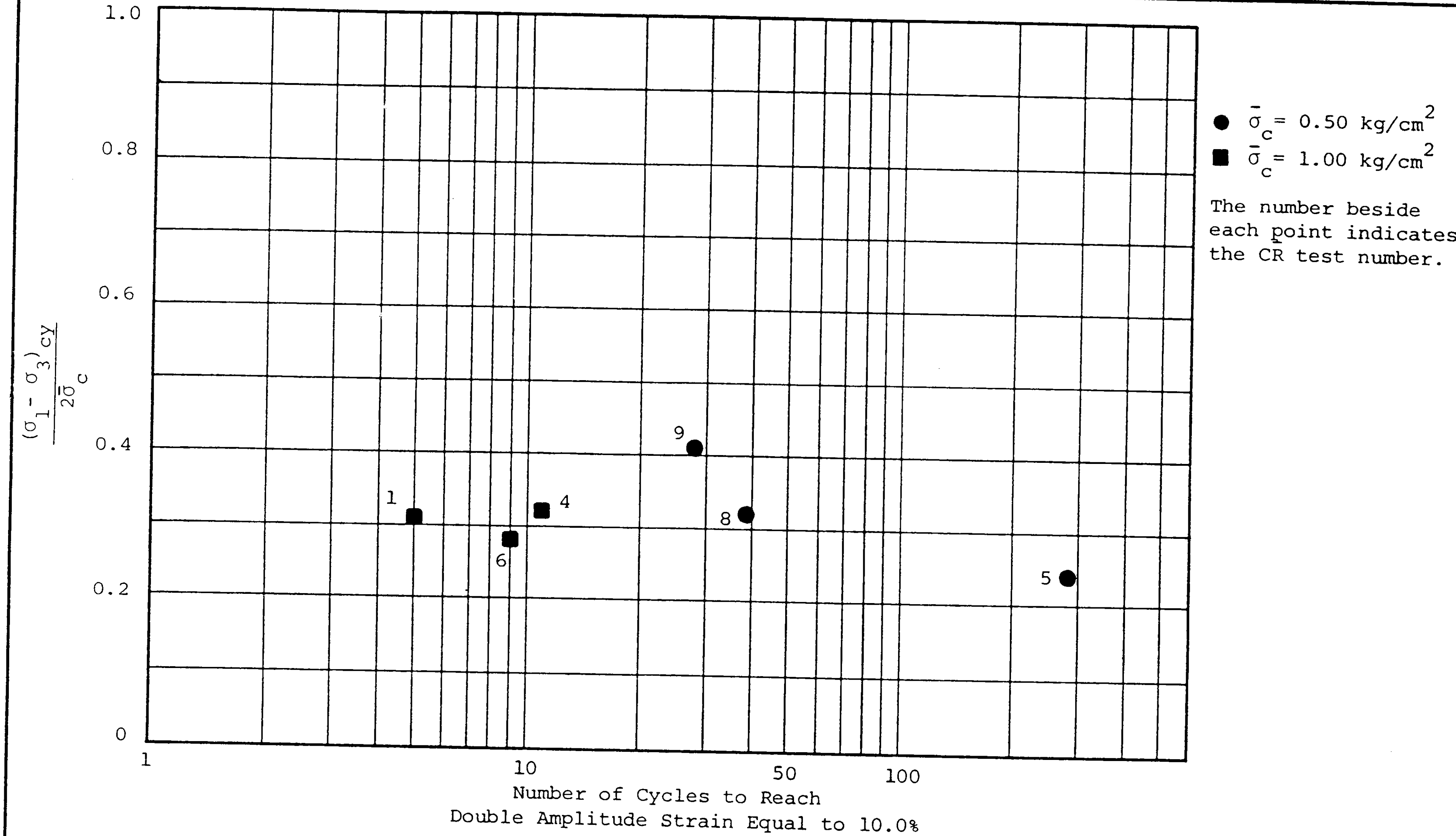
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TESTS INDIVIDUAL RESULTS Boring P-8, Sample UP1C Test No. CR-5
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 18



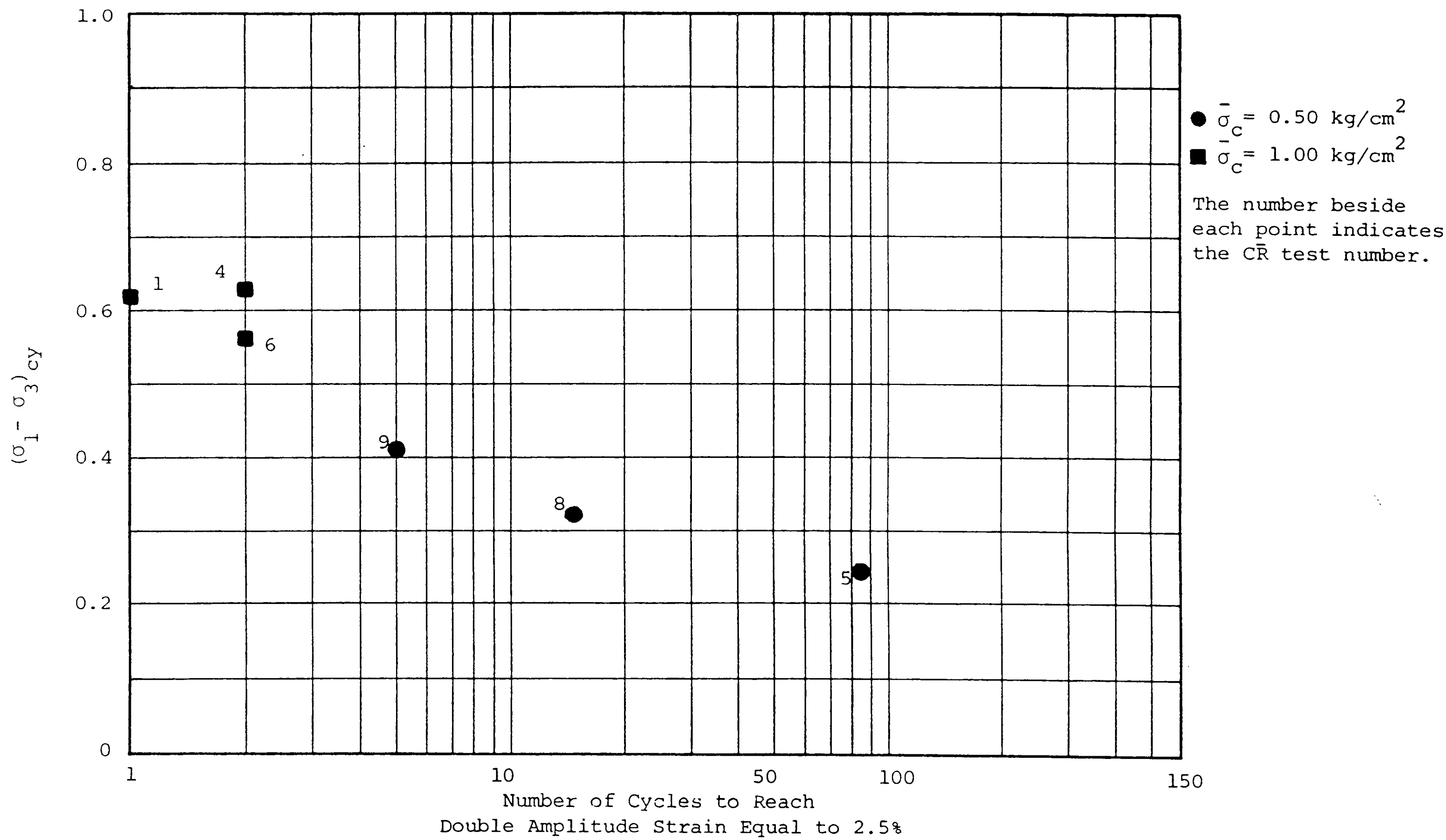
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TEST SUMMARY PLOT Cyclic Stress Ratio 2.5% D. A. Strain
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	Aug. 27, 1975 Fig. 19



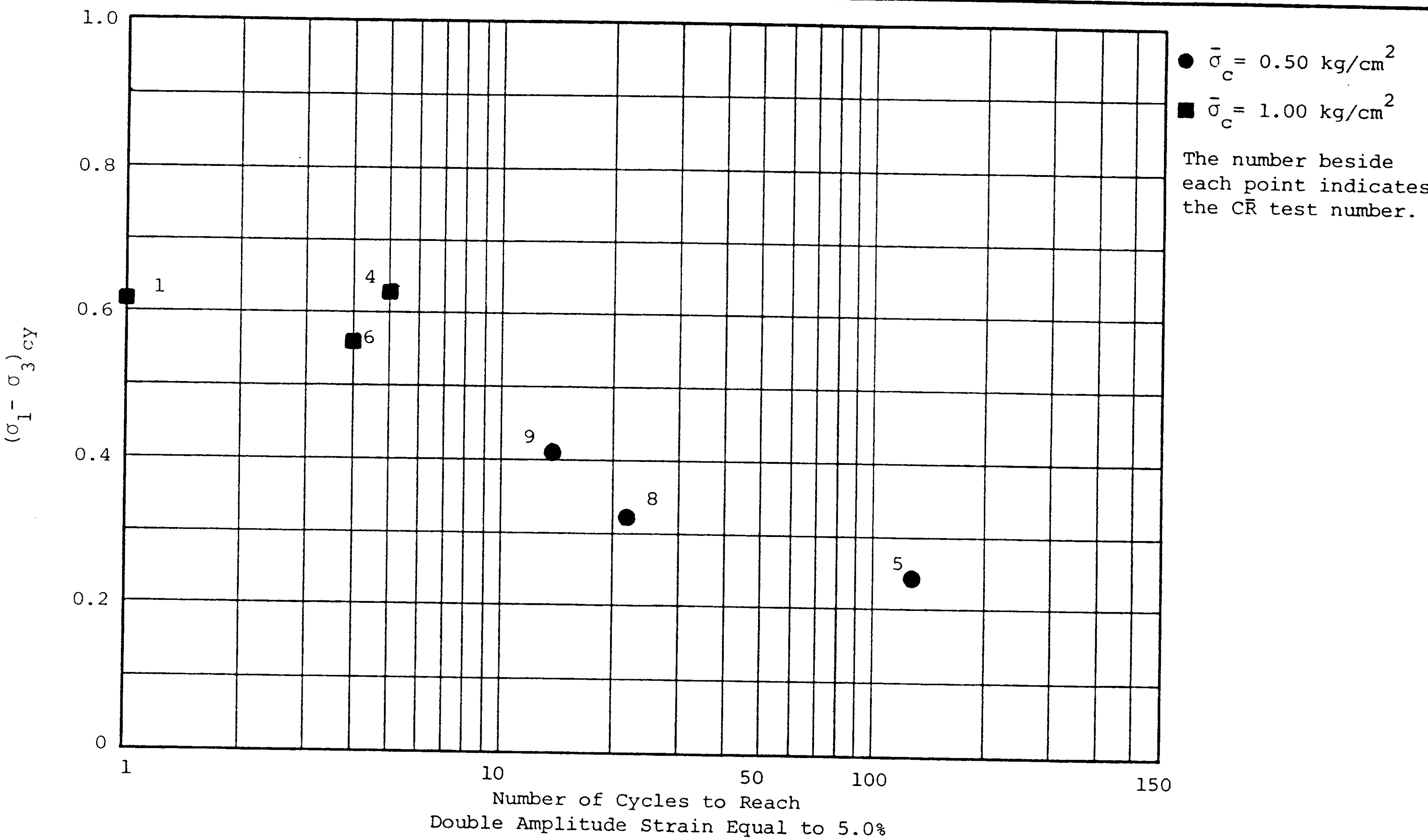
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TEST SUMMARY PLOT Cyclic Stress Ratio 5.0% D.A. Strain
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	Aug. 27, 1975 Fig. 20



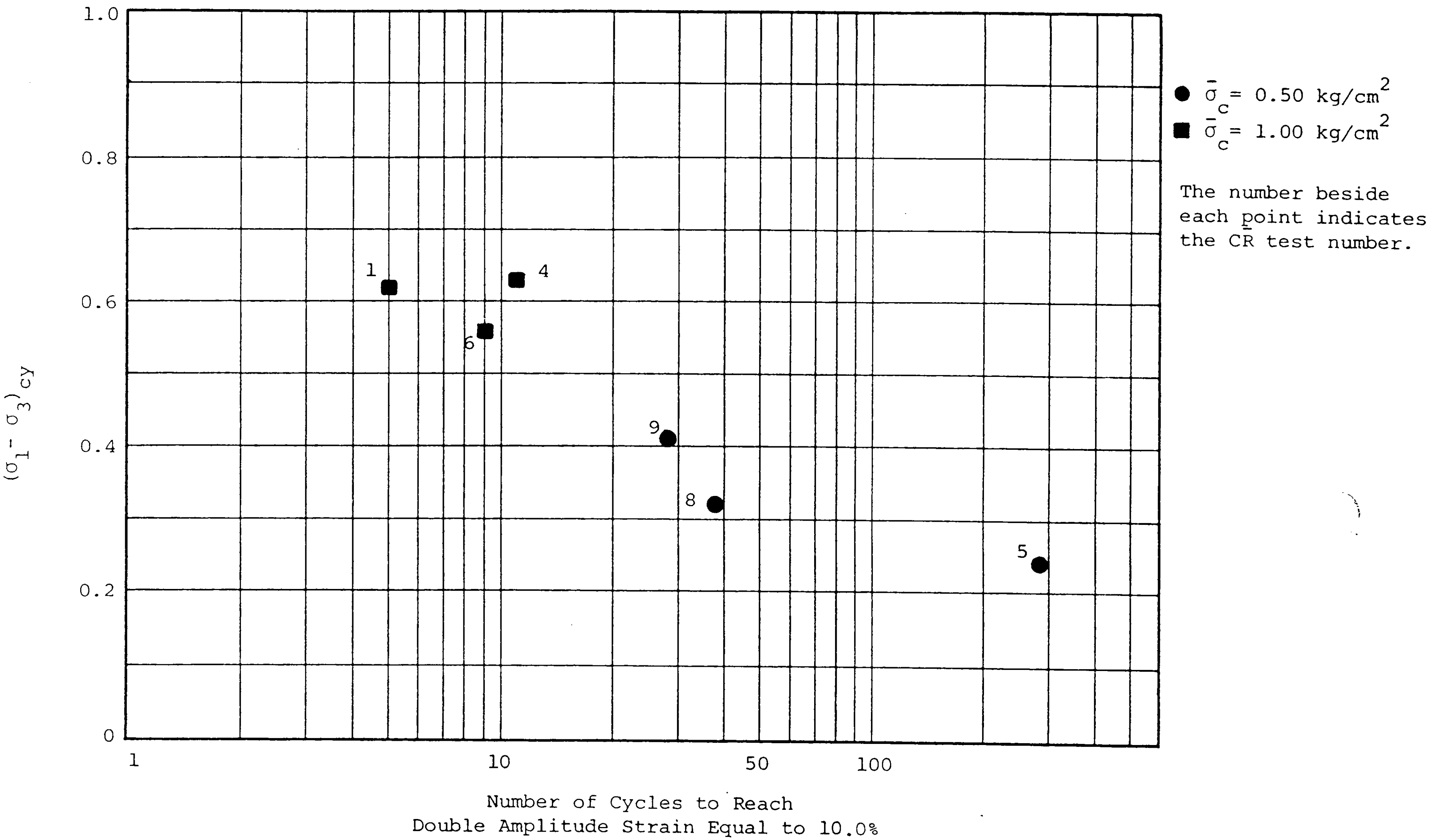
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TEST SUMMARY PLOT Cyclic Stress Ratio 10.0% D.A. Strain
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	Aug. 27, 1975 Fig. 21



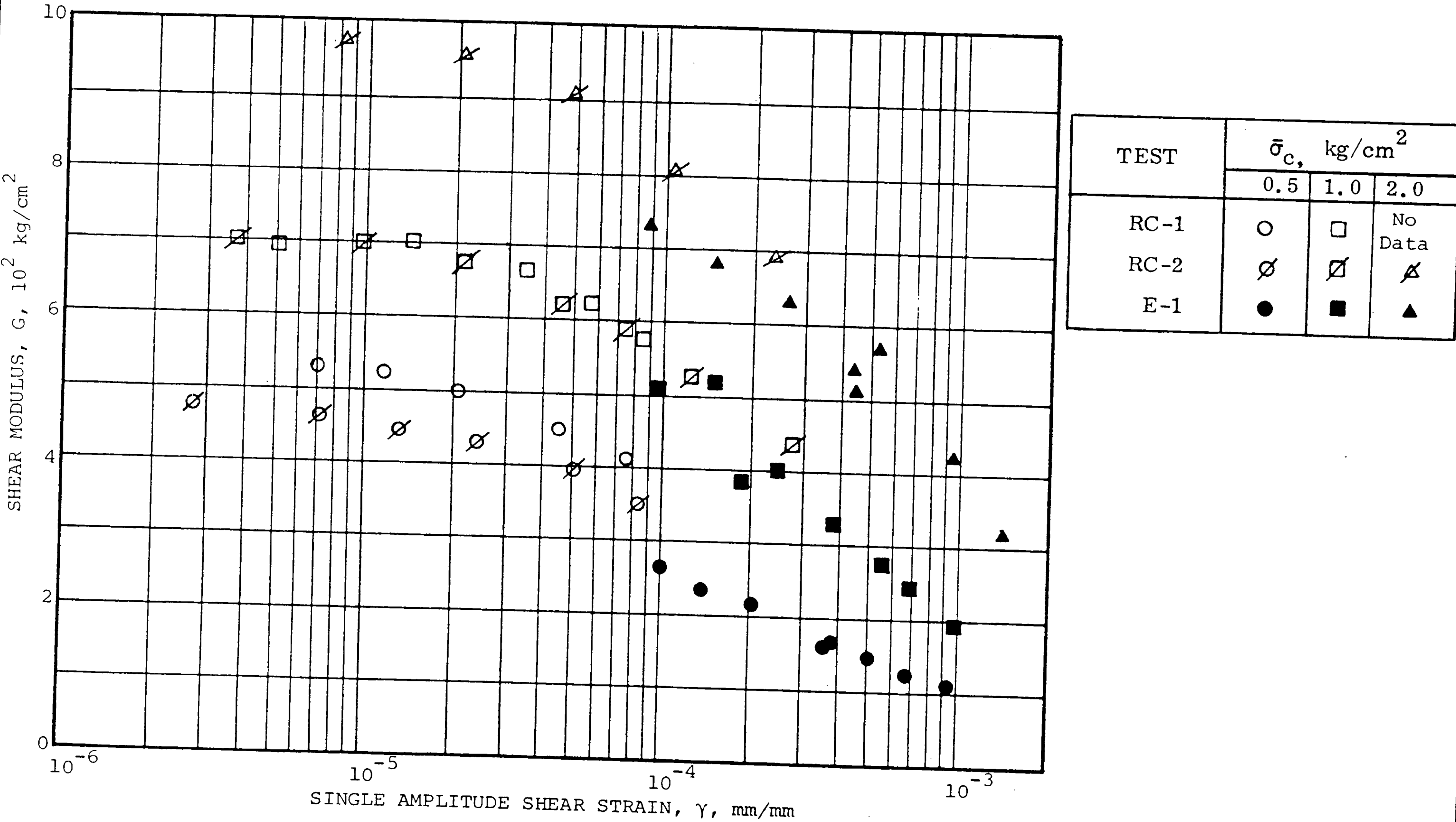
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TEST SUMMARY PLOT Cyclic Deviator Stress 2.5% D.A. Strain
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	Aug. 27, 1975 Fig. 22



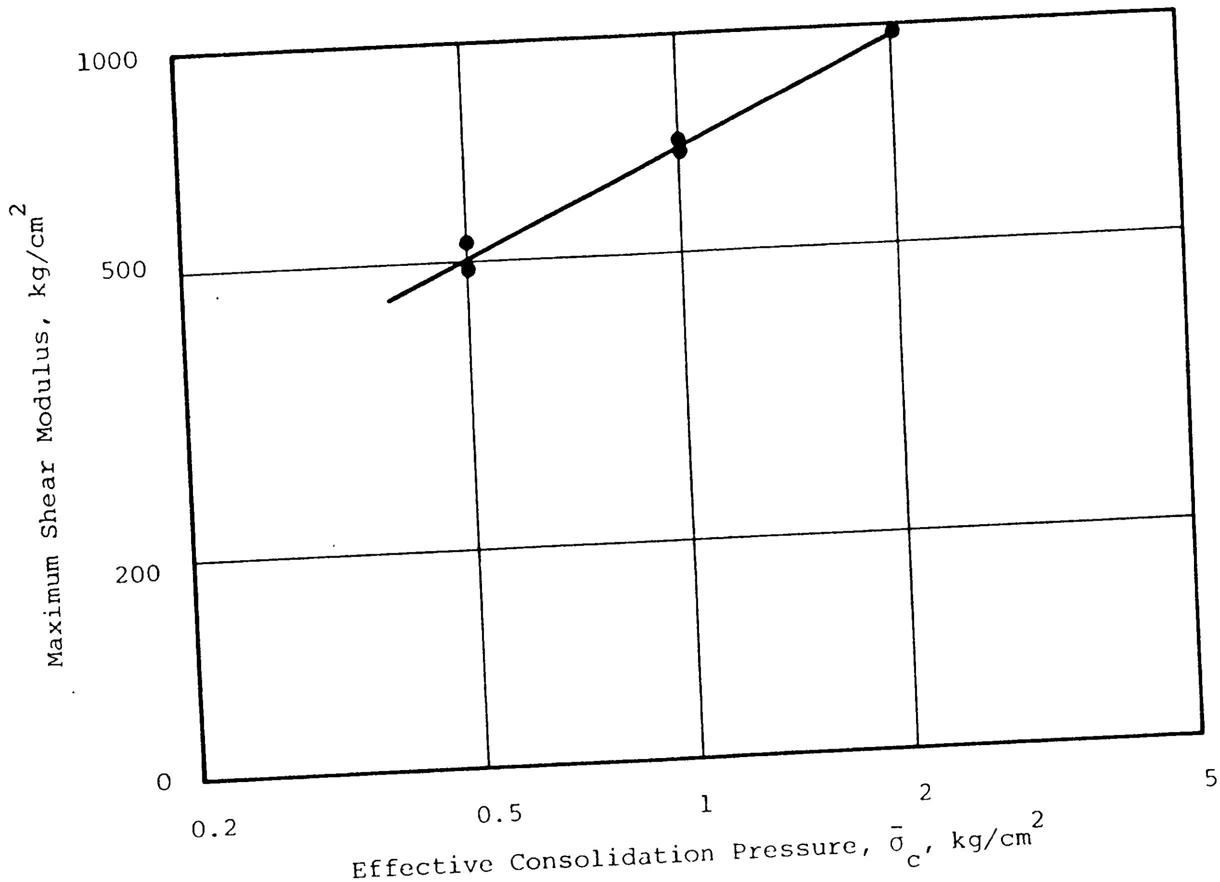
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TEST SUMMARY PLOT Cyclic Deviator Stress 5.0% D.A. Strain
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 23



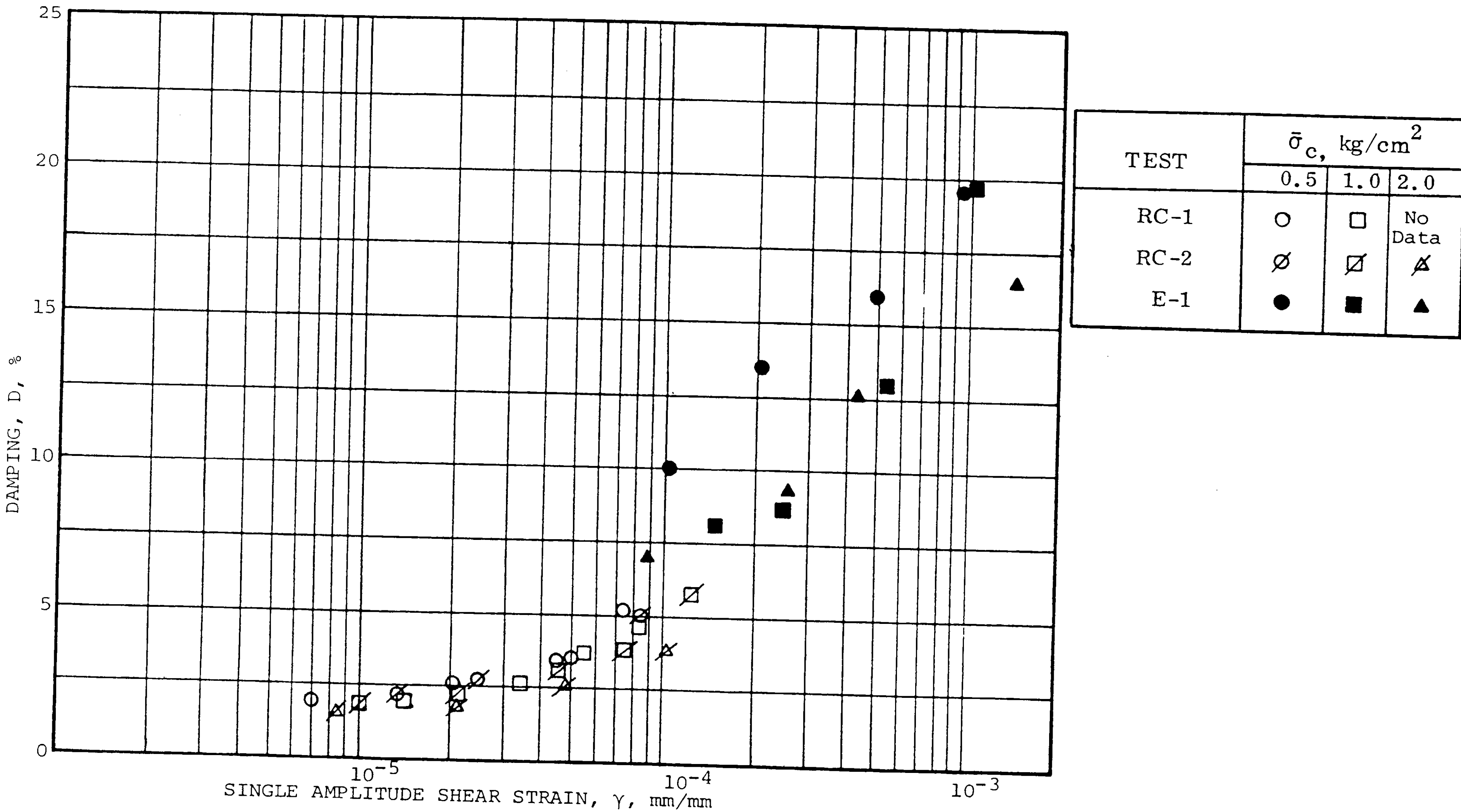
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	CYCLIC TRIAXIAL TEST SUMMARY PLOT Cyclic Deviator Stress 10.0% D.A. Strain
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	August 27, 1975 Fig. 24



Stone & Webster Engineering Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	SHEAR MODULUS DETERMINATIONS
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	Aug. 27, 1975 Fig. 25



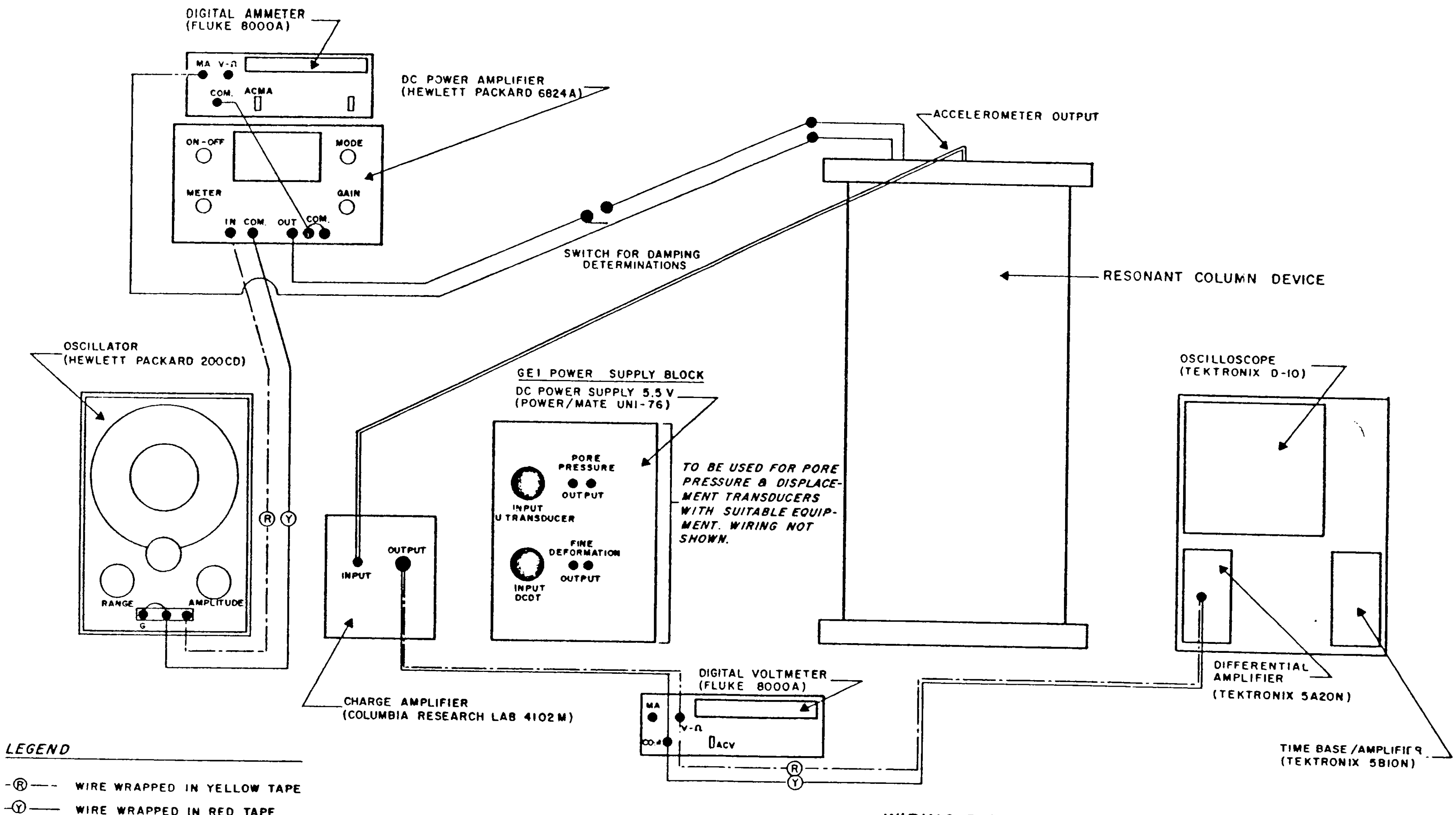
Stone & Webster Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy	MAXIMUM SHEAR MODULUS VS STRAIN
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244	Sept. 1975 Fig. 26



Stone & Webster Engineering Boston, Massachusetts	Millstone Nuclear Station Unit 3 Northeast Nuclear Energy
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 75244

DAMPING DETERMINATIONS

Aug. 27, 1975 Fig. 27



WIRING DIAGRAM FOR RESONANT COLUMN EQUIPMENT
GEOTECHNICAL ENGINEERS INC.
WINCHESTER MASSACHUSETTS
JUNE, 1975

FIG. 28

APPENDIX A

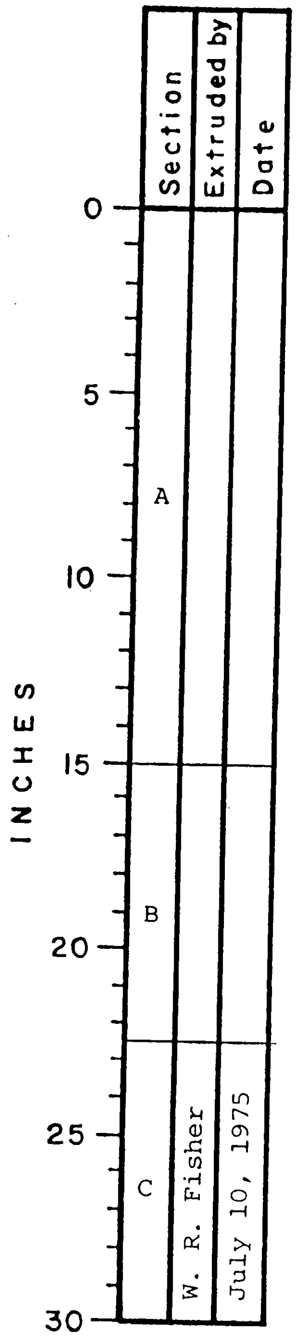
DESCRIPTION OF UNDISTURBED SAMPLES

DESCRIPTION OF UNDISTURBED SAMPLES

BORING NO. P-3

SAMPLE NO. UP3 DEPTH 27.0 ft

Project No. S & W 12179, GEI 75244



Section No.	Length of Section in.	Description
A	15.0	VOID
B	7.5	NOT EXTRUDED. Top 6.9 in. of section is void.
C	7.5	Bottom 0.63 in. of section is void. Dark brown micaceous slightly silty layered medium to fine sand. Coarse sand and gravel pieces, 2 mm to 1 cm in diameter, scattered throughout the specimen. Sand and silt layers are horizontal with a dark brown silt layer 1 to 2 mm in thickness. Sample used for Test C$\bar{R}$-8. Specimen failed by necking 2.5 in. from the top. Grain size distribution determined for failure zone (Fig. 1). Note: There were several small nicks in the tube cutting edge, one about 5 mm long by 2 mm deep.

Distance from top of tube to top of sample = 21.9 in., = 55.6 cm, Ruler # 15

Distance from bottom of tube to bottom of sample = 0.63 in, = 1.6 cm, Ruler # 20

Remarks

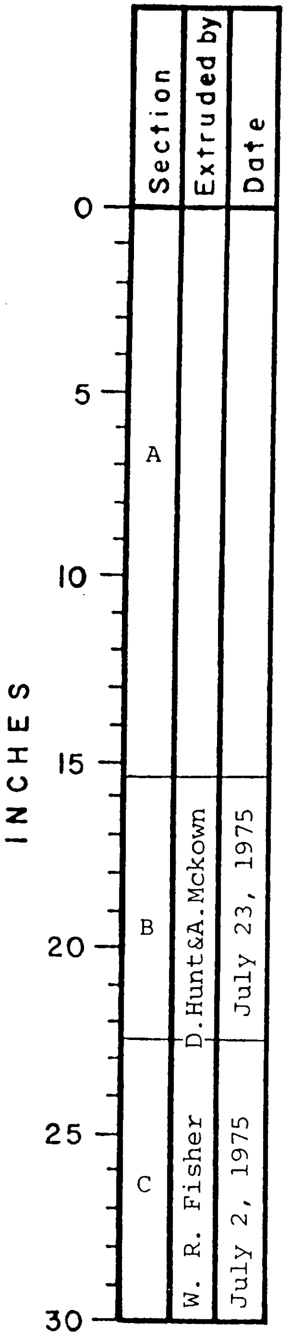
Lab. 2-4 rev. 0 28 May 74

DESCRIPTION OF UNDISTURBED SAMPLES

BORING NO. P-3

SAMPLE NO. UP4 DEPTH 32.0 ft

Project No. S & W 12179, GEI 75244



Section No.	Length of Section in.	Description
A	15.40	NOT EXTRUDED. The top 8.05 in. of section was void.
B	7.06	Brown micaceous silty fine sand. Contains layers of brown fine sandy silt up to 3 mm in thickness. Layering is concentrated in top one-half of specimen. Used for Test RC-1. Grain size distribution determined on a representative sample from the lower one-half of the specimen (Fig. 2).
C	7.54	Bottom 0.6 in. of section was void. Layered brown micaceous silty fine sand. Layers are 1-2 mm thick and are horizontal from the middle of the sample to the bottom. Layers at the top of the sample are at 45° to the horizontal. Used for Test CR-1. Specimen failed in extension. Test stopped in compression cycle so zone of necking not apparent. Grain size distribution determined for a representative sample of the specimen (Fig. 3).

Distance from top of tube to top of sample = 8.05 in., = 20.1 cm, Ruler # 5

Distance from bottom of tube to bottom of sample = 0.6 in, = 1.6 cm, Ruler # 5

Remarks

Lab. 2-4 rev. 0 28 May 74

DESCRIPTION OF UNDISTURBED SAMPLES

BORING NO. P-4

SAMPLE NO. UP1 DEPTH 5.0 ft

Project No. S & W 12179, GEI 75244

Section	Extruded by	Date	Inches
A			0–15.44
B	D. Hunt	Aug. 11, 1975	15.44–22.61
C	W.R. Fisher	July 2, 1975	22.61–30

Section No.	Length of Section in.	Description
A	15.44	NOT EXTRUDED. The top 9.8 in. of section was void.
B	7.17	Brown micaceous fine sand. Contains alternating darker layers, 1-2 mm thick, with a greater percentage of biotite mica, at approximately 15° from horizontal. Used for Test RC-2. Grain size distribution determined on a representative sample (Fig. 4).
C	7.36	Bottom 0.5 in. of section was void. Brown micaceous silty fine sand. Contains layers of dark brown silt, 1-2 mm thick, at 15° to the horizontal and one layer of fine sand 5 mm from the top. The bottom 2.5 cm of specimen was very silty fine sand. Used for Test CR-2. Test void due to specimen disturbance. Grain size distribution determined on a representative sample (Fig. 5).

Distance from top of tube to top of sample = 9.80 in., = 24.9 cm, Ruler # 5

Distance from bottom of tube to bottom of sample = 0.51 in, = 1.3 cm, Ruler # 5

Remarks

Lab. 2-4 rev. 0 28 May 74

DESCRIPTION OF UNDISTURBED SAMPLES

BORING NO. P-7

SAMPLE NO. UP1 DEPTH 12.0 ft

Project No. S & W 12179, GEI 75244

Section	Extruded by	Date
A		
B		
C	S. Morris	July 3, 1975

INCHES: 0, 5, 10, 15, 20, 25, 30

Section No.	Length of Section in.	Description
A	15.0	VOID.
B	7.32	NOT EXTRUDED. Top 2.92 in. of section was void.
C	7.68	Bottom 0.7 in. of section was void. Tan and light brown slightly silty fine to coarse sand. Contains some particles up to 1.5 cm in diameter, a noticeable quantity of mica, and appears widely graded with no visible layering. Used for Test CR̄-6. Specimen failed by necking 6.5 cm from the top in an area 4 cm thick. Grain size distribution determined for the zone of maximum deformation (Fig. 6). Note: The tube cutting edge had two large dents, 0.6 cm deep and 0.5 cm deep.

Distance from top of tube to top of sample = 19.4 in., = 49.3 cm, Ruler # 9

Distance from bottom of tube to bottom of sample = 0.70 in, = 1.78 cm, Ruler # 5

Remarks

Lab. 2-4 rev. 0 28 May 74

DESCRIPTION OF UNDISTURBED SAMPLES

BORING NO. P-7

SAMPLE NO. UP-2 DEPTH 19.5 ft

Project No. S & W 12179, GEI 75244

Section	Extruded by	Date	Inches
A			0–15.74
B	W.R. Fisher	July 11, 1975	15.74–22.52
C	W.R. Fisher	July 3, 1975	22.52–30

Section No.	Length of Section in.	Description
A	15.74	NOT EXTRUDED. Top 11.9 in. of section was void.
B	6.78	Brown micaceous uniform silty fine sand. Contains many layers of light brown sand and layers of fine sand with mica particles. Used for Test CR-9. Sample appeared cracked one-third of the way up from the bottom prior to the test. The specimen failed by necking in the top one-third of the sample. Grain size distribution determined for the zone of maximum deformation (Fig. 7).
C	7.5	Bottom 0.6 in. of section was void. Layered micaceous slightly silty fine sand. Contains layers of rust colored fine sand up to 2 mm thick, and many layers of fine sand and mica from 1 mm to 3.5 cm thick. Used for Test CR-3. Test void due to specimen disturbance. Grain size distribution determined on a representative sample (Fig. 8).

Distance from top of tube to top of sample = 11.9 in., = 30.23 cm, Ruler # 18

Distance from bottom of tube to bottom of sample = 0.6 in, = 1.53 cm, Ruler # 18

Remarks

Lab. 2-4 rev. 0 28 May 74

DESCRIPTION OF UNDISTURBED SAMPLES

BORING NO. P-7

SAMPLE NO. UP3 **DEPTH** 29.5 ft

Project No. S & W 12179, GEI 75244

Section	Extruded by	Date	Inches
A			0 – 16.10
B	S. Morris	July 28, 1975	16.10 – 22.60
C	W.R. Fisher	July 3, 1975	22.60 – 30

INCHES: 0, 5, 10, 15, 20, 25, 30

Section No.	Length of Section in.	Description
A	16.10	NOT EXTRUDED. Top 8.9 in. of section was void.
B	6.50	Light brown micaceous silty fine sand. Contains silty fine sand layers, 3 mm to 4 mm thick, at the top and lower one-third of the specimen. Used for Test E-1. Grain size distribution determined on a representative sample (Fig. 9).
C	7.40	Bottom 0.6 in. of section was void. Light brown silty fine sand. Contains a few layers of fine sandy silt from 1 to 4 mm thick. Used for Test CR-4. Specimen had some necking at two points, one-third from the top and bottom. Grain size distribution determined for the two zones of maximum deformation combined (Fig. 10).

Distance from top of tube to top of sample = 8.9 in., = 22.7 cm, Ruler # 18

Distance from bottom of tube to bottom of sample = 0.6 in, = 1.4 cm, Ruler # 18

Remarks ____________

Lab. 2-4 rev. 0 28 May 74

DESCRIPTION OF UNDISTURBED SAMPLES

BORING NO. P-8

SAMPLE NO. UP1 **DEPTH** 12.0 ft

Project No. S & W 12179, GEI 75244

INCHES: 0, 5, 10, 15, 20, 25, 30

Section	Extruded by	Date
A (0–15 in.)		
B (15–22.6 in.)		
C (22.6–30 in.)	W.R. Fisher	July 9, 1975

Section No.	Length of Section in.	Description
A	15.0	VOID.
B	7.6	Top 1.2 in. of section was void.
C	7.4	Bottom 0.6 in. of section was void. Layered silty fine to medium sand and stiff brown silty clay. Layers of fine to medium sand from 0.5 cm to 2.0 cm and stiff brown silty clay layers 4.0 and 5.0 cm thick. Used for Test CR-5. Specimen had some necking at the top and 7.0 cm from the top. Grain size distribution determined for the zone of maximum deformation (Fig. 11). Note: There were several small nicks and one dent 1 mm deep in the tube cutting edge.

Distance from top of tube to top of sample = 16.2 in., = 41.2 cm, Ruler # 9

Distance from bottom of tube to bottom of sample = 0.6 in, = 1.4 cm, Ruler # 18

Remarks

Lab. 2-4 rev. 0 28 May 74

APPENDIX 2.5G

CONSOLIDATED UNDRAINED TESTS ON BEACH SANDS

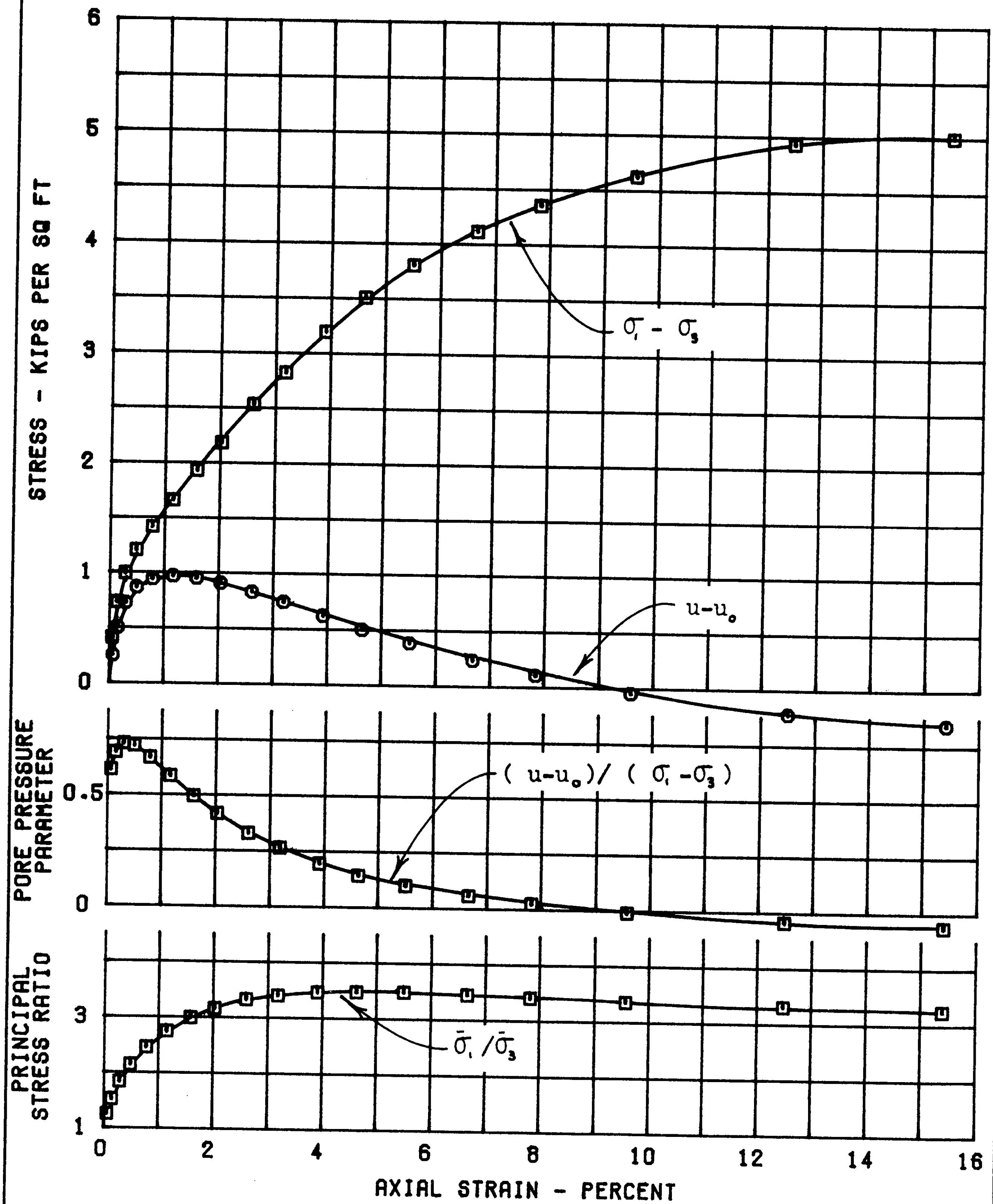
July 1976

Stone & Webster Engineering Corp.
Boston, Massachusetts

STONE & WEBSTER ENGINEERING CORPORATION

TRIAXIAL TEST REPORT

CLIENT NORTHEAST UTILITIES SERVICE COMPANY	J.O. NUMBER 12179	BORING NUMBER P3
SITE MILLSTONE POINT UNIT 3	DATE 1 JUL 76	SAMPLE NUMBER UP4A2
EFFECTIVE CONSOLIDATION PRESSURE: 1.92 KIPS PER SQ FT		DEPTH 32.0 FT

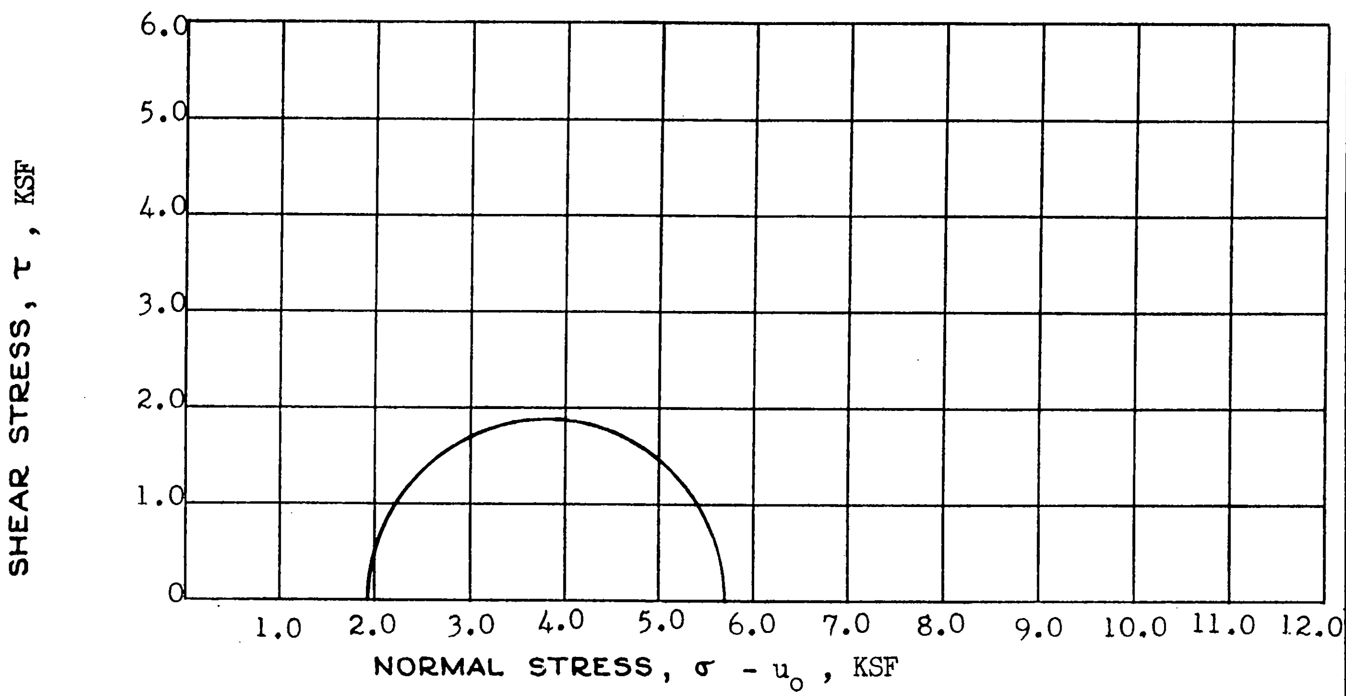


STONE & WEBSTER ENGINEERING CORPORATION

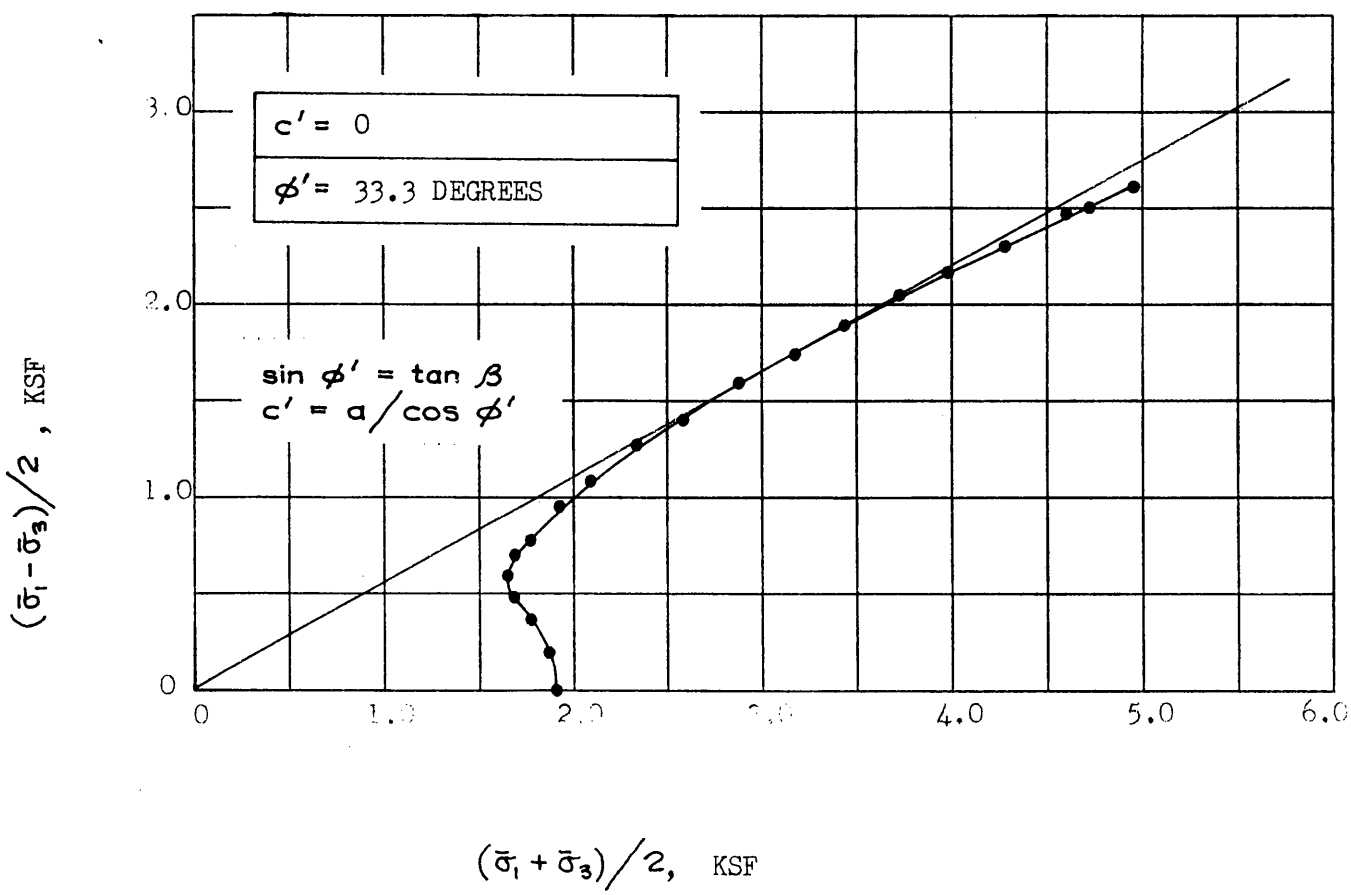
TRIAXIAL TEST STRENGTH SUMMARY

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES SERVICE COMPANY	12179	BORING P3
SITE	**DATE**	**SAMPLE NUMBERS**
MILLSTONE 3	1 JUL 76	UP4A2

TOTAL STRESS CIRCLES



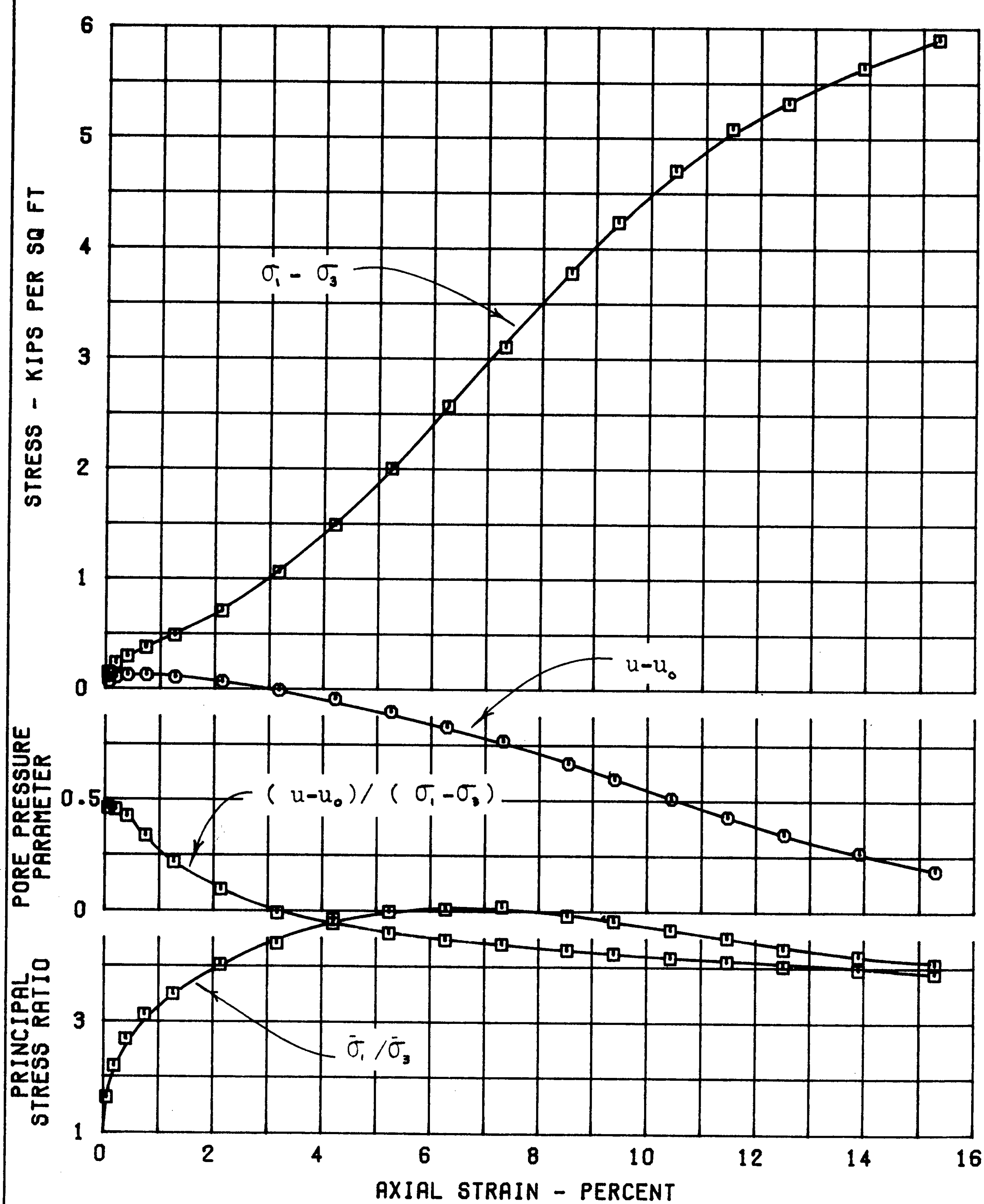
EFFECTIVE STRESS PATHS



STONE & WEBSTER ENGINEERING CORPORATION

TRIAXIAL TEST REPORT

CLIENT	J.O. NUMBER	BORING NUMBER
NORTHEAST UTILITIES SERVICE COMPANY	12179	P4
SITE MILLSTONE POINT UNIT 3	DATE 2 JUL 76	SAMPLE NUMBER UP1A2
EFFECTIVE CONSOLIDATION PRESSURE: 0.30 KIPS PER SQ FT		DEPTH 5.0 FT

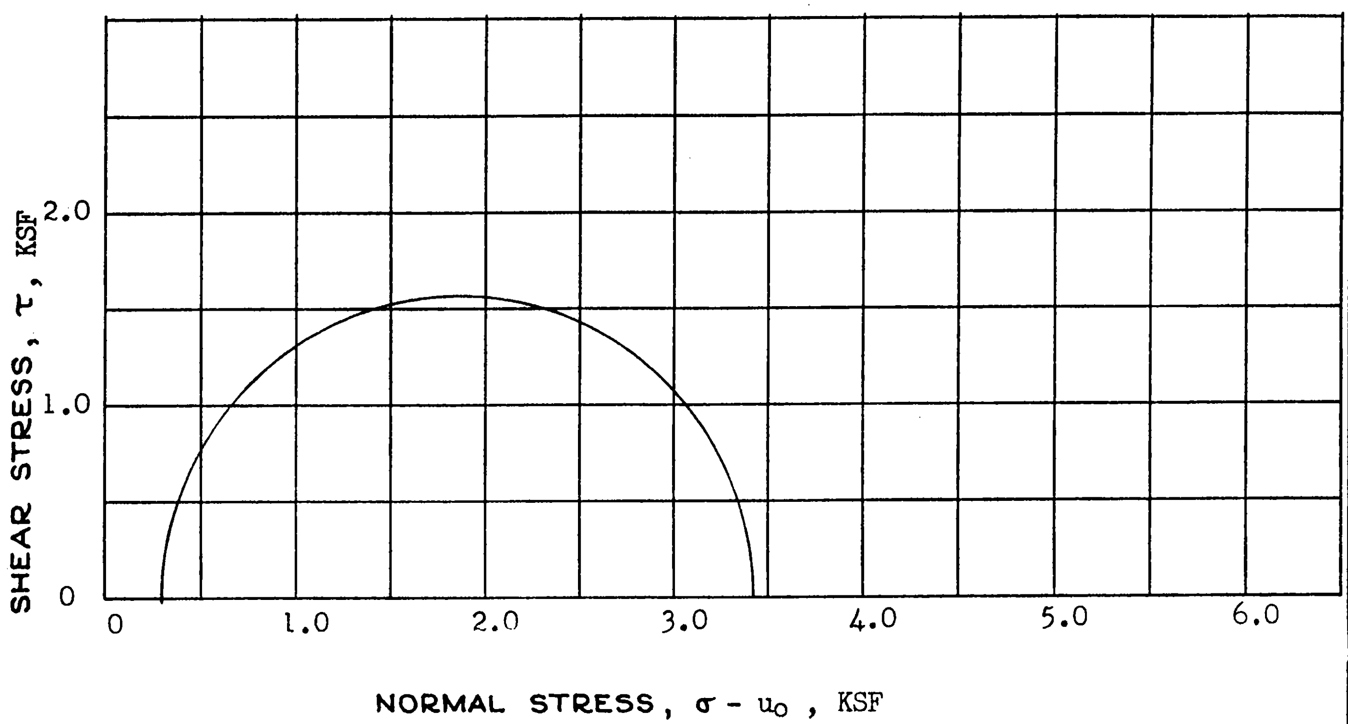


STONE & WEBSTER ENGINEERING CORPORATION

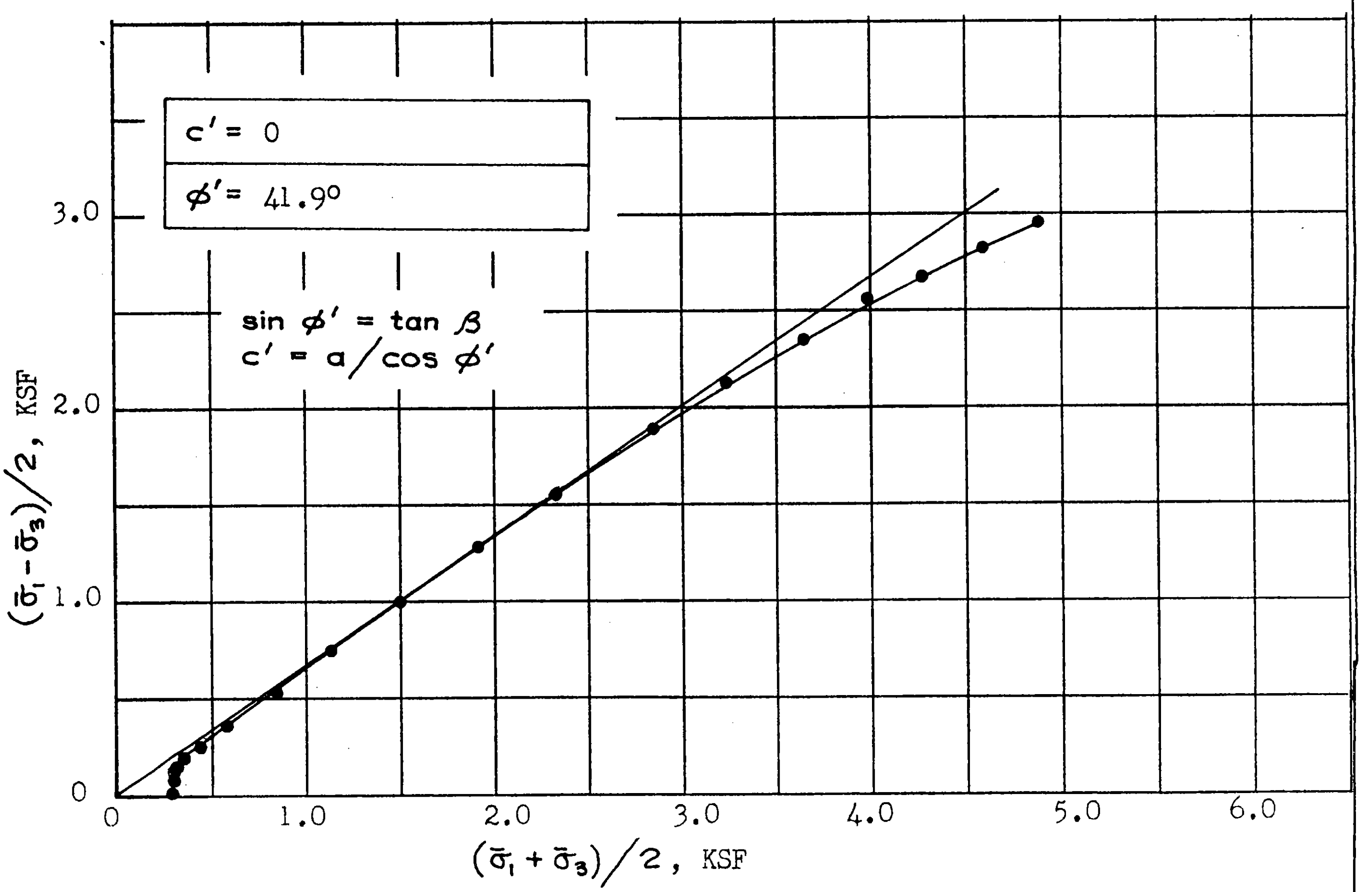
TRIAXIAL TEST STRENGTH SUMMARY

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES SERVICE COMPANY	12179	BORING P4
SITE	**DATE**	**SAMPLE NUMBERS**
MILLSTONE - 3	2 JUL 76	UP1A2

TOTAL STRESS CIRCLES



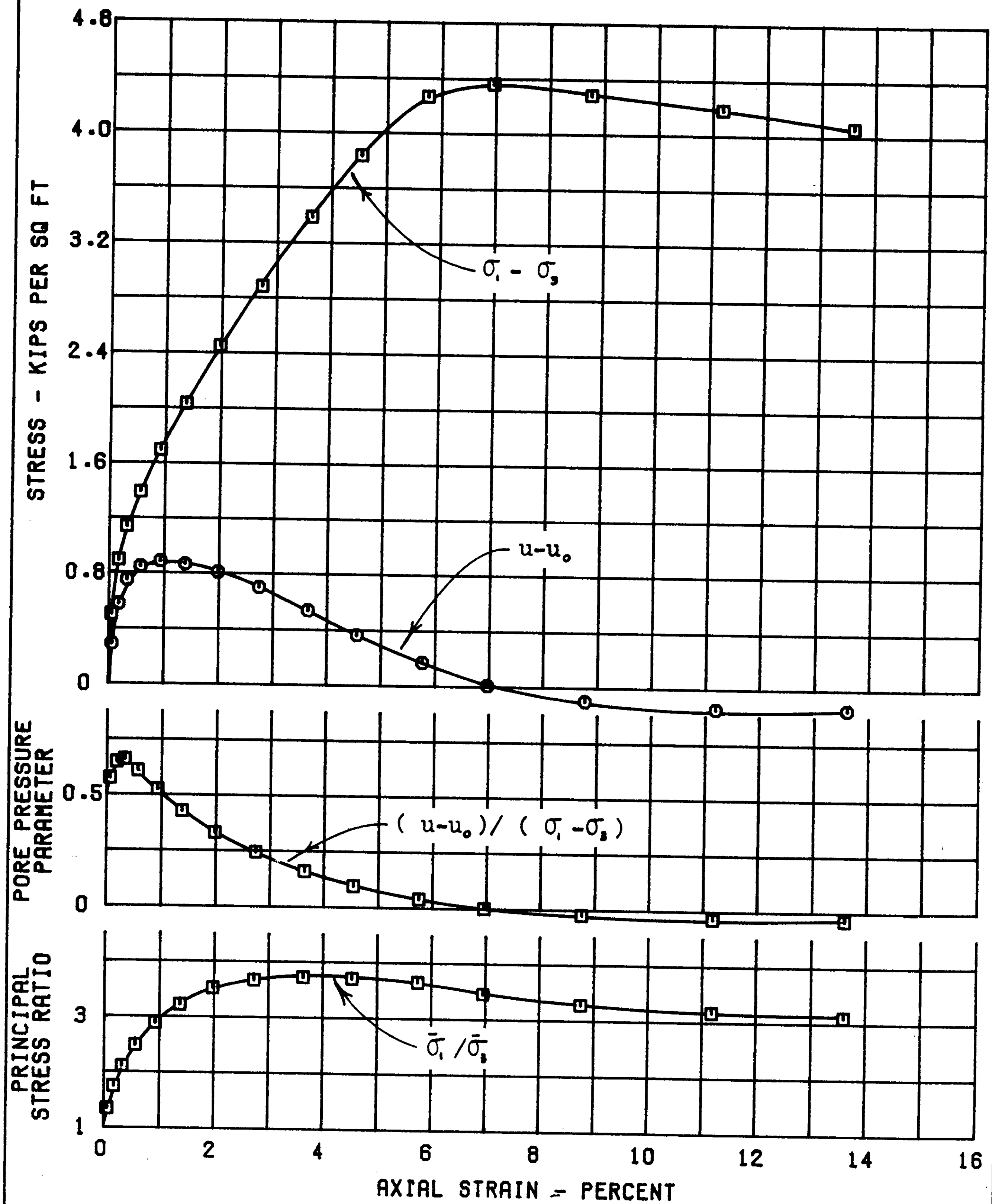
EFFECTIVE STRESS PATHS



STONE & WEBSTER ENGINEERING CORPORATION

TRIAXIAL TEST REPORT

CLIENT NORTHEAST UTILITIES SERVICE COMPANY	J.O. NUMBER 12179	BORING NUMBER P7
SITE MILLSTONE 3	DATE 8 JUL 76	SAMPLE NUMBER UP3A2
EFFECTIVE CONSOLIDATION PRESSURE: 1.78 KIPS PER SQ FT		DEPTH 29.6 FT

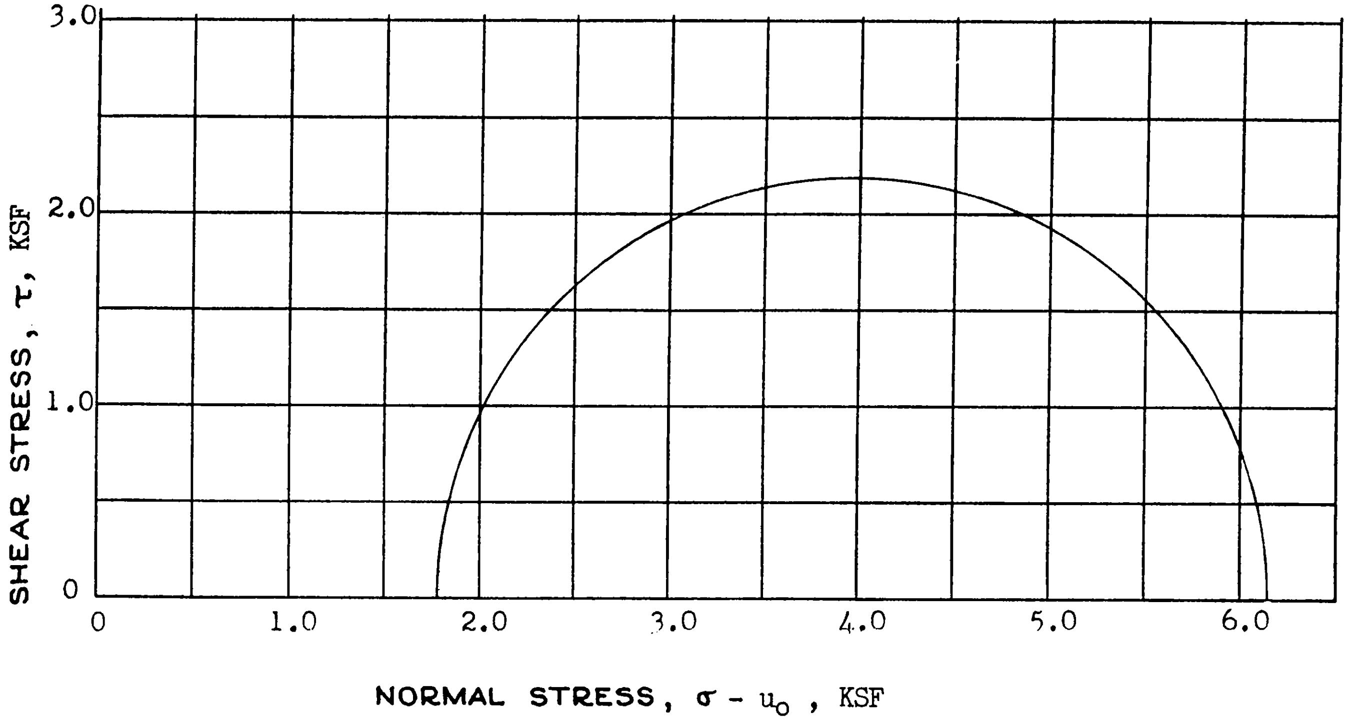


STONE & WEBSTER ENGINEERING CORPORATION

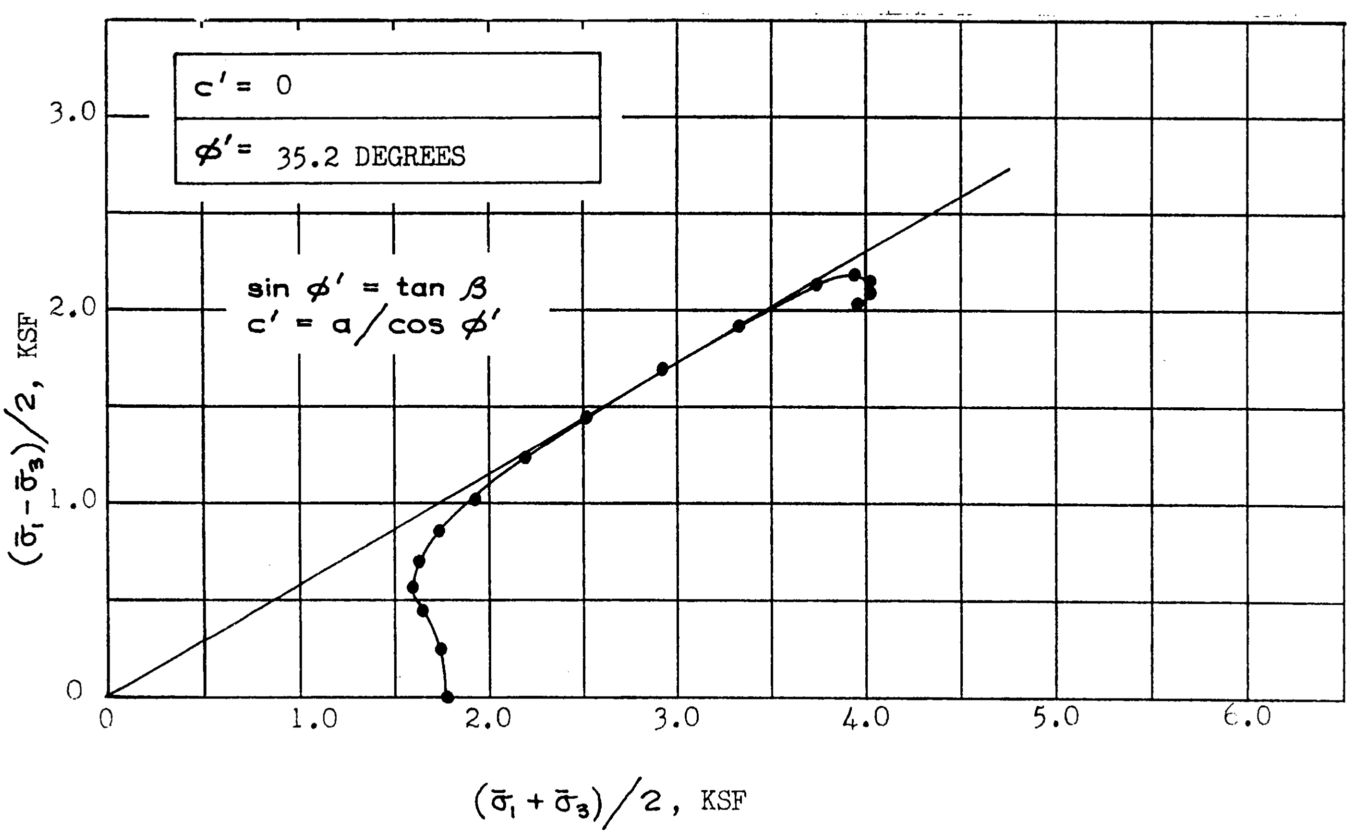
TRIAXIAL TEST STRENGTH SUMMARY

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES SERVICE COMPANY	12179	BORING P7
SITE	**DATE**	**SAMPLE NUMBERS**
MILLSTONE 3	9 JUL 76	UP3A2

TOTAL STRESS CIRCLES

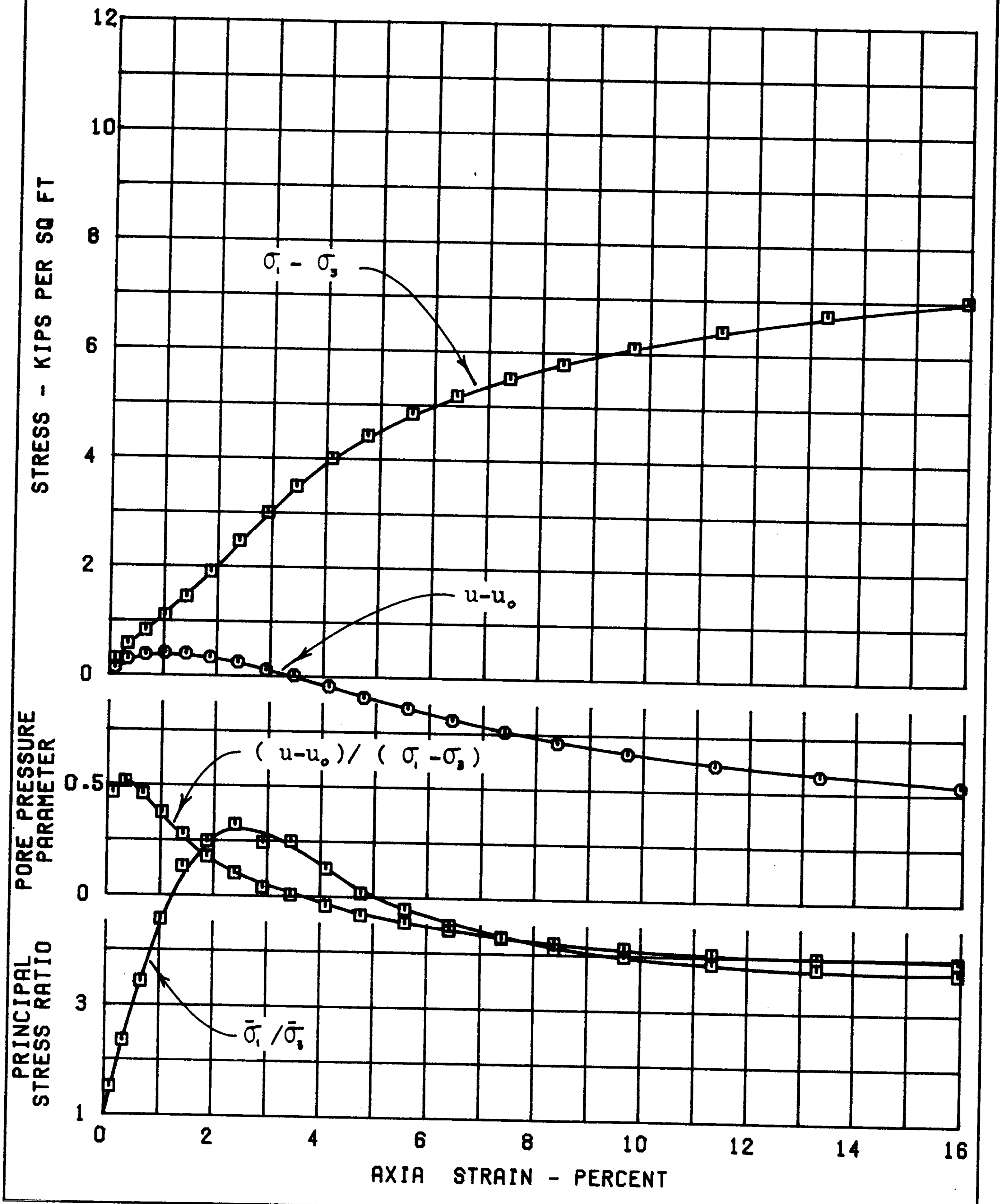


EFFECTIVE STRESS PATHS



TRIAXIAL TEST REPORT

CLIENT NORTHEAST UTILITIES SERVICE COMPANY	J.O. NUMBER 12179	BORING NUMBER P8
SITE MILLSTONE 3	DATE 16 JUL 76	SAMPLE NUMBER UP1A
EFFECTIVE CONSOLIDATION PRESSURE: 0.72 KIPS PER SQ FT		DEPTH 12.0 FT

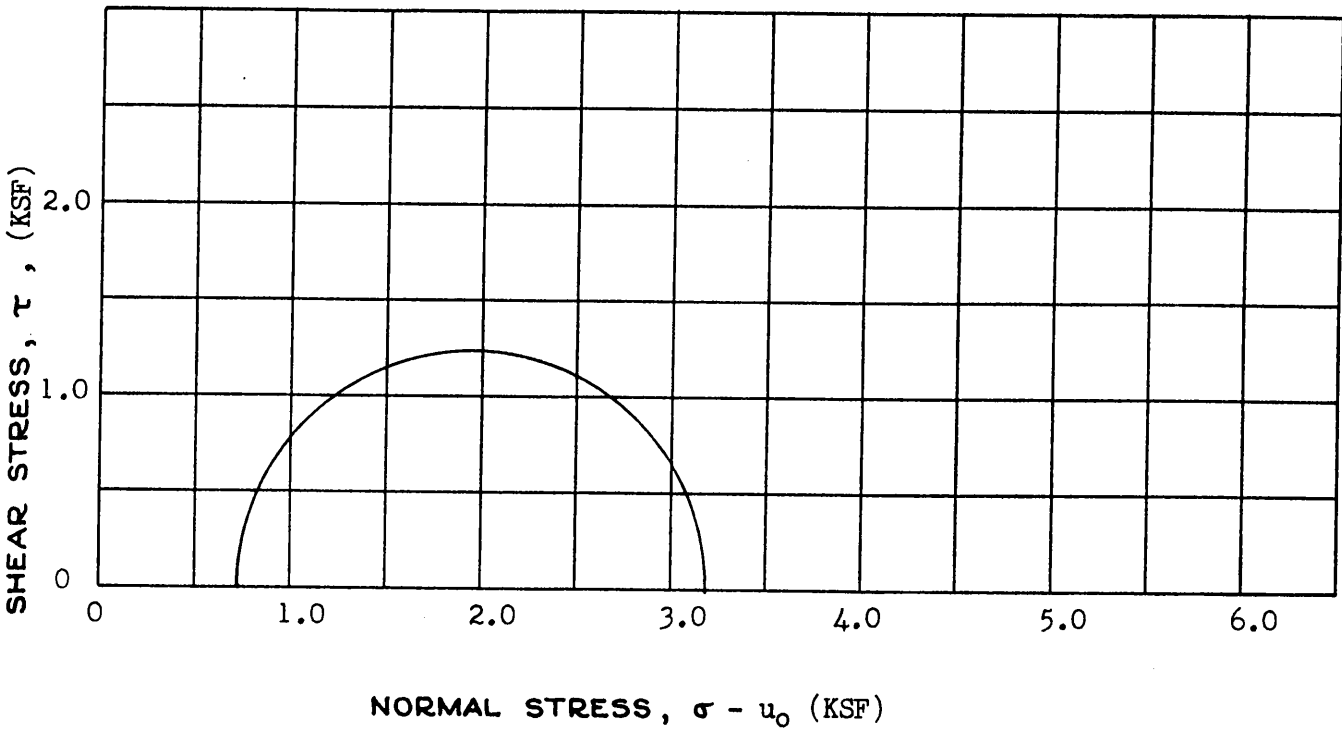


STONE & WEBSTER ENGINEERING CORPORATION

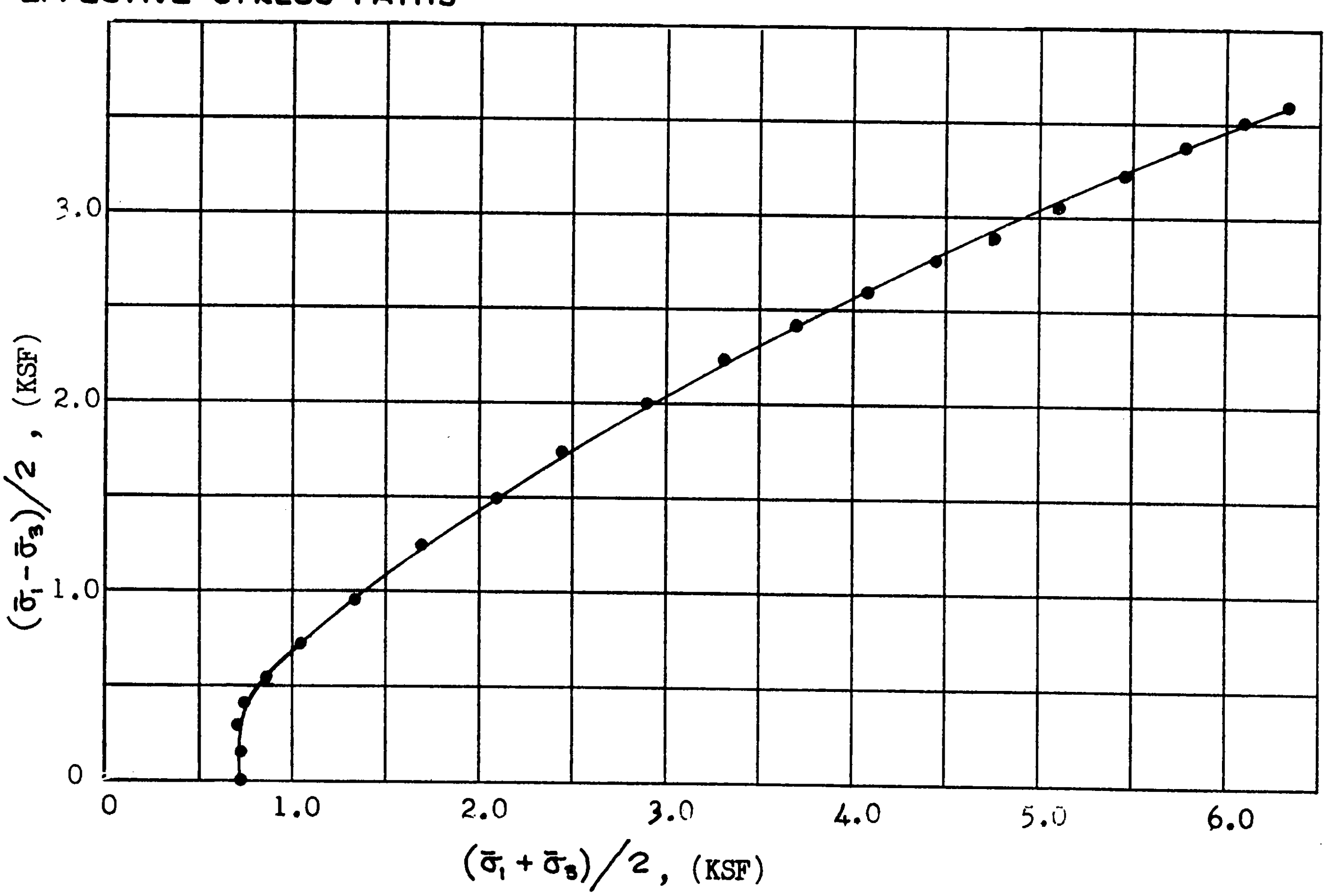
TRIAXIAL TEST STRENGTH SUMMARY

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES SERVICE COMPANY	12179	BORING P8
SITE	**DATE**	**SAMPLE NUMBERS**
MILLSTONE - 3	20 JUL 76	UP1A

TOTAL STRESS CIRCLES



EFFECTIVE STRESS PATHS



APPENDIX 2.5H

SEISMIC VELOCITY MEASUREMENTS

April 1972

Weston Geophysical Engineers, Inc.
Weston, Massachusetts

WESTON GEOPHYSICAL ENGINEERS, INC.

POST OFFICE BOX 306
WESTON, MASSACHUSETTS 02193
617 899-0060

April 19, 1972

Northeast Utilities Service Company
Post Office Box 270
Hartford, Connecticut 06101

Gentlemen:

Seismic velocity measurements were conducted at the site of the proposed Millstone Nuclear Power Plant in Connecticut in accordance with your Purchase Order Number 202144, dated September 2, 1971. The field work for this investigation was performed during the period of February 8 through 28, 1972.

This investigation was coordinated in the field by Mr. V. R. Nivargikar and Mr. Ralph Borjeson, Soils Engineer, Stone & Webster Engineering Corporation, and directed by our supervising geophysicist, Mr. Edward N. Levine.

Preliminary data have been submitted; this is a formal presentation of our findings.

Sincerely,

WESTON GEOPHYSICAL ENGINEERS, INC.

Thomas F. Sexton

TFS/cvt

SEISMIC VELOCITY MEASUREMENTS

MILLSTONE NUCLEAR POWER STATION

for

NORTHEAST UTILITIES SERVICE COMPANY

under the direction of

STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

WESTON, MASSACHUSETTS

SEISMIC VELOCITY MEASUREMENTS

MILLSTONE NUCLEAR POWER STATION

INTRODUCTION

This geophysical study consisted of the measurements of compressional "P" wave velocities and transverse "S" wave velocities using both downhole and cross-hole techniques.

Field work was completed during February 1972. The locations of these measurements were determined by the proposed plant layout and by the results of the seismic refraction survey conducted at Millstone during August 1971.

All of the borings shown on the enclosed plan map were used in making the cross-hole velocity measurements of the bedrock. Downhole velocity measurements of the bedrock were made in Boring 305, a hole drilled to Elevation -99 feet near the center of the proposed reactor.

Previous seismic refraction surveys and the logs of Borings 310, 313, 315, and 318 indicated the presence of dense glacial till in the Turbine area. Accordingly, those borings were used for the cross-hole velocity measurements of the glacial till.

FIELD PROCEDURE

Instrumentation

Photographic recordings were obtained using a portable twelve-channel seismograph. This seismograph amplifies and filters the seismic signals detected by three-dimensional geophones. Seismic energy was generated with explosives. Timing lines are provided across the entire recording at two-millisecond intervals. This timing system allows direct readings to a millisecond and with sharp "breaks" (high signal-to-noise ratio), readings can be made to a half millisecond.

Cross-hole Measurements

These measurements were made using three-dimensional geophones containing one vertical and two orthongonal horizontal elements. Seismic energy was generated in one hole and detected by the geophones in the three or four remaining holes with the seismic source and geophones at the same elevation level. This procedure was repeated using different combinations of shot source and detector arrays.

Downhole Measurements

These measurements were made with three, three-dimensional geophones positioned at 10-foot intervals in Boring 305. Energy was generated near the top of bedrock just below the casing of an adjacent hole, Boring 317. Measurements of the "P" and "S" wave arrivals were made down the length of the hole by overlapping a geophone position each time the array was lowered.

RESULTS - REACTOR AREA

In the vicinity of the reactor where bedrock is shallow, the seismic velocity measurements using cross-hole techniques were uniform throughout the elevations investigated, which range from +10 feet to -50 feet.

Downhole velocity measurements were made in Boring 305 from Elevation +5 feet to Elevation -99 feet. The data were uniform for the "P" wave velocity but some slight scattering of the data points resulted in a velocity range for the "S" wave of ±300 feet per second from the value reported below.

Elevation	"P" Wave ft./sec.	"S" Wave ft./sec.	Poisson's Ratio	Young's Modulus lbs./in.^{2}	Shear Modulus lbs./in.^{2}
+10 to -50*	12,800	6,500	.33	3.99×10^6	1.50×10^6
+5 to -99**	13,500	6,500	.35	4.05×10^6	1.50×10^6

Rock Density - 165 lbs./ft.^{3}
Density values for moduli computation provided by Stone & Webster Engineering Corporation.

*Cross-hole values

**Downhole values

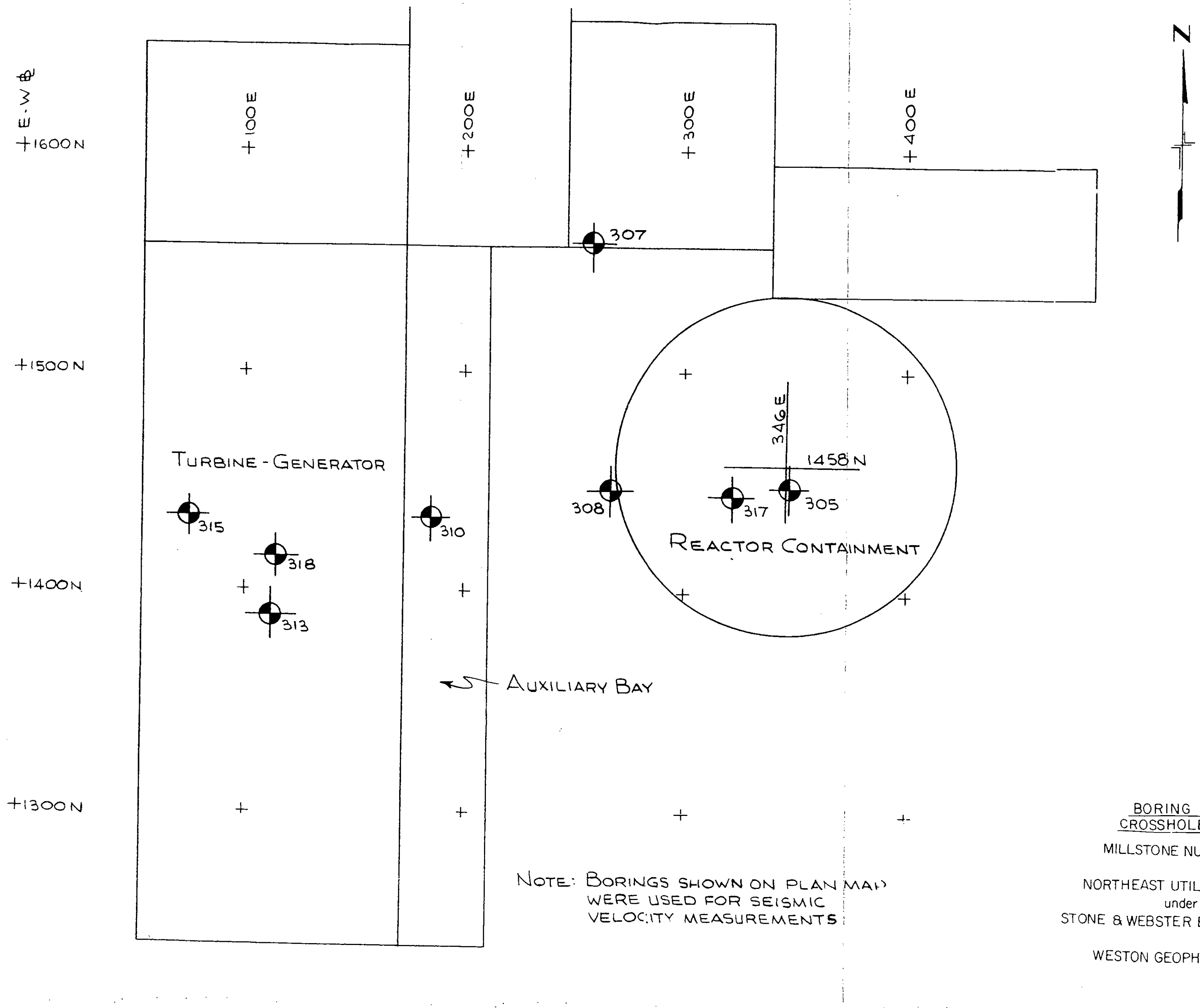
RESULTS – TURBINE AREA

Velocity measurements of the overburden materials indicate that two distinct glacial tills are present in the turbine area. The following seismic velocity profile and elastic moduli values are representative of Borings 313 and 318.

Elevation	"P" Wave ft./sec.	"S" Wave ft./sec.	Poisson's Ratio	Young's Modulus lbs./in.^{2}	Shear Modulus lbs./in.^{2}
+15 to +4	5,600	1,400	.47	1.49×10^5	5.08×10^4
+4 to -24	6,800	2,200	.44	4.07×10^5	1.41×10^5
-24 to -44	12,800	6,500	.33	3.99×10^6	1.50×10^6

+15 to +4 (Density - 120 lbs./ft.^{3})
+4 to -24 (Density - 135 lbs./ft.^{3})
-24 to -44 (Density - 165 lbs./ft.^{3})

Density values for moduli computation provided by Stone & Webster Engineering Corporation.



BORING LOCATIONS FOR
CROSSHOLE MEASUREMENTS

MILLSTONE NUCLEAR POWER PLANT
for
NORTHEAST UTILITIES SERVICE COMPANY
under the direction of
STONE & WEBSTER ENGINEERING CORPORATION
by
WESTON GEOPHYSICAL ENGINEERS, INC.

APPENDIX 2.5I

DIRECT SHEAR TESTS ON NATURAL ROCK JOINTS

Stone & Webster Engineering Corp.
Boston, Massachusetts

DIRECT SHEAR TESTS
ON NATURAL ROCK JOINTS
MILLSTONE NUCLEAR POWER STATION
UNIT 3 12179

J.O.No. 12179

DIRECT SHEAR TESTS ON NATURAL ROCK JOINTS

Direct shear tests were conducted on samples of both foliation and joints to determine the coefficient of friction for each plane. This information will be utilized in the stability analysis of the rock slopes produced by the containment structure and engineered safety building and the design of the ring girder. Since the normal forces on the joints and foliations encountered at these depths are relatively low, a direct shear machine capable of applying low normal forces and sensitive enough to measure the shear force was required. The method of testing outlined below was developed, using a direct shear machine specifically designed for testing soil samples.

Equipment

A Leonard Farnell Model 306 direct shear machine with a 10 cm square shear box was used. This is a constant rate-of-strain machine with a displacement rate variable from 1 mm/hr to 40 mm/hr and a maximum displacement of about 12 mm. The machine is shown schematically in Figure 2J-1. The normal load mechanism of this machine has been modified by the addition of a bellofram air piston which acts against the hanging yoke to produce the normal load. This allows easier operation and higher normal forces (to 2,000 lb max) to be applied. Measurement of the shear force was done with proving rings with a capacity of either 400 lb or 1,200 lb. The displacements were measured by dial gages accurate to 0.01 mm.

Two square frames with inside dimensions slightly less than 10 cm x 10 cm were made from 3/4 in. and 7/8 in. square steel stock. Pins were located at each corner of the frames so exact alignment of the inside frame edges could be maintained. These frames were used to cast the joint samples in capping material for placement in the shear box. Plastic templates 1/8 in. and 1/16 in. thick with center cutouts were also made to facilitate alignment of the sample pieces.

Sample Preparation

The two pieces of a joint sample were trimmed by sawing or splitting the core to about a 3/4 in. thickness measured perpendicular to the joint surface. Each piece was then cast individually in capping compound, using the frames and templates to form top and bottom blocks slightly less than 10 cm sq by 5/8 in. and 7/8 in. thick, respectively. The capping compound, Hydrostone, is a high-strength (11,000 psi), quick-set, gypsum-based cement.

The bottom piece was cast first, with the joint surface parallel to the top and bottom faces of the frame and centered in the frame. The desired shearing direction was also aligned parallel to an edge of the frame. The top piece was cast next by placing it on the previously cast bottom piece in the natural orientation and aligning the top frame, with the pins, on the bottom frame. This procedure automatically centered and correctly oriented the top piece in the top frame. Filler and spacer templates were used during the casting to prohibit any capping compound from getting on the joint surface and to ensure that the upper and lower blocks remained parallel. After the top block was allowed to cure, both blocks were removed from the frames.

The blocks were placed in the shear box, maintaining the correct joint orientation and shearing direction, and the dial gages attached and zeroed. The tests were run at a displacement rate of 35 mm/hr, with readings taken at about 0.5 mm displacement intervals.

This method of sample preparation was employed for the following reasons: First, it allowed several samples to be prepared and held to test at one time. This reduced the time the machine was used, so other testing could be done. Second, casting directly in the machine shear box frames would have monopolized the machine and could possibly have damaged the frames. Third, this method allowed the upper block to move vertically, independent of the shear box frame. Fourth, no load acted through the shear box frames, so the frictional drag induced from the box was negligible. Fifth, this method ensured that the joint plane was fixed parallel to the shear force and perpendicular to the normal force when the sample was placed in the machine.

Millstone Testing Program

A total of 24 shear tests were run on eight samples taken from borings around the containment. Each sample was run at normal stresses of 50, 100, and 200 psi. All the samples were fairly smooth; one exhibited slickensides, and some had a coating. Samples 8 and 9 were along the foliation, and sample 10 was cut parallel to the foliation; the others were all high angle joints. A complete list of samples is shown as Table 1. Two samples (Nos. 5 and 7) were not tested.

The normal force was held constant throughout each test. Shear force and displacement normal to the joint surface were measured at increments of the horizontal displacement.

Results

The results of each shear test are plotted as plots of shear vs. horizontal displacement. The peak and final shear force values, ϕ values, are given in Table 2. Figure 2 shows the peak and final ϕ values for the joints plotted as shear stress vs. normal stress; Figure 3 shows the ϕ values for the foliations tested (samples 8, 9, and 10).

The shear force vs. horizontal displacement plot (Appendix A) illustrates the variations in the shear strength across the sample. In these tests, the peak shear force was defined as the maximum recorded shear force, and the final shear force was defined as the last reading. Samples 1 through 6, being natural joints, gave somewhat irregular results. The irregular nature of the graphs indicates the effect of the asperities of the natural joint surface; in fact, the residual value was probably never achieved. The irregularities were overridden more easily at the lower normal stresses; however, at the higher normal stresses, the asperities become more important, as noted in the graphs. Some rock flour was developed on all the samples. Samples 8 and 9 were samples taken parallel to the foliation, and sample 10 was cut parallel to the foliation. Asperities were less of a factor along the foliation surfaces, although again rock flour was developed.

Photographs of the samples and profiles of the samples are shown in Appendix B.

Conclusion

The results of these direct shear tests indicate that the natural joints have an observed angle of friction of 34 deg and that the foliation has a friction angle of 32 deg. The added strength of the asperities has not been considered, and an irregularity component of zero is assumed.

Bibliography

Coulson, J. H. (1972), "Shear Strength of Flat Surfaces in Rock," in Stability of Rock Slopes, E. J. Cording (Ed.), Proceedings of 13th Symposium on Rock Mechanics, September, 1971, at University of Illinois, published by ASCE, 1972, pp. 77-105.

Donath, F. A., L. S. Fruth, Jr., and W. A. Olsson, "Experimental Study of Frictional Properties of Faults," in New Horizons in Rock Mechanics, H. Reginald Hardy and Robert Stefanko (Eds.), Proceedings of 14th Symposium on Rock Mechanics, June, 1972, at Penn State, published by ASCE, 1973, pp. 189-222.

Goodman, R. E. (1970), "The Deformability of Joints," in Determination of the In Situ Modulus of Deformation of Rock, ASTM STP 477, American Society for Testing Materials, 1970, pp. 174-196.

TABLE 1

DESCRIPTION OF SAMPLES

Sample	Boring	Depth	Description
1	305	48 ft	Joint dipping at approximately 65 deg, smooth surfaces with green coating
2	305	39 ft	Joint dipping at approximately 65 deg, smooth surfaces with slight coating
3	305	38 ft	Joint dipping at approximately 65 deg, with smooth surfaces
4	317	69 ft	Joint dipping at approximately 55 deg, smooth surfaces with white coating and slickensides (parallel to dip)
5	317	45 ft	Joint dipping at approximately 65 deg, fairly smooth surfaces, with coating and slickensides
6	317	23 ft	Joint dipping at approximately 85 deg, smooth surfaces with some coating
7	305	118 ft	Parting dipping at approximately 25 deg, in biotite seam (foliation)
8	317	56 ft	Parting dipping at approximately 35 deg, in biotite foliation
9	305	120 ft	Parting dipping at approximately 40 deg, fairly smooth foliation
10	305	121 ft	Cut surface through biotite seam dipping at 40 deg, parallel to the foliation

TABLE 2

LIST OF PEAK AND FINAL SHEAR STRESSES

Sample Nos.	Normal Stress	Shear Stress (Max)	Shear Stress (Final)
Joints			
1	50	47.2	29.4
	100	84.5	62.3
	200	150.3	133.7
2	50	55.3	36.0
	100	79.8	74.4
	200	147.5	129.6
3	50	49.5	27.7
	100	86.3	61.1
	200	149.6	124.5
4	50	37.1	33.1
	100	75.0	68.4
	200	152.9	146.2
6	50	46.9	32.8
	100	88.7	52.1
	200	189.1	138.1
Foliation			
8	50	44.7	34.6
	100	77.7	71.9
	200	138.7	127.6
9	50	45.9	42.3
	100	83.9	80.0
	200	158.2	131.0
10	50	30.0	28.7
	100	62.2	62.0
	200	127.6	127.2

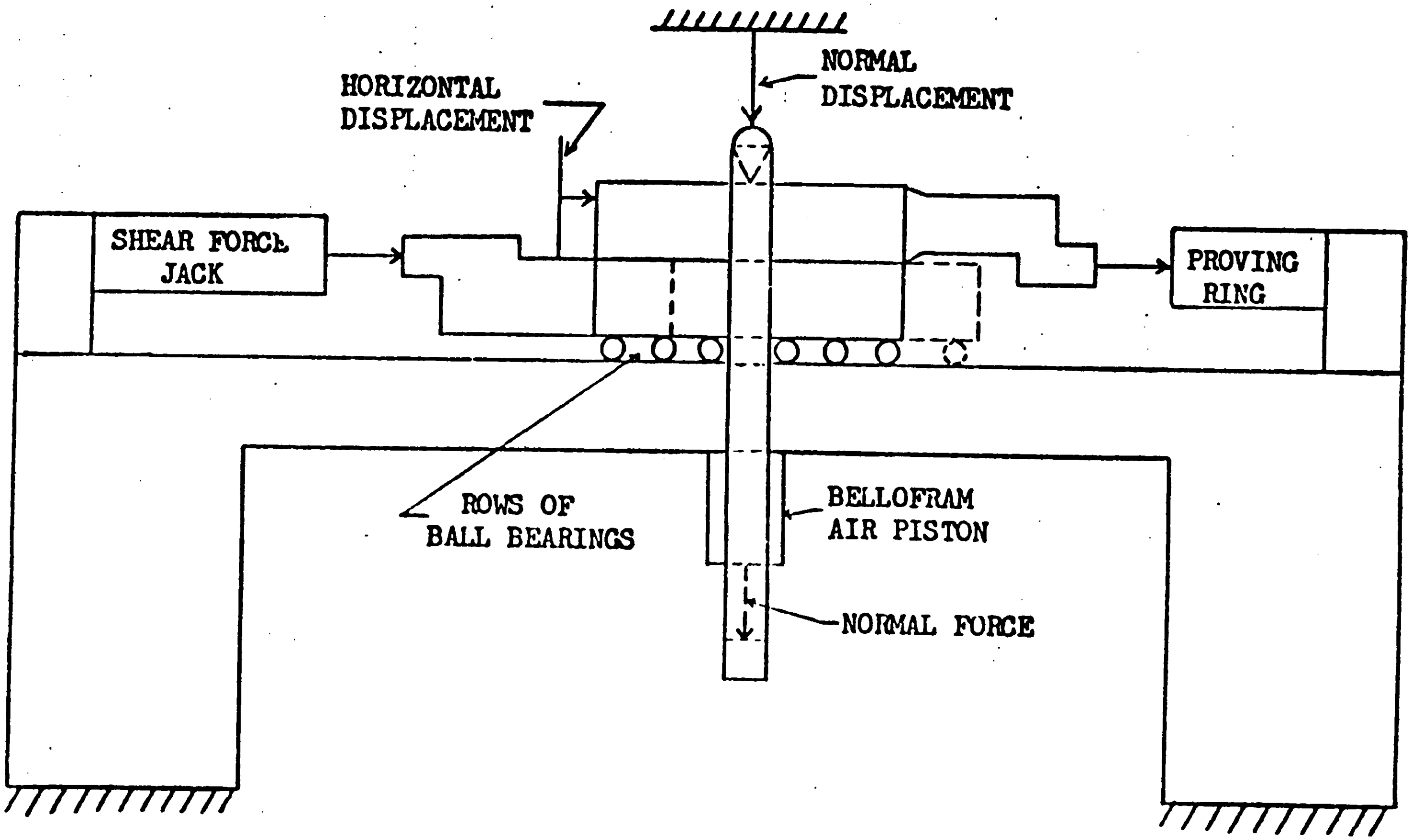
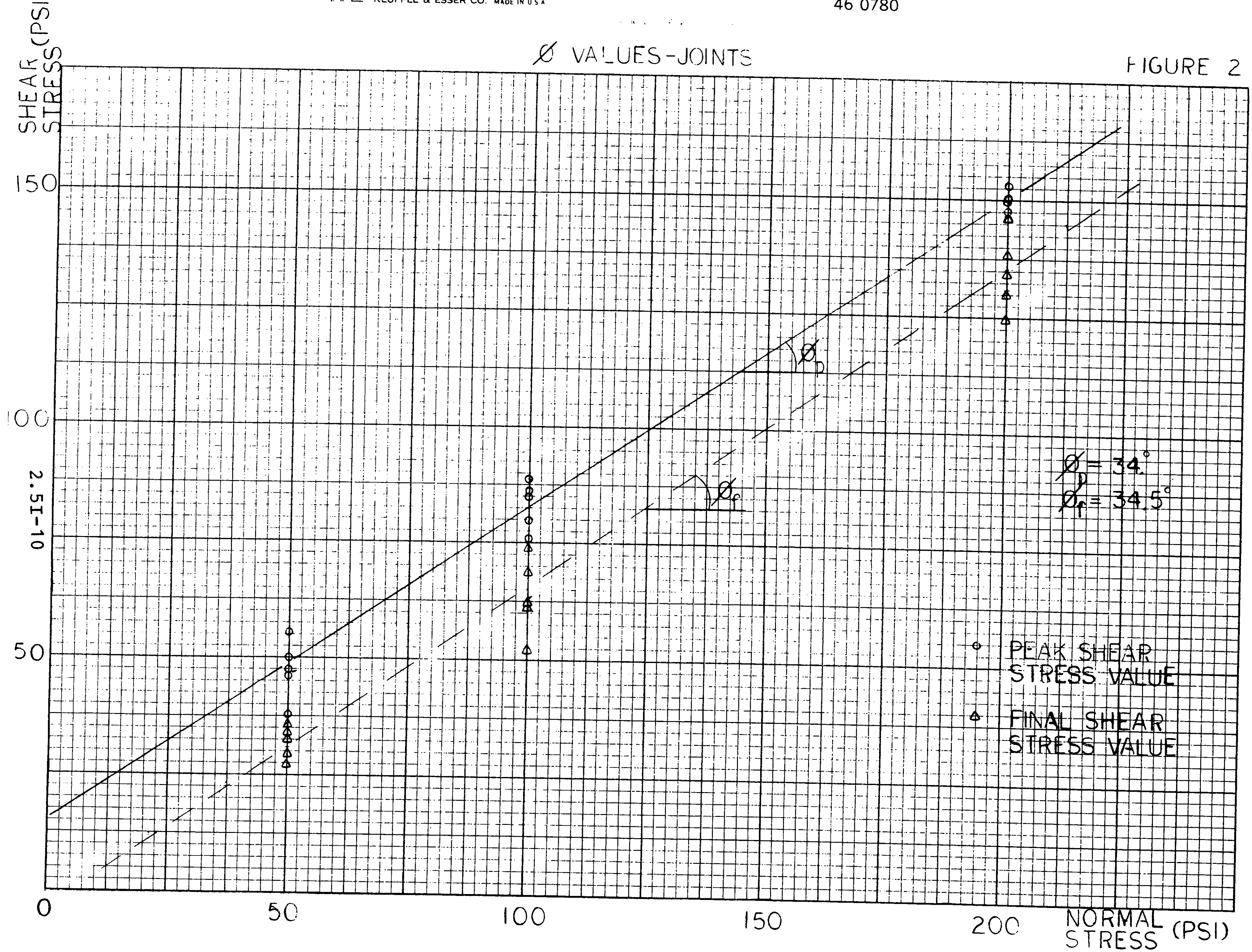


FIGURE 2J-1 - SCHEMATIC OF DIRECT SHEAR MACHINE

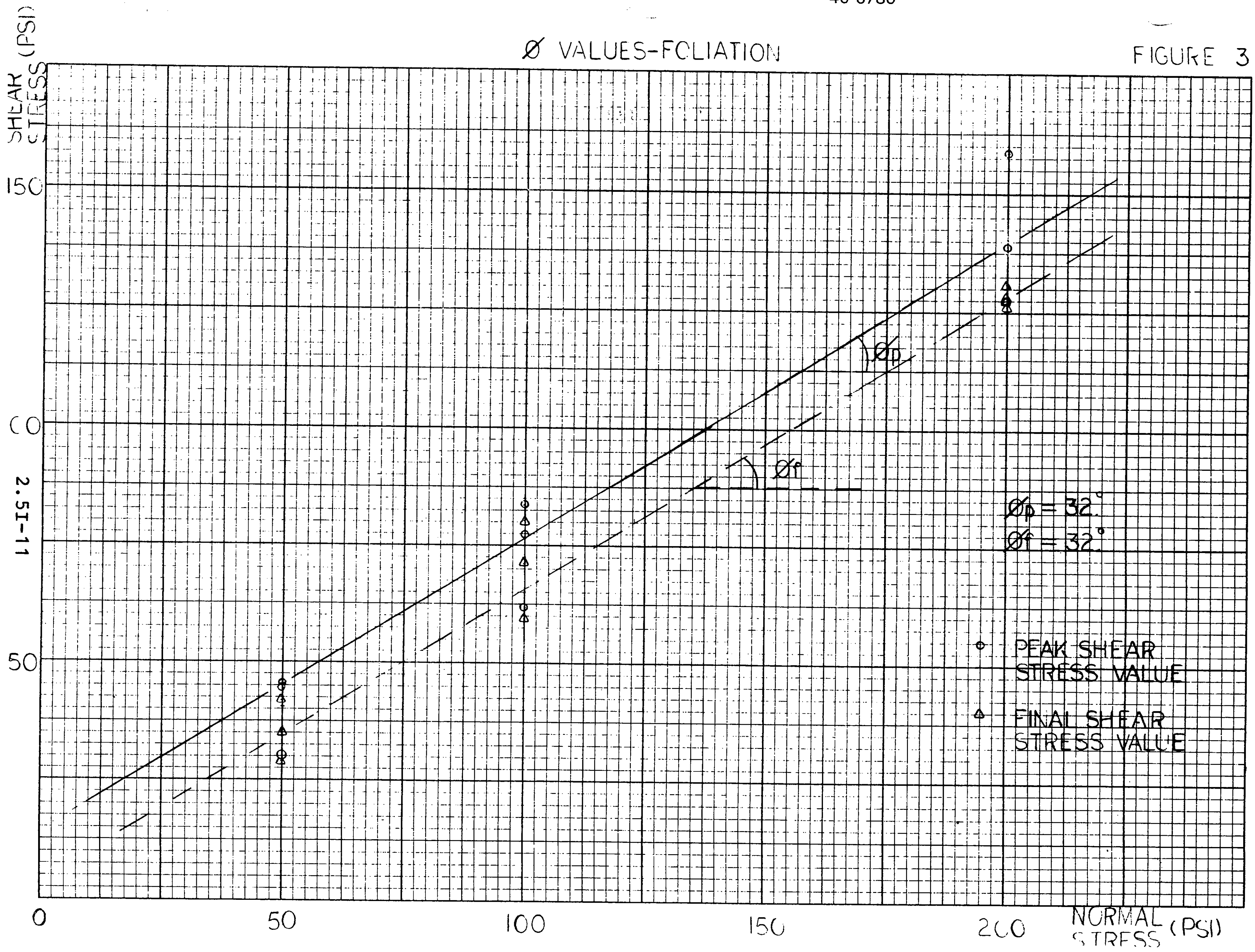
Ø VALUES-JOINTS

FIGURE 2



Ø VALUES-FOLIATION

FIGURE 3

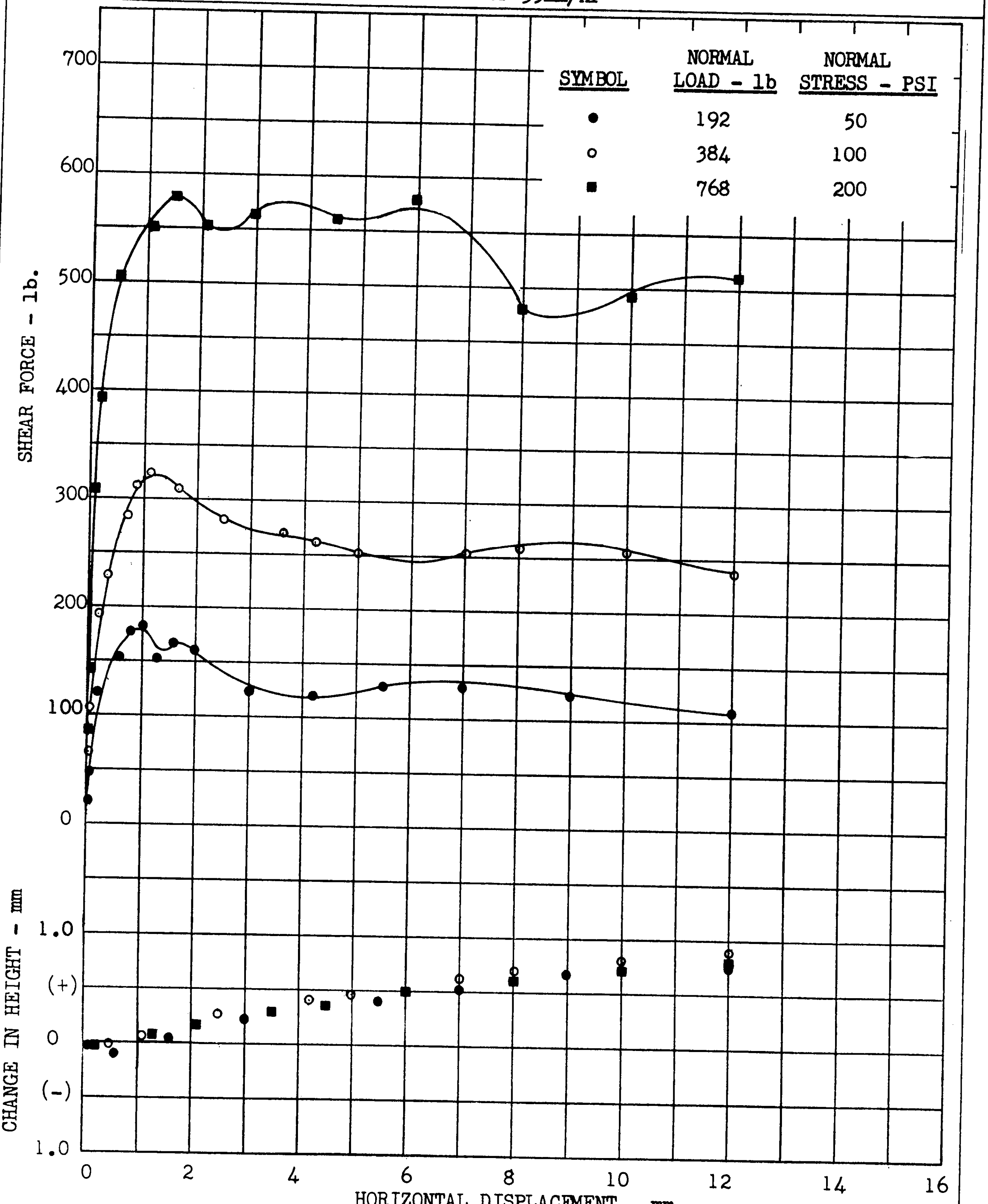


STONE & WEBSTER ENGINEERING CORPORATION

DIRECT SHEAR TEST REPORT

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO)	12179	-
SITE	**DATE**	**SAMPLE NUMBERS**
MILLSTONE 3	7 APR 76	SPECIMEN 1

ALL TESTS RUN AT HORIZONTAL DISPLACEMENT OF 35mm/hr

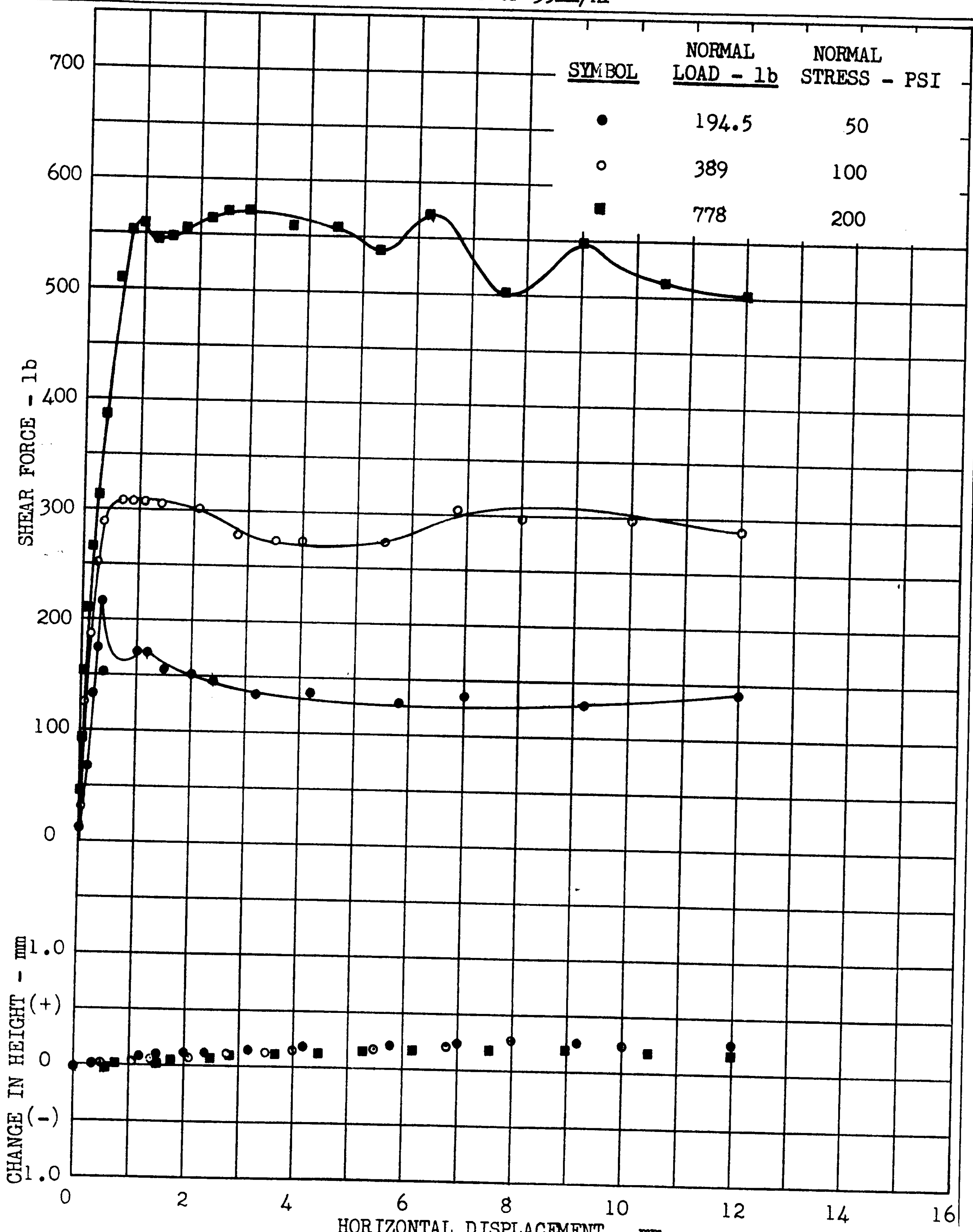


STONE & WEBSTER ENGINEERING CORPORATION

DIRECT SHEAR TEST REPORT

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO)	12179	-
SITE	**DATE**	**SAMPLE NUMBERS**
MILLSTONE 3	9 APR 76	SPECIMEN 2

ALL TESTS RUN AT HORIZONTAL DISPLACEMENTS OF 35mm/hr

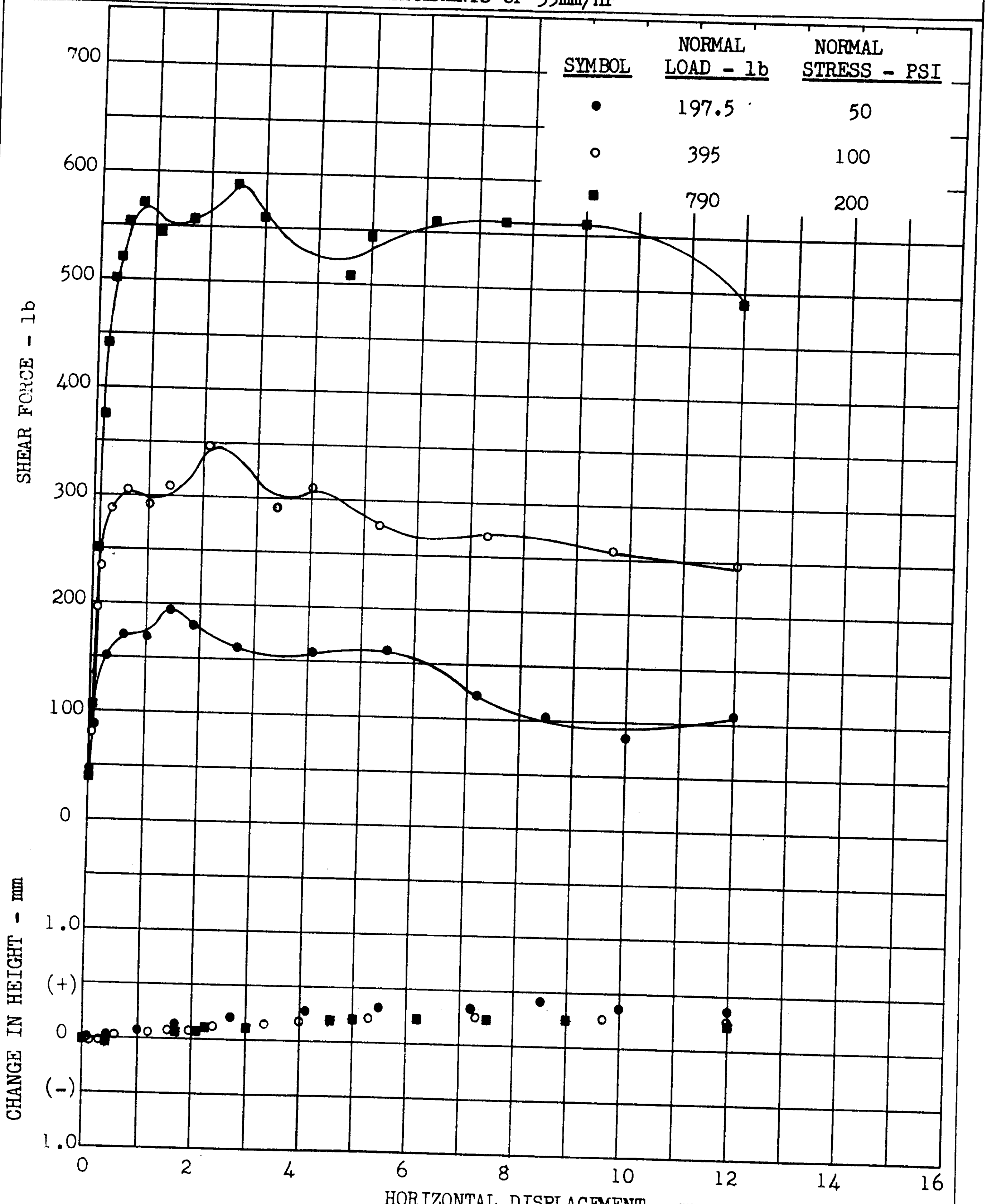


STONE & WEBSTER ENGINEERING CORPORATION

DIRECT SHEAR TEST REPORT

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO)	12179	-
SITE	**DATE**	**SAMPLE NUMBERS**
MILLSTONE 3	14 APR 76	SPECIMEN 3

ALL TESTS RUN AT HORIZONTAL DISPLACEMENTS OF 35mm/hr

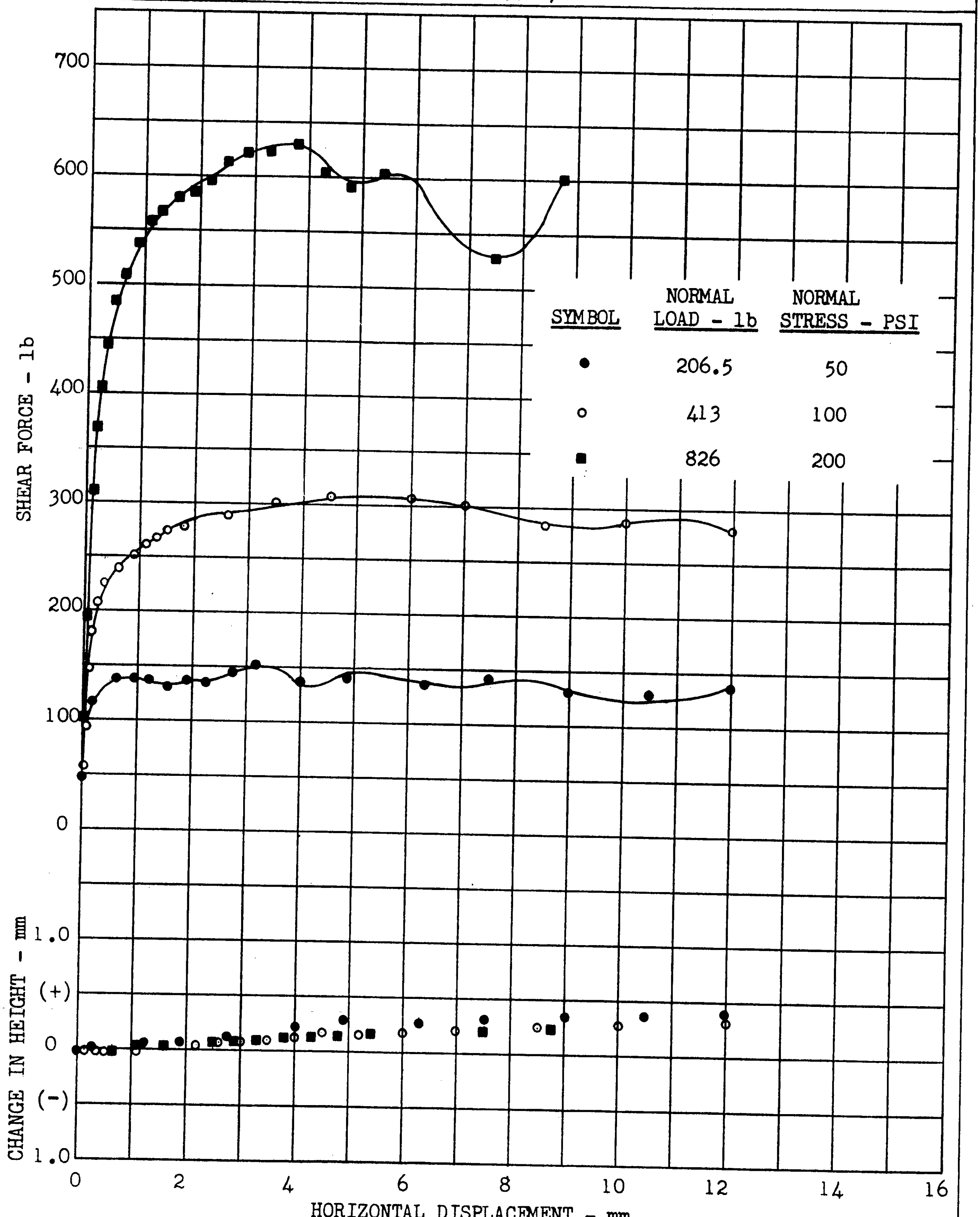


STONE & WEBSTER ENGINEERING CORPORATION

DIRECT SHEAR TEST REPORT

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO)	12179	-
SITE	DATE	SAMPLE NUMBERS
MILLSTONE 3	9 APR 76	SPECIMEN 4

ALL TEST RUN AT HORIZONTAL DISPLACEMENTS OF 35mm/hr

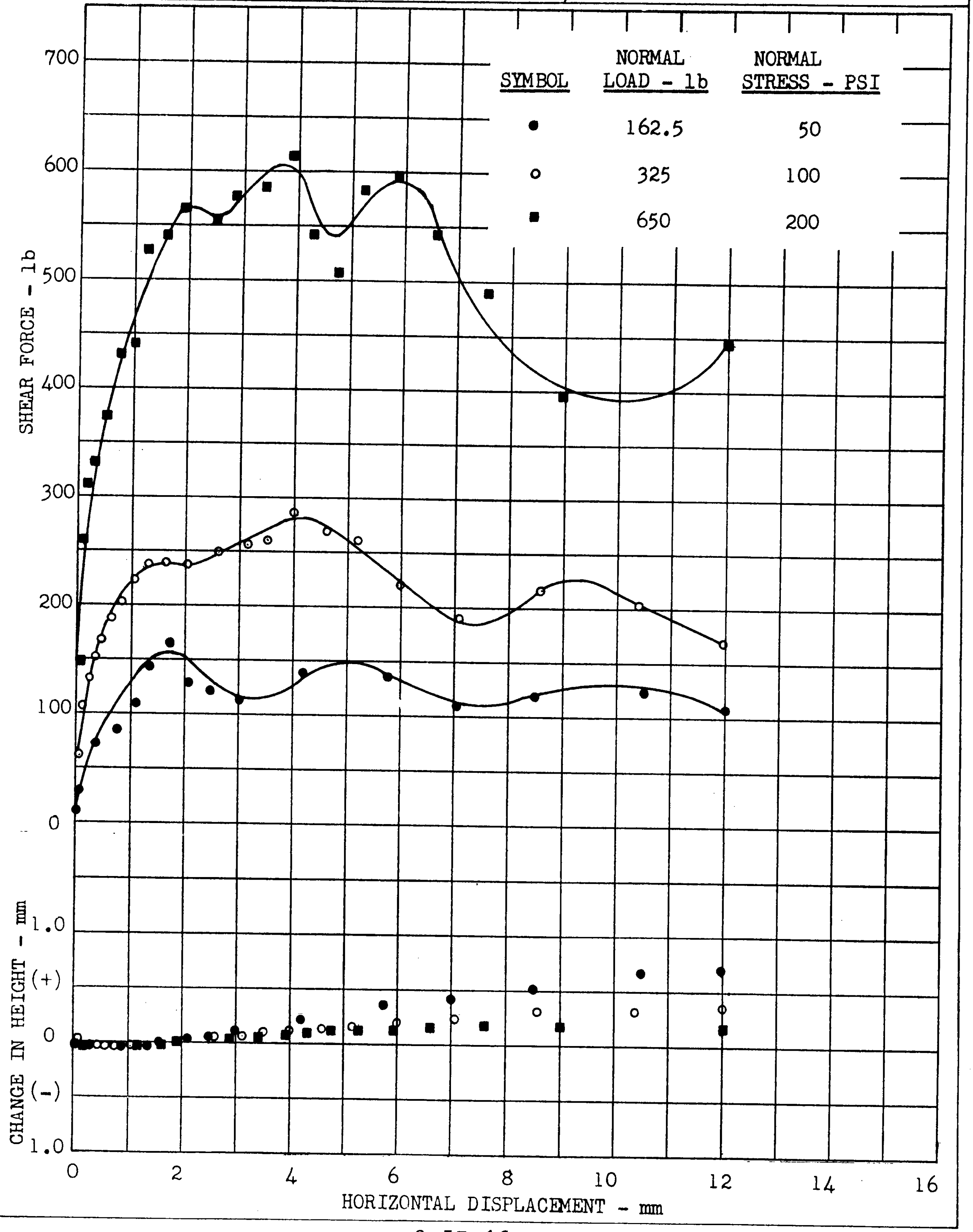


STONE & WEBSTER ENGINEERING CORPORATION

DIRECT SHEAR TEST REPORT

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO)	12179	-
SITE	**DATE**	**SAMPLE NUMBERS**
MILLSTONE 3	23 APR 76	SPECIMEN 6

ALL TESTS RUN AT HORIZONTAL DISPLACEMENTS OF 35mm/hr

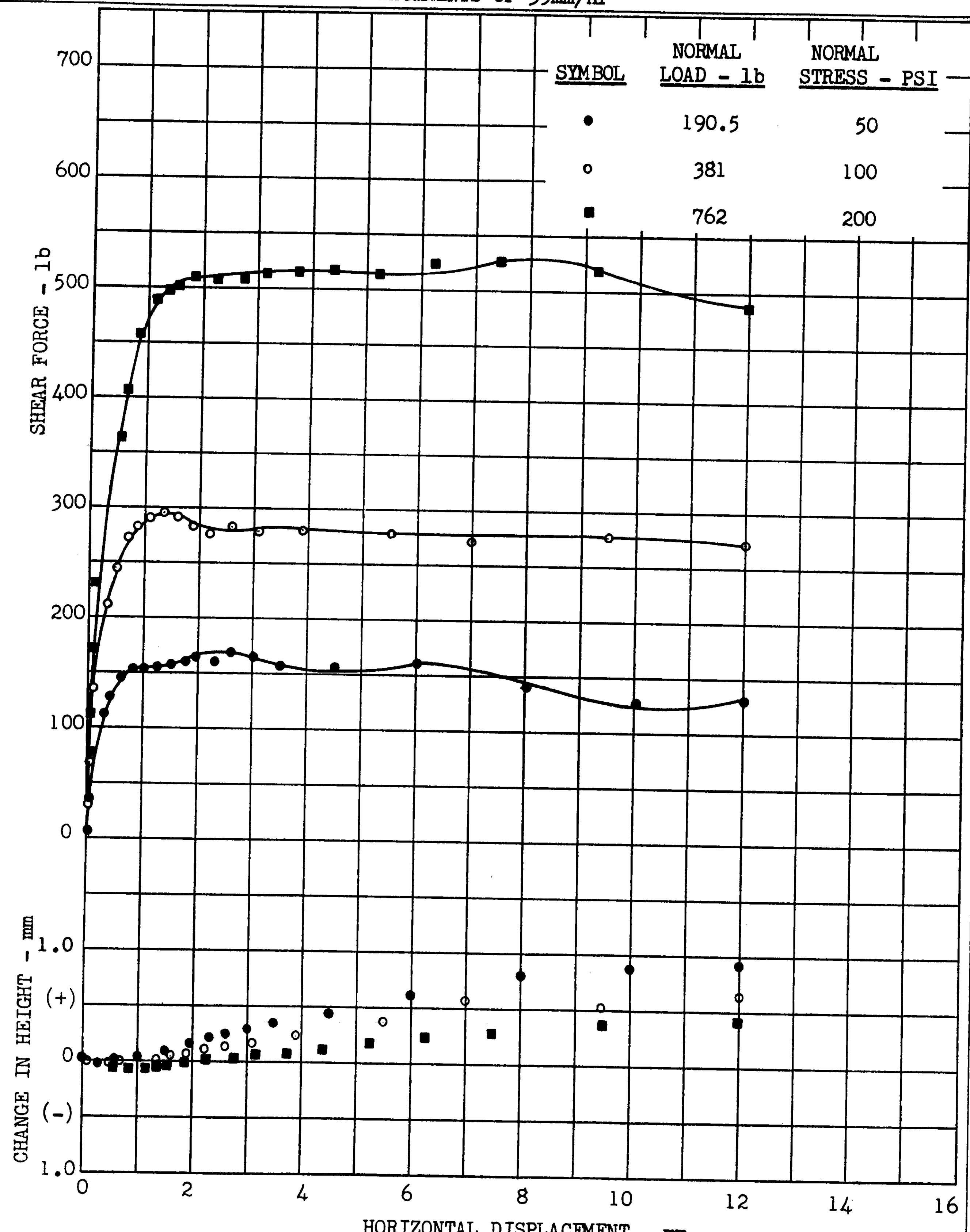


STONE & WEBSTER ENGINEERING CORPORATION

DIRECT SHEAR TEST REPORT

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO)	12179	-
SITE	DATE	SAMPLE NUMBERS
MILLSTONE 3	15 APR 76	SPECIMEN 8

ALL TESTS RUN AT HORIZONTAL DISPLACEMENTS OF 35mm/hr

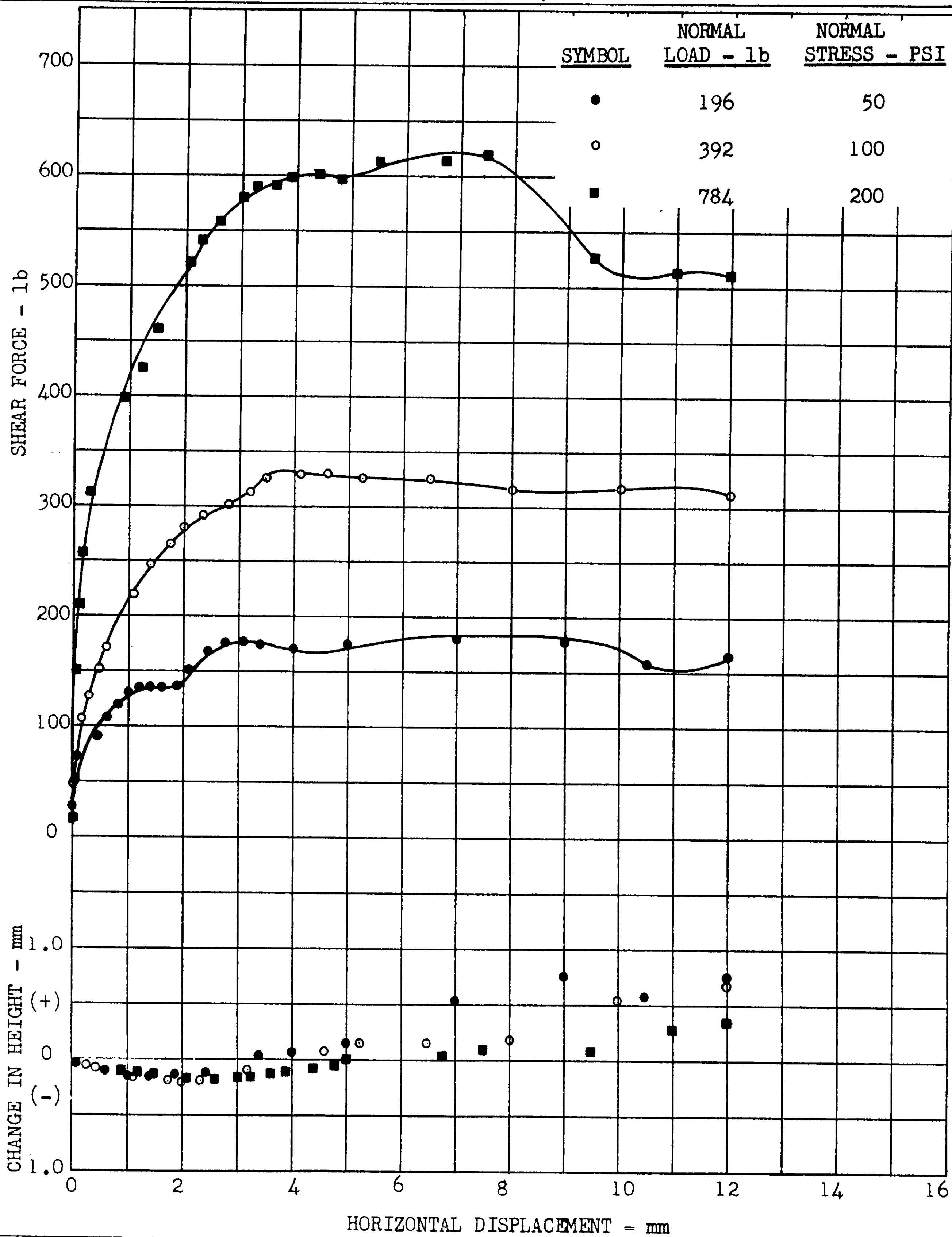


STONE & WEBSTER ENGINEERING CORPORATION

DIRECT SHEAR TEST REPORT

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO)	12179	-
SITE	DATE	SAMPLE NUMBERS
MILLSTONE 3	20 APR 76	SPECIMEN 9

ALL TETS RUN AT HORIZONTAL DISPLACEMENTS OF 35mm/hr

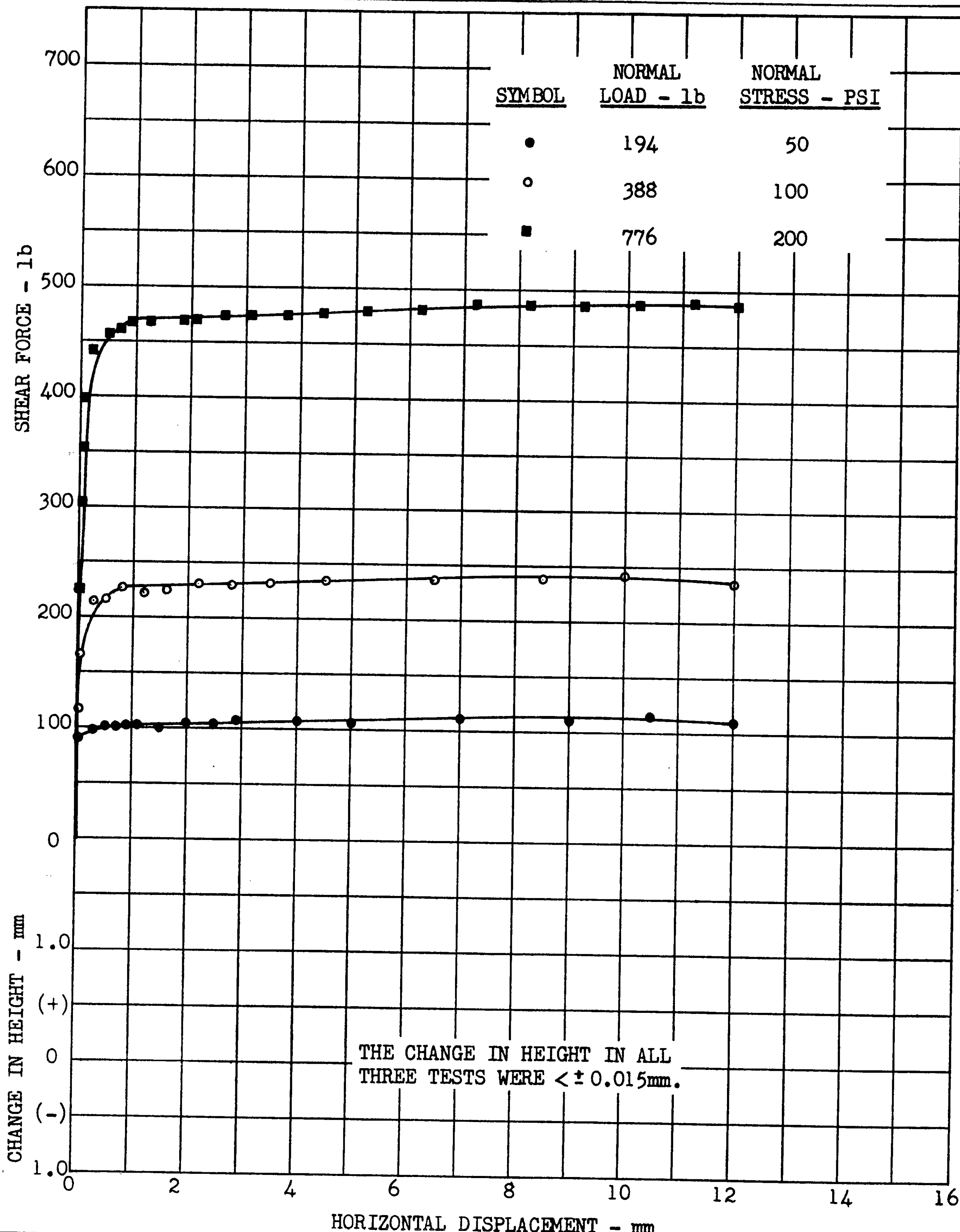


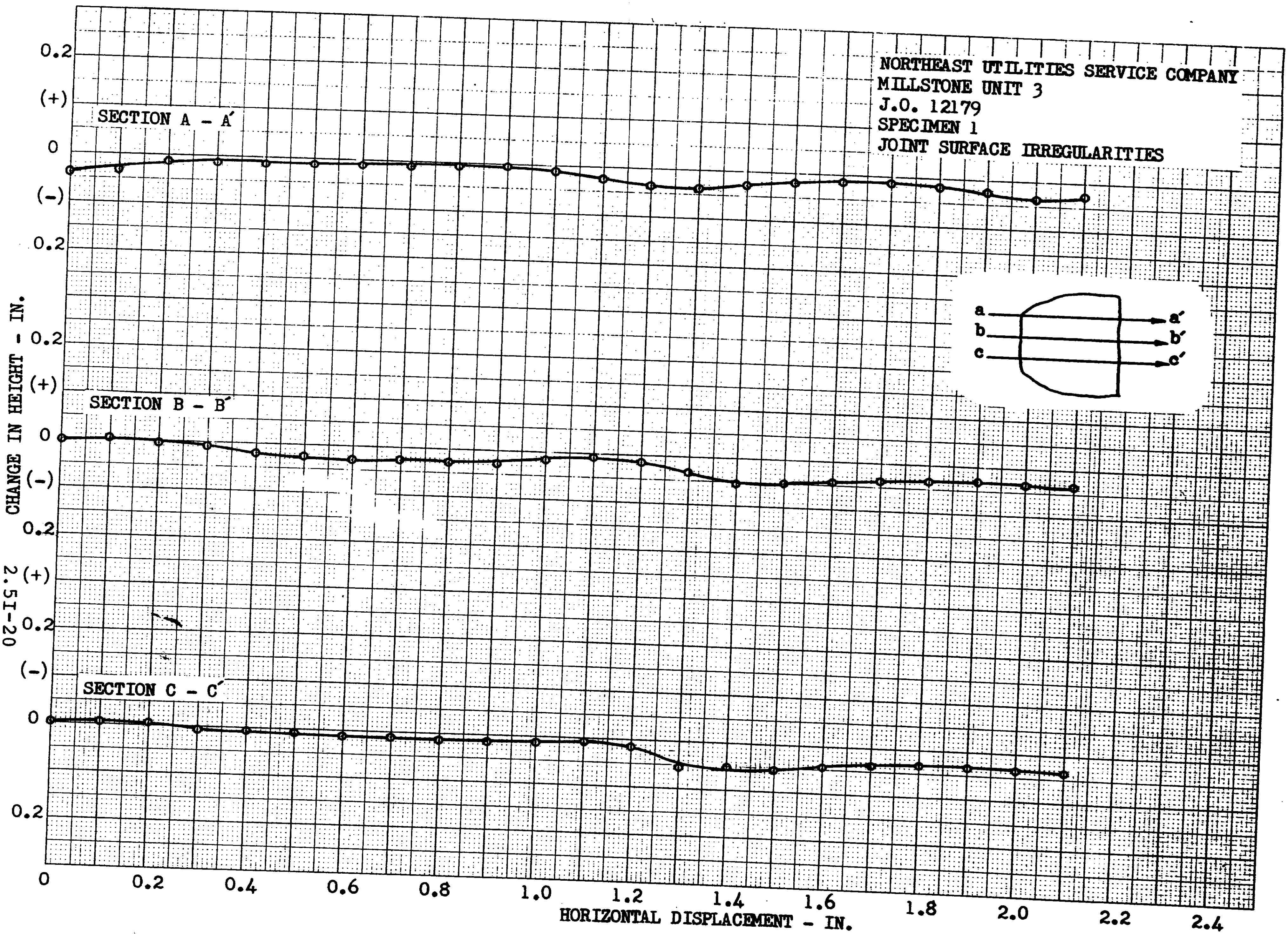
STONE & WEBSTER ENGINEERING CORPORATION

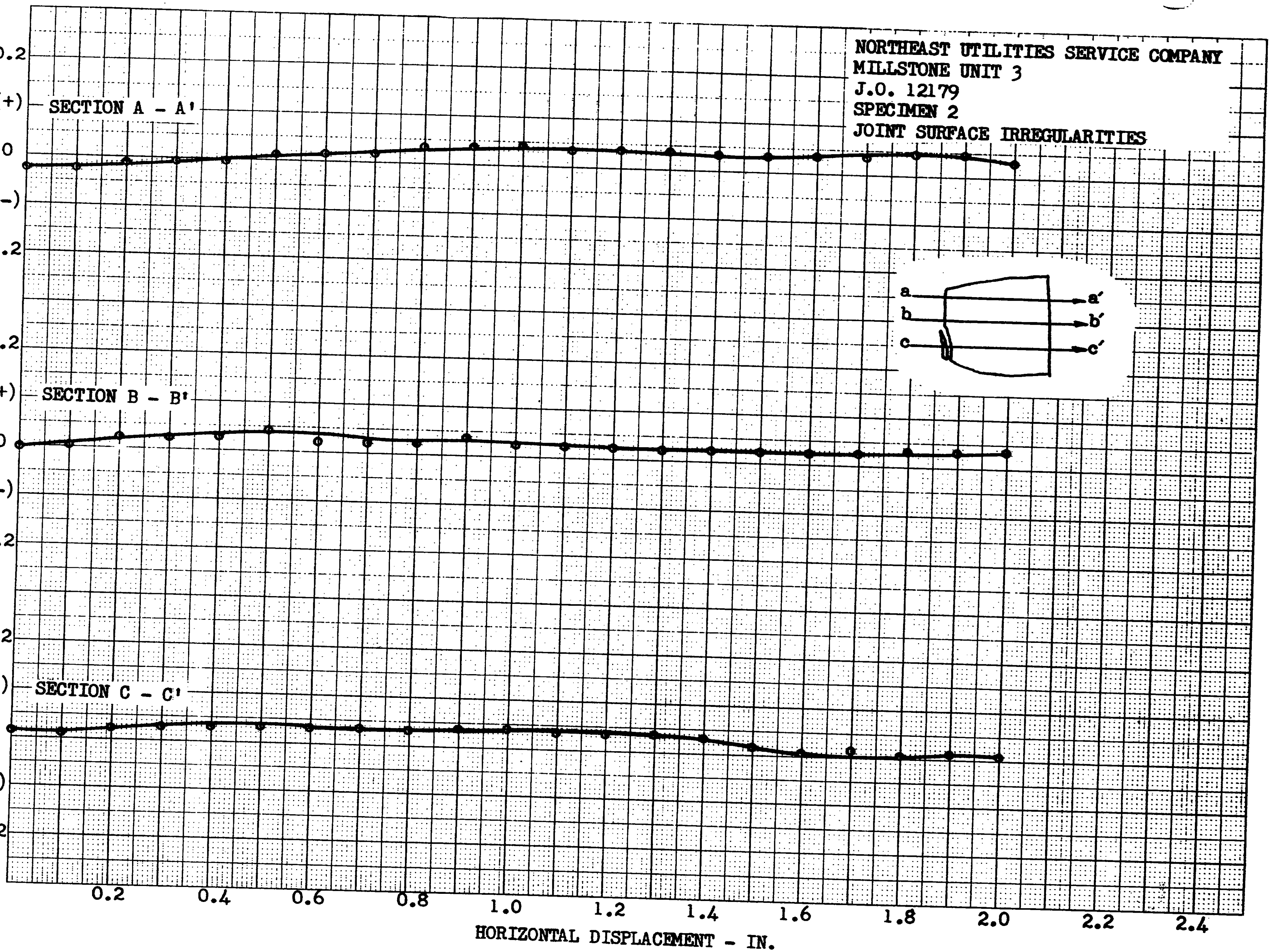
DIRECT SHEAR TEST REPORT

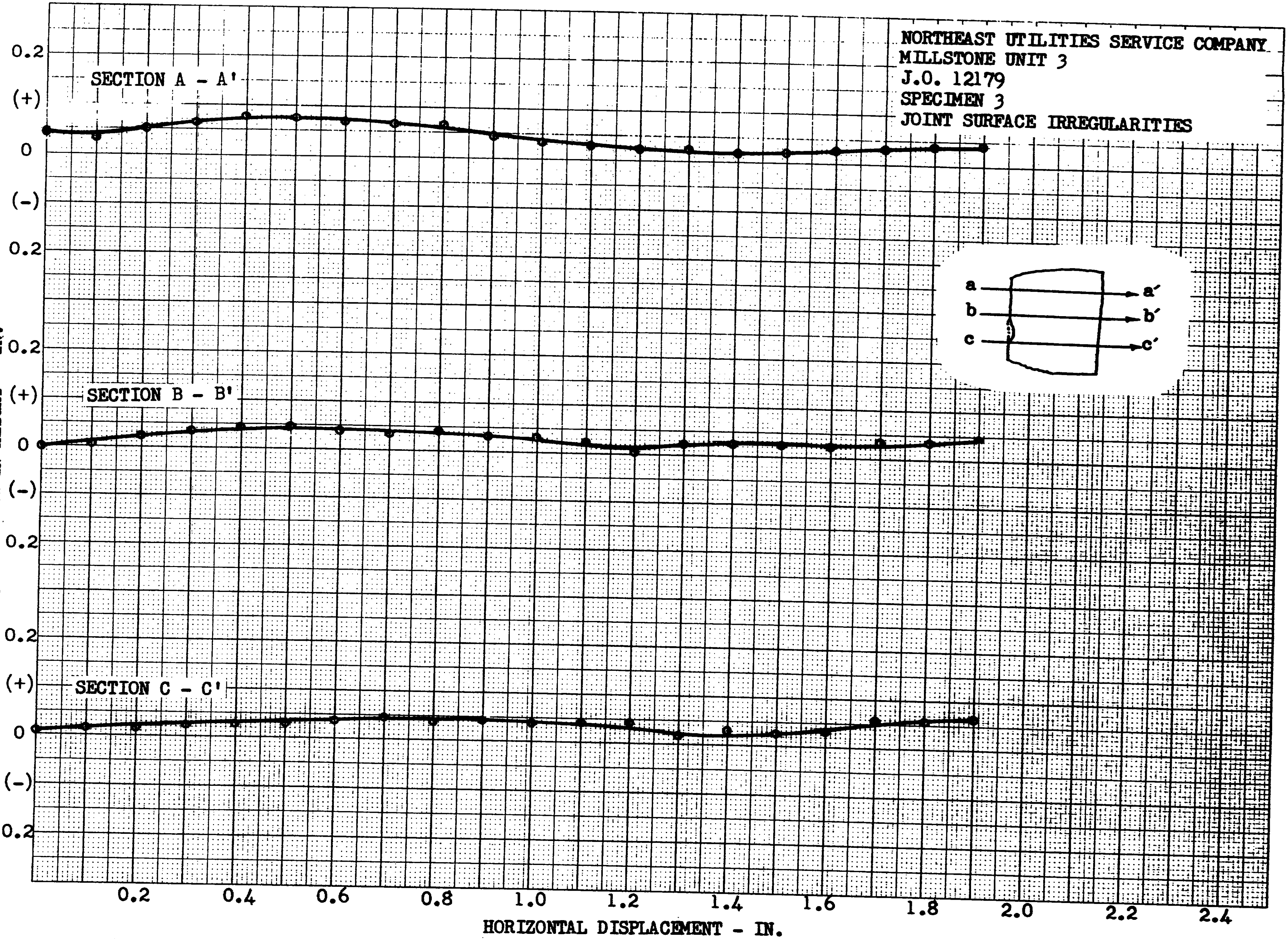
CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO)	12179	-
SITE	**DATE**	**SAMPLE NUMBERS**
MILLSTONE 3	23 APR 76	SPECIMEN 10

ALL TESTS RUN AT HORIZONTAL DISPLACEMENTS OF 35mm/hr

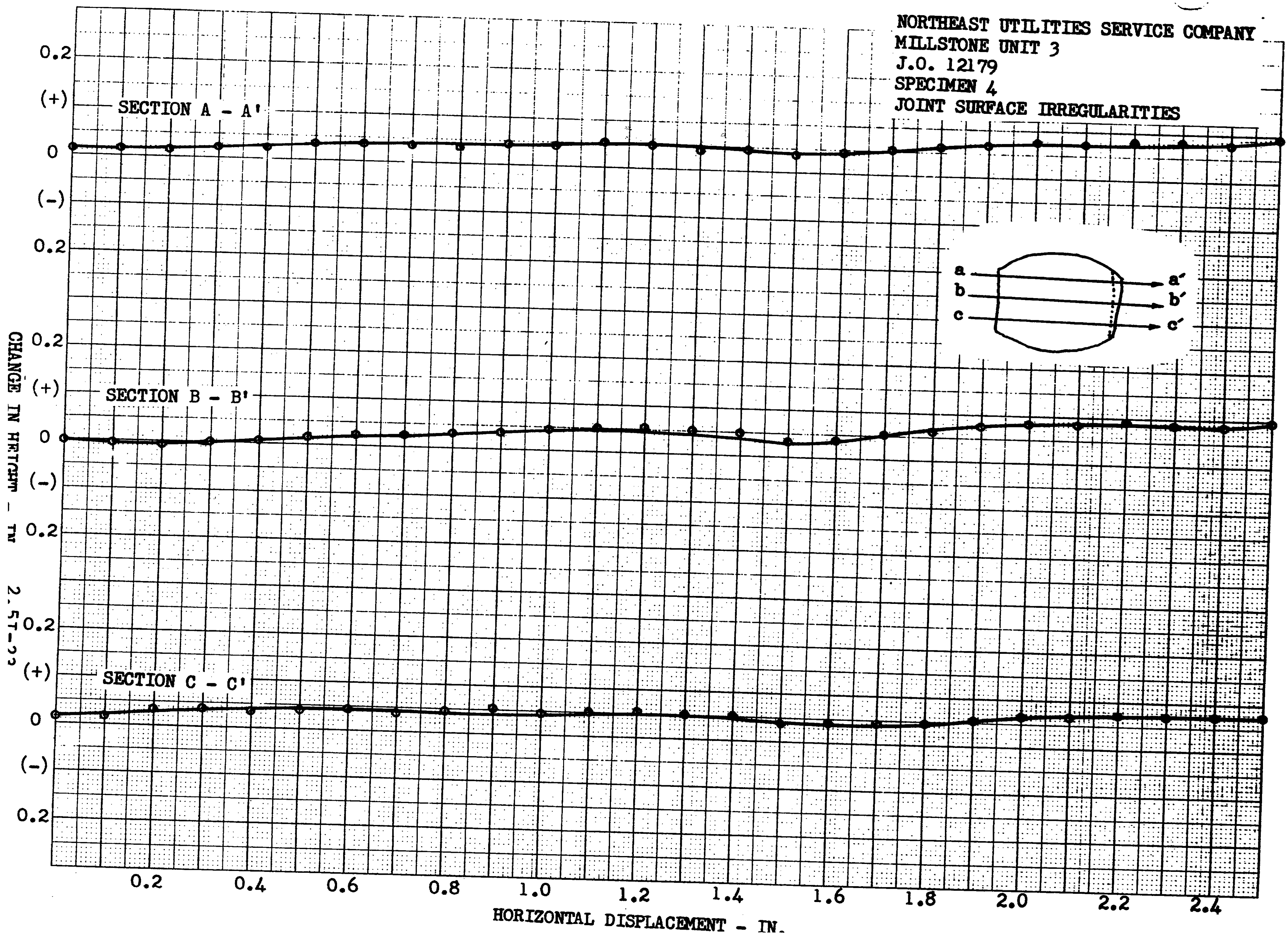



NORTHEAST UTILITIES SERVICE COMPANY
MILLSTONE UNIT 3
J.O. 12179
SPECIMEN 1
JOINT SURFACE IRREGULARITIES
SECTION A - A´
SECTION B - B´
SECTION C - C´
a
b
c
a´
b´
c´
CHANGE IN HEIGHT - IN.
0.2
(+)
0
(-)
0.2
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
HORIZONTAL DISPLACEMENT - IN.

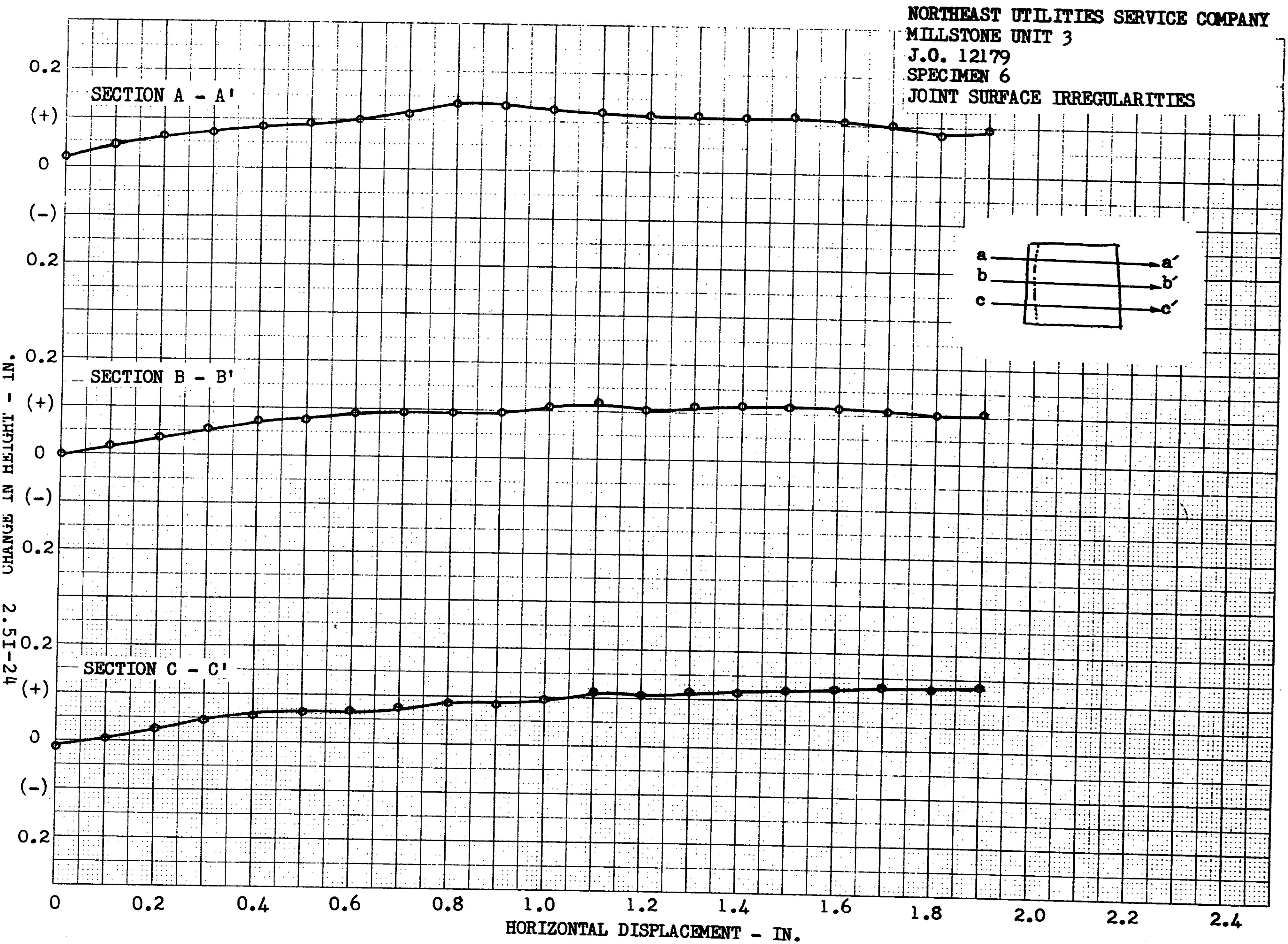

NORTHEAST UTILITIES SERVICE COMPANY
MILLSTONE UNIT 3
J.O. 12179
SPECIMEN 2
JOINT SURFACE IRREGULARITIES
SECTION A - A'
SECTION B - B'
SECTION C - C'
0.2
(+)
0
(-)
a
b
c
a'
b'
c'
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
HORIZONTAL DISPLACEMENT - IN.


NORTHEAST UTILITIES SERVICE COMPANY
MILLSTONE UNIT 3
J.O. 12179
SPECIMEN 3
JOINT SURFACE IRREGULARITIES
SECTION A - A'
SECTION B - B'
SECTION C - C'
a
b
c
a′
b′
c′
0.2
(+)
0
(-)
CHANGE IN HEIGHT - IN.
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
HORIZONTAL DISPLACEMENT - IN.

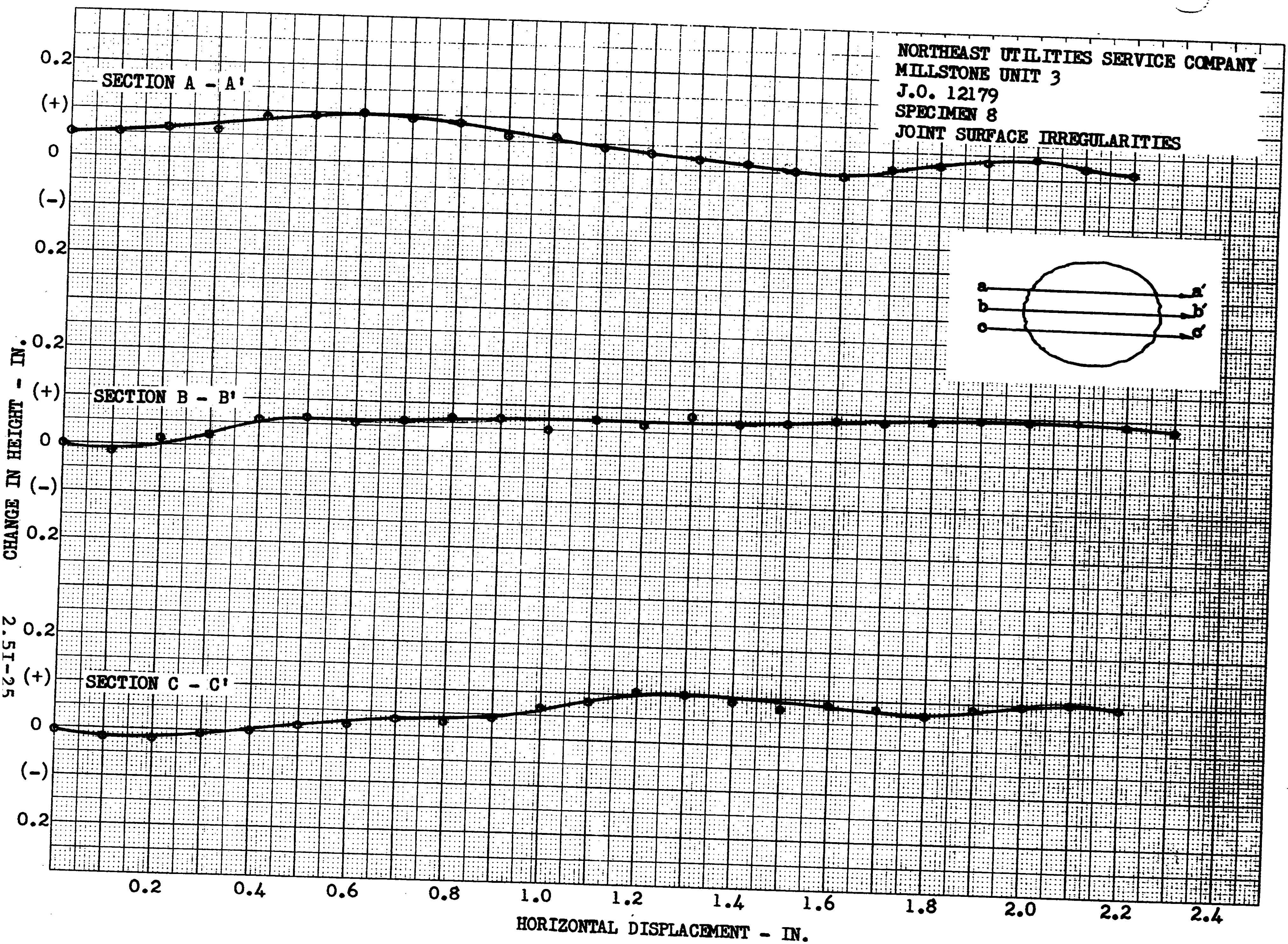
2.5I-22

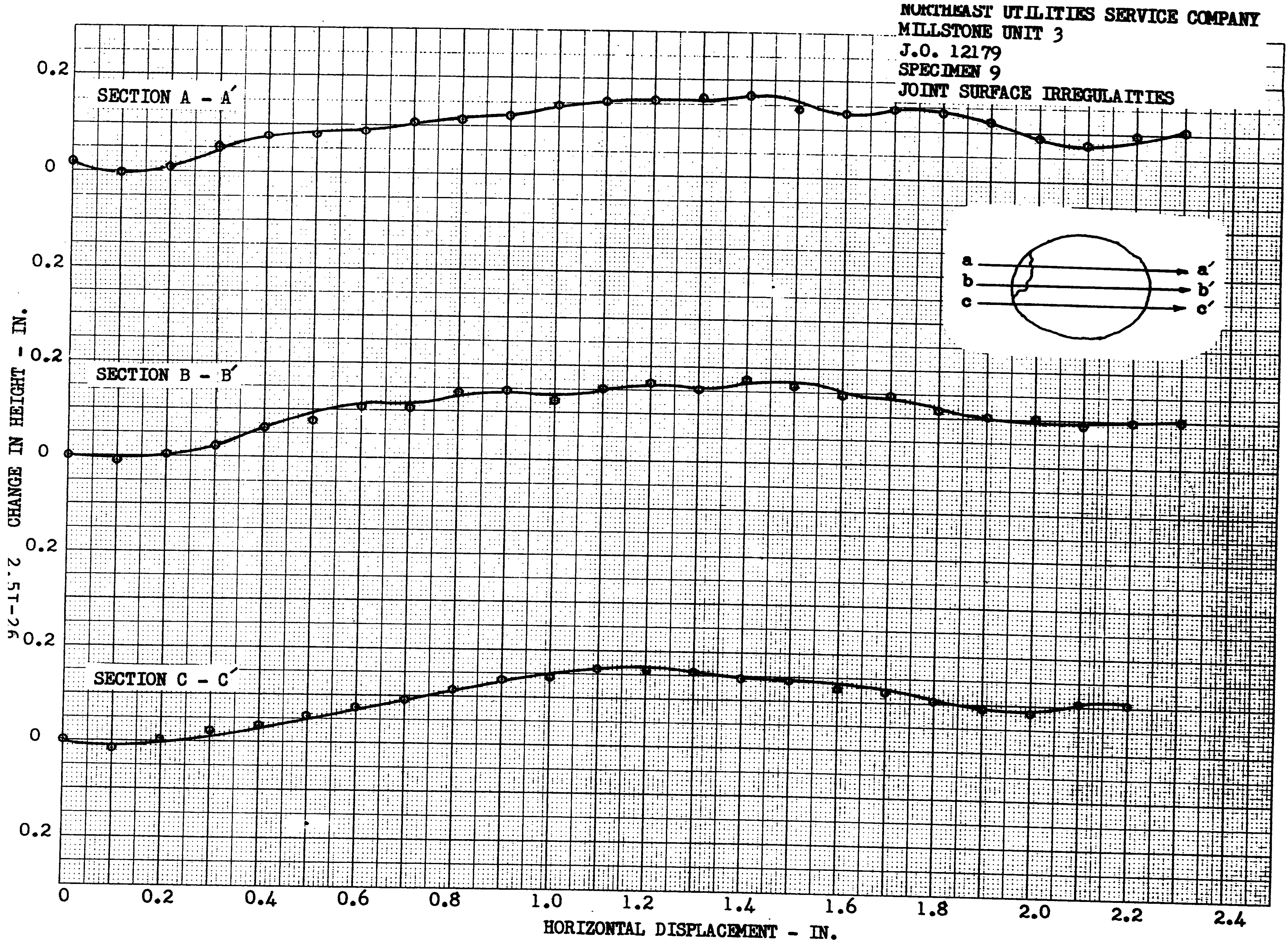


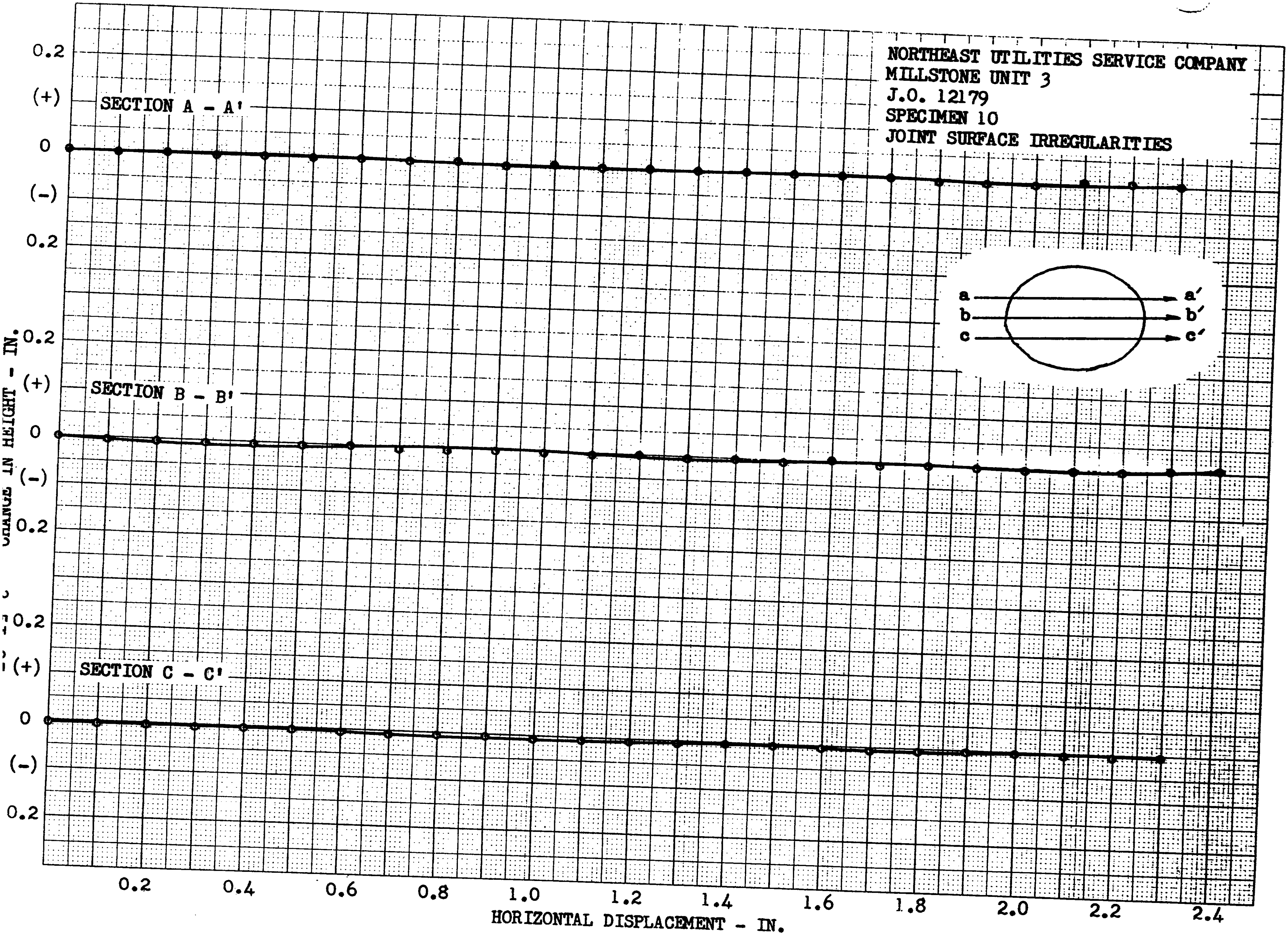
NORTHEAST UTILITIES SERVICE COMPANY
MILLSTONE UNIT 3
J.O. 12179
SPECIMEN 4
JOINT SURFACE IRREGULARITIES
SECTION A - A'
SECTION B - B'
SECTION C - C'
a
b
c
a'
b'
c'
0.2
(+)
0
(-)
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
HORIZONTAL DISPLACEMENT - IN.
CHANGE IN HEIGHT - IN.

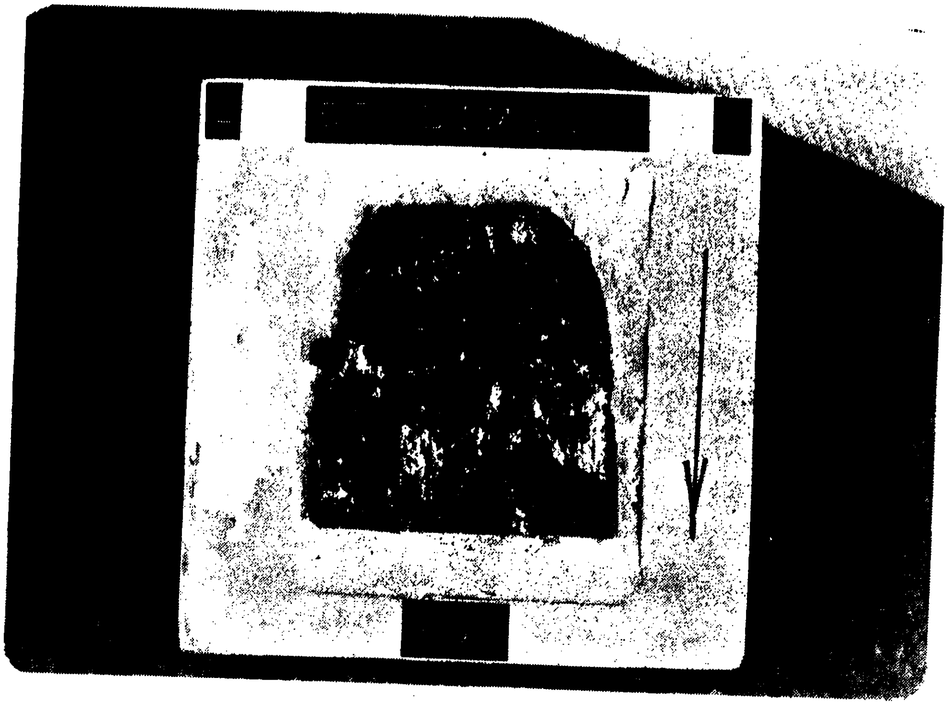

NORTHEAST UTILITIES SERVICE COMPANY
MILLSTONE UNIT 3
J.O. 12179
SPECIMEN 6
JOINT SURFACE IRREGULARITIES
SECTION A - A'
SECTION B - B'
SECTION C - C'
a
b
c
a'
b'
c'
0.2
(+)
0
(-)
CHANGE IN HEIGHT - IN.
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
HORIZONTAL DISPLACEMENT - IN.

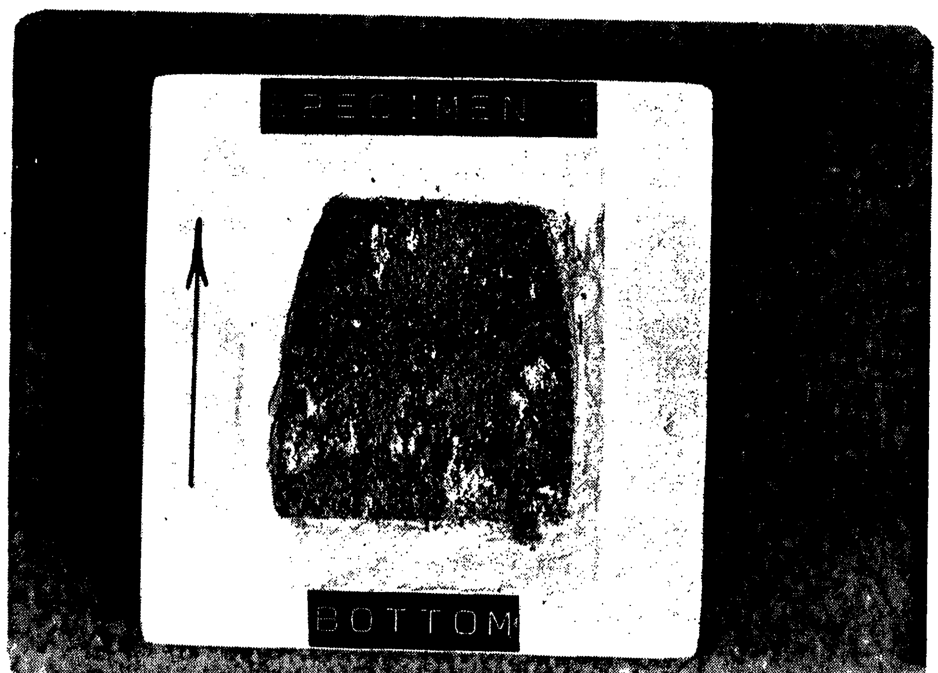
2.5I-24


NORTHEAST UTILITIES SERVICE COMPANY
MILLSTONE UNIT 3
J.O. 12179
SPECIMEN 8
JOINT SURFACE IRREGULARITIES
SECTION A - A'
SECTION B - B'
SECTION C - C'
a
b
c
a'
b'
c'
0.2
(+)
0
(-)
CHANGE IN HEIGHT - IN.
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
HORIZONTAL DISPLACEMENT - IN.

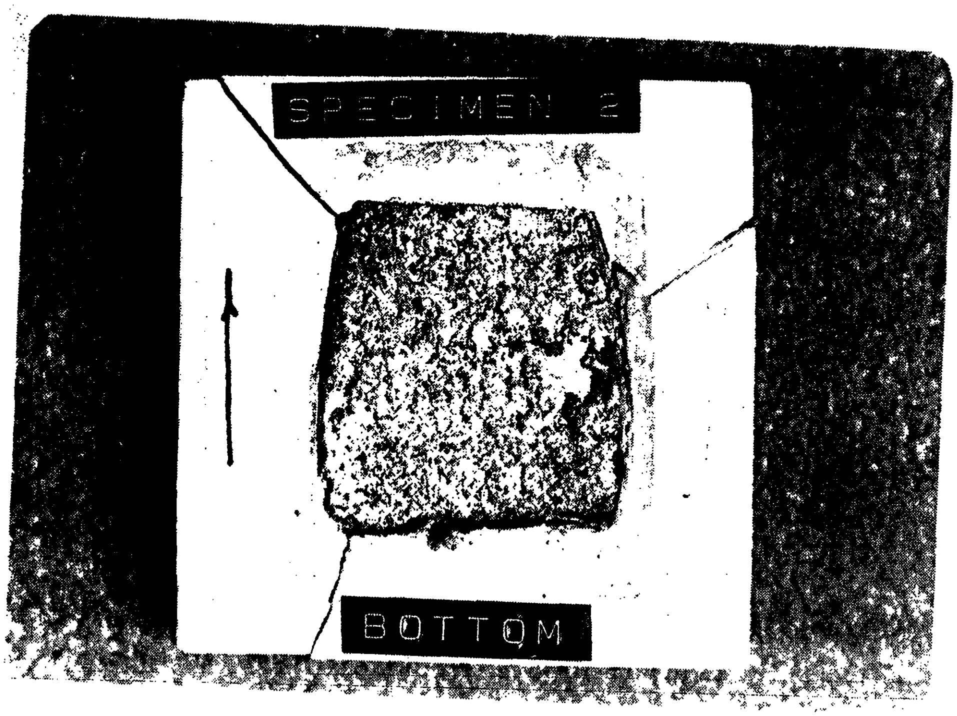

NORTHEAST UTILITIES SERVICE COMPANY
MILLSTONE UNIT 3
J.O. 12179
SPECIMEN 9
JOINT SURFACE IRREGULAITIES
SECTION A - A′
SECTION B - B′
SECTION C - C′
a
b
c
a′
b′
c′
CHANGE IN HEIGHT - IN.
0.2
0
0.2
0.2
0
0.2
0.2
0
0.2
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
HORIZONTAL DISPLACEMENT - IN.

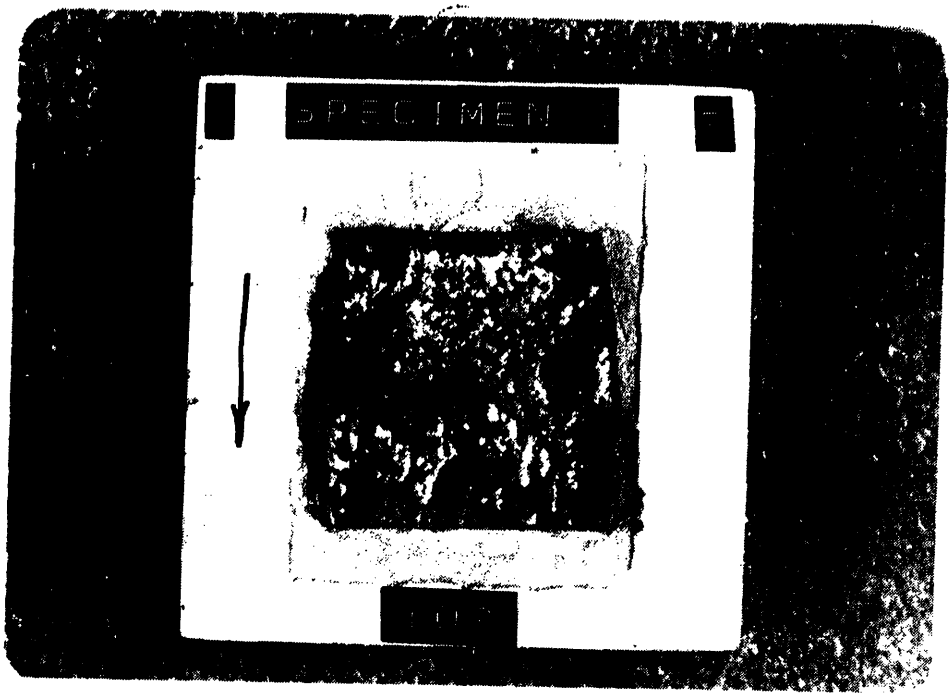

NORTHEAST UTILITIES SERVICE COMPANY
MILLSTONE UNIT 3
J.O. 12179
SPECIMEN 10
JOINT SURFACE IRREGULARITIES
SECTION A - A'
SECTION B - B'
SECTION C - C'
a
b
c
a'
b'
c'
0.2
(+)
0
(-)
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
HORIZONTAL DISPLACEMENT - IN.

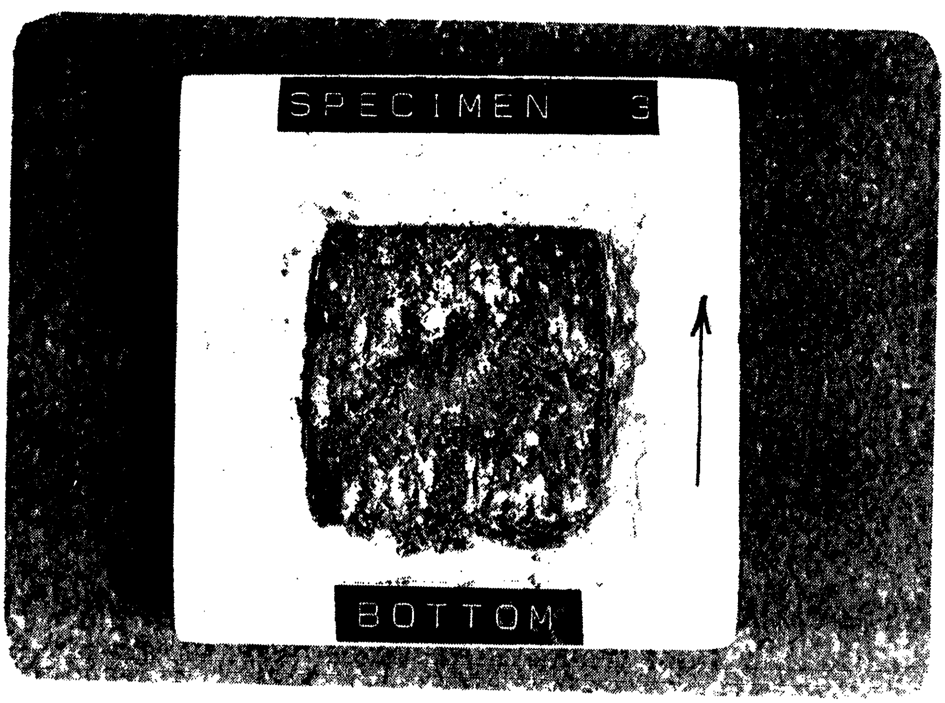


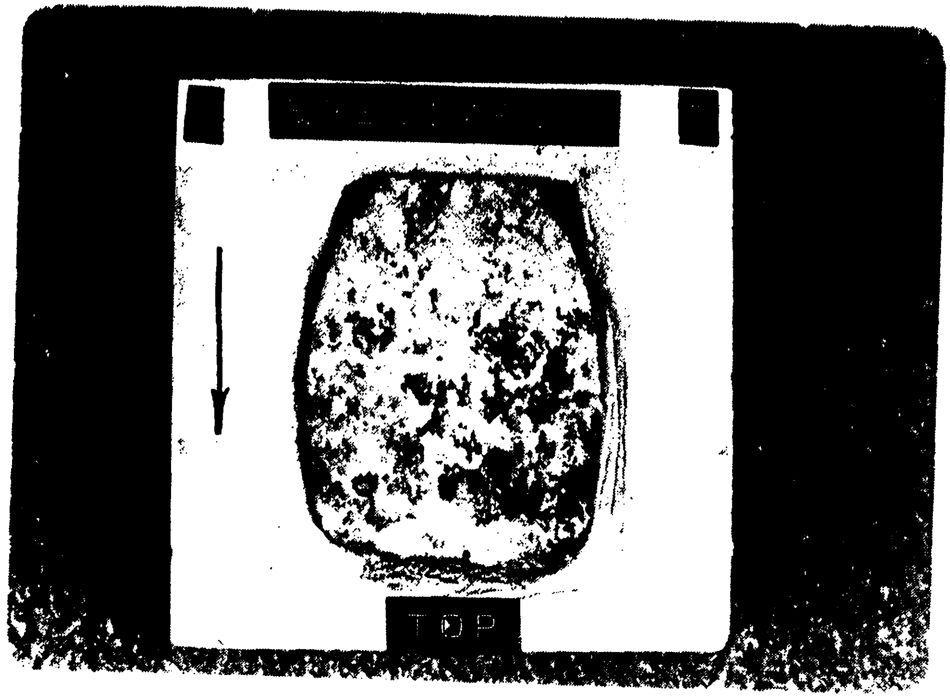

BOTTOM

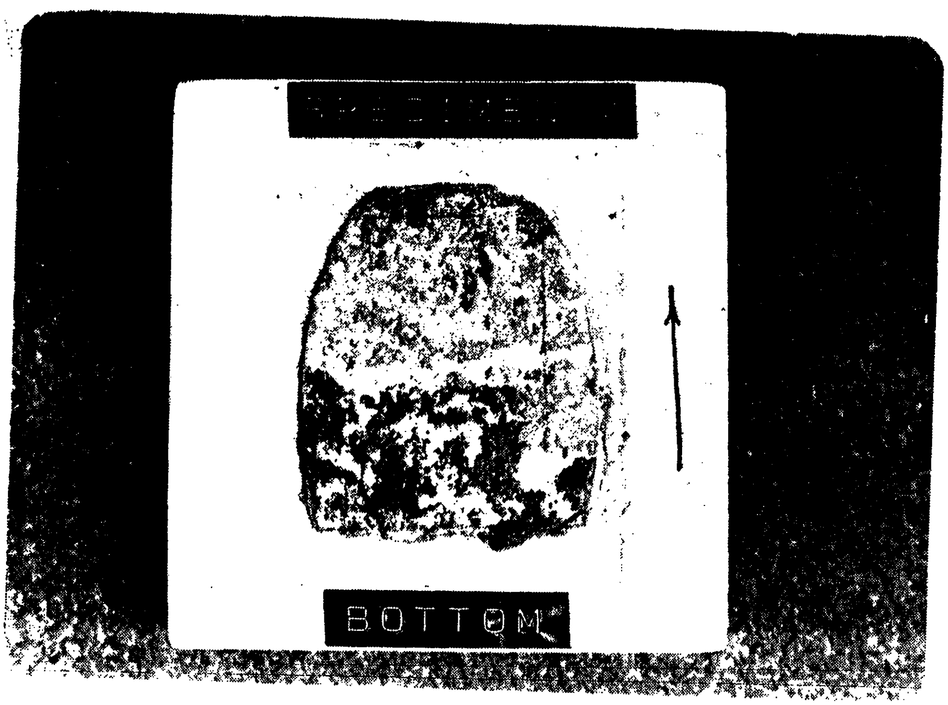

L
SPECIMEN 2
R
TOP

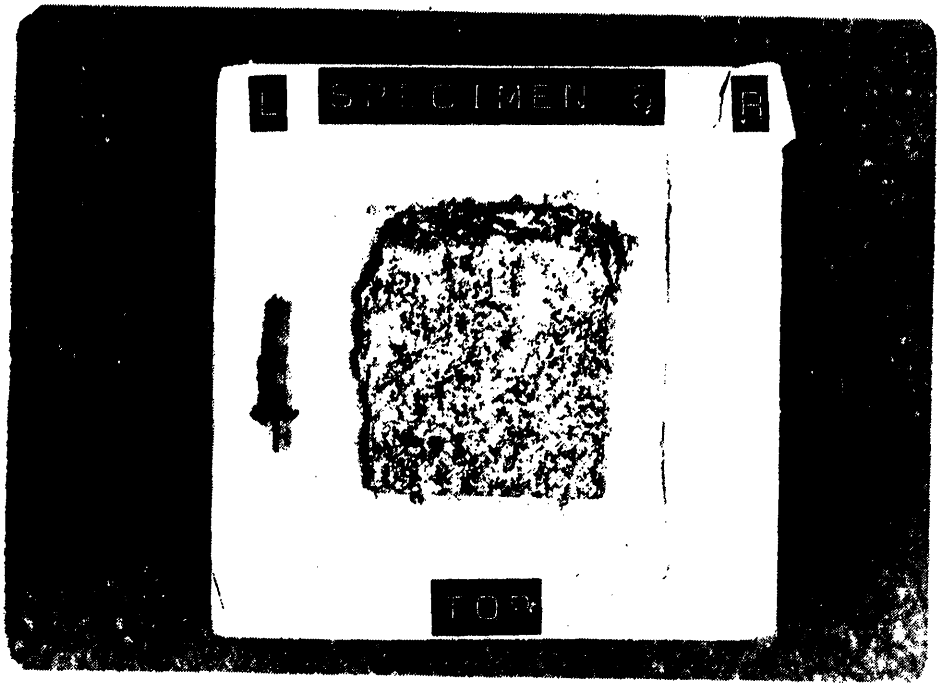

SPECIMEN 2
BOTTOM

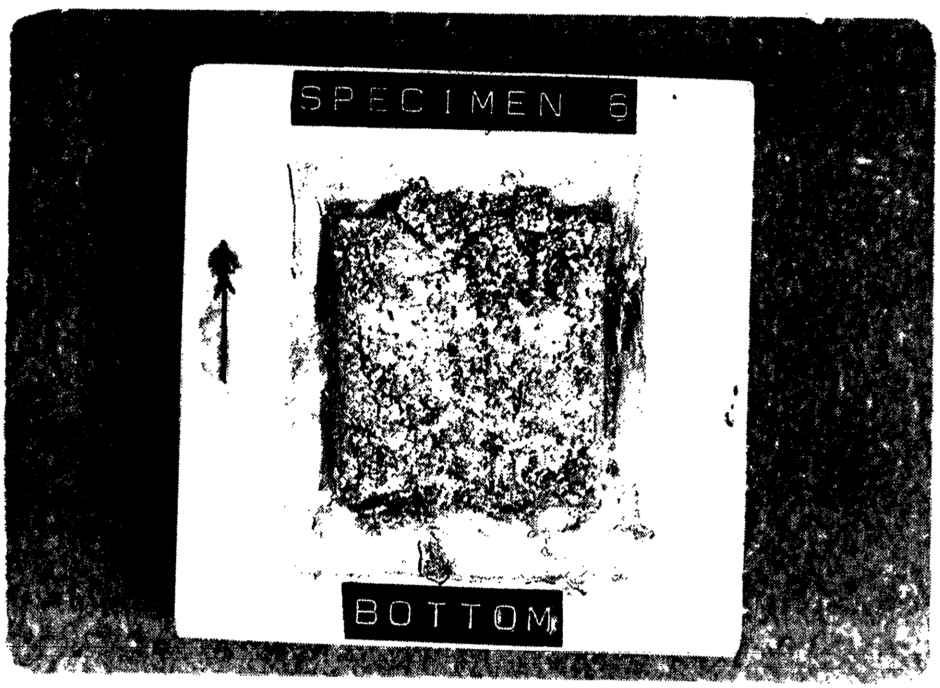

SPECIMEN

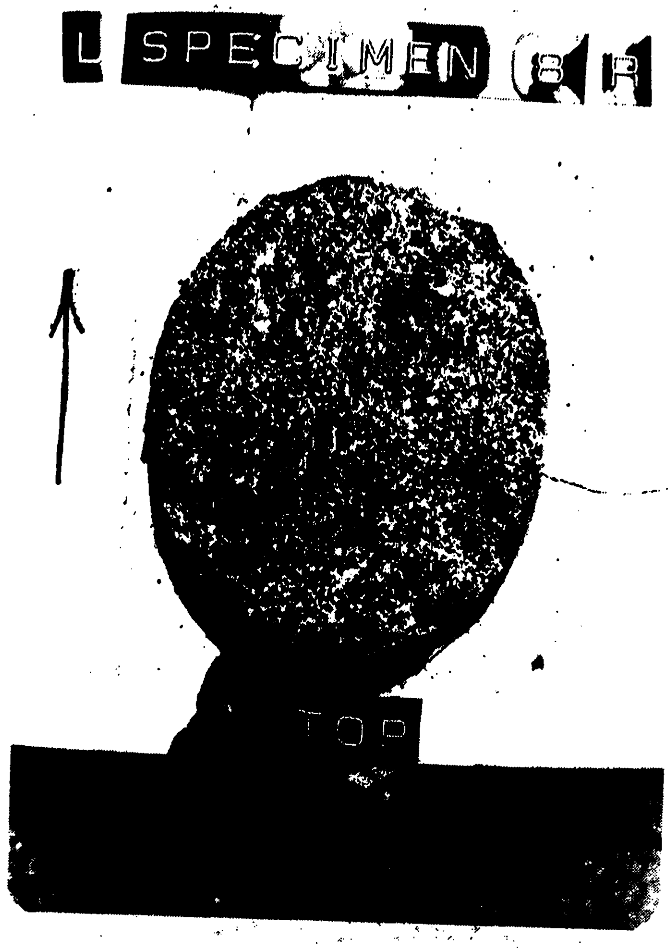

SPECIMEN 3
BOTTOM

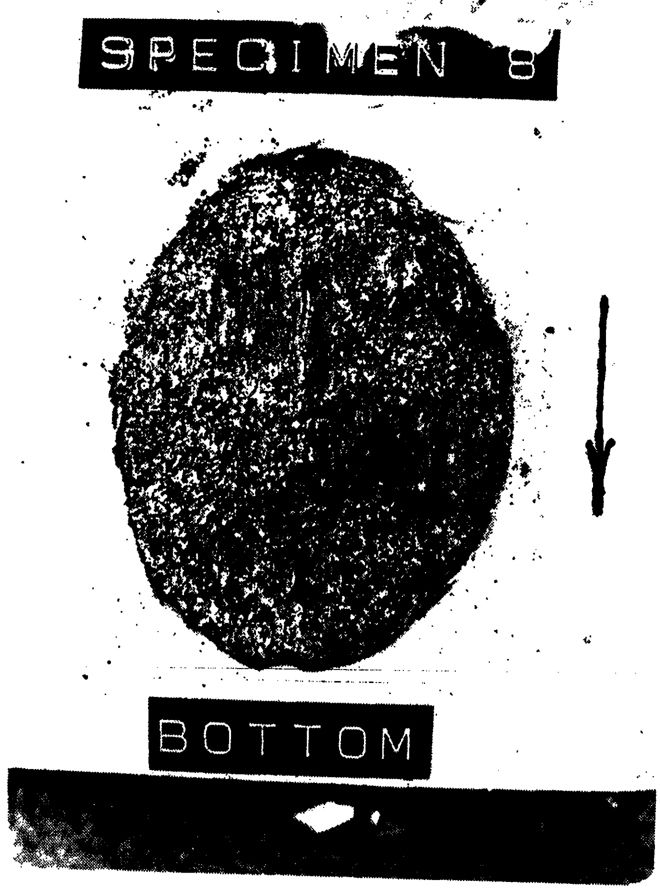

TOP

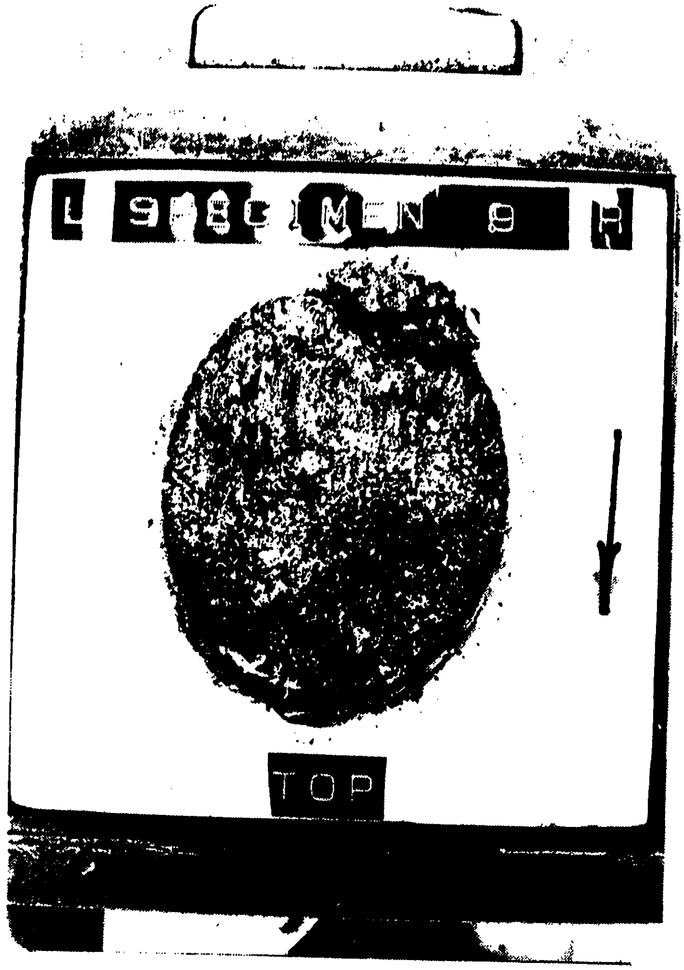

BOTTOM

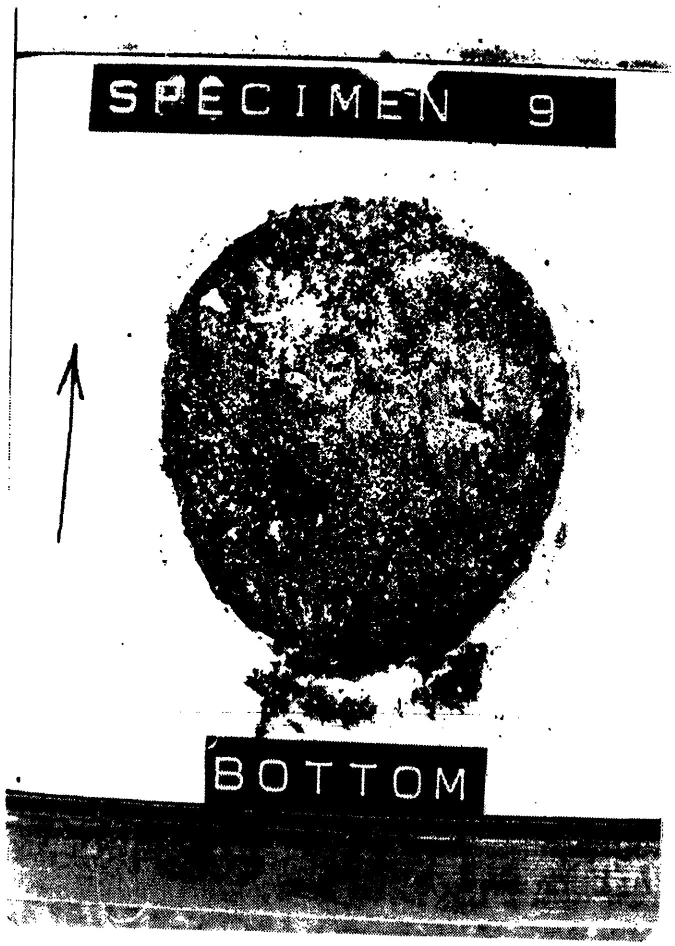

L
SPECIMEN 6
R
TOP

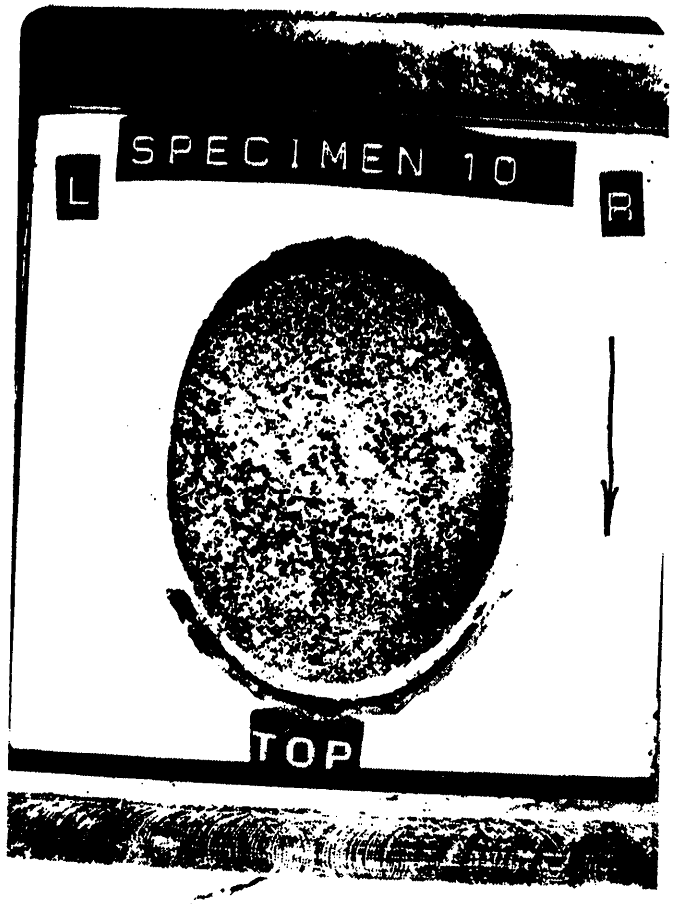

SPECIMEN 6
BOTTOM

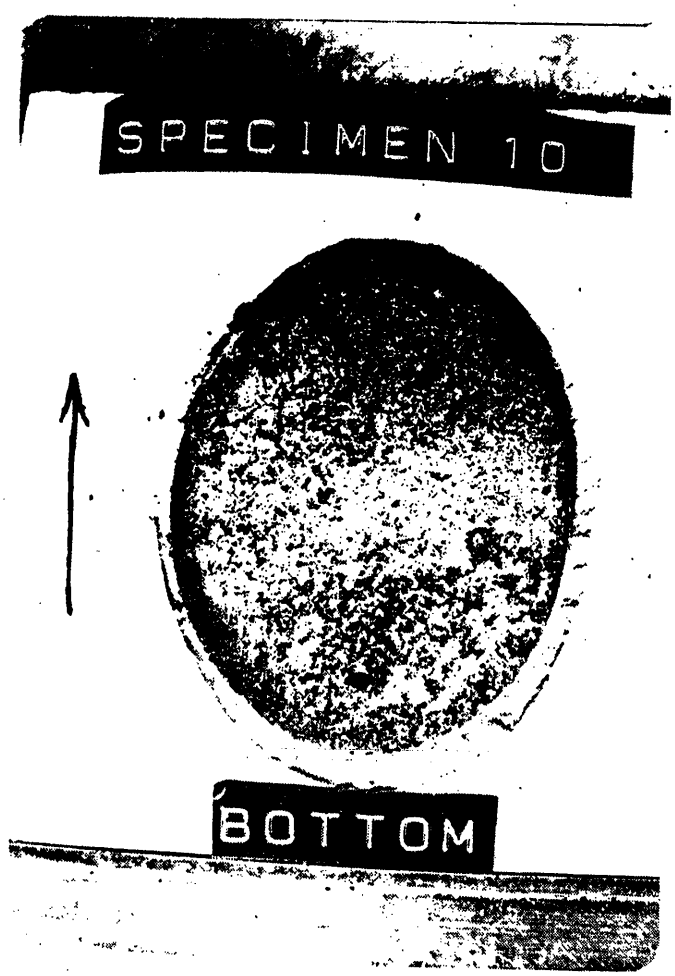

L SPECIMEN 8 R
TOP


SPECIMEN 8
BOTTOM


L
R
TOP


SPECIMEN 9
BOTTOM


SPECIMEN 10
L
R
TOP


SPECIMEN 10
BOTTOM

APPENDIX 2.5J

BORING LOGS

Stone & Webster Engineering Corp.
Boston, Massachusetts

BORING LOGS

This appendix contains the logs of borings drilled at the Millstone 3 site. The logs have been separated into five groups according to the purpose for which each boring was used. These groups are as follows:

Series	Use
300	Original Site Study
DT and 400	Discharge Tunnel Borings
I and P	Pumphouse Area
B	Millstone 2 Condensate Polishing Facility
T	Transformer Area

BORINGS FOR ORIGINAL SITE STUDY

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 301

TYPE OF BORING 4"-NX LOCATION 1562N-505E GROUND ELEV. 28.4'

DATE DRILLED 12/15/71 DRILLED BY AMERICAN DRILLING LOGGED BY R. SKEYNESS

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE ELEV. 28.4'							
			113	▼1		DENSE BROWN GRAY MEDIUM TO FINE SAND, SOME MEDIUM TO FINE GRAV., TR. SILT (FILL)	
24.4			20	▼2		MEDIUM DENSE RUST BRN.-GRAY BROWN SAND (F-M), TRACE OF SILT	
			22	▼3			
	10		23	▼4		(ABLATION TILL)	
13.4							
12.4			70/6"	▼5		(BASAL TILL) V. DENSE GRAY SAND, (F-M) SOME SILT	
						TOP OF ROCK	
		81	100			FRACTURE, WEATHERED ZONE	GRAY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) WITH GRANITE BANDS ABOUT 1-10' THICK FOLIATION ABOT 50°
						60° JT., TIGHT	
	20					HORZ. JT., RUST STAIN AND TR. OF WEATHERING	
						60° JT., TIGHT	
						60° JT., TIGHT	
3.4							
						HORZ. JT., RUST STAIN	
0.4		93	100				AT 25'-28' GRANITE
						60° JT., CLEAN, TIGHT	
	30						
						HORZ. JT.	
		98	100			SOFT WEATHERED ZONE	
-7.6	35						
						END OF BORING 36.0'	
						GROUND WATER LEVEL 1ST ENCOUNTERED 12/14/71 9.0' BELOW GROUND SURFACE, AFTER COMPLETION 12/15/71 8.0' BELOW GROUND SURFACE	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ▼6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD SBJ 1-26-73
3	APPD VRP 1/25/73
2	CHKD D.C.
1	PREPD R.S.

BORING LOG 301

MILLSTONE NUCLEAR POWER STATION - UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-2

NORTHEAST UTILITIES SERVICE COMPANY — SH 1 OF 2

SITE: MILLSTONE PT., WATERFORD, CONN. — J.O. NO. 12179 — BORING NO. 302

TYPE OF BORING: 4" - NX — LOCATION: 1458N-421E — GROUND ELEV. 28.2'

DATE DRILLED: 12/22/71 — DRILLED BY: AMERICAN DRILLING — LOGGED BY: R. SKRINESS

SUMMARY OF BORING: PIEZOMETER INSTALLED 1/18/72

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS or RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE ELEV. 28.2'							
			56	1			DENSE - V. DENSE GRAY-BRN. COARSE-FINE SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, BOULDERS AND COBBLES (FILL)
			155	2			
21.2							
			28	3			M. DENSE Y. BRN MEDIUM-FINE SAND, MICACEOUS, SOME SILT AND FINE GRAVEL (TRACE OF BLK. ORGANIC MAT'L.)
	10		32	4			
15.7							TOP OF ROCK
		18	92			FRACTURED, WEATHERED ZONE HORZ. JT., WEATHERED RUST STND. 60° JT., WEATHERED RUST STAINED HORZ. JT., WEATHERED RUST STND. 60° JT., WEATHERED RUST STAINED HORZ. JT., WEATHERED RUST STND.	GRAY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) WITH GRANITE SEAMS ABOUT 1-10' THICK. FOLIATION ABOUT 60°
10.7							AT 17.6' - 19.8' GRANITE
7.4	20	90	100			IRREG. JR., WITH RUST STAIN 10° JT., RUST STAIN HORZ. JT., RUST STAIN & WEATH. 45° JT. HORZ. JT., RUST STAIN & WEATH.	
2.4							
1.2							AT 25.8' - 27.0' GRANITE
		75	100			CLOSE SPACED HORZ. JTS. WITH LIGHT GRAY MINERALIZED SURF.	
	30					3" WEATHERED ZONE WITH YELLOW STAIN	FOLIATION ABOUT 50°
		75	100			70° JT., TIGHT HORZ. JT., RUST STAIN FRACTURED ZONE ABOUT 1" HORZ. JT., RUST STAIN 45° JT., SLIGHT WEATHERING 1" WEATHERED ZONE	
		95	100				
	40						
		92	99			ABOUT 2" WEATHERED ZONE VERT. JT., CHLORITE	
		88	100			HORZ. JT., WEATH. 30° JT., RUST STAIN & WEATH.	
	50						FOLIATION ABOUT 45°
		100	100			HORZ. JT., DK. GRAY STAIN HORZ. JT., WEATHERED HORZ. JT., RUST STAIN	
		92	100			5° JT., RUST STAIN & WEATH. 5° JT., RUST STAIN & WEATH.	
	60					HORZ. JT., TIGHT	
-34.3		97	100			5° JT., TIGHT	AT 62.5' - 65.0' CHLORITE GNEISS
-36.8							
		65	100			1" FRACTURED ZONE 20° CHLORITE SOFT WEATHERED ZONE VERT. JT., CHLORITE	
	70						

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

Rev.	Appd.
4	APPD. 1-26-73
3	APPD. VRN
2	APPD. D.C.
1	APPD.

BORING LOG 302
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK 3A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 2

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 302

TYPE OF BORING 4" - NX LOCATION 145SN-421E GROUND ELEV. 28.2'

DATE DRILLED 12/22/71 DRILLED BY AMERICAN DRILLING LOGGED BY R. SKRYNESS

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
						BORING NO. 302 (CONT'D)
		88	100			HORZ. JT., WEATHERED HORZ. JT., CHLORITE 45° JT., TIGHT 45° JT., TIGHT
-46.8	75					
						END OF BORING 75' GROUND WATER LEVEL 10.5' BELOW GROUND SURFACE ON 12/22/71

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≟ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APP'D	SB-L 1-26-73
3	APP'D	WRN 1/25/73
2	CHKD	D.C.
1	PREP'D	R.S.

BORING LOG 302 (CONT'D)

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-3B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 303
TYPE OF BORING 4"-NX LOCATION 1635-335E GROUND ELEV. 29.3'
DATE DRILLED 12/18/71 DRILLED BY AMERICAN DRILLING LOGGED BY R. SKRYNESS
SUMMARY OF BORING PIEZOMETER INSTALLED 1/18/72

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION — FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
						GROUND SURFACE ELEV. 29.3'	
			30	◤1			DENSE - V. DENSE MED. BROWN (F-C) SAND, SOME FINE GRAVEL AND SILT
			64	◤2			(ABLATION TILL?)
							(BASAL TILL?)
			103	◤3			
19.3	10					TOP OF ROCK	
						55° JT., RUST STAIN	GRAY, BANDED QTZ. BIOTITE GNEISS (MONSON GNEISS) WITH GRANITE SEAMS ABOUT 1-10' THICK; FOLIATION ABOUT 55°.
						6" SOFT, RUST STAIN WITH WEATHERED ZONE	
		94	100			HORZ. JT., RUST STAIN	
						HORZ. JT., YELLOW STAIN & WEATH.	
						HORZ. JT., YELLOW STAIN & WEATH.	
	20					HORZ. JT., LIGHT GRAY SILT	
						60° JT., DK. GREEN STAINING	AT.22.5' - 24.0' GRANITE
		89	100				
						HORZ. JT., YELLOW GREEN STAIN	
						50° JT., TIGHT	AT.26' - 29' GRANITE FOLIATION ABOUT 50°
						50° JT., TIGHT	
						50° JT., TIGHT	
-.7	30					END OF BORING 30'	

GROUND WATER LEVEL
1ST ENCOUNTERED 9.0' BELOW GROUND SURF. ON 12/17/71
6.5' BELOW GROUND SURF. ON 1/13/72

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸7 INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⏚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. SBA 1-26-73
3	APPD. VRN 1/15/73
2	CHK'D D.C.
1	PREP'D R.S.

BORING LOG 303
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-4

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 2

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 304
TYPE OF BORING 4"-NX LOCATION 1533N-371E GROUND ELEV. 28.5'
DATE DRILLED 12/21/71 DRILLED BY AMERICAN DRILLING LOGGED BY R. SKRYNESS
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE ELEV. 28.5'							
			88	1			V. DENSE BROWN MEDIUM TO FINE SAND, GRAVEL, AND COBBLES WITH SOME SILT. (FILL)
26							
			57	2			DENSE GRAY BROWN-YELLOW BROWN FINE SAND, SOME SILT AND FINE GRAVEL (ABLATION TILL)
			42	3			
	10						
			35	4			
14.5						TOP OF ROCK	
						HORZ. JT., RUST STAIN 65° JT., RUST STAIN HORZ. JT., RUST STAIN HORZ. JT., RUST STAIN 65° JT., RUST STAIN HORZ. JT., RUST STAIN 65° JT., CHLORITE 65° JT., RUST STAIN	GRAY, BANDED QTZ. BIOTITE GNEISS (MONSON GNEISS) WITH GRANITE SEAMS ABOUT 1-10' THICK. FOLIATION ABOUT 45° AT 14.5' - 19.0' GRANITE
9.5		81	94				
	20					HORZ. JT., RUST STAIN HORZ. JT., RUST STAIN HORZ. JT., CHLORITE HORZ. JT., CHLORITE 35° JT., YELLOW STAIN HORZ. JT., RUST STAIN HORZ. JT. YELLOW STAIN AND WEATHERED	FOLIATION ABOUT 55°
		86	95			10° JT., YELLOW STAIN 55° JT., YELLOW STAIN 3" FRACTURED ZONE	
	30					1" FRACTURED ZONE HORZ. JT., YELLOW STAIN 55° JT., YELLOW STAIN	
		78	100			50° JT., YELLOW STAIN 10° JT., YELLOW STAIN 60° JT., YELLOW STAIN 10° JT., YELLOW STAIN 15° JT., YELLOW STAIN	FOLIATION ABOUT 50°
	40					HORZ. JT., YELLOW STAIN HORZ. JT., YELLOW STAIN,TR. WEATH. HORZ. JT., YELLOW STAIN HORZ. JT., YELLOW STAIN HORZ. JT., GREEN YELLOW STAIN, WEATHERED 60° JT., GREEN-YELLOW STAIN, WEATHERED	
		33	100			FRACTURE ZONE, WEATHERED HORZ. JT., YELLOW STAIN, WEATH.	
-21.0						HORZ. JT., YELLOW STAIN	FOLIATION ABOUT 45°
-22.0	50	83	100			IRREG. JT., RUST STAIN	AT 49.5' - 50.5' GRANITE
							FOLIATION ABOUT 50°
		70	88			FRACTURE, WEATHERED 10° JT., YELLOW STAIN HORZ. JT., YELLOW STAIN 10° JT., YELLOW STAIN 10° JT., YELLOW STAIN 10° JT., YELLOW STAIN FRACTURED ZONE & YELLOW STAIN 15° JT., YELLOW STAIN 50° JT., YELLOW STAIN	
	60						
		89	95				
							AT 65.6' - 66.2' GRANITE
						50° JT., YELLOW STAIN	
		67	67				
	70					SOLID CORE	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⏚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. 8-6-4 / 1-26-73
3	APPD. 1-25-73
2	CHKD. D.C.
1	PREPD. RS.

BORING LOG 304
MILLSTONE NUCLEAR POWER STATION UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-5A

NORTHEAST UTILITIES SERVICE COMPANY

SITE: MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 304
TYPE OF BORING: 4"-NX LOCATION: 1533N-371E GROUND ELEV. 28.5'
DATE DRILLED: 12/21/71 DRILLED BY: AMERICAN DRILLING LOGGED BY: R. SKRYNESS
SUMMARY OF BORING:

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
						BORING NO. 304 (CONT'D)
						SOLID CORE
-46.5	75	67	67			
						END OF BORING 75' GROUND WATER LEVEL 9' BELOW GROUND SURFACE 1/7/72

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD 88-1 1-26-73
3	APPD VRN 1/25/73
2	CHKD D.C.
1	PREPD R.S.

BORING LOG 304 (CONT'D)
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
12179-OSK-5B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 2

SITE MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING No. 305

TYPE OF BORING 4" NX LOCATION 1448N - 347 E GROUND ELEV. 26.2'

DATE DRILLED 12/21/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL OR ROCK DESCRIPTION: SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
	GROUND SURFACE EL. 26.2'						
			67	1			DENSE GREY-BROWN COARSE-FINE SAND, SOME SILT, GRAVEL AND COBBLES. (FILL)
			58	2			
21.2			130/6"	3			V. DENSE, YELLOW-BROWN COARSE-FINE SAND, POORLY GRADED, STRATIFIED. SOME SILT, GRAVEL, AND BOULDERS. (BASAL TILL)
			98	4			
	10		135	5			
			84/6"	6			
7.2							TOP OF ROCK
	20	70	82			BROKEN ZONE W/YELLOW GREEN STAIN; 45° ALONG FOL., YELLOW GREEN STAIN; BROKEN ZONE	GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/GREY GRANITE SILLS APPROX. 1-10' THICK AND PINK PEGMATITE INTRUSIVE BANDS APPROX. 1-2' THICK. FOLIATION APPROX. 45°-50°.
	30	94	100			20-30° GREEN MINERALIZED SURFACES; 20-30° GREEN, SL. WX. SURFACES; 45° CHLORITE MINERALIZED SURF.	SOME JTS. SHOW SOME WX. BUT MAJORITY OF JTS. ARE CLEAN EXCEPT FOR SOME CHLORITE MINERALIZATION ON SURFACES.
-10.3							
	40	84	100			60° TIGHT MINERALIZED SURF.; 60° TIGHT MINERALIZED SURF.; 60° TIGHT MINERALIZED SURF.; 60° TIGHT MINERALIZED SURF.; 60° TIGHT MINERALIZED SURF.; 60° TIGHT MINERALIZED SURF.; 60° TIGHT MINERALIZED SURF.; HORZ. YELLOW STN.; 60° GREEN. STN.	@ 36.5-52.3' GREY GRANITE SILL WITH PINK PEGMATITE INTRUSIVE BANDS AT 37-38' & @ 47.5' - 52.3'.
	50	83	95			60° DK. GREY STN.; 30° TIGHT	FOL. APPROX. 50°
-26.1							
	60	100	100			TRACE OF YELLOW STN.; HORZ. W/YELLOW STN.; HORZ. W/YELLOW STN.	THIN GRANITE SEAMS 1"-4" THICK; FOL. APPROX. 55°
-38.8						ALL BREAKS ARE CLEAN WITH NO DISCOLORATION OR SIGNS OF WX.	@ 65-73.7' GREY GRANITE SILL FOL. APPROX. 50°.
	70	95	98				

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APPD. 1-24-73
3	APPD. 1/25/73
2	CHKD. D.C.
1	PREPD. R.S.

BORING LOG 305

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

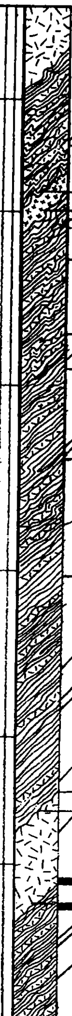
12179-GSK-6A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 2

SITE: MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 305
TYPE OF BORING: 4" NX LOCATION: 1448N - 347E GROUND ELEV. 26.2'
DATE DRILLED: 12/21/71 DRILLED BY: AMERICAN DRILLING LOGGED BY: R.S.
SUMMARY OF BORING:

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
						BORING NO. 305 (CONT'D)	
		100	100				FOLIATION - 45°-50°
						45° RUST STN.	
						HORZ. YELLOW STN.	
-53.8	80						
-54.8							@ 80' - 81' PEGMATITE
						HORZ. JT.	
						HORZ. JT. ALL BREAKS ARE FREE OF WX, & STN. & APPEAR TO BE FRESH.	
						HORZ. JT.	
		91	97				
						45° JT.	
	90					HORZ. JT.	
						45° TIGHT	
						45° TIGHT	
						HORZ. GREEN STN.	
		97	100				FOLIATION APPROX. 50°.
						20° LT. GREY MINERALIZED SURF.	
	100						
						HORZ. YELLOW STN.	
						50° ALONG FOL. - TIGHT	
		87	92				
						50° ALONG FOL. - TIGHT	
						50° ALONG FOL. - TIGHT	
	110						
						50° ALONG FOL.	
		97	100				
-87.3						HORZ. GREEN STN. & TR. OF WX.	
						50° JT.	@ 113.5'-118.5' GREY GRANITE SILL. GRANITE IS SOLID WITH FEW CLEAN BREAKS.
						BROKEN ZONE	
-92.3							
						BROKEN ZONE - GREEN STN.	
	120					45° ALONG FOL., SOME WX.	FOL. APPROX. 45°.
		86	100				
						45° ALONG FOL., SOME WX.	
-98.8							
						END OF BORING 125'	
						GROUND WATER LEVEL 9.2' BELOW GROUND SURFACE (1/7/72)	
	130						
	140						



1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ◻◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APPD. 88-4 1-26-73
3	APPD. VRN 1/25/73
2	CHKD. D.C.
1	PREPD. R.S.

BORING LOG 305 (CONT'D)

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-6B

NORTHEAST UTILITIES SERVICE COMPANY

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 306
TYPE OF BORING 4" NX LOCATION 1383 N - 346E GROUND ELEV. 24.1'
DATE DRILLED 12/15/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE

GROUND SURFACE EL. 24.1'

ELEV.	DEPTH	RQD	BLOWS OR RECOV.	TYPE
			103	1
			62	2
			46	3
			33	4
	10		50	5
10.6		88	100	
4.1	20	88	100	
-3.2		93	100	
	30	94	100	
		78	100	
	40	78	100	
		92	100	
	50	92	100	
		93	100	
	60	90	100	
		83	92	
	70			

DENSE GRAY-BROWN COARSE-FINE SAND, SOME MED.-FINE GRAV., TR. SILT (ABLATION TILL)

TOP OF ROCK

GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/GREY GRANITE SILLS 1-10' THICK & PEGMATITE INTRUSIVE BANDS 1-2" THICK. FOLIATION APPROX. 45°.

40° JT., MINERALIZED; LT. GREY, TIGHT SEAMS.
40° JT., MINERALIZED, LT. GREY, TIGHT SEAMS.
HORZ. JT., WX. SEAM, RUST STN.
30° JT., WX. SEAM, GREEN STN.

@ 20'-27.3' GRANITE SILL THE LOWER CONTACT OF GRANITE SILL IS A FRACTURED ZONE W/ SOME DISCOLORATION.

30° JT., TIGHT W/GREY MINERALIZED SURF.
IRREG. CLEAN BREAK
20° JT., RUST STN.
FRACTURED ZONE, GREEN & RUST BROWN STN.

10° JT., LT. GREY MINERALIZED SURF.
45° JT., LT. GREY MINERALIZED SURF.
45° JT., LT. GREY MINERALIZED SURF.
70° JT., WX. & RUST STN.
70° JT., WX. & RUST STN.
70° JT., WX. & GREEN STN.

CHLORITE MINERALIZED JOINTS

45° JT., LT. GREY MINERALIZED SURF.
45° JT., LT. GREY MINERALIZED SURF.
45° JT., GREEN STN.
HORZ. JT., CHLORITE
HORZ. JT., CHLORITE
WX., SOFT GREY GREEN
HORZ. JT., GREEN STN.
45° JT., CHLORITE
BROKEN ZONE
SOFT WX. ZONE
30° JT., SOME RUST STN.
30° JT., CHLORITE
50° JT., CHLORITE
50° JT., CHLORITE
50° JT., TIGHT
5° JT., CHLORITE
50° JT., TIGHT

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APPD. R.G.L. 1-26-73
3	APPD. VRN 1/25/73
2	CHKD. D.C.
1	PREPD. R.S.

BORING LOG 306
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-G3K-7A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 2

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 306
TYPE OF BORING 4" NX LOCATION 1383N - 346E GROUND ELEV. 24.1'
DATE DRILLED 12/15/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
						BORING NO. 306 (CONT'D)
		100	100			MOSTLY SOLID CORE — STOPPED RUN TO REPLACE BIT
-50.9	75	100	100			
						END OF BORING 75' GROUND WATER LEVEL 11.5' BELOW GROUND SURFACE ON 12/15/71

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □7 INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENTAGE)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD	1-26-73
3	APPD VCH	1/25/73
2	CHKD	D.C.
1	PREPD	R.S.

BORING LOG 306 (CONT'D)

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-7B

NORTHEAST UTILITIES SERVICE COMPANY

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 307

TYPE OF BORING 4" NX LOCATION 1556N - 256E GROUND ELEV. 28.4'

DATE DRILLED 12/13/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.

SUMMARY OF BORING

GROUND SURFACE EL. 28.4'

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	W_n CONTENT %	OTHER TESTS	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
			51	1				DENSE, YELLOW BROWN (F-MED.) SAND, TR. SILT & F. GRAVEL
			20	2	11.6	G		
			24	3	12.5	G		
			38	4	8.6	G		
18.4	10							TOP OF ROCK
		66	100				HORZ. JT. W/LT. GREY MINERALIZATION HORZ. JT. W/LT. GREY MINERALIZATION HORZ. JT.,W/LT. GREY MINERALIZATION HORZ. JT. W/LT. GREY MINERALIZATION HORZ. JT. W/LT. GREY MINERALIZATION HORZ. JT. W/LT. GREY MINERALIZATION 50° JT., LT. GREY MINERALIZATION	GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/ GRANITE SILL APPROX. 1-10' THICK AND PEGMATITE INTRUSIVE BANDS 1-2' THICK. FOL. ABOUT 50°
		87	97				HORZ. JT. W/LT. GREY MINERALIZATION FRACTURED ZONE APPROX. 1" HORZ. JT. W/LT. GREY MINERALIZATION	
9.0	20							@ 19.4-22.4' GRANITE SILL
6.0								FOL. APPROX. 50°
		86	92				HORZ. JT., RUST STN. 60° JT., QTZ. MINERALIZATION 60° JT., RUST STN. 70° JT., RUST STN. HORZ. JT., CHLORITE MINERALIZATION	
	30						HORZ. JT., CLEAN. HORZ. JT., CLEAN.	
	35	88	99				50-60° JT., RUST STAINED IRREG. FRACTURE, SOME RUST STN. 60° JT., RUST STAINED FRACTURES W/ PY. MINERALIZATION.	
-9.1							END OF BORING 37.5' GROUND WATER LEVEL 9.2' BELOW GROUND SURFACE ON 1/7/72	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENTAGE)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.
7. W_n IS NATURAL WATER CONTENT.
8. G IS GRAIN SIZE DISTRIBUTION CURVE.

4	APPD 88-L 1-26-73
3	APPD VRN 1/25/73
2	CHKD D.C.
1	PREPD R.S.

BORING LOG 307

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-8

NORTHEAST UTILITIES SERVICE COMPANY

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 308
TYPE OF BORING 4" NX LOCATION 1446N - 267E GROUND ELEV. 24.8'
DATE DRILLED 12/17/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE

GROUND SURFACE EL. 24.8'

ELEV.	DEPTH	RQD	BLOWS OR RECOV.	TYPE	FIELD / JOINTING DESCRIPTION	STRATA DESCRIPTION
			36	1		MED. DENSE, RUST BROWN-GREY BROWN COARSE - FINE SAND, SOME SILT AND FINE GRAVEL. (ABLATION TILL)
			34	2		
			24	3		
			26	4		
14.8	10					TOP OF ROCK
		95	100		10° JT., CLEAN; HORZ. JT., RUST	GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/GRANITE SILLS 1-10" THICK & PEGMATITE INTRUSIVES 1-2' THICK. FOL. APPROX. 45°.
11.8					HORZ. JT., RUST	@ 13-21.5' GRANITE SILL
8.3					70° JT., RUST; 5° JT., RUST	
		90	100		IRREG. BREAK, RUST STAIN	
	20				HORZ. JT., RUST STN. & TR. WX.	
		100	100		½" BROKEN & WX.	
-3.2		100	100		HORZ. JT., RUST STN., TR. WX.	
-4.2						28-29' GRANITE SILL
	30				HORZ. JT., YELLOW STN.	
		87	97		HORZ. JT., YELLOW STN.; 70° JT., RUST STN.; HORZ. JT., RUST STN.; HORZ. JT., GREEN STN.; 70° JT., YELLOW STN.	
		83	95		35° JT., GREEN STN.; HORZ. JT., GREEN STN.; 50° JT., YELLOW STN. & TR. WX.; BROKEN ZONE, ABOUT 1" RUST STN. & TR. WX.	
	40				HORZ. JT., LT. GREY, MINERALIZATION; HORZ. JT., LT. GREY, MINERALIZATION	
		85	100		HORZ. JT., LT. GREY MINERALIZATION	FOLIATION 50°
					HORZ. JT., LT. GREY MINERALIZATION; 45° JT., LT. GREY MINERALIZATION	
		93	100		HORZ. JT., CHLORITE; IRREG. JT., RUST STN. & TR. WX.	
	50				HORZ. JT., CHLORITE	
		92	100		WX. SEAM ABOUT 1"	
-29.4						
		85	100		BROKEN ZONE, NO STN. OR WX.	@ 54.2'-67.6' GRANITE SILL
	60					
		92	100		HORZ. JT., YELLOW GREEN STN.; 45° JT., YELLOW GREEN STN.; HORZ. JT., YELLOW GREEN STN	
-42.8		87	100			FOLIATION 45°
	70				10° JT., GREEN STN. & WX.; HORZ. JT., GREEN STN. & WX.; 50° JT., CHLORITE	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APPD. 88-1 1-24-73
3	APPD. VRN 1/15/73
2	CHKD. D.C.
1	PREPD. R.S.

BORING LOG 308
MILLSTONE NUCLEAR POWER PLANT
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
12179-GSK-9A

NORTHEAST UTILITIES SERVICE COMPANY

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 308
TYPE OF BORING 4" NX LOCATION 1446N - 267E GROUND ELEV. 24.8'
DATE DRILLED 12/17/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
						BORING NO. 308 (CONT'D)
		90	100			35° JT., GREEN STN. 45° JT., CHLORITE 10° JT., GREEN STN. & WX. BROKEN ZONE, NO STN. OR WX. 45° JT., CHLORITE
-50.2	75					
						END OF BORING 75' GROUND WATER LEVEL 6.8' BELOW GROUND SURFACE ON 12/17/71

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≟ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APP'D 1-24-73
3	APP'D VRN 12-5-72
2	CHK'D D.C.
1	PREP'D R.S.

BORING LOG 308 (CONT'D)

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-9B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE: MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 309

TYPE OF BORING: 4" NX LOCATION: 1632N - 167E GROUND ELEV. 27.3'

DATE DRILLED: 12/13/71 DRILLED BY: AMERICAN DRILLING LOGGED BY: R.S.

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE EL. 27.3'							
			20	1			MED. DENSE, YELLOW BROWN FINE SAND, TR. MED. SAND, TR. SILT, SOME FINE-MED. GRAVEL. (ABLATION TILL)
			16	2			
			24	3			
18.3	10		169	4			V. DENSE, GRAY BROWN COARSE-FINE SAND, MOSTLY FINE, SOME SUBANG. GRAVEL & COBBLES, SOME SILT. (BASAL TILL)
			105/6"	5			
	20						*CORED THROUGH (TILL), COULDN'T DRIVE SPOON.
-.7							TOP OF ROCK
	30	92	100			60° JT., CLEAN, FRESH HORZ. JT., CLEAN, FRESH HORZ. JT., CLEAN, FRESH	GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/GREY GRANITE SILLS APPROX. 1-10' THICK & PINK PEG. INTRUSIVE BANDS APPROX. 1-2' THICK. FOL. APPROX. 45°.
		79	98			HORZ. JT., CLEAN, IRREG. BREAK HORZ. JT., CLEAN, IRREG. BREAK HORZ. JT., CLEAN, IRREG. BREAK	SOME CHLORITE IN GNEISS
-11.7	40					60° JT., CLEAN HORZ. JT., CLEAN BREAK	@ 39'-42.8' PEGMATITE
-15.5		96	100			HORZ. JT. W/LT. GREY MINERALIZATION ON SURF. 60° JT. W/ RUST STN.	
-20.7						END OF BORING 48' GROUND WATER LEVEL 10' BELOW GROUND SURFACE ON 12/10/71	
	50						

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≑ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APPD	88-1 1-26-73
3	APPD	VRF 1-25-73
2	CHKD	D.C.
1	PREPD	R.S.

BORING LOG 309

MILLSTONE NUCLEAR POWER PLANT UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-10

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 310
TYPE OF BORING 4" NX LOCATION 1433N - 185E GROUND ELEV. 25.6'
DATE DRILLED 12/24/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE EL. 25.6'							
							DENSE YELLOW BROWN-BROWN MED.-FINE SAND, SOME SILT & GRAVEL. (ABLATION TILL)
			40	1			
			43	2			
15.6	10						
			190	3			V. DENSE, GREY BROWN-GREY COARSE-FINE SAND, SOME SILT & GRAV. (SUBANG.) (BASAL TILL)
			140 300#	4			
	20		110# 300#	5			
1.6							TOP OF ROCK
-.9		31	100			CORE IS BROKEN, WX. & STN YELLOW W/CLAY SEAMS IN UPPER 1' OF RUN.	GREY, BANDED, QTZ, BIOTITE (MONSON GNEISS) W/GRANITE SILLS APPROX. 1-10' THICK & PEG. INTRUSIVE APPROX. 1-2' THICK.
						60° JT.	FOL. APPROX. 45°
	30					BROKEN ZONE W/YELLOW STN. & WX.	
						BROKEN ZONE WITH RUST STN. & WX.	
		40	91			70° JT., YELLOW GREEN STN. & WX.	@ 26.5'-34.5' GRANITE SILL
						20° JT., RUST STN. & WX.	
-8.9						70° JT., RUST STN. & WX.	
						30° JT., YELLOW STN. & WX.	
						45° JT., GREY CLAY INFILLING & WX.	
						30° JT., YELLOW STN. & WX.	
						45° JT., YELLOW STN. & WX.	
		66	100			45° JT., YELLOW STN. & WX.	
						60° JT., RUST STN. & WX.	
	40					SOFT WX. ZONE	
						45° JT., PURPLE STN.	
-19.4		86	100			SOFT, WX. ZONE	
						HORZ. JTS., CLOSELY SPACED, WX.	
						HIGH ANGLE, MINERALIZED SEAM, NO STAINING OR WX.	

GROUND WATER LEVEL
1st ENCOUNTERED 9' ON 12/23/71
8.6' ON 1/7/72

END OF BORING 45'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.
7. 300# INDICATES USE OF 300 LB. HAMMER

4	APPD 1-26-73
3	APPD. 1/15/73
2	CHKD D.C
1	PREPD R.S

BORING LOG 310

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-11

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 311
TYPE OF BORING 4" NX LOCATION 1232N - 213E GROUND ELEV. 20.9'
DATE DRILLED 12/21/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.
SUMMARY OF BORING PIEZOMETER INSTALLED 1/18/72

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	W_n %	OTHER TESTS	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND SURFACE EL. 20.9'								
			98	◤1				V. DENSE, BROWN FINE SAND, TR. MED. SAND, SOME SILT & FINE GRAVEL. (ABLATION TILL)
			48	◸				
			35	◤2		8.8	G	
10.9	10							
			51	◤3		8.2	G	V. DENSE, GRAY BROWN F. SAND, TR. MED. SAND, SOME F.-MED. GRAVEL, SOME SILT & COBBLES. (SUBANGULAR)
			85	◤4		7.8	G	
	20		100/6"	◤5		6.7	G	BECOMING COARSER W/DEPTH W/OCC. COBBLES. (BASAL TILL)
			90/6" 300#	◤6		8.5	G	
-9.1	30							TOP OF ROCK
								45° JT., YELLOW STN. & WX. / 45° JT., YELLOW STN. & WX. / 45° JT., YELLOW STN. & WX. / 45° JT., YELLOW STN. & WX. — GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/GRANITE SEAMS APPROX. 1-10' THICK. FOLIATION APPROX. 45°.
-13.4		78	100					APPROX. 1" SOFT WX. ZONE
-16.1								@34.3'-37.0' GRANITE
								APPROX. 1" SOFT WX. ZONE; 65° JT., GREY STN.
	40							2" SOFT WX. ZONE
-21.6								3" WX. ZONE
		93	100					@ 42.5'-50.0' GRANITE
								1" WX. SEAM; 50° JT., RUST STN.; 50° JT., GREEN STN.
-29.1	50							

END OF BORING 50'

GROUND WATER LEVEL
12.3' BELOW GROUND SURFACE ON 1/7/72

NOTE: DEFINITION OF SYMBOLS USED UNDER OTHER TESTS.
G - GRAIN SIZE ANALYSIS

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.
7. W_n IS NATURAL WATER CONTENT %.
8. OTHER TESTS, SEE NOTE ABOVE.
9. 300# INDICATES USE OF 300 LB. HAMMER.

4	APPD. SG 1-26-73
3	APPD. VRN 1/25/73
2	CHKD. D.C.
1	PREPD. R.S.

BORING LOG 311

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSE-12

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 312

TYPE OF BORING 4" NX LOCATION 1544N - 123E GROUND ELEV. 25.9'

DATE DRILLED 12/29/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.

SUMMARY OF BORING PIEZOMETER INSTALLED 1/18/72

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE EL. 25.9'							
			15	1			MED. DENSE, BROWN FINE SAND, SOME SILT & GRAVEL. (FILL)
			10	2			
20.9			212	3			V. DENSE GREY-GREY BROWN FINE SAND WITH SOME SILT AND FINE-MED. GRAVEL. (SUBANG.) (ABLATION TILL)
			53	4			
	10		72	5			
			84	6			
5.9	20		148	7			V. DENSE GREY CRS.-F. SAND, POORLY GRADED, SOME SILT AND GRAVEL.
			208	8			
	30		229	9			(BOULDERS & COBBLES)
			285	10			(BASAL TILL)
	40						
-20.1						TOP OF ROCK	
-23.1		30	75			HORZ. JT., YELLOW STN. 30° JT., YELLOW STN. HORZ. JT., YELLOW STN. MISSING CORE	GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/GRANITE SEAMS APPROX. 1-10' THICK. FOL. APPROX. 45-50°.
-24.1	50						@ 49-50' GRANITE
-29.1		44	83			10°JT., YELLOW STN. 10°JT., YELLOW STN. 10°JT., YELLOW STN. 10°JT., YELLOW STN. 10°JT., YELLOW STN. FRACTURED ZONE 10" MISSING CORE	
-34.1	60	85	100			60 JT., RUST STN. HORZ. JT. 2" FRACTURED ZONE 10° JT., RUST STN. 10° JT., RUST STN. HORZ. JT., RUST STN.	55' - 65' GRANITE
-39.1		28	90			VERT. JT., RUST STN. 70° JT., RUST STN. HORZ. JT., RUST STN. HORZ. JT., RUST STN.	

END OF BORING 65'

GROUND WATER LEVEL
AFTER COMPLETION 10' BELOW GROUND SURFACE 1/4/72

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APPD. [illegible] 1-2-73
3	APPD. VPN 1/11/73
2	CHKD. D.C.
1	PREPD. R.S.

BORING LOG 312

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-05K-13

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING No. 313

TYPE OF BORING 4" NX LOCATION 1388N - 113E GROUND ELEV. 22.7'

DATE DRILLED 12/28/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND SURFACE EL. 22.7'						
			29	1		MED. DENSE BROWN FINE SAND, TR. MED. SAND, SOME FINE GRAV. & SILT. (ABLATION TILL)
			33	2		
			34	3		
			34	4		
	10		50	5		
			47	6		
2.7	20		117	7		V. DENSE GREY-BROWN COARSE-FINE SAND, SOME FINE-MED. GRAVEL, (SUBANGULAR), SOME SILT, BOULDERS & COBBLES, OCC. INTERSTRATIFIED W/ 1" (±) THICK FINE SAND LAYERS. (BASAL TILL)
			120	8		
	30		153	9		
			106	10		
	40		99	11		
-23.8						FRAC. & WX.; 50° JT., TIGHT; 50° JT., TIGHT; HORZ. JT., WX.; 50° JT., YELLOW STN.; 50° JT., WX.; 50° JT., WX.; 50° JT., WX.; 50° JT., WX. / GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/ GRANITE. FOLIATION 50°
	50	87	100			
						HORZ. JT., YELLOW STN.
	60	97	100			FEW BREAKS IN CORE
						15° JT., YELLOW STN.; HORZ. JT., LT. GREY DISCOLORATION
-43.8						END OF BORING 66.5'
						GROUND WATER LEVEL 6.8' BELOW GROUND SURF. ON 1/7/72

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APPD	1-26-73
3	APPD	VRN 1-26-73
2	CHKD	D.C
1	PREPD	R.S

BORING LOG 313

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-14

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING NO. 314
TYPE OF BORING 4" NX LOCATION 1628N - 62E GROUND ELEV. 24.9'
DATE DRILLED 12/14/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS or RECOV.	SAMPLE: TYPE	GRAPHIC LOG	W_n %	OTHER TESTS	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND SURFACE EL. 24.9'								
			32	◤1				DENSE, GREY BROWN-BROWN COARSE-FINE SAND, OCC. INTER-STRATIFIED W/1' THICK LAYERS OF LT. YELLOW (F.-MED.) SAND, SOME F.-MED. GRAVEL, TR. SILT. (ABLATION TILL)
			69	◤2		8.8	G	
			46	◤3				
14.9	10		89	◤4		8.4	G	V. DENSE, GREY BROWN COARSE-FINE SAND, POORLY GRADED, SOME SILT & MED.-FINE GRAVEL. (COBBLES) (BASAL TILL)
			96	◤5		7.4	G	
	20		205	◤6		9.0	G	
								BOULDERS
			98/6" 300#	◤7		9.6	G	
	30		98/6" 300#	◤8				
-8.1								TOP OF ROCK
		53	73					BOULDER OR TOP OF BEDROCK, ZONE OF NO RECOVERY; ZONE OF SOFT WX. GRANITE; IRREG. FRAC., WX. & RUST STN.; BROKEN, WX. & RUST STN.; BROKEN ZONE W/GREEN STN. — GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/GREY GR. SILLS APPROX. 1-10' THICK & PINK PEG. INTRUSIVE BANDS ABOUT 1-2' THICK. FOL. APPROX. 45°. @ 33'-40' GR. SILL W/PEG. INTRUSIVES APPROX. 1' THICK.
-15.1	40	73	100					70° RUST STN.; SOFT, RUST WX. ZONE; SOFT, RUST WX. ZONE; 45° JT., LT. GREY MINERALIZED SEAM; 45° JT., LT. GREY MINERALIZED SEAM
		92	100					45° JT., SL. WX.; HORZ. JT., SL. WX.; 45 JT., LT. GREY MINERALIZED SEAM
	50							
-28.1								

END OF BORING 53'

GROUND WATER LEVEL
1st ENCOUNTERED 64' BELOW GROUND SURFACE 12/13/71
9.0' BELOW GROUND SURFACE 12/17/71

NOTE: DEFINITIONS OF SYMBOLS USED UNDER OTHER TESTS,
G - GRAIN SIZE ANALYSIS

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.
7. W_n IS NATURAL WATER CONTENT %
8. OTHER TESTS SEE NOTE ABOVE
9. 300# INDICATES USE OF 300 LB. HAMMER

4	APPD	9&H 1-26-73
3	APPD.	VAN 1/25/73
2	CHKD	D.C.
1	PREPD	R.S.

BORING LOG 314

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-15

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 315
TYPE OF BORING 4" NX LOCATION 1433N - 76E GROUND ELEV. 23.3'
DATE DRILLED 12/23/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS or RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND SURFACE EL. 23.3'						
			115	1		DENSE GREY-BROWN FINE SAND, TR. CRS.-MED. SAND, TR. SILT & F. GRAVEL, OCC. COBBLES & BOULDERS. (ABLATION TILL)
			41	2		
13.0'	10					
			125	3		V. DENSE GREY (F.-CRS.)SAND, POORLY GRADED, SOME SILT & F. - MED. GRAVEL, COBBLES & BOULDERS AT 30-40'. (BASAL TILL)
			100/6 300#	4		
	20		90/6 300#	5		NOTE: DEFINITIONS OF TERMS USED UNDER OTHER TESTS, G - GRAIN SIZE ANALYSIS
			150 300#	6		
	30		83/6 300#	7		
			90/6 300#	8		
	40					
-19.7'						TOP OF ROCK
		62	100			BADLY WX. ZONE; 15° JT., WX.; 45° JT., WX.; BROKEN & WX. ZONE; BROKEN & WX. ZONE — GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/GREY GRANITE SILLS APPROX. 1-10' THICK & PEG. INTRUSIVE BANDS 1-2' THICK. FOL. 45-50°.
	50	0	100			BROKEN, BADLY WX. ZONE; BROKEN & WX. ZONE; 30° JT., GREEN STN.
		50	100			BROKEN & WX. ZONE; 50° JT. ALONG FOL. W/GREEN STN.; SOFT, WX. ZONE — ROCK BECOMES RICHER IN BIOTITE.
	60	82	100			50° JT. ALONG FOL., GREY MINERALIZED SURF.; 50° JT. ALONG FOL., TR. WX. & GREEN STN.
-39.7'						
						END OF BORING 63' GROUND WATER LEVEL 1st ENCOUNTERED 9.0' BELOW GROUND SURFACE 12/21/71 9.1' BELOW GROUND SURFACE ON 1/7/72

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.
7. W_n IS NATURAL WATER CONTENT %.
8. OTHER TESTS SEE NOTE ABOVE.
9. 300# INDICATES USE OF 300 LB. HAMMER.

4	APPD. 1-26-73
3	APPD. 1-26-73
2	CHKD. D.C.
1	PREPD. R.S.

BORING LOG 315
MILLSTONE NUCLEAR POWER STATION UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
12179-GSK-16

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE: MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 316
TYPE OF BORING: 4" NX LOCATION: 1270N - 10W GROUND ELEV. 15.6'
DATE DRILLED: 12/30/71 DRILLED BY: AMERICAN DRILLING LOGGED BY: R.S.
SUMMARY OF BORING: PIEZOMETER INSTALLED 1/18/72

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS (W_n %, OTHER TESTS)	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
		GROUND SURFACE EL. 15.6'					
				* 1			
			42	2		15.8 G	DENSE, BROWN FINE SAND, TR. MED. SAND, SOME SILT & FINE GRAVEL. (ABLATION TILL)
			78	3			
			55	4		9.4 G	
	10		55	5			
			30	6		10.4 G	
-4.4	20		165	7			V. DENSE, GREY SAND (F.-CRS.), MOSTLY FINE, TR. OF SILT, GRAVEL, OCC. BOULDERS & COBBLES. (BASAL TILL)
			100/6	8			
	30						
-17.4							TOP OF ROCK
						HORZ. JT., RUST STN., WX. SURF. 60° JT., RUST STN., WX. SURF. 60° JT., RUST STN., WX. SURF. 60° JT., RUST STN., WX. SURF.	GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/GREY GR. SILLS APPROX. 1-10' THICK & PINK PEG. INTRUSIVE BANDS APPROX. 1-2' THICK. FOL. APPROX. 40°. @ 33-36.5' GREY GRANITE
-20.9		67	94			SOFT, WX., BROKEN & RUST STN. 50° JT., RUST STN. & WX. SURF. 40° JT., GREEN STN. & WX. SURF. 40° JT., GREEN STN. & WX. SURF. 40° JT., GREEN STN. & WX. SURF. 40° JT., GREEN STN. & WX. SURF.	
	40					10° JT. 10° JT. 10° JT. 10° JT. LT. GREY MINERALIZED SURFACES W/ A TR. OF WX.	ROCK BECOMES LESS WX. WITH DEPTH.
		88	98			10° JT. 40° JT., RUST STN. 40° JT., RUST STN.	
	50					40° JT., RUST STN W/TR. WX.	
-37.4						40° JT., RUST STN.	

END OF BORING 53'

GROUND WATER LEVEL
9.2' BELOW GROUND SURFACE ON 1/14/72

NOTE: DEFINITIONS OF SYMBOLS USED IN OTHER TESTS,
G - GRAIN SIZE ANALYSIS

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
□◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.
7. W_n IS NATURAL WATER CONTENT.
8. OTHER TESTS SEE NOTE ABOVE.
9. * INDICATES AUGER SAMPLE FROM 0-1.5' BELOW GROUND SURFACE.

4	APPD. 86-1 1-26-73
3	APPD. 1-17-73
2	CHKD. D.C.
1	PREPD. R.S.

BORING LOG 316

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-17

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 2

SITE: MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 317
TYPE OF BORING: 4" NX LOCATION: 1446N - 322E GROUND ELEV. 25.3'
DATE DRILLED: 12/27/71 DRILLED BY: AMERICAN DRILLING LOGGED BY: R.S.
SUMMARY OF BORING:

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)

GROUND SURFACE EL. 25.3'

ELEV.	DEPTH	RQD	BLOWS / RECOV.	TYPE
			65	▼1
20.7				
			106	▼2
			34	▼3
15.8	10			
13.7		95	100	
		93	100	
	20	53	100	
		62	100	
	30	92	96	
-7.7				
		96	100	
-12.2	40	90	100	
		53	100	
-24.2	50	88	100	
-26.7				
		66	92	
-35.7	60	78	100	
-38.2				
		85	100	
	70			

V. DENSE, YELLOW BROWN COARSE-FINE SAND, SOME SILT & COARSE-FINE GRAVEL, COBBLES. (FILL)

V. DENSE-DENSE GREY BROWN-YELLOW BROWN FINE SAND, TR. CRS.-MED. SAND, TR. SILT & SOME GRAVEL.

TOP OF ROCK

GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/GR. BANDS ABOUT 1-10' THICK. FOL. ABOUT 45°.

HORZ. JT., RUST STN.
15° JT., RUST STN.
HORZ. JT., RUST STN.
HORZ. JT.
12' - 33' GRANITE
75 JT., YELLOW-GREEN STN.; JT. EXTENDS FROM 19' - 23'.
HORZ. JT., RUST STN. & WX.
60° JT., TIGHT
FRAC. ZONE, WX.
75° JT., RUST STN. & WX.
HORZ. JT., RUST STN.
60° JT., TIGHT
HORZ. JT., WX.
ROCK IS SOLID W/SOME MINERALIZED (TIGHT) SEAMS.
@37.5' - 44.0' GRANITE
60° JT., GREEN (CHLORITE)
FRAC. ZONE
50° JT., CHLORITE
50° JT., CHLORITE
50° JT., CHLORITE
50° JT., CHLORITE
2" FRAC. ZONE
50° JT., TIGHT
30° JT., GREEN STN. & WX.
50° JT., GREEN STN.
50° JT., GREEN STN.
@ 49' - 52' GRANITE
HORZ. WX.
1" FRAC. ZONE
15° JT., RUST STN. & WX.
FOLIATION APPROX. 60°
HORZ. JT., RUST STN.
50° JT., YELLOW STN.
10° JT., YELLOW STN.
10° JT., YELLOW STN.
1" FRAC. ZONE
10° JT., RUST STN.
@ 61'-63.5' GRANITE
6" FRAC. ZONE
60° JT., GREEN STN.
70° JT., TIGHT SEAMS
10° JT., GREEN STN.
4" FRAC. ZONE

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ▼6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APPD.	4-6-73
3	APPD.	1-15-73
2	CHKD.	D.C.
1	PREPD.	R.S.

BORING LOG 317

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-16A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 2

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 317
TYPE OF BORING 4" NX LOCATION 1446N - 322E GROUND ELEV. 25.3'
DATE DRILLED 12/27/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
						BORING NO. 317 (CONT'D)
		48	100			9" FRAC. ZONE 65° JT., CHLORITE 65° JT., CHLORITE 6" FRAC. ZONE
-49.7	75					END OF BORING 75' GROUND WATER LEVEL 8.7' BELOW GROUND SURFACE ON 1/7/72

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APPD. BB 1-26-73
3	APPD. VRM 1/15/73
2	CHKD. D.C.
1	PREPD. R.S.

BORING LOG 317 (CONT'D)

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-18B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE: MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 318
TYPE OF BORING: 4" NX LOCATION: 1415N - 115E GROUND ELEV. 25'
DATE DRILLED: 1/12/72 DRILLED BY: AMERICAN DRILLING LOGGED BY: R.S.
SUMMARY OF BORING:

GROUND SURFACE EL. 26'(±)

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	W_n %	OTHER TESTS	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
22.5			16	1			MED. DENSE-DENSE BROWN-GREY BROWN F. SAND, TR. MED. SAND SOME F. GRAVEL, & TR. SILT. (FILL)
			66	2	5.9	G	V. DENSE GREY BROWN FINE SAND, TR. MED. SAND, F. GRAVEL & SILT. (ABLATION TILL)
			150	3			
			78	4	9.1	G	
	10		77	5			
10.0							
			111	6	8.6	G	BECOMING COARSER & MORE DENSE W/DEPTH, W/OCC. COBBLES & BOULDERS. (BASAL TILL)
	20		192	7			NOTE: DEFINITION OF SYMBOLS USED UNDER OTHER TESTS, G - GRAIN SIZE ANALYSIS
			351	8	10.9	G	
	30		218	9			
			219	10	8.7	G	
	40		242/6	11			
-19.5			237	12			V. DENSE GRAY BROWN SAND (MED.-CRS.) & F. GRAVEL.
-22.5							TOP OF ROCK
	50	0	73				CORE RUN IS FRAC.& WX. — GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/GRANITE SEAMS 1-10' THICK. FOL. ABOUT 50°.
-26.2		87	100				70° JT., TIGHT; 70° JT., TIGHT; 60° JT., CHLORITE; 3" FRAC. ZONE, WX.; 50° JT., WX. — @ 52.2' - 56.5' GRANITE
-31.5		35	90				SOFT WX. ZONE; 50° JT., YELLOW STN.; 60° JT., YELLOW STN.; FRAC. ZONE, WX.
	60						
-37.0		27	90				70° JT., TALC.; FRAC. ZONE & WX. — 62.0'-64.8' GRANITE
-39.8							CORE IS BADLY WX. IN A VERT. PLAIN. — 66.3' - 67.0' GRANITE
-42.0							
	70						END OF BORING 67'
							GROUND WATER LEVEL FINAL READING 9.7' BELOW GROUND SURFACE 1/12/72

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⏚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.
7. W_n IS NATURAL WATER CONTENT %.
8. OTHER TESTS SEE NOTE ABOVE.

4	APPD 1-26-73
3	APPD 1/11/73
2	CHKD D.C.
1	PREPD R.S.

BORING LOG 318

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE UNIT

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-19

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 2

SITE MILLSTONE PT. WATERFORD, CONN. J.O. NO. 12179 BORING NO. 319
TYPE OF BORING NX LOCATION 1.708N-65E GROUND ELEV. 25.0
DATE DRILLED 11/11/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND SURFACE ELEV. 25.0						
			15	1		MEDIUM DENSE, RUST BROWN-DARK BROWN, POORLY GRADED, MEDIUM TO FINE SAND, SOME SILT.
21.0			15	2		(FILL)
			99	3		V. DENSE, GRAY BROWN, WELL GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, TRACE OF SILT.
			58	4		V. DENSE, GRAY BROWN, POORLY GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, SOME SILT.
	10		95	5		
11.0						(ABLATION TILL)
			120/0.2			VERY DENSE COBBLES AND BOULDERS
	20		152/1.2	6		VERY DENSE, GRAY BROWN, POORLY GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, SOME SILT.
			100/.9	7		
	30		100/.3	8		(BASAL TILL)
						VERY HEAVILY WEATHERED GREENISH GRAY BIOTITE GNEISS (CHLORITIZED)
-10.0			120/.2	9		TOP OF ROCK
-10.2		0	12			VERY HEAVILY WEATHERED BROKEN ZONE, POCKETS OF GREENISH GRAY CLAY AT 35.0 TO 40.4 — GREENISH GRAY BIOTITE GNEISS (MONSON GNEISS) FOLIATION ABOUT 45°
	40					80° JT. SLICKENSIDES AT 40.7' ǁ TO JT. DIP; VERY HEAVILY WEATHERED ZONE AT 42.9-43.3
		33	73			45° FRAC. CLAY POCKETS AT 45.3'; TYPICALLY VERY CLOSE JT. THROUGHOUT
	50					VERY HEAVILY WEATHERED (SANDLIKE) BROKEN ZONE AT 50.0 TO 52.2
		12	53			60° JT., TIGHT YELLOWISH GREEN STAIN, SLICKENSIDES AT 53.5 ǁ TO JT. DIP; 80° JT. TIGHT, RUST STAIN; VERY HEAVILY WEATHERED ZONE AT 55.2 - 55.6; TYPICALLY V. CL. JT. THROUGHOUT
	60					80° JT. HEAVY RUSTY GREEN STN. SLICKENSIDES AT 60.6-61.8 ǁ TO JT. DIP; 70° JT. TIGHT POSSIBLE SLICKENSIDES AT 65.6
		15	83			SOME WEATHERING, BROKEN ZONE AT 65.6-66.5; TYPICALLY V. CL. JT. THROUGHOUT; HORIZ. JT. TIGHT, YELLOWISH GREEN STN.; SEVERAL 80° JTS. 0.5 IN. LONG ENECHELON (STEPLIKE) AT 68.6-69.0
	70	38	92			80° JT. HEAVY YELLOWISH GREEN MINERALIZATION

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD 88-1 1-26-73
3	APPD 1/25/73
2	CHKD D.C
1	PREPD P.W

BORING LOG 319
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
12179-GSK-20A

NORTHEAST UTILITIES SERVICE COMPANY

SITE MILLSTONE PT. WATERFORD, CONN. J.O. No. 12179 BORING No. 319
TYPE OF BORING NX LOCATION 1,708N-65E GROUND ELEV. 25.0
DATE DRILLED 11/11/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
		36	100			SOME WEATHERING, BROKEN ZONE AT 70.5-71.8 80° FRAC. TIGHT, YELLOWISH GREEN STN. 45° JT. SLICKENSIDES 80° JTS. SLICKENSIDES ON TALC AT 73.3-74.3 SOME WEATHERING, BROKEN ZONE AT 74.3-74.7 90° JT. YELLOWISH GREEN STN. 15° JT. YELLOWISH GREEN STN. 60° JT. POSSIBLE SLICKENSIDES
-54.3	80					END OF BORING 79.3' GROUND WATER LEVEL AFTER COMPLETION 11/13/72 8.4' BELOW GROUND SURFACE

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ∇ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. 12-6-73
3	APPD. VRN 1-5-73
2	CHKD. DC.
1	PREPD. P.W.

BORING LOG 319
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
12179-GSK-20B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT. WATERFORD, CONN. J.O. NO. 12179 BORING NO. 320

TYPE OF BORING NX LOCATION 1,705N-183E GROUND ELEV. 28.3

DATE DRILLED 11/2/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
			43	1		DENSE, RUST TO LT. BROWN, POORLY GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, TRACE OF SILT.	
24.3			17	2		MEDIUM DENSE, LT. BROWN, POORLY GRADED, MEDIUM TO FINE SAND, SOME SILT. (FILL)	
21.3			101	3		V. DENSE, MEDIUM BROWN, WELL GRADED, COARSE TO FINE SAND, SOME GRAVEL, TRACE OF SILT. (ABLATION TILL)	
			120/.1'			VERY DENSE, COBBLES AND BOULDERS	
	10		120/.1'				
12.5			120/.1'			(BASAL TILL) TOP OF ROCK	
		100	100			30° JT. TIGHT YELLOW STAIN	GRAY BIOTITE GNEISS (MONSON GNEISS) FOLIATION ABOUT 45°-60°
						45° FRAC. CLEAN	
	20					30° JT. YELLOW STAIN & CALCITE MINERALIZATION.	
						60° FRAC. CLEAN	
		90	99			JT. TYPICALLY 10°-30°, RUST STAIN	
2.3		89	96			30° JT. RUST STAIN AND CALCITE MINERALIZATION.	
						END OF BORING 26.0'	
						GROUND WATER LEVEL AFTER COMPLETION 11/3/72 7.7' BELOW GROUND SURFACE	
	30						

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≑ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD 88-1 1-26-73
3	APPD VRP 1-25-73
2	CHKD D.C.
1	PREPD P.W.

BORING LOG 320

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-21

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT. WATERFORD, CONN. J.O. NO. 12179 BORING NO. 321
TYPE OF BORING NX LOCATION 1,808N-174E GROUND ELEV. 27.6
DATE DRILLED 11/3/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
			21	1		MEDIUM DENSE, RUST BROWN, POORLY GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, TRACE OF SILT.	
			13	2		MEDIUM DENSE, RUST LT. BROWN, POORLY GRADED, MEDIUM TO FINE SAND, SOME SILT. (FILL)	
22.8							
			39	3		DENSE, MEDIUM, BROWN, POORLY GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, TRACE OF SILT.	
			54	4		VERY DENSE, LT. GRAYISH BROWN, POORLY GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, SOME SILT. (ABLATION TILL)	
18.0	10		120/0.0			VERY DENSE, LIGHT GRAYISH BROWN, POORLY GRADED, COARSE TO FINE SAND, SOME SILT.	
						VERY DENSE COBBLES AND BOULDERS.	
			120/0.0				
	20		120/0.0				
			120/0.0				
	30		120/0.0				
			120/0.0				
	40		120/0.0				
			120/0.0				
-19.0						TOP OF ROCK	
-20.6						HEAVILY WEATHERED BROKEN ZONE TO 48.2	GREENISH GRAY BIOTITE GNEISS (MONSON GNEISS) WITH ONE GRANITE BAND FOLIATION ABOUT 45°
	50	0	68			60°-90° JTS. BROKEN ZONE ABUNDANT YELLOWISH GREEN TALC MINERALIZATION AT 48.2-50.3; MANY HIGH ANGLE JTS. OFTEN ALONG FELDSPAR CLEAVAGE AT 52.0-53.5; 45° CONTACT	PINK GRANITE AT 48.2-53.5
-25.9		18	76			45° JT. YELLOWISH GREEN STAIN POSSIBLE SLICKENSIDES 11 TO FOL. AT 53.6; 15° JT. YELLOW BROWN STAIN, SOME CALCITE MINERALIZATION; BROKEN ZONE, HEAVILY WEATHERED, SEVERAL 45°-90° JTS. (SANDLIKE 0.2') AT 57.8-61.6	
	60					JT. TYPICALLY 15°-45°, STAINED, WITH OCC. MINERALIZATION AND SLICKENSIDES	
		53	95			80° JT. YELLOW BROWN STAIN, SOME CALCITE MINERALIZATION; 85° JT. YELLOWISH GREEN AND RUST STAIN, SOME CALCITE MINERALIZATION; 60° JT., CALCITE MINERALIZATION, SLICKENSIDES, 30° TO JT. DIP AT 69.1	
-43.5	70					80° JT. RUST & YELLOW GREEN STAIN, SLICKENSIDES AT 70.7	
						END OF BORING 71.1'	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≢ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

GROUND WATER LEVEL
AFTER COMPLETION 11/7/72
14.5' BELOW GROUND SURFACE

4	APPD 9-8-? 1-26-73
3	APPD ??? 1/15/73
2	CHKD. D.C.
1	PREPD P.W.

BORING LOG 321
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
12179-GSK-22

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT. WATERFORD, CONN. J.O. No. 12179 BORING No. 322
TYPE OF BORING NX LOCATION 1,808N-264E GROUND ELEV. 30.3
DATE DRILLED 10/31/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

SOIL OR ROCK DESCRIPTION

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
			87	1	VERY DENSE, GRAYISH BROWN, POORLY GRADED, COARSE TO FINE GRAVEL, SOME SAND, TRACE OF SILT.	
			39	2		
			18	3	MEDIUM DENSE, MEDIUM BROWN, POORLY GRADED, MEDIUM TO FINE SAND, SOME SILT.	(FILL)
22.3			43	4	DENSE GRAYISH BROWN POORLY GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, TRACE OF SILT.	(ABLATION TILL)
20.5	10		120/.7'	5	VERY DENSE, LIGHT GRAYISH BROWN, WELL GRADED, COARSE TO FINE SAND, SOME GRAVEL, TRACE OF SILT.	
			120/0.3			
	20		120/.5'	6		(BASAL TILL)
6.3					TOP OF ROCK	
		0	60		BROKEN ZONE, SHARP CLEAN BREAKS AT 24.0-25.0 HORIZ. FRAC. YELLOWISH GREEN STN.	GRAY BIOTITE GRANITE (MONSON GNEISS)
		72	95		JT. TYPICALLY 30°-60°, STAINED, W/SOME MINERALIZATION	
	30				60° JT. 1/8" GRAY MINERALIZATION (POSSIBLE GROUTLIKE CEMENT) 30° FRAC. CLEAN, TIGHT 60° JT. HEAVY GREEN GRAY TALC MINERALIZATION TYPICALLY V. CL. JT. THROUGHOUT	
-4.7					END OF BORING 35.0' GROUND WATER LEVEL AFTER COMPLETION 11/1/72 8.1' BELOW GROUND SURFACE	
	40					

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. 1-26-73	
3	APPD. VRN 1/5/73	
2	CHKD. D.C.	
1	PREPD. P.W.	

BORING LOG 322
MILLSTONE POWER
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-23

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT. WATERFORD, CONN. J.O. NO. 12179 BORING NO. 323

TYPE OF BORING NX LOCATION 1,708N-264E GROUND ELEV. 29.3

DATE DRILLED 10/30/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
			26	1		MEDIUM DENSE, MEDIUM BROWN, POORLY GRADED, COARSE TO FINE GRAVEL, SOME SAND, TRACE OF SILT.
25.3			12	2		(FILL)
			39	3		DENSE TO VERY DENSE, BROWN, POORLY GRADED, COARSE TO FINE, SAND, TRACE OF SILT.
19.6	10		68	4		(ABLATION TILL)
			120/.7	5		VERY DENSE, LIGHT BROWN, POORLY GRADED, COARSE TO FINE GRAVEL, SOME SAND, TRACE OF SILT.
12.3			300 LB. 120/.6	6		VERY DENSE, LT. BROWN, POORLY GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, TRACE OF SILT. (BASAL TILL)
	20	13	94			30° JT. TIGHT, RUST STN. / 45° JT. SOME CALCITE MINERALIZATION / TYPICALLY V. CL. JT. THROUGHOUT — GRAY BIOTITE GNEISS (MONSON GNEISS) FOLIATION ABOUT 45°
		73	82			75° JT. SOME CALCITE MINERALIZATION / TYPICALLY VL. CL. JT., 15°-45°, WITH SOME CALCITE MINERALIZATION
-1.9	30	84	100			60° JT. SOME YELLOWISH GREEN STAIN, SLICKENSIDES AT 29.6
-2.7						70° CONTACT — PINK GRANITE

END OF BORING 32.0'

GROUND WATER LEVEL AFTER COMPLETION 10/31/72 8.2' BELOW GROUND SURFACE

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. 1-26-73
3	APPD. 1-25-73
2	CHKD. J.C.
1	PREPD. P.W.

BORING LOG 323

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-24

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT. WATERFORD, CONN. J.O. NO. 12179 BORING NO. 324
TYPE OF BORING NX LOCATION 1,718N-364E GROUND ELEV. 30.1
DATE DRILLED 10/26/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLCK
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
			63	1			VERY DENSE, MEDIUM BROWN, POORLY GRADED, COARSE TO FINE GRAVEL, SOME SAND, TRACE OF SILT.
26.0			19	2			MEDIUM DENSE, MEDIUM BROWN, POORLY GRADED, MEDIUM TO FINE SAND, SOME SILT (FILL)
			43	3			DENSE, LIGHT BROWN, POORLY GRADED, COARSE TO FINE SAND, SOME SILT.
	10		21	4			
			24	5			MEDIUM DENSE, GRAYISH BROWN, POORLY GRADED, COARSE TO FINE SAND, SOME GRAVEL, TRACE OF SILT. (ABLATION TILL)
15.8			120/0.0				VERY DENSE, BOULDERS AND COBBLES
	20		120/0.0				
		0	9				
		25	55				
		14	26				(BASAL TILL)
	30						
		0	10				
-4.9						TOP OF ROCK	
		74	88			80° JT. HEAVY YELLOWISH GREEN MINERALIZATION AT 35.0-35.6; JT. TYPICALLY HORIZ. - 30°, TIGHT THROUGHOUT; 75° JT. HEAVY YELLOWISH GREEN MINERALIZATION AT 38.4-39.1	GRAY BIOTITE GNEISS (MONSON GNEISS) FOLIATION ABOUT 60°
-11.4	40					80° JT. SL. TALC MINERALIZATION; 15° FRAC. SL. YELLOWISH GREEN STN.	PINK GRANITE GNEISS AT 41.5-44.0
-13.9		77	100			85° JT. HEAVY TALC AFTER CALCITE MINERALIZATION AT 46.2-47.9; JT. TYPICALLY 10°-30° WITH SOME MINERALIZATION (TALC & CALCITE); 80° JT. HEAVY TALC & CALCITE MINERALIZATION AT 48.4-49.4	GREEN GRAY BIOTITE GNEISS
-21.2	50					END OF BORING 51.3'	

GROUNDWATER LEVEL
AFTER COMPLETION 10/30/72
8.5' BELOW GROUND SURFACE

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ▼6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≑ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. 98-1 1-26-73
3	APPD. VRN 1/24/73
2	CHKD. D.C.
1	PREPD. P.W.

BORING LOG 324
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
12179-GSK-25

NORTHEAST UTILITIES SERVICE COMPANY — SH 1 OF 1

SITE MILLSTONE PT. WATERFORD, CONN. J.O. NO. 12179 BORING NO. 325
TYPE OF BORING NX LOCATION 1,718N-476E GROUND ELEV. 30.1
DATE DRILLED 10/18/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
			61	1		V. DENSE TO MEDIUM DENSE, MEDIUM BROWN, POORLY GRADED, COARSE TO FINE GRAVEL, SOME SAND, TRACE OF SILT
			15	2		WOOD
			5			PEAT?
23.1						(FILL)
			35	3		DENSE, MEDIUM BROWN, POORLY GRADED, COARSE TO FINE GRAVEL, SOME SAND, TRACE OF SILT.
	10		21	4		MEDIUM DENSE TO DENSE, MEDIUM BROWN, POORLY GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, TRACE OF SILT.
13.6			43	5		(ABLATION TILL)
						COBBLES AND BOULDERS
	20		120			
			100			
	30		91			VERY DENSE, GRAYISH BROWN, POORLY GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, TRACE OF SILT.
-6.7						(BASAL TILL)
						TOP OF ROCK
						60° JT. TIGHT YELLOW BROWN STN. / GRAY BIOTITE GRANITE (MONSON GNEISS) SMALL PEGMATITE BANDS
	40					JT. TYPICALLY 10°-30°, STAINED
						75° JT. HEAVY YELLOWISH GREEN STAIN AT 41.7-42.3
						60° JT. HEAVY YELLOWISH BROWN STN. AND CALCITE MINERALIZATION
-16.9						80° JT. SOME YELLOWISH BROWN STAIN AND CALCITE MINERALIZATION AT 45.0-45.8
						END OF BORING 47.0
	50					GROUND WATER LEVEL AFTER COMPLETION 10/26/72 8.8' BELOW GROUND SURFACE

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [ ] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD.	
3	APPD. VER	
2	CHKD. D.C.	
1	PREPD. P.W.	

BORING LOG 325
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
12179-GSK-26

NORTHEAST UTILITIES SERVICE COMPANY SH 1 OF 2

SITE: MILLSTONE PT. WATERFORD, CONN. J.O. No. 12179 BORING NO. 326
TYPE OF BORING: NX LOCATION: 1,432N-476E GROUND ELEV. 27.0
DATE DRILLED: 10/10/72 DRILLED BY: AMERICAN DRILLING LOGGED BY: P. WALLACK
SUMMARY OF BORING:

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
					VERY DENSE, GREENISH BROWN, POORLY GRADED, COARSE TO FINE SAND, SOME GRAVEL, TRACE OF SILT.	
			56	1		
			90	2		
19.5			100			(ABLATION TILL)
17.9					TOP OF ROCK	(BASAL TILL)
		40	90		15° RUST STAIN TIGHT	PINK GRANITE AT 9.1-10.7
16.3	10	0	100			
					45° JT. YELLOW STAIN AND TR. OF WEATHERING, PARALLEL TO FOL. (TYPICAL THROUGHOUT)	GRAY BIOTITE GNEISS (MONSON GNEISS) FOLIATION ABOUT 45° GRANITE BANDS
		46	90			
					15° JT., RUST STAIN AND CALCITE MINERALIZATION	
		100	100			
	20					
					HORIZ. JT. YELLOW STAIN, TRACE MINERALIZATION	
2.6		80	99			
					80° JT., RUST STAIN, (CEMENTED) 60° CONTACT, GRANITE AND GNEISS	PINK GRANITE AT 24.4-27.4
-0.4						
					80° JT. GREEN STAIN, HEAVILY WEATHERED, MINERALIZATION	FOLIATION ABOUT 50°
	30					
					BROKEN ZONE, YELLOWISH GREEN STAIN, HEAVILY WEATHERED AT 30.1 TO 30.4	
					80° JT., GREEN STN., SOME WEATHERING	
		77	94			
					15° JT., YELLOWISH GREEN STAIN, TR. OF WEATHERING (TYPICAL THROUGHOUT)	
		0	100			
					15° FRACTURE, CLEAN	
		98	100			
	40					
					HORIZ. FRACTURE, CLEAN	
		98	99		FRAC. TYPICALLY 0°-15°, CLEAN, TIGHT, WITH OCC. STAIN INFREQUENT SL. WX.	
	50					
		100	100		60° JT. GREEN STAIN, CALCITE MINERALIZATION, SLICKENSIDES (PARALLEL TO DIP)	
		100	100			
	60					
					JT. TYPICALLY HORIZ. TO 15° STAINED, WITH OCC. CLEAN FRAC. INFREQUENT SL. WX.	
		88	100			
	70					

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD 1-26-73
3	APPD VIN
2	CHKD D.C.
1	PREPD P.W.

BORING LOG 326
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
12179-GSK-27A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 2

SITE MILLSTONE PT. WATERFORD, CONN. J.O. NO. 12179 BORING NO. 326

TYPE OF BORING NX LOCATION 1,432N-476E GROUND ELEV. 27.0

DATE DRILLED 10/10/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS or RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
-43.7							
-44.3						50° CONTACT (PARALLEL TO FOLIATION) JT. & FRAC. TYPICALLY 0-15°, STND.	PINK GRANITE AT 70.7-71.3
-47.5		63	94			15° FRAC. RUST STAIN	
-49.1						HORIZ. FRAC. TYPICALLY CLEAN/W. OCC. MX.	PINK GRANIT, RICH AT 74.5-76.1 MAGNETITE
						60° CONTACT GRANITE AND GNEISS	FOLIATION 45°
						60° JT., RUST STAIN (CEMENTED)	
	80	88	94			66% BREAKS, CLEAN JT.; 34% BREAKS, STAINED JT. TYPICALLY 0°-15°	
						15° JT., RUST STAIN, MINERALIZATION	
-58.3							
						END OF BORING 85.3'	
						GROUND WATER LEVEL AFTER COMPLETION 10/17/72 10.5' BELOW GROUND SURFACE	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. BE 1-26-73
3	APPD. VRH 1-25-73
2	CHKD. D.C.
1	PREPD. P.W.

BORING LOG 326

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

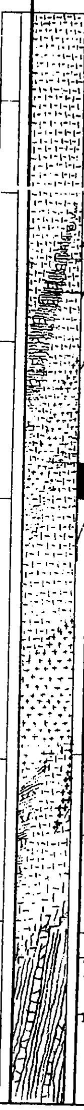
12179-GSK-27B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 2

SITE: MILLSTONE PT. WATERFORD, CONN.
J.O. No.: 12179
BORING No.: 327
TYPE OF BORING: NX @ 45°
LOCATION: 1,510N-456E; S70°E
GROUND ELEV.: 28.7'
DATE DRILLED: 11/2/72
DRILLED BY: AMERICAN DRILLING
LOGGED BY: P. WALLACK
SUMMARY OF BORING:

ELEV. FEET	DEPTH FEET ALONG BOREHOLE AXIS	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
							OVERBURDEN
20.8	10					TOP OF ROCK	
		36	82			80° JT., LT. BROWN SILT JT. SOME STAIN THROUGHOUT 15° JT., LT. BROWN SILT	PINK GRANITE AT 11.0-24.7
	20	62	90			BROKEN ZONE, LT. BROWN SILT ON HIGH ANGLE SURFACES AT 16.0-16.4 JT. SOME STAIN THROUGHOUT, OCC. SILT	
11.1		81	99			BROKEN ZONE, LT. BROWN SILT ON HIGH ANGLE SURFACES AT 23.8-24.0 70° CONTACT, GRANITE AND GNEISS	
9.7						70° JT., RUST STAIN	GRAY BIOTITE GNEISS (MONSON GNEISS)
	30	70	93			80° CONTACT GNEISS AND GRANITE 85°-65° JT., (CURVED), HEAVY RUST STAIN JT. TYPICALLY 45°. RUST STAIN	PINK GRANITE AT 26.6-52.4 PEGMATITE AT 32.3-35.0 AT 35.8-36.3
2.7							
1.5						BROKEN ZONE, VERY HEAVILY WEATHERED SOME BROWNISH GRAY CLAY, ABUNDANT YELLOW STAIN, SANDLIKE, AT 36.3-38.2	
	40	66	100			70° JT., RUST AND GRAYISH GREEN STN. JT. TYPICALLY 45°, RUST STAIN 70° JT., GRAYISH GREEN STAIN	
	50	91	99			FRAC. TYPICALLY 45°. CLEAN 45° CONTACT GRANITE AND GNEISS AT 52.4	PEGMATITE AT 45.9-52.4
-8.7							
-9.3						FRAC. TYPICALLY 10°, CLEAN	GRAY BIOTITE GNEISS AT 53.4
	60	97	98			80° CONTACT GNEISS AND GRANITE FRAC. TYPICALLY 45°, CLEAN W/ OCC. CALCITE FILLING	PINK GRANITE, PEGMATITE AT 54.3-56.9
-15.8	70	97	100			45° CONTACT (WHITE GRANITE) AT 63.4-63.6 FRAC. TYPICALLY 45°. CLEAN	GRAY BIOTITE GNEISS FOLIATION 80°



1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD 1-26-73
3	APPD VRP 1-25-73
2	CHKD D.C.
1	PREPD P.W.

BORING LOG 327
MILLSTONE NUCLEAR POWER STATION UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-28A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 2

SITE MILLSTONE PT. WATERFORD, CONN. J.O. No. 12179 BORING No. 327

TYPE OF BORING NX @ 45° LOCATION 1,510N-456E; S70°E GROUND ELEV. 28.7

DATE DRILLED 11/2/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET ALONG BOREHOLE AXIS	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
						FRAC. TYPICALLY (10°-45°) CLEAN	
		97	100			30° FRAC., SL. PYRITE	
						60° JT. SL. MINERALIZATION	
	80						
		85	98			JT. TYPICALLY 45° HEAVY RUST STAIN	
						BROKEN ZONE, SOME WEATHERING AT 86.9-87.1	
	90					45° FRAC., TIGHT, SL. LT. BROWN SILT	
						45° JT. SOME CALCITE	
		91	97			BROKEN ZONE, VERY HEAVILY WEATHERED BIOTITE GNEISS ABUNDANT RUST STAIN, (SANDLIKE) AT 95.3-95.9	PINK GRANITE AT 95.2-95.3
	100					45° FRAC., TIGHT, CLEAN	
						FRAC. TYPICALLY (0°-45°), CLEAN	
		96	98			70° JT., YELLOWISH GREEN STAIN	
-50.3	110					15° FRAC., TIGHT, CLEAN	
						END OF BORING 111.3'	
						GROUND WATER LEVEL AFTER COMPLETION 11/7/72 7.9' BELOW GROUND SURFACE	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◩6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □/ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ∇ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. BC 1-26-73
3	APPD. VRN 1/25/73
2	CHKD. D.C.
1	PREPD. P.W.

BORING LOG 327

MILLSTONE NUCLEAR POWER STATION

UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-28B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 3

SITE MILLSTONE PT. WATERFOD, CONN. J.O. NO. 12179 BORING NO. 328
TYPE OF BORING NX @ 45° LOCATION 1,593N-384E; S65°W GROUND ELEV. 29.1
DATE DRILLED 10/12/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET ALONG BOREHOLE AXIS	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS or RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
	10						
	20						OVERBURDEN
10.5						TOP OF ROCK	
		18	97			JT. SL. STAINED THROUGHOUT	GRAY BIOTITE GNEISS (MONSON GNEISS) FOLIATION ABOUT HORIZ.
8.3						45° JT., RUST STAIN	
7.7	30					10° CONTACT	PINK GRANITE AT 29.3-30.1
6.4						60° JT. YELLOWISH GREEN STAIN	GRAY BIOTITE GNEISS FOLIATED ABOUT 10°
		86	98				
5.3						10° CONTACT	PINK GRANITE AT 31.9-33.5
3.2		81	97			45° CONTACT	GRAY BIOTITE GNEISS FOLIATION ABOUT 10°
						60° JT., RUST STAIN AND GREENISH BLUE STAIN	PINK GRANITE
		13	90			BROKEN ZONE, SEVERAL 45° & 60° JTS., YELLOWISH GREEN STAIN AT 38.7 - 39.3	
	40	39	89			45° JT. SOME TALC MINERALIZATION	
						JT. TYPICALLY STAINED THROUGHOUT, OCC. SL. WX	
		83	97				
	50	86	100				
-8.7						45° CONTACT	GRAY BIOTITE GNEISS FOLIATION ABOUT 10°
						JT. TYPICALLY STAINED OVERALL	
						45° JT. SOME CALCITE MINERALIZATION	
-14.0	60	94	100				
-14.4							PINK GRANITE GNEISS AT 60.7-61.6
						45° JT. SOME CALCITE MINERALIZATION	
						JT. COMMONLY STAINED, OCC. SL. WX.	
		70	100			45° JT. HEAVY TALC AND CALCITE MINERALIZATION	
-18.6							
-19.1						10° CONTACT (11 FOL.)	PINK GRANITE GNEISS AT 67.4 - 68.0
	70						

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   ◻◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD.	98-1 4-26-73
3	APPD.	
2	CHKD.	D.C.
1	PREPD.	P.W.

BORING LOG 328

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-29A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 3

SITE MILLSTONE PT. WATERFORD, CONN. J.O. No. 12179 BORING No. 328
TYPE OF BORING NX @ 45° LOCATION 1,993N-364E; 865°W GROUND ELEV. 29.1
DATE DRILLED 10/12/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS & RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
						45° JT., CALCITE MINERALIZATION	
		70	100			60° JT., YELLOWISH GREEN STAIN	
						70° JT., CALCITE MINERALIZATION	
						30% JT. CLEAN, REMAINDER STAINED WITH OCC. CALCITE FILLING	
	80	45	96			45° JT. GREENISH BLUE AND RUST STAIN	
-30.0						JT. TYPICALLY STAINED WITH OCC. CALCITE, 20% CLEAN	
-31.6						45° JT. GREENISH BLUE STAIN AND TALC MINERALIZATION	PINK GRANITE AT 83.1-85.4
		31	85			JT. STAINED THROUGHOUT, OCC. CAL. AND TALC FILLINGS	GRAY BIOTITE GNEISS FOLIATION ABOUT (0°-15°)
	90	88.8 TO 94.0 RQD = 0				BROKEN ZONE, SOME WEATHERING, AND HEAVY TALC MINERALIZATION AT 89.4-89.7	
						70° JT., TALC AND CALCITE MINERALIZATION	
						BROKEN ZONE, 30°, 45°, 70° JTS. HEAVY TALC AFTER CALCITE MINERALIZATION	
		RQD = 0				89.7	
						70° JT., TALC AND CALCITE MINERALIZATION	
						BROKEN ZONE, 30°, 45°, 70° JTS. HEAVY TALC AFTER CALCITE MINERALIZATION AT 91.6-91.9 AT 92.1-92.9	
		63	98			JT. CL., TYP. STAINED, OCC. TALC, CAL. FILLING, INFREQUENT SL. WX.	
	100					45° JT. HEAVY TALC AND CALCITE MINERALIZATION	
						FOL. PARTINGS CLEAN	
						70° JT. CALCITE MINERALIZATION	
						JT. CL. TO MOD., TYPICALLY STND. WITH SOME CALCITE FILLING	
	110	84	98			45° JT. CALCITE MINERALIZATION	
						MANY PARTINGS PARALLEL TO FOL., CLEAN (DRILLING ERROR?)	
						JT. TYPICALLY STAINED W/OCC. CALCITE FILLING	
						80° JT. CEMENTED	
						80° JT. CEMENTED	
						8-45° JTS., 3-CEMENTED, 5-V. HEAVY CALC MINERALIZATION AT 119.8-120.3	
	120	66	99			FOL. PARTINGS USUALLY CLEAN	
						80° JT., TIGHT, CLEAN	
						JT. COMMONLY SL. STAINED	
						70° JT. CEMENTED	
		67	99				
	130					MANY FOL. PARTINGS, TYPICALLY FRESH AND CLEAN	
						JT. AND FOL. PARTINGS AS ABOVE	
		99	99			45° JT., TIGHT YELLOWISH GREEN STAIN	
	140						

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⏚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. 1-26-73	
3	APPD. 1/25/73	
2	CHKD. AC.	
1	PREPD. P.W.	

BORING LOG 328
MILLSTONE NUCLEAR POWER STATION
UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-29B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT. WATERFORD, CONN. J.O. No. 12179 BORING No. 328
TYPE OF BORING NX @ 45° LOCATION 1,593N-384E; S65°W GROUND ELEV. 29.1
DATE DRILLED 10/12/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET ALONG BOREHOLE AXIS	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
-73.4		100	100			– 60° JT., YELLOWISH GREEN STN.
	145					END OF BORING 144.3'
						GROUND WATER LEVEL
						AFTER COMPLETION 10/20/72 12.7' BELOW GROUND SURFACE

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◩6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. SBd 1-26-73	
3	APPD. VRP 1/25/73	
2	CHKD. D.C.	
1	PREPD. P.W.	

BORING LOG 328
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
12179-GSK-29C

NORTHEAST UTILITIES SERVICE COMPANY SH 1 OF 2

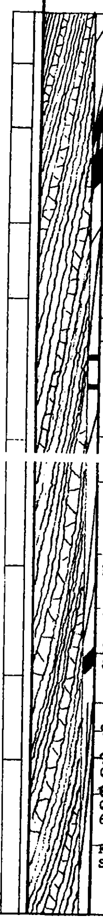
SITE: MILLSTONE PT. WATERFORD, CONN. J.O. NO. 12179 BORING NO. 329

TYPE OF BORING: NX @ 45° LOCATION: 1,520N-369E; N30°E GROUND ELEV. 28.1

DATE DRILLED: 10/26/72 DRILLED BY: AMERICAN DRILLING LOGGED BY: P. WALLACK

SUMMARY OF BORING:

ELEV. FEET	DEPTH FEET (ALONG BOREHOLE AXIS)	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS)	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
	10						
	20						(OVERBURDEN)
13.2						TOP OF ROCK	
		13	93			60° JT., HEAVY RUST STAIN	GRAY BIOTITE GNEISS (MONSON GNEISS) FOLIATION ABOUT 80°
						JT. TYPICALLY RUST STAIN W/OCC. CALCITE MINERALIZATION	
		28	86			80° JT. CLACITE MINERALIZATION	
						BROKEN ZONE, SEVERAL 70°-85° JT. JT. SURFACES W/CALCITE MIN. AT 26.6-27.6	
						2-85° JTS. HEAVY TALC AND CALCITE MINERALIZATION	
	30	25	91			BROKEN ZONE (DUE TO 85° JTS.) SEVERAL 45° JTS. WITH SOME TO HEAVY YELLOW STAIN AT 28.9-30.8	
						60° JT., QUARTZ MINERALIZATION	
		87	100			JT. TYPICALLY 60°, SOME YELLOW STN. W/OCC. MINERALIZATION	
						85° JT. CALCITE AND TALC. MIN.	
	40					JT. TYPICALLY 45°-60° STND. W/OCC MOD. WX.	
		33	99			BROKEN ZONE, HEAVILY WX. ZONE, SANDLIKE, CRUMBLY AT 40.4-40.8 AND AT 42.2-42.4	
						75° JT. TALC AND CALCITE MINERALIZATION	
		60	99			JT. TYPICALLY STAINED, W/OCC. TALC AND CALCITE MINERALIZATION	
	50					85° JT. TALC AND CALCITE MINERALIZATION	
		35	100			80° JT. HEAVY TALC MINERALIZATION	
						BROKEN ZONE (DUE TO 75°-80° JTS.) SEVERAL 45°-60° FRACS. AT 57.1-58.1	
-14.3	60	35	98				
						90° JT. HEAVY QUARTZ MINERALIZATION	PINK GRANITE
						90° JT., PARTIALLY CEMENTED, HEAVY QUARTZ MINERALIZATION AT 61.3-63.2	
		81	100			85° JT., PARTIALLY CEMENTED, HEAVY QUARTZ MINERALIZATION W/CRYSTALS AT 63.8-65.7	
						FRAC. TYPICALLY CLEAN WITH OCC. SL. YELLOW STAIN	
	70						



1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE ~~SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A~~ 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. YB-1 1-24-73
3	APPD. VRP 1/25/73
2	CHKD. D.C.
1	PREPD. P.W.

BORING LOG 329

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-30A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 2

SITE MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING No. 329
TYPE OF BORING NX @ 45° LOCATION 1,520N-369E; N30°E GROUND ELEV. 28.1
DATE DRILLED 10/26/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET ALONG BOREHOLE AXIS	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
						85° JT., SOME QUARTZ MINERALIZATION AT 71.1-71.7
		90	100			FRAC. TYPICALLY IRREG., CLEAN
		34	94			FRAC. TYPICALLY IRREG., SL. RUST STN.
						70° FRAC., TIGHT, RUST STAIN
	80					BROKEN ZONE, (70°-90°) JTS. HEAVY QUARTZ MIN. WITH CRYSTALS, SEVERAL IRREG. FRAC. AT 79.1-82.5
		0	95			80° JT. HEAVY QUARTZ (CRYSTAL) MIN. W/SOME RUST AND BLACK STAIN AT 82.5-83.3 AND AT 83.3-85.9
		6	98			70° JT., LT. GREEN STAIN
						85° JT., SOME QUARTZ MINERALIZATION
	90					6-70° JTS., 4 CEMENTED, 2 OPEN-QUARTZ MINERALIZATION, SOME BLUE GREEN STAIN 89.2-89.8
		69	95			50% JT. CLEAN, 50% JT. RUST STAIN W/ SOME SL. TO H. WX.
						70° JT., SOME QUARTZ MIN., RUST STN.
						80° JT. DK. BROWN STN, SOME WEATHERING
	100	67	98			BROKEN ZONE, 45-70° JTS., SOME QTZ. MIN. RUST STAIN AT 99.7-101.1
						JT. TYPICALLY 30°-45° RUST STAIN
						70° JT. RUST STAIN
						3- 80° JTS., HEAVY QUARTZ (CRYSTAL) MIN. PARTIALLY CEMENTED AT 106.9-107.9
	110	65	97			BROKEN ZONE, SEVERAL 70-90° JTS. W/ SOME QUARTZ (CRYSTAL) MINERALIZATION PEGMATIC AT 107.9-108.6
						4-85° JTS., YELLOWISH GREEN STAIN AT 108.6-109.9
						JT. TYPICALLY 30-60° STAIN W/OCC. SOME CLEAN FRAC.
						85° JT. LT. GREEN AND RUST STAIN.
		68	100			
-57.7	120					
						END OF BORING 120.7'
						GROUND WATER LEVEL AFTER COMPLETION 11/1/72 12.8' BELOW GROUND SURFACE

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. 98-1 1-26-73
3	APPD. VAN 1/15/73
2	CHKD. D.C.
1	PREPD. P.W.

BORING LOG 329

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-30B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 2

SITE: MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING No. 330

TYPE OF BORING: NX @45° LOCATION: 1,521N-309E; N70°W GROUND ELEV. 28.2

DATE DRILLED: 11/15/72 DRILLED BY: AMERICAN DRILLING LOGGED BY: P. WALLACK

SUMMARY OF BORING

SOIL OR ROCK DESCRIPTION

ELEV. FEET	DEPTH FEET (ALONG BOREHOLE AXIS)	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
	10						(OVERBURDEN)
19.4						TOP OF ROCK	
19.0						HORIZ. JT., HEAVY BIOTITE MIN.	PINK BIOTITE GRANITE
		32	95			45° CONTACT	GRAY BIOTITE GNEISS (MONSON GNEISS) FOLIATION ABOUT 45°
						JT. TYPICALLY RUST STAIN W/OCC. CLEAN FRAC.	
						45° FRAC., CLEAN, TIGHT	
	20	93	100			60° JT. YELLOW STAIN	
						60° JT. RUST STAIN, SLICKENSIDES (30° TO JT. DIP) AT 23.1	
						50% FRAC. CLEAN, 50% JT. RUST STN.	
	30	83	100			45° JT. HEAVY RUST STAIN AND MIN.	
3.8							
2.9						HORIZ. FRAC. STAIN	PINK MAGNETITE GRANITE AT 34.4-35.6
						60° JT. RUST STAIN	
	40	81	97			TYPICALLY 45° RUST STAIN	
						45° JT. GREEN STAIN, SLICKENSIDES (ANGLE TO JT. DIP) AT 40.2	
-2.8							
-3.2							PINK GRANITE AT 43.7-44.2
						JT. TYPICALLY 45° RUST STAIN W/OCC. CLEAN FRAC.	
	50	96	99				
						60° JT. RUST STAIN, PERPENDICULAR TO FOLIATION	
						BROKEN ZONE, YELLOWISH GREEN AND RUST STAIN, SOME WEATHERING AT 56.5-56.7	
	60	80	99			JT. TYPICALLY YELLOWISH GREEN STAIN, WITH OCC. CALCITE MINERALIZATION	
						60° RUST STAIN, SOME CALCITE MIN.	
		75	98			30° FRAC. SL. CALCITE MINERALIZATION	
	70						

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◩6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯/ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD.	SBH 1-26-73
3	APPD.	VEW 1/25/73
2	CHKD.	D.C.
1	PREPD.	P.W.

BORING LOG 330

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

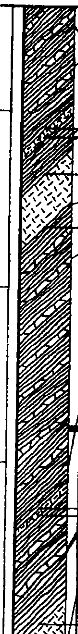
12179-GSK-31A

NORTHEAST UTILITIES SERVICE COMPANY

SITE MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING NO. 330
TYPE OF BORING NX @45° LOCATION 1,521N-309E; N70°W GROUND ELEV. 28.2
DATE DRILLED 11/15/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

SOIL OR ROCK DESCRIPTION

ELEV. FEET	DEPTH FEET (ALONG BOREHOLE AXIS)	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
		75	98			60° JT. SOME CALCITE MINERALIZATION (PERPENDICULAR FOL.) 30° JT. SOME CALCITE MINERALIZATION	
-26.1							
-26.7						45° FRAC., CLEAN, // TO CONTACT	PINK GRANITE AT 76.9-77.4
-28.1	80	90	99			30° JT. SOME BROWNISH RED AND YELLOWISH GREEN STAIN	
-30.3						15° FRAC. CLEAN	PINK GRANITE AT 79.5-82.6
						30° JT., GREEN STAIN, HEAVY CALCITE MINERALIZATION JT. TYPICALLY 30°-60° CALCITE MIN. W/OCC. CLEAN FRAC. SOME YELLOWISH GREEN STAIN	
	90	89	100			BROKEN ZONE, MODERATELY WEATHERED AT 94.1-94.3 80° JT. YELLOWISH GREEN STAIN SL. MINERALIZATION	
-41.7						60° CONTACT	PINK GRANITE AT 98.7-99.0
-41.9	100	78	100			2-60° JT. YELLOWISH GREEN STAIN JT. TYPICALLY YELLOWISH GREEN STAIN	
-46.4						30° CONTACT	
-47.0						80° JT. YELLOWISH GREEN STAIN	PINK GRANITE AT 105.2 TO ?
	110					END OF BORING 106.0 GROUND WATER LEVEL AFTER COMPLETION 7.4' BELOW GROUND SURFACE	



1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE ~~SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A~~ 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. 1-26-73
3	APPD. 1-25-73
2	CHKD. D.C.
1	PREPD. P.W.

BORING LOG 330
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-31B

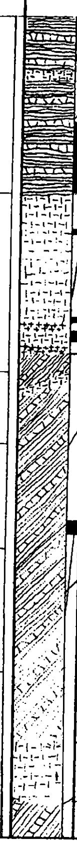
NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 2

SITE: MILLSTONE PT. CONN., WATERFORD, CONN. J.O. NO. 12179 BORING NO. 331
TYPE OF BORING: NX@45° LOCATION: 1,460N-375E; 80°E GROUND ELEV. 27.4
DATE DRILLED: 11/7/72 DRILLED BY: AMERICAN DRILLING LOGGED BY: P. WALLACK
SUMMARY OF BORING:

SOIL OR ROCK DESCRIPTION

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS or RECOV.	SAMPLE TYPE	GRAPHIC LOG	FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
	10						
	20						
9.0						TOP OF ROCK	(OVERBURDEN)
						80° JT., RUST STAIN AND LT. BROWN CLAY	GRAY BIOTITE GNEISS (MONSON GNEISS)
6.8						10° JT. SANDY CLAY	
6.5	30	12	76				PINK GRANITE AT 29.0-29.5
						60° JT. SOME LT. BROWN CLAY	GREENISH GRAY BIOTITE GNEISS
						BROKEN ZONE, VERY HEAVILY WEATHERED ABUNDANT RUST STAIN, (SANDLIKE) SOME LT. BROWN AND GRAY CLAY AT 32.0-36.0	
1.8							PINK GRANITE AT 36.0-44.9
						BROKEN ZONE, YELLOW AND RUST STAIN AT 38.0-38.3	
	40	41	93			2-80° JTS., RUST STAIN AND SOME WEATHERING	
						BROKEN ZONE, ABUNDANT RUST STAIN ON HIGH ANGLE SURFACES AT 43.1-43.3	PEGMATIC 43.3-43.7
-4.4						BROKEN ZONE, HEAVILY WEATHERED 43.7-44.3	PEGMATIC 44.5-44.9
-5.5						HORIZ. JT., RUST STAIN, PYRITE	GRAY BIOTITE GNEISS FOLIATION ABOUT 45°
-5.9		13	82			20° CONTACT	PINK GRANITE AT 46.5-47.0
	50					30° JT., LT. BROWN YELLOW STAIN	
		31	95			JT. TYPICALLY STAINED	
						BROKEN ZONE, HEAVILY WEATHERED, YELLOW STAIN ON HIGH ANGLE FACES AT 54.3-55.0	
						85° JT., YELLOWISH GREEN STAIN AND HEAVILY WEATHERED	
		57	100			45° JT., YELLOWISH GREEN STAIN AND SLICKENSIDES 90° TO DIP OF JT. AT 57.5	
	60					JT. TYPICALLY STAINED	
						FRAC. TYPICALLY CLEAN	
-19.8							PINK GRANITE AT 66.6-70.0
-22.1		80	99			30° FRAC., CLEAN (CONTACT)	



1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸7 INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. 88-4 1-26-73
3	APPD. [illegible] 1-15-73
2	CHKD. D.C.
1	PREPD. P.W.

BORING LOG 331

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-32A

NORTHEAST UTILITIES SERVICE COMPANY

SITE MILLSTONE PT. WATERFORD, CONN. J.O. NO. 12179 BORING NO. 331

TYPE OF BORING NX@45° LOCATION 1,460N-375E; 30°E GROUND ELEV. 27.4

DATE DRILLED 11/7/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET ALONG BOREHOLE AXIS	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
						60% FRAC. CLEAN, 40% JT. SL. YELLOW STAIN	
						15° FRAC., CLEAN, TIGHT	
		77	100				
-28.4							
-29.5	80					45° CONTACT	PINK GRANITE AT 78.8-80.3
						30° FRAC., CLEAN, TIGHT	
-33.8							
-34.0						15° FRAC., CLEAN	PINK GRANITE AT 86.1-86.7
		65	100				
-36.9	90					45° JT. YELLOW AND BLUISH GREEN STAIN, HEAVILY WEATHERED	
						45° JT., ~~QUARTZ (CRYSTALS)~~ MIN. AND YELLOW AND BLUISH GREEN STAIN	PINK GRANITE AT 90.9-95.9
-40.4						45° JT. BLUISH GREEN STAIN, POSSIBLE SLICKENSIDES (90° TO JT. DIP)	
		62	96				
	100					HORIZ. FRAC., CLEAN, TIGHT	
						66% FRAC. CLEAN, 34% JT. SOME GREEN STAIN	
						60° FRAC., CLEAN, TIGHT	
		91	100				
						30° JT. HEAVY GREEN STAIN, SLICKENSIDES (90° TO JT. DIP) AT 110[illegible]	
	110					[illegible]0° JT. HEAVY GREEN STAIN, SLICKENSIDES (PARALLEL TO JT. DIP) AT 110.75	
-52.6						30° JT. HEAVY GREEN STAIN, SLICKENSIDES (PARALLEL TO JT. DIP) AT 110.8	
						END OF BORING 112.5'	
						GROUND WATER LEVEL AFTER COMPLETION 11/13/72 9.1' BELOW GROUND SURFACE	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD	88-4 1-26-73
3	APPD	VRN 1/25/73
2	CHKD	D.C.
1	PREPD	P.W.

BORING LOG 331

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-32B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE: MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. DT-1

TYPE OF BORING: 4" NX LOCATION: 980N - 580E GROUND ELEV. 15.1'

DATE DRILLED: 12/30/71 DRILLED BY: AMERICAN DRILLING LOGGED BY: R.S.

SUMMARY OF BORING:

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE EL. 15.1'						
			101	1		V. DENSE BROWN COARSE-FINE SAND, TR. SILT, SOME GRAVEL (FINE-COARSE) & COBBLES. (FILL)
			126	2		
			22	3		
5.1	10					
			96	4		V. DENSE, YELLOW BROWN COARSE-FINE SAND, TR. SILT, FINE GRAVEL & BLACK ORGANIC MATERIAL.
			136	5		
	20		59	6		
-9.4					TOP OF ROCK	
					45° JT., TIGHT	GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/ GRANITE SILLS ABOUT 1-10' THICK & PEG. INTRUSIVES ABOUT 1-2' THICK. FOL. APPROX. 45°.
					45° JT., TIGHT	
					VERT. JT., RUST STN.	
					FRAC. ZONE, RUST STN.	
	30	83	100			
					60° JT., LT. GREY MINERALIZED SURF.	
					VERT. JT., LT. GREY MINERALIZED SURF.	
					45° JT., LT. GREY MINERALIZED SURF.	
					HORZ. JT., RUST STN.	
		79	87			
	40				45° JT., TIGHT	
					45° JT., TIGHT	
					HORZ. JT., RUST STN.	
					60° JT., TIGHT	
-29.4					HORZ. JT., RUST STN.	
					END OF BORING 44.5'	
					GROUND WATER LEVEL AFTER COMPLETION 10.1' BELOW GROUND SURFACE ON 12/30/71	
	50					

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⏚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APPD	RS-1 1-26-73
3	APPD	VRN 1-16-73
2	CHKD	D.C.
1	PREPD	R.S.

BORING LOG DT-1

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GAK-65

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 3

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. DT-2

TYPE OF BORING 4" - NX LOCATION 250N-1040E GROUND ELEV. 9.8

DATE DRILLED 1/11/72 DRILLED BY AMERICAN DRILL. LOGGED BY R. SKRYNESS

SUMMARY OF BORING PRESSURE TEST PERFORMED 1/11/72

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS or RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE ELEV. 9.8'							
			25	1		MED. DENSE, Y-BROWN - BROWN MED. FINE SAND, SOME BLK ORGANIC MAT'L., SILT AND FINE GRAVEL	
			7	2			
			18	3			
+1.8			50/6"	4		V. DENSE, YELLOW GRAY SAND, (F-M) TR. SILT & SOME (F-M) GRAV. TOP OF ROCK	
	10	84	73			HORZ. JT. WITH TR. RUST STAIN HORZ. JT. WITH TR. RUST STAIN HORZ. JT. WITH TR. RUST STAIN 25° JT., TIGHT JT., TIGHT	GRAY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) WITH GRANITE SILLS ABOUT 1-10' THICK AND PEGMATITE INTRUSIVE BANDS ABOUT 1-2' THICK FOLIATION ABOT 20°
-5.6						IRREG. WITH WEATH. AND RUST STAIN, LOST 1' CORE HERE	AT 15.4' - 18.5' PEGMATITE
-8.7	20	95	100			25° JT., RUST STAIN HORZ. JT., RUST STAIN HORZ. JT., RUST STAIN 25° JT., RUST STAIN	ROCK CORE HAS SEVERAL BREAKS, BUT APPEAR FRESH AND CLEAN
	30	87	96			HORZ. JT., RUST STAIN HORZ. JT., RUST STAIN 25° JT., RUST STAIN HORZ. JT., RUST STAIN	
-24.5						25° JT., RUST STAIN 10° JT., RUST STAIN 10° JT., RUST STAIN	FOLIATION ABOUT 25° AT 34.3' - 39' GRANITE SILL AT 39.0' - 42' GRANITE XTL. SIZE INCREASING WITH DEPTH
	40	91	99			25° JT., RUST STAIN IRREG. JT., TIGHT	
-32.2						3" FRACTURED ZONE, UNSTAINED SURFACE 10° JT., GRAY STAIN 25° JT., CLEAN, TIGHT	
	50	100	100			55° JT., TR. RUST STAIN 25° JT., CLEAN, TIGHT	
						25° JT., CLEAN AND TIGHT 25° JT., CLEAN AND TIGHT 25° JT., CLEAN AND TIGHT	
	60	100	100			25° JT., CLEAN AND TIGHT	
-55.7						30° JT., CLEAN AND TIGHT	AT 65.5' - 67.5' PEGMATITE
-57.7							FOLIATION ABOUT 30°
	70	96	100				

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯▱ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. 1-26-73
3	APPD. VRN 1/12/73
2	CHKD. D.C.
1	PREPD. R.S.

BORING LOG DT-2

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-66A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 3

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. DT-2

TYPE OF BORING 4" NX LOCATION 250N - 1040E GROUND ELEV. 9.8'

DATE DRILLED 1/11/72 DRILLED BY AMERICAN DRILLING LOGGED BY R. SKRYNESS

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
						BORING NO. DT-2 (CONT'D)	
						30° JT., CLEAN AND TIGHT 30° JT., CLEAN AND TIGHT	71.5-72.5' PEGMATITE
		96	100			60° JT., DK. GREY GREEN STN.	
-68.2							
	80						GRAY, FINE GRAINED GRANITE (WESTERLY GRANITE), MASSIVE, FEW FRACT. AND JOINTS.
		96	100			HORZ. JT., CLEAN, TIGHT	
						HORZ. JT., TRACE OF RUST STAIN	
	90	100	100				
	100	100	100			HORZ. JT., TRACE OF RUST STAIN	
	110	100	100				
	120	100	100				
						HORZ. JT., TRACE OF RUST STAIN	
		100	100				
	130						
		100	100				
	140						

1. ~~FIGURES IN BLOW OR RECOVERY COLUMN~~ OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⏚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [ ] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APP'D. 1-2-73
3	APP'D. VRN 1/11/73
2	CHK'D. D.C.
1	PREP'D. R.S.

BORING LOG DT-2 (CONT'D)

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-66B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE POINT, WATERFORD, CONN. J.O. NO. 12179 BORING NO. DT-2

TYPE OF BORING 4" - NX LOCATION 250N-1040E GROUND ELEV. 9.8'

DATE DRILLED 1/11/72 DRILLED BY AMERICAN DRILLING LOGGED BY R. SKRYNESS

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
		BORING NO. DT-2 (CONT'D)				
						CORE IS SOLID WITH FEW CLEAN BREAKS
						HORZ. JT., CLEAN AND TIGHT
		100	100			
-140.2	150					
						END OF BORING 150'
						GROUND WATER LEVEL AFTER COMPLETION. 6.5' BELOW GROUND SURFACE ON 1/11/72

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □7 INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≡ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [ ] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. RB-? 1-26-73
3	APPD. VRN 1/12/73
2	CHKD. D.C.
1	PREPD. R.S.

BORING LOG DT-2 (CONT'D)

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-66C

NORTHEAST UTILITIES SERVICE COMPANY

SITE MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING NO. DT-3
TYPE OF BORING 4"-NX LOCATION 690S-1360E GROUND ELEV. 10.6
DATE DRILLED 1/7/72 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE ELEV. 10.6'							
						QUARRY DUMP MATERIAL; BOULDERS. NO SS SAMPLES TAKEN	
3.6						TOP OF ROCK	
		89	100			30° JT., RUST STAIN 60° JT., RUST STAIN	GRAY MASSIVE, GRANITE (WESTERLY GRANITE) FINE GRAINED
	10	95	100			10° JT., RUST STAIN 45° JT., RUST STAIN HORZ. JT., RUST STAIN & WEATHERED 15° JT., RUST STAIN	
		82	100			HORZ. JT., RUST STAIN 70° JT., RUST STAIN 10° JT., RUST STAIN 65° JT., RUST STAIN	
	20	88	100			25° JT., RUST STAIN 10° JT., RUST STAIN & WEATHERED HORZ. JT., BROWN STAIN HORZ. JT., WEATHERED HORZ. JT., RUST STAIN HORZ. JT., RUST STAIN	
		100	100			65° JT., YELLOW STAIN	
	30	100	100			60° JT., CLEAN AND TIGHT 10° JT., RUST STAIN	
		92	100			55° JT., TR. RUST STAIN 55° JT., RUST STAIN 10° JT., RUST STAIN 10° JT., RUST STAIN 55° JT., PINK MINERALIZATION 55° JT., NEEDLE-LIKE XTLS. ON JT. SURFACE	NEEDLE-LIKE XTLS ON JOINT SURFACE ARRANGED IN A FAN-LIKE PATTERN
	40	92	100			55° JT., RUST STAIN HORZ. JT., GRAY STAIN HORZ. JT., RUST STAIN	
		90	100			10° JT., RUST STAIN 60° JT., RUST STAIN HORZ. JT., YELLOW STAIN 60° JT., RUST STAIN 65° JT., RUST STAIN 70° JT., YELLOW & GREEN STAIN	POSS. SLICKENSIDES AT 51'
	50	88	100			60° JT., RUST STAIN 60° JT., RUST STAIN	
		80	100			60° JT., RUST STAIN HORZ. JT., RUST STAIN	
	60	100	100			HORZ. JT., TRACE OF RUST STAIN	THIN MINERALIZED SEAMS ABOUT 70°
		100	100			50° JT., YELLOW STAIN	
	70						

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
□◿ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.(PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD. SPS 1-26-73	
3	APPD. VAN 1-18-73	
2	CHKD. D.C.	
1	PREPD. R.S.	

BORING LOG DT-3
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
12179-GSK-67A

NORTHEAST UTILITIES SERVICE COMPANY

SITE MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING NO. DT-3

TYPE OF BORING 4" NX LOCATION 690S-1360E GROUND ELEV. 10.6'

DATE DRILLED 1/7/72 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.

SUMMARY OF BORING

BORING NO. DT-3 (CONT'D)

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
		100	100			HORZ. JT., RUST STAIN HORZ. JT., CLEAN
		97	100			50° JT., RUST STAIN HORZ. JT., RUST STAIN
	80					10° JT., RUST STAIN
		100	100			55° JT., RUST STAIN
		100	100			HORZ. JT., RUST STAIN HORZ. JT., RUST STAIN
	90					
		100	100			HORZ. JT., RUST STAIN
		100	100			SOLID
	100					
		100	100			HORZ. JT., RUST STAIN
		100	100			SOLID
	110					
		100	100			50° JT., CLEAN, TIGHT HORZ. JT., BROWN STAIN & WEATH.
		100	100			SOLID
	120					
		100	100			65° JT., PINK NEEDLE-LIKE MINERAL IN A FAN-LIKE PATTERN
		100	100			HORZ. JT., TRACE OF RUST STAIN
	130					
		100	100			
-125.1						
		100	100			GRAY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) FOLIATION ABOUT 30°
		100	100			10° JT., TR. OF RUST STAIN
	140					

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≑ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APP'D 1-26-73
3	APP'D VRN 1-18-73
2	CHK'D D.C.
1	PREP'D R.S.

BORING LOG DT-3 (CONT'D)

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-67B

NORTHEAST UTILITIES SERVICE COMPANY

SH 3 OF 3

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. DT-3
TYPE OF BORING 4"-NX LOCATION 690S-1360E GROUND ELEV. 10.6
DATE DRILLED 1/7/72 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.
SUMMARY OF BORING

BORING NO. DT-3 (CONT'D)

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
						60° JT., ORTHOCLASE MINERALIZATION	
						60° JT., ORTHOCLASE MINERALIZATION	
						60° JT., ORTHOCLASE MINERALIZATION	
						60° JT., ORTHOCLASE MINERALIZATION	
		82	100			30° JT., BLK. WEATHERED	JOINTS ARE ALONG BIOTITE RICH PLANES
						30° JT., BLK. WEATHERED	
						30° JT., BLK. WEATHERED	
		100	100			SOLID	
-139.4	150						
						END OF BORING 150'	
						GROUND WATER LEVEL AFTER COMPLETION 7.0' BELOW GROUND SURFACE ON 1/7/72	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ◻◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊥ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD / 1-26-73
3	APPD / VRN 1/25/73
2	CHKD / D.C.
1	PREPD / R.S.

BORING LOG DT-3 (CONT'D)

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-67C

SH 1 OF 1

SITE MILLSTONE POINT J.O. NO. 12179 BORING NO. 401

TYPE OF BORING SPLIT SPOON NX DOUBLE BARREL LOCATION N 1303 E 487 GROUND ELEV. 21.9'

DATE DRILLED JUNE 4, 1974 DRILLED BY AMERICAN DRILLING LOGGED BY LGM

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
20.0			91*	1		SAND, COARSE TO FINE, 4-15% GRAVEL TO 1", 1-7% NONPLASTIC FINES, LIGHT GRAYISH BROWN (COMPACTED FILL) (SW).
	5		26	2		TOP OF SPOON - SILTY SAND, UNIFORM, MOSTLY VERY FINE, 10-30% SLIGHTLY PLASTIC FINES, WET, MEDIUM, BROWNISH GRAY, (SP-SM). BOTTOM SAND, UNIFORM, MOSTLY FINE, 1-8% NONPLASTIC FINES, WET, DARK ORANGISH BROWN, (SP)
10.0	10		76	3		SILTY SAND, COARSE TO FINE, MOSTLY FINE, 1-5% GRAVEL TO 1", 5-10% NONPLASTIC FINES, VERY DENSE, DARK GRAYISH BROWN (TILL) (SP-SM).
	15		46*	4		SAND, UNIFORM, MOSTLY FINE, 1-5% GRAVEL, 1-7% NONPLASTIC FINES, VERY DENSE, DARK GRAYISH BROWN (TILL) (SP).
0	20		50/3" 50*/3"	5		TOP - SAND, UNIFORM, MOSTLY FINE, 5-10% SLIGHTLY PLASTIC FINES, DARK BROWNISH GRAY, (SP-SC). BOTTOM - SAND, UNIFORM, MOSTLY MEDIUM, 1-5% NONPLASTIC FINES, MEDIUM GRAYSIH BROWN, (SP). TOP OF ROCK AT 21.7'
	25	10	28	NX		BLACK GNEISS, VERY CLOSE JOINT, 10°, VERY CLOSE FOLIATION AT HIGH ANGLE, SLIGHTLY WEATHERED, HARD, 60° JOINT AT 22.2', WEATHERED AND IRON STAINED.
-10	30	80	97	NX		GRAY PINK GRANITE, VERY CLOSE TO MODERATELY CLOSE JOINTING, 10-20°, NO DISTINCT FOLIATION, HARD, FRESH, WEATHERED ZONE, 25.3-26', 45° JOINT AT 27' IRON STAINED, AT 29.7 45° JOINT, IRON STAINED.
	35					END OF BORING AT 35.3'
-20	40					

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ◻◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

* INDICATES 300 LB HAMMER FALLING 30 INCHES.

4	
3	
2	
1	[illegible]

BORING LOG

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK- 68

SH 1 OF 1

SITE MILLSTONE J.O. NO. 12179 BORING NO. 402

TYPE OF BORING SPLIT SPOON / NX DOUBLE BARREL LOCATION N 950 E 840 GROUND ELEV. 16.4'

DATE DRILLED JUNE 3, 1974 DRILLED BY AMERICAN DRILLING LOGGED BY LGM

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS or RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
			50	1		SAND, COARSE TO FINE, MOSTLY MEDIUM FINE, 1-8% GRAVEL TO 1" MAXIMUM, 1-3% NONPLASTIC FINES, DARK GRAYISH BROWN (FILL) (SW).
10	5		20	2		SAND, UNIFORM, MOSTLY MEDIUM, 1-4% GRAVEL, 1-5% NONPLASTIC FINES, WET, MEDIUM ORANGISH BROWN, (SP).
	10		15	3		SAND, UNIFORM, MOSTLY FINE, 4-8% NONPLASTIC FINES, MICACEOUS, MEDIUM YELLOWISH BROWN, (SP).
8	15		31 50/3	4		TOP OF SAMPLE - SILTY SAND, UNIFORM, MOSTLY FINE, 8-15% NONPLASTIC FINES, MEDIUM YELLOWISH BROWN, (SP-SM). BOTTOM SAND, UNIFORM, MOSTLY FINE, 3-7% GRAVEL TO 0.75" MAXIMUM, 1-5% NONPLASTIC FINES, VERY DENSE, MEDIUM YELLOWISH BROWN, (SP). TOP OF ROCK AT 16.5'
		80	80	NX		BLACK GNEISS, CLOSE JOINTING, 10°, VERY CLOSE FOLIATION 10°, FRESH, HARD.
	20	70	97	NX		BLACK GNEISS: CLOSE TO MODERATE CLOSE JOINTING, 10-20° FOLIATION, VERY CLOSE 10° AT TOP, 60° TO BOTTOM OF RUN, FRESH, HARD, FINE GRAINED, 80° JOINTING AT 19 AND 26', 60° JOINT AT 24', ZONES OF PINK PEGMATITE, MODERATELY WEATHERED, IRON STAINED ZONE AT 25-26.
-10	25					
						END OF BORING AT 28.0'
	30					
-20	35					

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □/ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

4		
3		
2		
1	11/26/74 RGV	

BORING LOG

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-69

SITE MILLSTONE POINT J.O. No. 12179 BORING No. 403

TYPE OF BORING SPLIT SPOON NX DOUBLE BORING LOCATION N 710 E 925 GROUND ELEV. 12.8'

DATE DRILLED MAY 30, 1974 DRILLED BY AMERICAN DRILLING LOGGED BY LGM

SUMMARY OF BORING

ELEV. FEET: 10.0, 0, -10, -20, -30, -40, -50

DEPTH FEET: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70

OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
	12	1		SILTY SAND, UNIFORM, MOSTLY VERY FINE, 0-1% GRAVEL, 5-12% NONPLASTIC FINES, DARK YELLOWISH BROWN, MICACEOUS (TOPSOIL) (SM-SP).
	24	2		SANDY SILT, NONPLASTIC, 5-10% VERY FINE SAND, DARK YELLOWISH BROWN, MICACEOUS, (SP-SM).
	34	3		SAND, UNIFORM, MOSTLY MEDIUM SAND 0-5% NONPLASTIC FINES, WET, DARK ORANGISH BROWN, MICACEOUS, (SP).
	24	4		SILTY SAND, UNIFORM, MOSTLY FINE SAND, 0-4% GRAVEL TO 0.75" MAXIMUM, 0-7% NONPLASTIC FINES, WET, MICACEOUS, DARK ORANGISH BROWN, (SP).
	11	5		SILT, NONPLASTIC, 1-4% VERY FINE SAND, MICACEOUS, DARK GRAY, (SM).
	24	6		SAND, UNIFORM, MOSTLY FINE, 0-3% GRAVEL, 1-5% NONPLASTIC FINES, MICACEOUS, DARK GRAY, (SP).
		NX		BOULDER CORED TO 35'
	58, 50/2"	7		SAND, UNIFORM, MOSTLY FINE, 5-10% GRAVEL, 1-7% NONPLASTIC FINES, MICACEOUS, DENSE, DARK GRAY (TILL) (SP).
	50/4"	8		NO RECOVERY - PIECES OF ROCK. PIECES OF ROCK CORED BETWEEN 40' AND 45' BOULDERS
	162*	9		SAND, UNIFORM, MOSTLY FINE, 5-10% GRAVEL, 1-7% NONPLASTIC FINES, MICACEOUS, VERY DENSE, DARK BROWNISH GRAY (TILL) (SP). TOP OF ROCK AT 46.5'
36	60	NX		GRAY GRANITE, CLOSE JOINT, 10° FRESH TO SLIGHTLY WEATHERED, HARD, TOP OF RUN WEATHERED, JOINT AT 48.1' WEATHERED AND IRON STAINED, PINK ORTHOCLASE, QUARTZ AND BIOTITE.
74	85	NX		GRAY PINK GRANITE, VERY CLOSE TO CLOSE JOINTING 20°, FRESH TO SLIGHTLY WEATHERED, HARD, 80° JOINT AT 52.6 AND 55.3', VERY CLOSE SPACED JOINTS AT 55.5 - 56.2, 30° JOINTS WITH WEATHERED SURFACES, 30° JOINT AT 56.8' WITH WEATHERED SURFACES.

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

* INDICATES 300 LB HAMMER FALLING 30 INCHES.

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-70

SITE MILLSTONE J.O. No. 12179 BORING NO. 404

TYPE OF BORING SPLIT SPOON / NX DOUBLE BARREL LOCATION N 388 E 924 GROUND ELEV. 11.7'

DATE DRILLED MAY 29, 1974 DRILLED BY AMERICAN DRILLING LOGGED BY LGM

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
10			18	Split spoon 1		SILTY SAND, UNIFORM, MOSTLY VERY FINE, 1-4% GRAVEL TO 1" MAXIMUM, 5-10% NONPLASTIC FINES, MEDIUM REDDISH BROWN (FILL)(SP-SM).
	5		15	Split spoon 2		SAND, UNIFORM, MOSTLY FINE, 1-4% GRAVEL TO 1" MAXIMUM, MICACEOUS, MEDIUM GRAY BROWN, (SP).
0	10		25	Split spoon 3		SAND, SIMILAR TO #2 EXCEPT 1-5% NONPLASTIC FINES, (SP).
	15			No recovery 4		NO RECOVERY. TOP OF ROCK AT 16.1'
-10	20	57	73	NX		GRAY GNEISS; VERY CLOSE TO CLOSE JOINTING, 40° FOLIATION, NOT DISTINCT AT 10°; SLIGHTLY WEATHERED, HARD, 60% BIOTITE, 30% QUARTZ, 60° JOINT AT 16.8', CLOSELY JOINTED, 10° AT 17.7' TO 18.1' ALSO MODERATELY WEATHERED AND SOFT WITH IRON STAIN.
	25	96	99	NX		GRAY GNEISS, MODERATELY CLOSE JOINTING 20°; FOLIATION NOT PROMINENT AT 10-20° FRESH, HARD; ZONE OF PINK GRANITE AT 33'-38.2', MEDIUM GRAINED, JOINT SURFACES FRESH TO SLIGHTLY WEATHERED.
-20	30, 35	65	100	NX		GRAY BLACK GNEISS, VERY CLOSE TO CLOSE JOINTING 10-20°, VERY CLOSE FOLIATION, 10-20°, SLIGHTLY WEATHERED, HARD; JOINTS IN BIOTITE ZONES AT LOW ANGLES EXHIBIT WEATHERED SURFACE AND IRON STAINED, FOLIATION STEEPENS TO 60° AT 35' TO 36.2' 60° JOINT AT 36.2' PARALLEL TO FOLIATION
						END OF BORING AT 36.2'
-30	40, 45					

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □7 INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ∇ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4		
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1	11/20/74	

BORING LOG

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-71

SH 1 OF 1

SITE MILLSTONE J.O. NO. 12179 BORING NO. 405

TYPE OF BORING SPLIT SPOON NX DOUBLE BARREL LOCATION N 301 E 720 GROUND ELEV. 17.7'

DATE DRILLED MAY 23, 1974 DRILLED BY AMERICAN DRILLING LOGGED BY LGM

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
			29	1		SAND, UNIFORM, MOSTLY FINE, 5-15% COBBLES, MICACEOUS, SOME ROOTS, DARK BROWN (FILL) (SP). LOST WATER AT 4.5'
10	5		100/3"	2		NO RECOVERY. TOP OF ROCK AT 7.8'
	10	46	100	NX		WHITE PINK GRANITE, CLOSE JOINT, 10°, MODERATELY WEATHERED TO FRESH, HARD, ZONE AT 8.0-9.7' MODERATELY WEATHERED, FINE GRAINED, CONTACT AT 9.75' TO MEDIUM GRAINED PINK GRANITE.
0	15	61	96	NX		GRANITIC GNEISS, CLOSE JOINT, 10° VERY CLOSE FOLIATION, FRESH, WITH WEATHERED ALONG SOME FOLIATION PLANES, HARD, FINE GRAINED; LAYER AT 13.3'-15.6 GRANITIC GNEISS IS BIOTITE RICH AND WEATHERED ALONG THOSE PLANES, JOINTS APPEAR MOSTLY ALONG FOLIATION.
	20 / 25	99	100	NX		LIGHT GRAY GRANITE; MODERATELY CLOSE JOINTING, 10° FRESH, VERY HARD, FINE GRAINED.
-10	30	95	98	NX		LIGHT GRAY GRANITE, SIMILAR TO ABOVE EXCEPT JOINT SURFACES, SLIGHTLY WEATHERED.
-20	35 / 40	100	100	NX		LIGHT GRAY GRANITE, SIMILAR TO ABOVE EXCEPT VERY HARD.
-30	45 / 50					END OF BORING AT 42.6'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. [ ] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	
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BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-72

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

BORING NO. 406
SHEET 1 OF 2

COORDINATES N800 E924 GROUND ELEV. (1) 14.03

INCLINATION VERTICAL BEARING ______ INSPECTOR F.S. VETERE

DATE : START / FINISH 4/30/80 / 4/30/80 CONTRACTOR / DRILLER GUILD/ MASON

STATIC GROUNDWATER DEPTH / DATE 8.0 (FT) / 4/30/80 DRILL RIG TYPE TRUCK MOUNTED ROTARY

DEPTH TO BEDROCK 34.5 (FT) TOTAL DEPTH DRILLED 44.5 (FT)

METHODS :

DRILLING SOIL TRICONE ROLLER BIT WITH 4 INCH CASING, DRILLED WITH WATER

SAMPLING SOIL SPLIT SPOON

DRILLING ROCK NX DOUBLE BARREL

SPECIAL TESTING OR INSTRUMENTATION NONE

COMMENTS

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
							4" ASPHALT ROAD COVERING
9.03	5	S	1	6-8-8	16	SP	SAND, POORLY GRADED, COARSE TO FINE, MOSTLY MEDIUM, 1-3% NONPLASTIC FINES, MOIST, MEDIUM-BROWN (FILL).
	∇ (8.0)						
	10	S	2	11-21-18	39	SP	SAND, WIDELY GRADED, MOSTLY MEDIUM SAND, 2-5% SUBANGULAR GRAVEL TO 3/4 IN., 1-3% NONPLASTIC FINES, MOIST, ORANGE-BROWN (FILL).
0.03	15	S	3	4-6-6	12	SM	SILTY SAND, UNIFORM, FINE, 15-20% SLIGHTLY PLASTIC FINES, THIN MICACEOUS BANDING, LIGHT BROWNISH GRAY.
	20	S	4	5-5-4	9	SM	SILTY SAND, UNIFORM VERY FINE, 25-40% SLIGHTLY PLASTIC FINES, MICACEOUS, GRAY.
-10.97	25	S	5	14-13-12 (2")	25	SM	SILTY SAND, WIDELY GRADED, MOSTLY FINE SAND, 3-5% SUBANGULAR GRAVEL TO 1 IN., 15-20% NONPLASTIC FINES, GRAY. (STONE STUCK IN SAMPLER).

LEGEND / NOTES

1. DATUM IS MEAN SEA LEVEL
2. ∇ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. S-SPLIT SPOON, US-SHELBY TUBE, UO-OSTERBERG, UF-FIXED PISTON.

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENG. CORP.
SKETCH No. 12179-GSK-73A

APPROVED	DATE	BORING NO.	SHEET
FBV	6/25/80	406	1 OF 2

BORING NO. 406
SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		S	6	15-25-35	60	SM	SILTY SAND, SIMILAR TO ABOVE, EXCEPT GRAVEL TO ½ IN.
-19.47							TOP OF TILL AT 33.5
-20.47	35						TOP OF ROCK AT 34.5
		NX	1	100/88			GRAY MONSON GNEISS, HIGH ANGLE WIDELY SPACED JOINTING, 40-50° MODERATELY CLOSE FOLIATION, FRESH, VERY HARD, FINE GRAINED.
-25.47	40	NX	2	95/87			GRAY MONSON GNEISS, SIMILAR TO ABOVE, 40.5 - 42.4 SLIGHTLY WEATHERED BIOTITE SEAM.
-30.47	45						END OF BORING AT 44.5 FT

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.

STONE & WEBSTER ENG. CORP. SKETCH No. 12179-GSK-73B | APPROVED FBV | DATE 6/25/80 | BORING NO. 406 | SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

BORING NO. 407

SHEET 1 OF 2

COORDINATES N625 E924 GROUND ELEV. (1) 14.94

INCLINATION VERTICAL BEARING ——— INSPECTOR F.S. VETERE

DATE : START / FINISH 4/28/80 / 4/30/80 CONTRACTOR / DRILLER GUILD/MASON

STATIC GROUNDWATER DEPTH / DATE 10.0 (FT) / 4/30/80 DRILL RIG TYPE TRUCK MOUNTED ROTARY

DEPTH TO BEDROCK 60.0 (FT) TOTAL DEPTH DRILLED 65.0 (FT)

METHODS :

DRILLING SOIL TRICONE BIT WITH NW RODS, HW 4 INCH FLUSH JOINT CASING WITH WATER

SAMPLING SOIL SPLIT SPOON

DRILLING ROCK NXX DOUBLE BARREL

SPECIAL TESTING OR INSTRUMENTATION NONE

COMMENTS

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
9.94	5	S	1	6-8-8 (16")	16	SP	SAND, POORLY GRADED, COARSE TO MEDIUM, MOSTLY MEDIUM, 3-5% SUBROUNDED GRAVEL TO 1/2 IN., 3-5% NONPLASTIC FINES, SOME IRON OXIDE STAINING, DRY, ORANGE, BROWN (FILL).
	▽	S	2	11-16-15 (10")	31	SP	SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY MEDIUM, 1-3% SUBROUNDED GRAVEL TO 1/4 IN., 3-5% NONPLASTIC FINES, MOIST, MEDIUM BROWN (FILL).
-0.06	15	S	3	5-7-9 (14")	16	SP-SM	SILTY SAND, UNIFORM, FINE, 10-15% NONPLASTIC FINES, MOIST, LIGHT BROWN.
	20	S	4	12-12-10 (14")	22	SP	SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 5-10% NONPLASTIC FINES, MOIST, BROWN.
	25	S	5	4-6-6 (16")	12	SM	SILTY SAND, UNIFORM, VERY FINE, 20-40% NONPLASTIC FINES, SLIGHTLY MICACEOUS, GRAY.
							TOP OF ABLATION TILL - 30 FT

LEGEND / NOTES

1. DATUM IS MEAN SEA LEVEL
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. S-SPLIT SPOON, US-SHELBY TUBE, UO-OSTERBERG, UF-FIXED PISTON.

BORING LOG

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENG. CORP.
SKETCH No. 12179-GSK-74A

APPROVED	DATE	BORING NO.	SHEET
FSV	6/25/80	407	1 OF 2

	BORING NO. 407
	SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

ELEVATION (FEET) (1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
-15.06	30	S	6	9-9-10 (16")	19	SM	SILTY SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 15-30% NONPLASTIC FINES, GRAY.
	35	S	7	17-19-19 (14")	38	SM	SILTY SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 15-30% NONPLASTIC FINES, GRAY.
-25.06	40						TOP OF BASAL TILL AT 40.0 FT.
		S	8	43-92-104 (16")	196	GW	TOP 6 IN.: GRAVELLY SAND, WELL GRADED, 5-10% SUBANGULAR GRAVEL TO 1.5 IN., 5-10% NONPLASTIC FINES, GRAY, BASAL TILL. BOTTOM: GRAVELLY SAND, GAP GRADED, MOSTLY FINE, 20-30% COARSE TO FINE GRAVEL TO 2 IN., 5-10% NONPLASTIC FINES, GRAY, BASAL TILL.
	45	S	9	83/6" 100/2"* (6")	100	SP-SM	SILTY SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 5-10% SUBROUNDED GRAVEL TO 1/2 IN. INCLUDING DECOMPOSED BIOTITE, 10-15% NONPLASTIC FINES, GRAY, BASAL TILL.
	50	S	10	49-155 (8")	204	SM	SILTY SAND, UNIFORM, FINE, 20-40% NONPLASTIC FINES, GRAY, BASAL TILL.
	55	S	11	100/2" 75/4"*	100	SM	SILTY SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 15-30% NONPLASTIC FINES, 5-10% COARSE SAND SIZED WEATHERED BIOTITE, GRAY, BASAL TILL.
-45.06	60						TOP OF ROCK AT 60.0 FT.
		NX	1	100/63			PINK WESTERLY GRANITE, MODERATELY CLOSELY JOINTED, FRESH, VERY HARD, MEDIUM GRAINED. 62.5 - 62.8, SEVERELY WEATHERED BIOTITE SEAM.
-50.06	65						END OF BORING - 65.0 FT

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.	STONE & WEBSTER ENG. CORP. SKETCH No. 12179-GSK-74B	APPROVED FBV	DATE 6/25/80	BORING NO. 407	SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

BORING NO. 408

SHEET 1 OF 2

COORDINATES N788.117 E879.832 GROUND ELEV. (1) 14.36

INCLINATION VERTICAL BEARING ______ INSPECTOR ______

DATE : START / FINISH 5/5/80 / 5/7/80 CONTRACTOR / DRILLER GUILD/ MASON

STATIC GROUNDWATER DEPTH / DATE NOT MEASURED (FT) / ______ DRILL RIG TYPE TRUCK MOUNTED ROTARY

DEPTH TO BEDROCK 43.5 (FT) TOTAL DEPTH DRILLED 45.0 (FT)

METHODS :

DRILLING SOIL TRICONE ROLLER BIT WITH 4 INCH CASING, DRILLED WITH WATER

SAMPLING SOIL SPLIT SPOON, OSTERBERG AND FIXED PISTON

DRILLING ROCK NX DOUBLE BARREL

SPECIAL TESTING OR INSTRUMENTATION INCLINOMETER AND CROSS HOLE SOURCE HOLE.

COMMENTS ______

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	0						
		S	1	17-17-15	32	SW-SM	GRAVELLY SAND, WELL GRADED, 10-15% SUBANGULAR GRAVEL TO 1 IN. MAXIMUM, 10-15% NONPLASTIC FINES, DRY, MEDIUM BROWN (FILL).
9.36	5						
		S	2	7-3-2	5	SW	GRAVELLY SAND, SIMILAR TO ABOVE.
	10	S	3	5-6-6	12	SP-SM	SILTY SAND, GAP GRADED, MEDIUM TO FINE, 3-5% SUBROUNDED GRAVEL TO 1 IN. MAXIMUM, 8-12% NONPLASTIC FINES, MOIST, DARK BROWN (FILL).
-1.64	15	S	4	11-12-13	25	SP-SM	GRAVELLY SAND, GAP GRADED, MEDIUM TO FINE, 30-35% ANGULAR GRAVEL TO 2 IN. MAXIMUM, 3-8% NONPLASTIC FINES WITH MICA FLAKES AND IRON OXIDE STAINING, ORANGE AND LIGHT BROWN (FILL).
		S	5	3-5-5	10	SP-SM	SILTY SAND, UNIFORM, FINE, 15-20% SLIGHTLY PLASTIC FINES, THIN MICACEOUS BANDING, GRAY.
	20	UO	6			SP-SM	TOP: SILTY SAND, UNIFORM, FINE, 1-3% ANGULAR GRAVEL TO ½IN., 8-12% SLIGHTLY PLASTIC FINES, MICACEOUS, GRAY.
						SP-SM	BOTTOM: SILTY SAND, UNIFORM, FINE, 20-25% SLIGHTLY PLASTIC FINES, MICACEOUS BROWN GRAY.
		S	7	3-4-6	10	SP-SM	SILTY SAND, UNIFORM, FINE, 25-30% SLIGHTLY PLASTIC FINES, GRAY, SOME MICA.
		UF	8			ML	TOP: SANDY SILT, NONPLASTIC, 5-10% VERY FINE SAND, MEDIUM BROWN.
						ML	BOTTOM: SANDY SILT. SIMILAR TO ABOVE.
	25	S	9	2-3-3	6	ML	SANDY SILT, NONPLASTIC, 30-35% FINE SAND, GRAY, MICACEOUS.
-13.64		S	10	2-7-6	13	ML	SANDY SILT, NONPLASTIC, 3-5% ANGULAR ROCK FRAGMENTS TO 1 IN. MAXIMUM, 20-40% VERY FINE SAND, GRAY.
							TOP OF TILL AT 28.0 FT. BOULDER - 28.0 - 31.0 FT.

LEGEND / NOTES

1. DATUM IS MEAN SEA LEVEL
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2"O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. S-SPLIT SPOON, US-SHELBY TUBE, UO-OSTERBERG, UF-FIXED PISTON.

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENG. CORP.
SKETCH No. 12179-GSK-75A

APPROVED	DATE	BORING NO.	SHEET
FSV	6/25/80	408	1 OF 2

BORING NO. 408
SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	30						
		S	11	10-10-8	18	SP	GRAVELLY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY MEDIUM SAND, 10-15% SUBROUNDED GRAVEL TO 1 IN. MAXIMUM, 4-8% NONPLASTIC FINES, GRAY BASAL TILL.
	35						
	40						
-29.14							TOP OF ROCK AT 43.5 FT.
							ROLLER BIT THROUGH ROCK
-30.64	45						END OF BORING AT 45.0 FT.

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.

STONE & WEBSTER ENG. CORP. SKETCH No. 12179-GSK-75B | APPROVED PBV | DATE 6/25/80 | BORING NO. 408 | SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

BORING NO. 409

SHEET 1 OF 2

COORDINATES N782.271 E870.024 GROUND ELEV. (1) 14.54

INCLINATION VERTICAL BEARING ——— INSPECTOR F. S. VETERE

DATE : START / FINISH 5/2/80 / 5/2/80 CONTRACTOR / DRILLER GUILD/MASON

STATIC GROUNDWATER DEPTH / DATE 9.0 (FT) / 5/2/80 DRILL RIG TYPE TRUCK MOUNTED ROTARY

DEPTH TO BEDROCK 34.0 (FT) TOTAL DEPTH DRILLED 39.0 (FT)

METHODS :

DRILLING SOIL TRICONE ROLLER BIT WITH 4 INCH CASING, DRILLED WITH WATER

SAMPLING SOIL SPLIT SPOON

DRILLING ROCK NX DOUBLE BARREL

SPECIAL TESTING OR INSTRUMENTATION INCLINOMETER AND CROSS HOLE RECEIVING HOLE

COMMENTS

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
9.54	5	S	1	4-3-5	8	SP-SM	SILTY SAND, POORLY GRADED, COARSE TO FINE, MOSTLY MEDIUM, 1-3% SUBROUNDED GRAVEL TO 1 IN. MAXIMUM, 8-12% NONPLASTIC FINES, DAMP, ORANGE-BROWN (FILL)
4.54	10	S	2	4-7-10	17	SM	SILTY SAND, UNIFORM FINE, 20-40% NONPLASTIC FINES, MOIST, LIGHT GRAYISH BROWN.
	15	S	3	4-7-8	15	SP-SM	SILTY SAND, POORLY GRADED, MOSTLY MEDIUM, 10-15% NONPLASTIC FINES, SATURATED, LIGHT GRAYISH BROWN.
	20	S	4	4-4-4-	8	SM	SILTY SAND, UNIFORM, VERY FINE, 25-40% SLIGHTLY PLASTIC FINES, MICACEOUS, BROWNISH GRAY.
	25	S	5	3-3-3	6	ML	SANDY SILT, SLIGHTLY PLASTIC, 30-40% VERY FINE SAND, FIRM, GRAY.
-13.96							TOP OF BASAL TILL AT 28.5

LEGEND / NOTES

1. DATUM IS MEAN SEA LEVEL
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. S-SPLIT SPOON, US-SHELBY TUBE, UO-OSTERBERG, UF-FIXED PISTON.

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENG. CORP.
SKETCH No. 12179-GSK- 76A

APPROVED	DATE	BORING NO.	SHEET
FSV	6/20/80	409	1 OF 2

BORING NO. 409

SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

ELEVATION (FEET) (1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	30	S	6	10-20-25	45	SW	GRAVELLY SAND, WELL GRADED, 10-15% SUBANGULAR GRAVEL TO 1 IN. MAXIMUM, 2-5% NONPLASTIC FINES GRAY, BASAL TILL.
							TOP OF ROCK AT 34 FT
-19.46	35	NX	1	40/40			GRAY MONSON GNEISS, WIDELY SPACED FOLIATION 40-45°, FRESH, VERY HARD, THIN BIOTITE BANDING (2 FT RECOVERY DUE TO LOSS OF CORE IN HOLE)
-24.46	40						END OF BORING AT 39.0 '

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.

STONE & WEBSTER ENG. CORP. SKETCH No.12179-GSK-76B | APPROVED FBV | DATE 6/25/80 | BORING NO. 409 | SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

BORING NO. 410

SHEET 1 OF 2

COORDINATES N775.206 E860.026 GROUND ELEV. (1) 14.36

INCLINATION VERTICAL BEARING ______ INSPECTOR F. S. VETERE

DATE : START / FINISH 5/1/80 / 5/1/80 CONTRACTOR / DRILLER GUILD/ MASON

STATIC GROUNDWATER DEPTH / DATE —— (FT) / —— DRILL RIG TYPE TRUCK MOUNTED ROTARY

DEPTH TO BEDROCK 34.0 (FT) TOTAL DEPTH DRILLED 39.0 (FT)

METHODS :

DRILLING SOIL TRICONE ROLLER BIT WITH 4 INCH CASING, DRILLED WITH WATER

SAMPLING SOIL SPLIT SPOON

DRILLING ROCK NX DOUBLE BARREL

SPECIAL TESTING OR INSTRUMENTATION INCLINOMETER AND CROSS-HOLE RECEIVING HOLE

COMMENTS

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
9.36	5						
		S	1	4-5-5	10	SW-SM	SILTY SAND, WELL GRADED, 8-12% NONPLASTIC FINES, MOIST, ORANGE-BROWN (FILL).
	10						
		S	2	7-17-17	34	SP-SM	SILTY SAND, GAP GRADED, 5-10% FINE, SUBANGULAR GRAVEL WITH PIECES TO 1¼ IN. MAXIMUM, MOSTLY FINE AND MEDIUM SAND, 10-15% NONPLASTIC FINES, SATURATED, BROWN (FILL).
	15						
		S	3	4-5-5	10	SM	SILTY SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 15-20% SLIGHTLY PLASTIC FINES, MICACEOUS, LIGHT GRAYISH BROWN.
	20						
		S	4	4-5-5	10	SM	SILTY SAND, UNIFORM, VERY FINE, 25-40% SLIGHTLY PLASTIC FINES THIN MICACEOUS BANDING, LIGHT GRAYISH BROWN.
	25						
-12.64		S	5	3-3-4	7	ML	SANDY SILT, SLIGHTLY PLASTIC, 15-30% VERY FINE SAND, OCCASIONAL SMALL CLAY POCKETS, GRAY.
							TOP OF TILL AT 27 FT.

LEGEND / NOTES

1. DATUM IS MEAN SEA LEVEL
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. S-SPLIT SPOON, US-SHELBY TUBE, UO-OSTERBERG, UF-FIXED PISTON.

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENG. CORP.
SKETCH No. 12179-GSK-77A

APPROVED	DATE	BORING NO.	SHEET
FBV	6/25/80	410	1 OF 2

BORING NO. 410

SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	30	S	6	16-64-10	74	SP-SM	SILTY SAND, WIDELY GRADED, MOSTLY FINE SAND, 10-15% ANGULAR ROCK FRAGMENTS TO 1½ IN., 10-15% NONPLASTIC FINES, GRAY. BASAL TILL.
-19.64							TOP OF ROCK AT 34.0 FT.
	35	NX	1	100/88			GRAY MONSON GNEISS, WIDELY SPACED FOLIATION 40-45%, FRESH, VERY HARD, THIN BIOTITE BANDING.
-24.64							
	40						END OF BORING AT 39.0 FT.

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.

STONE & WEBSTER ENG. CORP. SKETCH No. 12179-GSK-77B	APPROVED FBV	DATE 6/25/80	BORING NO. 410	SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

BORING NO. 411
SHEET 1 OF 2

COORDINATES N519.2 E922.6 GROUND ELEV. (1) 13.94

INCLINATION VERTICAL BEARING ______ INSPECTOR F. S. VETERE

DATE : START / FINISH 5/7/80 / 5/8/80 CONTRACTOR / DRILLER GUILD/ MASON

STATIC GROUNDWATER DEPTH / DATE 10.5 (FT) / 5/8/80 DRILL RIG TYPE TRUCK MOUNTED ROTARY

DEPTH TO BEDROCK 61.5 (FT) TOTAL DEPTH DRILLED 64.5 (FT)

METHODS :

DRILLING SOIL TRICONE ROLLER BIT WITH 4 IN. CASING, DRILLED WITH WATER

SAMPLING SOIL SPLIT SPOONS - N RODS

DRILLING ROCK NX DOUBLE BARREL

SPECIAL TESTING OR INSTRUMENTATION NONE

COMMENTS

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	5						
		S	1	9-11-10	21	SP	SAND, POORLY GRADED, COARSE TO FINE, MOSTLY MEDIUM, 3-8% NONPLASTIC FINES, LIGHT BROWN (FILL).
	▽						
		S	2	7-9-11	20	SW	SAND, SIMILAR TO ABOVE, EXCEPT 1-3% SUBROUNDED GRAVEL TO ½ IN. (FILL).
-1.06	15						
		S	3	7-10-8	18	ML	SANDY SILT, NONPLASTIC, 25-40% VERY FINE SAND, GRAYISH BROWN, MICACEOUS.
	20						
		S	4	4-5-5	10	SM	SILTY SAND, UNIFORM, FINE, 1-3% SUBROUNDED GRAVEL TO ¼ IN., 15-20% NONPLASTIC FINES, BROWN WITH IRON OXIDE STAINING.
	25						
-12.56		S	5	6-6-7	13	ML	SANDY SILT, NONPLASTIC, 10-15% FINE SAND, BROWNISH GRAY WITH THIN BANDS OF FINE SAND.

LEGEND / NOTES

1. DATUM IS MEAN SEA LEVEL
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2"O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. S-SPLIT SPOON, US-SHELBY TUBE, UO-OSTERBERG, UF-FIXED PISTON.

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENG. CORP.
SKETCH No. 12179-GSK-78A

APPROVED	DATE	BORING NO.	SHEET
FBV	6/25/80	411	1 OF 2

BORING NO. 411

SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		S	6	12 15-16	31	SP-SM	SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY FINE, 3-8% SUBROUNDED GRAVEL TO ½ IN., 10-15% NONPLASTIC FINES, BROWNISH GRAY(ZONES OF COARSE SAND 30.5 to 31.0 FT.)
	35	S	7	11-15-11	26	SP-SM	SILTY SAND, GAP GRADED, MOSTLY MEDIUM AND FINE SAND, 2-4% SUBROUNDED GRAVEL TO 3/4 IN.,10-15% NONPLASTIC FINES, GRAY.
-25.56							TOP OF BASAL TILL AT 39.5 FT.
	40						BOULDER CORED 40.0 - 42.0
		S	8	9-17-21	38	SM	SILTY SAND, WIDELY GRADED, MEDIUM TO FINE, MOSTLY FINE, 2-5% SUBROUNDED GRAVEL TO ½ IN. MAXIMUM, 15-20% NONPLASTIC FINES, GRAY BASAL TILL.
	45						
	50	S	9	60-118	178	SM	SILTY SAND, SIMILAR TO ABOVE. CORED BOULDER 51 - 52 FT.
							CORED DENSE TILL 52 - 55 FT.
	55	S	10	48-105	153	SM	SILTY SAND, SIMILAR TO ABOVE, EXCEPT WITH ANGULAR GRAVEL TO 1 IN. MAXIMUM.
	60	S	11	110-85*			SILTY SAND, SIMILAR TO ABOVE. TOP OF ROCK AT 61.5 FT.
-47.56		NX	1	67/67			PINK AND GRAY WESTERN GRANITE, WIDELY JOINTED, FRESH, VERY HARD, MEDIUM GRAINED.
-50.56	65						END OF BORING AT 64.5 FT.

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.	STONE & WEBSTER ENG. CORP. SKETCH No. 12179-GSK-78B	APPROVED FSV	DATE 6/25/80	BORING NO. 411	SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

BORING NO. 412

SHEET 1 OF 2

COORDINATES N463.6 E921.2 GROUND ELEV. (1) 13.34

INCLINATION VERTICAL BEARING ______ INSPECTOR F.S. VETERE

DATE : START / FINISH 5/9/80 / 5/9/80 CONTRACTOR / DRILLER GUILD/MASON

STATIC GROUNDWATER DEPTH / DATE ____ (FT) / ______ DRILL RIG TYPE TRUCK MOUNTED ROTARY

DEPTH TO BEDROCK 48.5 (FT) TOTAL DEPTH DRILLED 57 (FT)

METHODS :

DRILLING SOIL DRILLING MUD WITH NW RODS AND TRICONE BIT (6") SW CASING TO 7 FT

SAMPLING SOIL SPT WITH AW RODS

DRILLING ROCK ROLLER BIT

SPECIAL TESTING OR INSTRUMENTATION NONE

COMMENTS

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
13.34	0						
	5	S	1	8-8-9	17	SP	SAND, GAP-GRADED, MEDIUM TO FINE, MOSTLY MEDIUM, 1-3% SUBROUNDED GRAVEL TO 1/4 IN., 1-3% NONPLASTIC FINES, DAMP, BROWN (FILL).
3.34	10	S	2	6-13-14	27	SP	SAND, POORLY GRADED, COARSE TO FINE, MOSTLY MEDIUM, 2-5% NONPLASTIC FINES, DAMP, BROWN (FILL).
-0.66	15	S	3	6-5-6	11	ML	SANDY SILT, NONPLASTIC, 25-40% VERY FINE SAND, MOIST, MICACEOUS, GRAYISH BROWN.
	20	S	4	7-9-14	23	SM	SILTY SAND, UNIFORM, FINE, 15-20% NONPLASTIC FINES, THIN MICACEOUS BANDING, GRAYISH BROWN.
-8.66							TOP OF ABLATION TILL AT 22 FT.
	25	S	5	30-33-42	75	SP-SM	SILTY SAND, GAP-GRADED, MOSTLY MEDIUM AND FINE SAND, 2-4% SUBANGULAR GRAVEL TO 3/4 IN. MAXIMUM,10-15% NONPLASTIC FINES, MEDIUM BROWN.

LEGEND / NOTES

1. DATUM IS MEAN SEA LEVEL
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. S-SPLIT SPOON, US-SHELBY TUBE, UO-OSTERBERG, UF-FIXED PISTON.

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENG. CORP.
SKETCH No. 12179-GSK-79A

APPROVED	DATE	BORING NO.	SHEET
FSV	6/25/80	412	1 OF 2

BORING NO. 412
SHEET 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION-UNIT 3 J.O. NO. 12179

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
-16.66	30	S	6	43-40-35	75	SM	SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY MEDIUM, 4-7% SUB-ANGULAR GRAVEL TO 1/2 IN. MAXIMUM, 15-20% NONPLASTIC FINES, MEDIUM BROWN.
-20.66							TOP OF BASAL TILL AT 34.0 FT.
	35	S	7	17-48-90	138	SP-SM	SILTY SAND, GAP-GRADED, MOSTLY MEDIUM AND FINE SAND, 2-4% SUBROUNDED GRAVEL TO 1/2 IN. MAXIMUM, 10-15% NONPLASTIC FINES, GRAYISH BROWN.
	40	S	8	44-110	154	SP	SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY MEDIUM, 3-5% SUBROUNDED GRAVEL TO 1/2 IN., 3-5% NONPLASTIC FINES, GRAY, BASAL TILL. BOULDER AT 41'-41.75'
	45	S	9	45-88	133	SM	SILTY SAND, POORLY GRADED, COARSE TO FINE, MOSTLY FINE, 3-5% SUBROUNDED GRAVEL TO 3/4 IN., 15-20% NONPLASTIC FINES, GRAY, BASAL TILL.
-35.16							TOP OF ROCK AT 48.5 FT.
	50						BEDROCK ADVANCED WITH ROLLER BIT.
	55						
-43.66							END OF BORING AT 57 FT
	60						

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.

STONE & WEBSTER ENG. CORP. SKETCH No. 12179-GSK-79B	APPROVED FSV	DATE 6/25/80	BORING NO. 412	SHEET 2 OF 2

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-1

TYPE OF BORING 4" NX LOCATION 1720N - 980W GROUND ELEV. 18.1'

DATE DRILLED 12/31/71 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE EL. 18.1'							
			7	1		MED. DENSE, BROWN-YELLOW BROWN MED.-FINE SAND, W/TR. GRAVEL & COBBLES & SILT. (ABLATION TILL)	
			27	2			
			50/0"				
10.6			78	3			
	10					DENSE GREY SILT & SAND W/TR. GRAVEL & COBBLES. (BASAL TILL?)	
7.6						TOP OF ROCK	
						FRAC., WX.	GREY, BANDED, QTZ. BIOTITE GNEISS (MONSON GNEISS) W/ GRANITE SEAMS 1-10' THICK. FOLIATION 50°.
						HORZ. JT., TIGHT	
						10° JT., RUST STN.	
						SOFT WX. ZONE	
		47	100			50° JT., RUST STN. & WX.	
						HORZ. JT., RUST STN. & WX.	
	20					50° JT., RUST STN. & WX.	
						50° JT., RUST STN. & WX.	
						4" SOFT WX. ZONE	
-5.7						50° JT., RUST STN. & WX.	
						SOFT WX. ZONE	
						30° JT., RUST STN.	23.6'- 30' GRANITE
		67	100			HORZ. JT., RUST STN.	
-12.1	30					50 JT., RUST STN.	
-13.6						FRAC. ZONE	
						END OF BORING 31.5'	
						GROUND WATER LEVEL AFTER COMPLETION 11.5' BELOW GROUND SURFACE ON 12/31/71	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≑ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M. S. L.

4	APPD. SRB 1-26-72
3	APPD. VRN 1-25-72
2	CHKD. D.C
1	PREPD. R.S.

BORING LOG I-1

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-33

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-2

TYPE OF BORING 4"-NX LOCATION 1520N-450W GROUND ELEV. 9.3

DATE DRILLED 1/14/72 DRILLED BY AMERICAN DRILLING LOGGED BY R.S.

SUMMARY OF BORING

GROUND SURFACE ELEV. 9.3

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	NAT. WATER CONTENT	OTHER TESTS	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
			16	1			VERY DENSE YELLOW BROWN (MEDIUM-FINE) SAND, TRACE FINE GRAVEL (FILL?)
			49	2	3.4	G	
			40	3			
1.8			15	4	16.5	G	MEDIUM DENSE YELLOW BROWN MEDIUM TO FINE SAND, TRACE FINE GRAVEL (FILL?)
	10		7	5	17.6	G	
			13	6			
-7.7	20		22	7	23.3	G	MED. DENSE TO DENSE GRAY FINE SAND, TRACE MICA
			24	8			
-20.7	30		35	9	13.7	G	MED. DENSE, GRAY-BROWN FINE SAND, MICACEOUS, TRACE OF SILT, WITH OCCASIONAL TRACE FINE GRAVEL AND ROCK FRAGMENTS NOTE: DEFINITION OF SYMBOLS USED UNDER HEADING "OTHER TESTS" G - GRAIN SIZE ANALYSIS
			26	10			
	40		26	11	10.8	G	
			20 50/6"	12			
-38.2							TOP OF ROCK
	50	15	60				FRACTURED, WEATHERED, MOST OF ROCK IS YELLOW STAINED / GRAY, BANDED, QTZ. BIOTITE GNEISS, (MONSON GNEISS), WITH GRANITE SILLS ABOUT 1-10' THICK AND PEGMATITE INTRUSIVES ABOUT 1-2' THICK FOLIATION ABOUT 60°
		63	100				HORZ. JT., YELLOW STAIN, TRACE WEATHERING HORZ. JT., YELLOW STAIN, TRACE WEATHERING FRACTURED ZONE WITH YELLOW STAIN
	60	80	100				HORZ. JT., WITH SILT INFILLING / AT 59-60' PEGMATITE BAND FRACTURED ZONE HORZ. JT., TR. WEATHERING 10° JT., YELLOW STAIN
-54.2		83	100				IRREG. JT., RUST STAIN / AT 63.5'-68.0' GRANITE SILT FOLIATION 55° 45° JT., SILT INFILLING IRREG. JT., SILT INFILLING
-59.2	70						END OF BORING 68.5' GROUNDWATER LEVEL AFTER COMPLETION 8.0' BELOW GROUND SURFACE ON 1/14/72

GRAPHIC LOG:

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.
7. W_n IS NATURAL WATER CONTENT %
8. OTHER TESTS: SEE NOTE ABOVE

4	APPD.	1-26-73
3	APPD.	VRN 1/25/73
2	CHKD.	D.C.
1	PREPD.	R.S.

BORING LOG I-2

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-34

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE POINT, WATERFORD, CONN. J.O. No. 12179 BORING NO. I-3
TYPE OF BORING NX LOCATION 1,097N-370W GROUND ELEV. 0.6'
DATE DRILLED 11-17-72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
			9	1		LOOSE TO MEDIUM DENSE, WHITE TO LIGHT BROWN POORLY GRADED MEDIUM TO FINE SAND.
			12	2		
			59	3		VERY DENSE, MEDIUM BROWN WELL GRADED COARSE TO FINE SAND, SOME GRAVEL.
			12	4		MEDIUM DENSE, MEDIUM TO DARK BROWN, POORLY GRADED, COARSE TO FINE MOSTLY MEDIUM SAND, TRACE OF GRAVEL, TRACE OF SILT.
	10		9	5		
			12	6		
	20		8	7		LOOSE RUSTY BROWN, POORLY GRADED, MEDIUM TO FINE SILTY SAND, SOME SILT.
			9	8		LOOSE RUSTY BROWN, POORLY GRADED, COARSE TO FINE MOSTLY MEDIUM SAND, TRACE OF SILT.
-29.4	30		120/0.1			VERY DENSE BOULDERS AND COBBLES
						BASAL TILL
-34.2						TOP OF ROCK
		0	91			JT. TYP. STAINED — RED-GRAY GARNET BIOTITE GNEISS (MONSON GNEISS); 60° JT. HEAVY YELLOWISH GREEN MINERALIZATION (TALC?)
		46	79			JT. TYPICALLY 60°, GREEN STAIN
	40	67	100			30° JT. SL. YELLOWISH GREEN STAIN, SOME GREENISH GRAY CLAY
						85° IRREG. JT. SOME DARK GREENISH BROWN STAIN; JT. TYPICALLY STAINED THROUGHOUT
		46	94			85° JT. VERY HEAVY YELLOWISH GREEN MINERALIZATION WITH 0.7 IN OFFSET IN 4 HORIZONTAL BREAKS.
-47.8						
	50					END OF BORING 48.4'
						GROUNDWATER LEVEL AFTER COMPLETION 11/21/72 2.2' BELOW GROUND SURFACE

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ▼6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD / 1-26-73
3	APPD / VRN 1-25-73
2	CHKD / D.C.
1	PREPD / P.W.

BORING LOG I-3
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-35

NORTHEAST UTILITIES SERVICE COMPANY

SH. 1 OF 1

SITE: MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-4
TYPE OF BORING: NX LOCATION: 1,260N-200W GROUND ELEV. 16.5
DATE DRILLED: 11/15/72 DRILLED BY: AMERICAN DRILLING LOGGED BY: P. WALLACK
SUMMARY OF BORING:

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
16.0			5	1	LOAM
					LOOSE TO MEDIUM DENSE, LIGHT YELLOWISH BROWN, POORLY GRADED, MEDIUM TO FINE SILTY SAND, TRACE OF GRAVEL, SOME SILT.
			24	2	
			84	3	VERY DENSE, ORANGE BROWN, WELL GRADED, COARSE TO FINE SAND, TRACE OF GRAVEL, TRACE OF SILT.
			58	4	
	10		65	5	
2.3					ABLATION TILL
			120/0.1		VERY DENSE CORED .7' BOULDER
	20		180/0.8	6	VERY DENSE LIGHT GRAYISH BROWN, POORLY GRADED, COARSE TO FINE SAND, TRACE OF SILT.
					BASAL TILL
			120/0.2	7	TOP OF ROCK
					30° JT. SOME YELLOWISH LT. BROWN STAIN — GRAY BIOTITE GNEISS (MONSON GNEISS) FOLIATION ABOUT 45°
		20	78		53% JT. HORIZ. SL. STAIN
	30				BROKEN ZONE STAINED SURFACES AT 29.1-29.3
					JT. TYPICALLY STAINED, SOME WEATHERING
					VERY HEAVILY WEATHERED ZONE (CHLORITIZED?) AT 34.4-34.8
-18.6		36	82		
-20.0					0.2' ZONE GRAY BIOTITE GNEISS — PINK GRANITE AT 35.1-36.5
-21.9					VERY HEAVILY WEATHERED ZONE (CHLORITIZED?) AT 36.6-38.4
-22.1					PINK GRANITE AT 38.4-38.6
	40				JT., TYPICALLY STAINED W/OCC. WX.
					10° JT. SOME YELLOWISH LT. BROWN STAIN
		78	98		45° JT. SOME TALC MINERALIZATION
					30° JT. SOME GRAY DEPOSIT, SOME YELLOWISH GREEN STAIN
-33.8	50				END OF BORING 50.3'
					GROUND WATER LEVEL AFTER COMPLETION 11/16/72 15.4' BELOW GROUND SURFACE

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APP'D	1-26-73
3	APP'D	VRN 1/25/73
2	CHK'D	D.C.
1	PREP'D	P.W.

BORING LOG I-4
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-36

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 2

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-5

TYPE OF BORING NX LOCATION 1,470N-20W GROUND ELEV. 20.1

DATE DRILLED 11/8/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS & RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
19.6			76	1		LOAM
			55			VERY DENSE, MEDIUM BROWN, POORLY GRADED, COARSE TO FINE SAND, TRACE OF SILT.
15.1			120/.3'			ABLATION TILL
						VERY DENSE, COBBLES AND BOULDERS
	10		120/.2'			
						DRILLED CORE BARREL TO 15.0', THEN DRILLED 3" CASING OVER IT TO 15.0' AND THE CORE BARREL WENT TO 19.0' TRIED TO GET A SAMPLE AT 19.0' - REFUSAL
	20					
			120/.3	2		VERY DENSE, LIGHT GRAYISH BROWN, POORLY GRADED, COARSE TO FINE SAND, SOME GRAVEL, TRACE OF SILT.
	30		140/.7	3		
			185/.8	4		
-19.9	40		100/1.0	5		VERY HEAVILY WEATHERED, GREEN BIOTITE GNEISS (SAND LIKE) CHLORITIZED.
-22.9		10	50			TOP OF ROCK
						JT. SL. YELLOWISH GREEN STAIN THROUGHOUT / GRAY BIOTITE GNEISS FOLIATION ABOUT 60°
-25.1						80° JT. HEAVY YELLOWISH GREEN STAIN (PEGMATIC) / PINK GRANITE AT 45.2-45.7
-25.6						80° CONTACT / GRAY BIOTITE GNEISS FOLIATION ABOUT 60°
	50	49	98			JT. TYPICALLY YELLOWISH-LT. BROWN STAIN THROUGHOUT, SOME WEATHERING
		20	78			60° JT. HEAVILY YELLOWISH-GREEN MINERALIZATION VERY HEAVILY WEATHERED (SAND LIKE)
-35.0						JT. TYPICALLY S. STAIN THROUGHOUT / PINK GRANITE (PEGMATIC) AT 55.1-57.0
-36.9						JT. TYPICALLY SOME STAIN THROUGHOUT PARALLEL TO FOLIATION
-39.4	60					60.6 45° JT. SLICKENSIDES
-41.5						60.7 45° JT. GREEN GRAY CLAY / YELLOWISH GREEN BIOTITE GNEISS AT 59.9-61.6
		35	94			60.9 45° JT. SLICKENSIDES 61.0 60° JT. SLICKENSIDES 61.2 45° JT. SLICKENSIDES 61.4 30° JT. SLICKENSIDES
-43.6						90° FRAC. CLEAN / PINK GRANITE AT 63.7-64.6
-44.5						45° JT. SLICKENSIDES (VERY HEAVILY WEATHERED AT 64.7
-47.1						45° JT. 1/4IN. WIDE SEAM (SAND LIKE)
-47.4						PINK GRANITE (PEGMATIC) AT 67.2-67.5
	70					JT. TYPICALLY STAINED THROUGHOUT

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD / SBP / 1-24-73
3	APPD / VAN / 1/12/73
2	CHKD / D.C.
1	PREP'D / P.W.

BORING LOG I-5

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-37A

NORTHEAST UTILITIES SERVICE COMPANY

SITE MILLSTONE PT. WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-5
TYPE OF BORING NX LOCATION 1,470N-20W GROUND ELEV. 20.1
DATE DRILLED 11/8/72 DRILLED BY AMERICAN DRILLING LOGGED BY P. WALLACK
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
		96	100			JT. TYPICALLY YELLOWISH-WHITE MINERALIZATION
-54.9	75					60° IRREG. CLEAN
						END OF BORING 75.0'
						GROUND WATER LEVEL AFTER COMPLETION 11/10/72 12.3' BELOW GROUND SURFACE

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≑ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION. (PERCENT)
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS M.S.L.

4	APPD ... 1-26-73
3	APPD VKN 1/12/73
2	CHKD. D.C.
1	PREPD P.W.

BORING LOG I-5

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179-GSK-37B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-6

TYPE OF BORING SPLIT SPOON/NX CORE LOCATION 1529 N - 150 W GROUND ELEV. 20.29

DATE DRILLED SEPTEMBER 10, 1973 DRILLED BY AMERICAN LOGGED BY J.E.P.

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
20.29						
			53	1		GRAVELLY SAND, POORLY GRADED, 10-20% ANGULAR GRAVEL TO 1.4 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 5-10% NONPLASTIC FINES, VERY DENSE, MOIST, DARK GRAY. (SP)
			159	2		GRAVELLY SAND, SAME AS S#1. (SP)
			100/1"	3		NO RECOVERY.
	10					
			69	4		GRAVELLY SAND, SIMILAR TO S#1, EXCEPT ORANGE MOTTLED WITH MEDIUM BROWN. (SP)
			100*	5		SANDY GRAVEL, GAP GRADED, SUBANGULAR TO 1.4 INCH MAXIMUM, 15-25% FINE SAND, LESS THAN 5% NONPLASTIC FINES, VERY DENSE, MOIST, MEDIUM BROWN. (GP)
	20					
			113*	6		SILTY SAND, WIDELY GRADED, 5-10% ANGULAR GRAVEL TO 0.7 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 15-20% NONPLASTIC FINES, VERY DENSE, SATURATED, LIGHT GRAY WITH LAYERS OF DARK AND LIGHT BROWN AT BOTTOM. (SM)
			135*	7		SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 3-8% NONPLASTIC FINES, VERY DENSE, MEDIUM GRAY WITH POCKETS OF ORANGE, FEW 1.0 INCH GRAINS DECOMPOSED ROCK. (SP)
-11.21	30		100/5" (SEAT)	8		SAND, UNIFORM, FINE, VERY DENSE, MIXED GRAY, BLACK AND BROWN. (SP)
						TOP OF ROCK AT 31.5'
		50	100	NX		31.4'- 41.5' LIGHT GRAY BIOTITE GRANITE GNEISS, VERY CLOSE TO CLOSE JOINTING, SLIGHT TO MODERATE WEATHERING, HARD TO MODERATELY HARD, MEDIUM GRAINED.
		66	99	NX		
	40					
		45	100	NX		41.5'- 46.5' SIMILAR TO ABOVE, EXCEPT SEVERLY WEATHERED BY CHLORITIZATION, VERY SOFT TO HARD.
-26.21	46.5					
						END OF BORING AT 46.5'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS
7. * INDICATES USE OF 300 LB HAMMER - 24 INCH FALL.

4	
3	
2	
1	6/23/88 RSL

BORING LOG I-6

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 38

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-7

TYPE OF BORING SPLIT SPOON/ NX CORE LOCATION 1388 N - 205 W GROUND ELEV. 18.18'

DATE DRILLED SEPTEMBER 5-6, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS or RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
18.18						
			58	1		SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY FINE, 10-20% NONPLASTIC FINES, VERY DENSE, DAMP, DARK BROWN. (SM)
			57	2		GRAVELLY SAND, POORLY GRADED, 8-12% GRAVEL TO 0.5 INCH MAXIMUM, MEDIUM TO FINE SAND, VERY DENSE, (COMPACT IN SAMPLE) DAMP, LIGHT ORANGE BROWN, MICACEOUS. (SP)
			66	3		GRAVELLY SAND, SIMILAR TO S#2, EXCEPT WIDELY GRADED, COARSE TO FINE SAND. (SP)
	10		35	4		SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, DENSE, MOIST, LIGHT ORANGE BROWN, MICACEOUS. (SP)
			38/100/2"	5		SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY FINE, 12-15% NONPLASTIC FINES, MOIST, VERY DENSE, LIGHT GRAY BROWN, LARGE PIECE OF COBBLE AT TOP OF SAMPLE CORED THROUGH BY SAMPLER. (SM)
	20		150/6" (SEAT)	6		SILTY SAND, POORLY GRADED, MEDIUM TO FINE SAND, 10-15% NONPLASTIC FINES, VERY DENSE, DAMP, LIGHT GRAY, ORANGE INCLUSIONS (TILL) (SM-SP) (LAST 50 BLOWS WITH 300 LB HAMMER)
			100/1"	7		GRAVELLY SAND, WIDELY GRADED, GRAVEL TO 1.0 INCH MAXIMUM, COARSE TO FINES, LESS THAN 5% NONPLASTIC FINES, VERY DENSE, DAMP, LIGHT GRAY. (SP)
	30		25*/0"			REFUSAL
-13.82						TOP OF ROCK AT 32.0'
		47	100	NX		32.0'- 37.0' LIGHT GRAY BIOTITE GRANITE GNEISS, CLOSE TO MODERATELY CLOSE JOINTING, SLIGHT WEATHERING, VERY HARD, MEDIUM GRAINED, HIGH QUARTZ CONTENT. (AXIAL JOINTS FILLED WITH CALCITE).
	40	76	100	NX		37.0'- 42.0' SAME AS ABOVE, EXCEPT MODERATE JOINTING AND JOINTS CHLORITIZED. (NO CALCITE IN JOINTING).
				NX		42.0'- 47.0' SAME AS ABOVE.
-28.82	47					
						END OF BORING AT 47.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS
7. * INDICATES USE OF 300 LB HAMMER - 24 INCH FALL.

4	
3	
2	
1	6/3/74 FB

BORING LOG I-7

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 39

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-8

TYPE OF BORING SPLIT SPOON/ NX CORE LOCATION 1257 N - 310 W GROUND ELEV. 14.7'

DATE DRILLED SEPTEMBER 7, 1973 DRILLED BY AMERICAN LOGGED BY J.E.P.

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
			52	1	TOP 5 INCHES: GRAVELLY SAND, POORLY GRADED, 10-20% ANGULAR GRAVEL TO 1.0 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, VERY DENSE, DAMP, LIGHT GRAY. (SP) BOTTOM 5 INCHES: GRAVELLY SAND, SIMILAR TO TOP 5 INCHES, EXCEPT 5-10% NONPLASTIC FINES, LIGHT ORANGE BROWN. (SP)
			52	2	SAND, UNIFORM, FINE, LESS THAN 5% NONPLASTIC FINES, VERY DENSE, (COMPACT IN SAMPLE), DAMP, LIGHT ORANGE BROWN, 4 INCH LAYER HIGHLY WEATHERED QUARTZITE IN MIDDLE. (SP)
	10		16	3	SAND, UNIFORM FINE, 3-8% NONPLASTIC FINES, COMPACT, DRY, LIGHT ORANGE BROWN AND BLACK, MICACEOUS. (SP)
			15	4	TOP 7 INCHES: SILTY SAND, UNIFORM, VERY FINE, 10-15% NONPLASTIC FINES, COMPACT, DAMP, MEDIUM GRAY, MICACEOUS, FEW 0.2 INCH LAYERS CLAY. (SM-SP) BOTTOM 3 INCHES: SILTY SAND, POORLY GRADED, COARSE TO FINE, MOSTLY FINE, 10-15% NONPLASTIC FINES, COMPACT, LIGHT ORANGE BROWN. (SM-SP)
			14	5	TOP 13 INCHES: SILTY SAND, UNIFORM, FINE, 15-25% NONPLASTIC FINES, COMPACT, SATURATED, DARK BROWN WITH THIN BLACK LAYERS, MICACEOUS, 3 INCH LAYER MEDIUM TO FINE SAND IN MIDDLE. (SM) BOTTOM 3 INCHES: SANDY SILT, SLIGHTLY PLASTIC, 20-30% VERY FINE SAND, SOFT, MOIST, GRAY BROWN, MICACEOUS. (ML)
	20		29	6	SAND, UNIFORM, FINE, 3-8% NONPLASTIC FINES, COMPACT, ORANGE BROWN AND BLACK, TRACE MICA. (SP)
			69	7	SILTY SAND, WIDELY GRADED, ROUNDED, MEDIUM TO FINE, MOSTLY FINE, 10-20% NONPLASTIC FINES, VERY DENSE, GRAY BROWN. (SM).
	30	0	6	NX	28.0' - 30.0' BOULDER
					[illegible]
			100/3"	8	GRAVELLY SAND, WIDELY GRADED, 10-20% SUBANGULAR GRAVEL TO 0.8 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINES, 8-12% NONPLASTIC FINES, VERY DENSE, MEDIUM GRAY. (SP)
			100/5"	9	GRAVELLY SAND, SAME AS S#8. (SP)
	40				40.0' - 43.5' WEATHERED ROCK AND TILL.
-28.8					TOP OF ROCK AT 43.5'
		67	99	NX	43.5' - 44.5' LIGHT GRAY GRANITE, CLOSELY JOINTED, MODERATE WEATHERING, HARD, FINE TO MEDIUM GRAINED. 44.5' - 45.3' DARK GRAY HORNBLEND BIOTITE GNEISS, VERY CLOSELY JOINTED, BAND OF COMPLETE WEATHERING, VERY SOFT TO MODERATELY HARD, FINE GRAINED.
	50	95	100	NX	45.3' - 46.2' LIGHT GRAY-PINK GRANITE, (CONTACT), VERY CLOSE JOINTING, MODERATE WEATHERING, HARD, MEDIUM TO COARSE GRAINED. 46.2' - 48.5' LIGHT GRAY GRANITE GNEISS, CLOSE JOINTING, SLIGHT WEATHERING, HARD, MEDIUM GRAINED. 48.5' - 53.5 LIGHT GRAY HORNBLEND BIOTITE GNEISS, CLOSE TO MODERATELY CLOSE JOINTING, FRESH, VERY HARD, MEDIUM GRAINED.
		98	100	NX	53.5' - 58.5' SAME AS ABOVE, EXCEPT MODERATELY JOINTED.
-58.5	58.5				END OF BORING AT 58.5'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □7 INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊥ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

4	
3	
2	
1	6/23/80 FSV

BORING LOG I-8

MILLSTONE NUCLEAR POWER STATION

UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 40

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-8 (A)
TYPE OF BORING SPLIT SPOON/PISTON SAMPLE LOCATION 1258 N - 307 W GROUND ELEV. 14.82
DATE DRILLED SEPTEMBER 11, 1973 DRILLED BY AMERICAN LOGGED BY J.E.P.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
			21"	PS-1		SAND, POORLY GRADED, COARSE TO FINE, MOSTLY FINE, LESS THAN 1% NON-PLASTIC FINES, VERY LOOSE, DAMP, DARK GRAY TO LIGHT BROWN, MICACEOUS; LENSES OF YELLOWISH BROWN SILTY SAND. (SP)
	10		16	1		SAND, POORLY GRADED, COARSE TO FINE, MOSTLY FINE, LESS THAN 5% NON-PLASTIC FINES, COMPACT, DRY, ALTERNATING LAYERS LIGHT BROWN AND ORANGE. (SP)
			19"	PS-2		SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 1-3% NONPLASTIC FINES, DAMP, COMPACT, YELLOWISH BROWN, LAYERS OF PURE MICA. (SP)
			21	2		SILTY SAND, UNIFORM, FINE, 15-20% NONPLASTIC FINES, COMPACT, MOIST, MEDIUM BROWN, MICACEOUS. (SM)
-3.18	18		31	3		SILTY SAND, SIMILAR TO S#2, EXCEPT SMALL AMOUNT OF MICA AT TOP. (SM)
						END OF BORING AT 18.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □/ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

4		
3		
2		
1	6/13/80	

BORING LOG I-8A

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 41

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING No. I-9

TYPE OF BORING SPLIT SPOON / NX CORE LOCATION 1225 N - 538 W GROUND ELEV. 7.38'

DATE DRILLED SEPTEMBER 5-6, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
7.38'						
			6	1		SAND, POORLY GRADED, MEDIUM TO FINE, LOOSE, DRY, LIGHT BROWN. (BEACH SAND) (SP)
			6	2		SAND, SIMILAR TO S#1, EXCEPT DAMP. (SP)
			57	3		GRAVELLY SAND, WIDELY GRADED, 10-15% GRAVEL, COARSE TO FINE SAND, VERY DENSE, DAMP, LIGHT BROWN MOTTLED WITH ORANGE, 6 INCH LAYER OF SLIGHTLY PLASTIC, GRAY CLAYEY SAND IN MIDDLE OF SAMPLE. (SP)
	10		39	4		SAND, WIDELY GRADED, LESS THAN 5% GRAVEL TO 0.50 INCH MAXIMUM, COARSE TO FINE SAND, 5-10% NONPLASTIC FINES, DENSE, DAMP, ORANGE BROWN. (SP-SM)
			36	5		SAND TOP 8" POORLY GRADED, MEDIUM TO FINE, MOSTLY MEDIUM, DENSE, MOIST, LIGHT BROWN. BOTTOM 6" GRAVELLY SAND, SAME AS ABOVE EXCEPT 10-20% GRAVEL TO 0.5 INCH MAXIMUM. (SP)
			24	6		SAND, WIDELY GRADED, COARSE TO FINE, LESS THAN 5% NONPLASTIC FINES, COMPACT, MOIST ORANGE BROWN. (SP)
			28	7		GRAVELLY SAND, POORLY GRADED, 5-12% SUBROUNDED GRAVEL TO 1.2 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, COMPACT, MOIST, ORANGE BROWN, 1 INCH LAYER OF MODERATELY TO HIGHLY PLASTIC GRAY SANDY CLAY AT TOP OF SAMPLE. (SP)
	20		23	8		SAND, POORLY GRADED, LESS THAN 5% ANGULAR GRAVEL TO 1.0 INCH MAXIMUM, MEDIUM TO FINE SAND, MOSTLY FINE, COMPACT, MOIST, ORANGE BROWN. (SP)
			17	9		SILTY SAND, UNIFORM, FINE, 15-25% NONPLASTIC FINES, COMPACT, MOIST, ORANGE BROWN, BOTTOM 8 INCHES HAS MANY THIN SANDY CLAY LENSES, MICACEOUS. (SM)
	30		15	10		CLAYEY SAND, UNIFORM, FINE, 10-20% SLIGHTLY PLASTIC FINES, COMPACT, DAMP, LIGHT BROWNISH GRAY, MICACEOUS. (SC)
			52	11		GRAVELLY SAND, WIDELY GRADED, 10-15% GRAVEL TO 1.2 INCH MAXIMUM, COARSE TO FINE, MOSTLY FINE SAND, 5-10% NONPLASTIC FINES, VERY DENSE, DAMP, GRAYISH BROWN. (SP)
-31.38						TOP OF ROCK AT 38.0'
	40	50	100	NX		38.0'- 43.0' LIGHT GRAY BIOTITE GRANITE GNEISS, WIDELY JOINTED, FRESH, VERY HARD, MEDIUM GRAINED, HIGH QUARTZ CONTENT.
		32	100	NX		43.0'-46.0' SAME AS ABOVE EXCEPT NO JOINTING.
		68	100	NX		46.0'-51.0' SAME AS ABOVE.
	50					
		53	100	NX		51.0'-55.5' SAME AS ABOVE.
-48.12	55.5					END OF BORING AT 55.5'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

4	
3	
2	
1	6/25/80 RBV

BORING LOG I-9

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 42

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE: MILLSTONE PT., WATERFORD, CONN. J.O. NO.: 12179 BORING NO.: I-10

TYPE OF BORING: SPLIT SPOON/ NX CORE LOCATION: 1148 N - 409W GROUND ELEV.: 5.02'

DATE DRILLED: SEPTEMBER 10, 1973 DRILLED BY: AMERICAN LOGGED BY: J. GUSTIN

SUMMARY OF BORING:

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
5.02						
			13	1		SAND, UNIFORM, FINE, COMPACT, LOOSE IN SAMPLE, DRY, LIGHT BROWN. (BEACH SAND) (SP)
			29	2		SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, COMPACT, LOOSE IN SAMPLE, DRY, LIGHT BROWN. (SP) (BEACH SAND) GRAVEL TO 0.25 INCH MAXIMUM AT BOTTOM OF SAMPLE.
			11	3		SILTY SAND, UNIFORM, FINE, 20-30% NONPLASTIC FINES, LOOSE, DAMP, DARK BROWN, MICACEOUS. (SM)
	10		11	4		SAND, POORLY GRADED, COARSE TO FINE, MOSTLY FINE, 5-10% NONPLASTIC FINES, LOOSE, MOIST, ORANGE BROWN. (SP-SM)
			10	5		SAND, SIMILAR TO ABOVE EXCEPT FOR GRAVEL TO 1.0 INCH MAXIMUM AT BOTTOM OF SAMPLE. (SP-SM)
			15	6		SILTY SAND, TOP 6", POORLY GRADED, TRACE OF GRAVEL TO 0.5 INCH MAXIMUM, COARSE TO FINE, MOSTLY FINE, 8-12% NONPLASTIC FINES, LOOSE, MOIST BROWN, MICACEOUS. (SM-SM) BOTTOM 7", UNIFORM FINE, 10-15% NONPLASTIC FINES, LOOSE, MOIST, BROWN, MICA. (SP-SM)
			14	7		SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, LOOSE, MOIST, BROWN, MICA. (SP)
	20		15	8		SANDY SILT, 10-20% FINE SAND, NONPLASTIC FINES, SOFT, DAMP, HIGH DILATANCY, LIGHT BROWN, MICACEOUS. (ML)
			15	9		SILTY SAND, UNIFORM, VERY FINE, 40-50% NONPLASTIC FINES, COMPACT, DAMP, LIGHT BROWN, MICACEOUS. (SM-ML)
	30		17	10		SILTY SAND, TOP 12", SIMILAR TO S#9, EXCEPT 5-10% SLIGHTLY PLASTIC FINES (SM-ML). BOTTOM 5", SILTY SAND, UNIFORM, FINE, 15-25% NONPLASTIC FINES, COMPACT, DAMP, LIGHT BROWN. (SM)
			66	11		GRAVELLY SAND, POORLY GRADED, 10-12% ANGULAR GRAVEL TO 0.375 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, VERY DENSE, MOIST, ORANGE BROWN. (SP)
	40		58	12		SANDY GRAVEL, POORLY GRADED, ANGULAR GRAVEL TO 1.0 INCH MAXIMUM, 40-50% COARSE TO FINE SAND, MOSTLY FINE, 10-15% NONPLASTIC FINES, VERY DENSE, DAMP, ORANGE BROWN. (GP)
-40.88			80 / 5"	13		GRAVELLY SAND, POORLY GRADED, 10-20% GRAVEL TO 0.8 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY MEDIUM, 10-15% SLIGHTLY PLASTIC FINES AT BOTTOM OF SAMPLE, DENSE, MOIST, GRAY BROWN. (BASAL TILL) (SP)
						TOP OF ROCK AT 45.9'
		42	100	NX		45.9'- 50.9' LIGHT GRAY BIOTITE GRANITE GNEISS, VERY CLOSE TO CLOSE JOINTING, SLIGHTLY WEATHERED, HARD, MEDIUM GRAINED, CHLORITIZED JOINTS.
	50	58	100	NX		50.9'- 60.9' SIMILAR TO ABOVE EXCEPT SOME MODERATE TO SEVERE WEATHERING BY CHLORITIZATION.
-55.88	60.9					
						END OF BORING AT 60.9'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⚲ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

BORING LOG I-10

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

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NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-10A

TYPE OF BORING SPLIT SPOON/ PISTON SAMPLE LOCATION 1121 N - 368 W GROUND ELEV. 5.37

DATE DRILLED SEPTEMBER 18, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
5.37						
			25	1		SILTY SAND, UNIFORM, FINE, 15-25% NONPLASTIC FINES, COMPACT, DAMP, DARK BROWN, MICA. (SM)
			31	2		SANDY GRAVEL, SUBANGULAR GRAVEL TO 0.50 IN. MAX., 40-50% POORLY GRADED, COARSE TO FINE, MOSTLY FINE SAND, LESS THAN 5% NONPLASTIC FINES, COMPACT, MOIST, ORANGE BROWN, (GP)
			13	3		NO RECOVERY - LARGE PIECE OF GRAVEL LODGED IN SHOE.
	10		17"	PS-1		SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 5-8% NONPLASTIC FINES, COMPACT, DAMP, DARK BROWN, MICA. (SP)
			20	4		SILTY SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 10-20% NONPLASTIC FINES, COMPACT, MOIST, DARK BROWN, MICA. (SM)
			19"	PS-2		SILTY SAND, UNIFORM, FINE, 25-30% NONPLASTIC FINES, LOOSE, SATURATED, DARK BROWN, MICA. (SM)
			18	5		SILTY SAND, UNIFORM, VERY FINE, 20-30% NONPLASTIC FINES, COMPACT, DAMP, DARK BROWN, MICA. (SM)
			16"	PS-3		SANDY SILT, 20-30% UNIFORM FINE SAND, 5-8% SLIGHTLY PLASTIC FINES, COMPACT, DAMP, DARK BROWN. (MS-ML)
-13.83			21	6		SAND, UNIFORM, FINE, 3-5% NONPLASTIC FINES, COMPACT, DAMP, DARK BROWN, MICA. (SP)
						END OF BORING AT 19.2'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

4	
3	
2	
1	6/6/80 RSU

BORING LOG I-10A

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 44

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-11

TYPE OF BORING SPLIT-SPOON / NX CORE LOCATION 1073 N - 279 W GROUND ELEV. 7.12'

DATE DRILLED SEPTEMBER 12-13, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS or RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTION / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
7.12						
			3	1		SAND, UNIFORM, FINE, VERY LOOSE, DRY, LIGHT BROWN. (BEACH SAND) (SP)
			17	2		SAND, UNIFORM, FINE, COMPACT, DAMP, DARK GRAY. (SP) (TRACE OF SANDY GRAVEL IN SHOE.)
			20	3		SILTY SAND, UNIFORM, FINE, 20-30% NONPLASTIC FINES, COMPACT, DAMP, ORANGE BROWN, MICACEOUS. (SM)
			14	4		SILTY SAND, SIMILAR TO ABOVE EXCEPT LOOSE, DARK BROWN. (SM)
			10	5		SILTY SAND, UNIFORM, FINE, 10-20% NONPLASTIC FINES, LOOSE, DAMP, ORANGE BROWN, MICACEOUS. (SM)
	10		9	6		SANDY SILT, 10-20% UNIFORM, VERY FINE SAND, NONPLASTIC FINES, SOFT, MOIST, LIGHT ORANGE BROWN, MICACEOUS. (ML)
			81	7		CLAYEY SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 10-15% MODERATELY PLASTIC FINES, VERY DENSE, DAMP, DARK BROWNISH BLACK, MICA. (SC-SP) (FRESHLY BROKEN GRAVEL FRAGMENTS IN BOTTOM OF SHOE)
-10.88			60* / 1"	8		TRACES OF SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY FINE, 10-20% SLIGHTLY PLASTIC FINES, LOOSE, SATURATED, GRAY BROWN. (SM) TOP OF ROCK 18.0'
	20	80	83	NX		18.0'- 20.5' LIGHT GRAY BIOTITE GRANITE GNEISS, CLOSE JOINTING, FRESH, VERY HARD, MEDIUM GRAINED.
		37	100	NX		20.5'- 25.5' 1ST. 40" - LIGHT GRAY BIOTITE GRANITE GNEISS, VERY CLOSE TO CLOSE JOINTING, FRESH TO SEVERE WEATHERING, VERY HARD TO VERY SOFT, MEDIUM GRAINED. LAST 20"- LIGHT GRAYISH PINK GRANITE, VERY CLOSE JOINTING, SLIGHT WEATHERING, HARD, MEDIUM GRAINED (PARTIALLY METAMORPHOSED INTO GNEISS.)
	30	42	83	NX		25.5'- 35.5' LIGHT PINKISH GRAY GNEISSOSE GRANITE, VERY CLOSE TO CLOSE JOINTING, SLIGHT TO SEVERE WEATHERING, VERY HARD TO SOFT, MEDIUM TO COARSE GRAINED, CHLORITIZED JOINTING, LAST 56" LIGHT GRAY BIOTITE GRANITE GNEISS, CLOSE JOINTING, FRESH, VERY HARD, MEDIUM GRAINED.
	40	80	100	NX		35.5'- 45.5' LIGHT GRAY BIOTITE GRANITE GNEISS, VERY CLOSE TO CLOSE JOINTING, FRESH, VERY HARD, MEDIUM GRAINED, FEW CALCITE SEAMS IN JOINT.
	50	100	100	NX		45.5'- 55.5' SAME AS ABOVE EXCEPT WIDELY JOINTED.
-52.88	60	87	100	NX		55.5'- 60.0' LIGHT GRAY BIOTITE GRANITE GNEISS, WIDELY JOINTED, FRESH TO MODERATE WEATHERING, VERY HARD, MEDIUM TO COARSE GRAINED, SOME CHLORITIZATION, PARTIALLY UNMETAMORPHOSED GRANITE.
						END OF BORING AT 60.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸7 INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS
7. * INDICATES USE OF 300 LB HAMMER, 24 INCH FALL.

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1	6/4/76 PBN

BORING LOG I-11

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 45

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-12

TYPE OF BORING SPLIT SPOON/ NX CORE LOCATION 989 N - 171 W GROUND ELEV. 8.97'

DATE DRILLED SEPTEMBER 14, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
8.97						
			3	1		SAND, UNIFORM, FINE, VERY LOOSE, DRY, LIGHT BROWN, (BEACH SAND) (SP)
			125	2		SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 5-10% NONPLASTIC FINES, VERY DENSE, DAMP, LIGHT TO DARK BROWN, POCKET OF ORANGE SAND, TRACES OF FRESHLY BROKEN GRAVEL AT BOTTOM OF SAMPLE. (SP-SM)
			87	3		TOP 5 INCHES: SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY FINE 15-25% NONPLASTIC FINES, VERY DENSE, DAMP, GRAY BROWN. (SM) BOTTOM 5 INCHES: CRUSHED GRANITE GNEISS WITH FRESHLY BROKEN FRAGMENTS OF GRANITE GNEISS.
	10		59	4		SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY FINE, 20-30% NONPLASTIC FINES, VERY DENSE, DAMP, GRAY BROWN. (SM)
			128	5		SILTY SAND, SAME AS ABOVE, BOTTOM 2 INCHES: 1.4 INCH ROCK FRAGMENT. (SM)
-5.03						TOP OF ROCK AT 14.0'
		92	100	NX		14.0'- 19.0' LIGHT GRAY BIOTITE GRANITE GNEISS, WIDELY JOINTED, FRESH VERY HARD, MEDIUM GRAINED, (SOME UNMETAMORPHOSED PINK GRANITE.)
	20	100	100	NX		19.0'- 20.0' LIGHT GRAY BIOTITE GRANITE GNEISS, CLOSE JOINTING, FRESH, VERY HARD, MEDIUM GRAINED.
		73	96	NX		20.0'- 29.0' TOP 60" - SIMILAR TO ABOVE EXCEPT CLOSE TO MODERATELY CLOSE JOINTING. BOTTOM 44" - PINKISH GRAY GNEISSOSE GRANITE, VERY CLOSE TO CLOSE JOINTING, FRESH, VERY HARD, MEDIUM TO COARSE GRAINED.
-20.03						
						END OF BORING AT 29.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ◻◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

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1	[illegible]

BORING LOG I-12

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 46

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-14

TYPE OF BORING SPLIT SPOON LOCATION 1020 N - 485 W GROUND ELEV. -4.5'

DATE DRILLED SEPTEMBER 19, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
-4.5						
			11	◤1		GRAVELLY SAND, POORLY GRADED, 10% GRAVEL TO 1.0 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 5-8% NONPLASTIC FINES, COMPACT, SATURATED, GRAY BROWN. (SP)
			11	◤2		GRAVELLY SAND, POORLY GRADED, 10% GRAVEL TO 0.5 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY MEDIUM, LESS THAN 5% NONPLASTIC FINES, COMPACT, SATURATED, ORANGE BROWN. (SP) (2.0 INCHES OF UNIFORM FINE SAND AT BOTTOM OF SAMPLE)
	10		14	◤3		SILTY SAND, WIDELY GRADED, 10% GRAVEL TO 0.5 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY MEDIUM, 15-20% NONPLASTIC FINES, COMPACT, SATURATED ORANGE BROWN. (SM)
			10	◤4		SAND, POORLY GRADED, LESS THAN 5% GRAVEL TO 0.6 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 5-8% NONPLASTIC FINES, LOOSE, SATURATED, GRAY BROWN, MICACEOUS. (SP)
			15	◤5		SAND, SAME AS ABOVE. (SP)
	20		43	◤6		GRAVELLY SAND, POORLY GRADED, 10-15% GRAVEL TO 0.5 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 5-8% NONPLASTIC FINES, DENSE, DAMP, ORANGE. (SP)
			13	◤7		SILTY SAND, UNIFORM, VERY FINE, 10-20% NONPLASTIC FINES, COMPACT, DAMP, GRAY BROWN, VERY MICACEOUS. (SM)
	30		14	◤8		SAND, UNIFORM, FINE, LESS THAN 5% NONPLASTIC FINES, COMPACT, DAMP, GRAY BROWN, MICA. (SP)
			124	◤9		SILTY SAND, WIDELY GRADED, COARSE TO FINE SAND, MOSTLY FINE, 20-30% SLIGHTLY PLASTIC FINES, VERY DENSE, DAMP, GRAY. (BASIL TILL) (SM)
-41.25			100 * / 0"	DXX		REFUSAL
						END OF BORING AT 36.75'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≑ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. [ ] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS
7. * INDICATES USE OF 300 LB HAMMER, 24 INCH FALL.
8. DXX INDICATES A DXX SIZE OPEN END ROD.

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1	6/26/ / RU

BORING LOG I-14

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 47

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE: MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING No. I-15
TYPE OF BORING: SPLIT SPOON/ NX CORE LOCATION: 948 N - 394 W GROUND ELEV. -4.6'
DATE DRILLED: SEPTEMBER 26, 1973 DRILLED BY: AMERICAN LOGGED BY: J. GUSTIN
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
-4.6						
			4	1		NO RECOVERY
			9	2		SAND, POORLY GRADED, LESS THAN 5% GRAVEL TO 0.75 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, VERY LOOSE, SATURATED, YELLOW BROWN. (SP) (MOSTLY WASH)
			13	3		NO RECOVERY
			13	4		SILTY SAND, POORLY GRADED, COARSE TO FINE, MOSTLY FINE, 8-12% NONPLASTIC FINES, COMPACT, SATURATED, GRAY BROWN. (SP-SM)
	10		17	5		SILTY SAND, SAME AS ABOVE. (SP-SM)
			24	6		SILTY SAND, POORLY GRADED, TRACE OF GRAVEL TO 0.5 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 10-12% NONPLASTIC FINES, COMPACT, MOIST, DARK BROWN. (SP-SM)
	20		17	7		SAND, POORLY GRADED, LESS THAN 5% SUBROUNDED GRAVEL TO 0.25 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, COMPACT, MOIST, YELLOW BROWN. (SP)
			20	8		SAND, POORLY GRADED, COARSE TO FINE, MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, COMPACT, MOIST, YELLOW BROWN, MICACEOUS. (SP)
	30		20	9		SAND, SAME AS S#8.
			29	10		SILTY SAND, POORLY GRADED, 5-8% GRAVEL TO 1.0 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 10-15% NONPLASTIC FINES, COMPACT, MOIST, BROWN, MICA. (SP-SM)
-40.6						TOP OF ROCK AT 36.0
		77	95	NX		36.0'- 41.0' LIGHT GRAY BIOTITE GRANITE GNEISS, CLOSE TO MODERATELY CLOSE JOINTING, FRESH WEATHERING, VERY HARD, MEDIUM TO COARSE GRAINED. (LAST 3 INCHES OF CORE SHOWS MODERATE WEATHERING.)
	40	72	100	NX		41.0'- 51.0' LIGHT GRAY BIOTITE GRANITE GNEISS, CLOSE TO MODERATELY CLOSE JOINTING, FRESH TO SLIGHT WEATHERING, VERY HARD, MEDIUM TO COARSE GRAINED. (SOME PINK GNEISSOSE GRANITE)
-55.6	50					END OF BORING AT 51.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
□◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≜ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

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1	[illegible]

BORING LOG I-15

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 48

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-19A

TYPE OF BORING SPLIT SPOON/ NX CORE LOCATION 837 N - 272 W GROUND ELEV. -12.0'

DATE DRILLED SEPTEMBER 25, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
-12.0						
			29	1		SILTY SAND, POORLY GRADED, LESS THAN 5% GRAVEL TO 0.8 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 20-30% NONPLASTIC FINES, COMPACT, MOIST, GRAY BROWN, (SM) (TILL)
			19	2		GRAVELLY SAND, POORLY GRADED, 20-30% GRAVEL TO 1.2 INCH MAXIMUM, COARSE TO FINE, SAND, MOSTLY FINE, 10-15% NONPLASTIC FINES, COMPACT, MOIST, GRAY BROWN. (SP)(TILL)
			79	3		SANDY GRAVEL, POORLY GRADED, GRAVEL TO 1.5 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 10-15% NONPLASTIC FINES, VERY DENSE, MOIST, GRAY BROWN. (GP)(PIECE OF COBBLE CORED THROUGH BY SHOE)
-19.4			100/2"	4		SANDY GRAVEL, SIMILAR TO ABOVE, (GP)
						TOP OF ROCK AT 7.4'
	10	68	92	NX		7.4'- 12.4' LIGHT GRAY BIOTITE GRANITE GNEISS, CLOSE TO MODERATELY CLOSE JOINTING, FRESH TO SLIGHTLY WEATHERED, VERY HARD TO HARD, MEDIUM GRAINED. (LAST 15" OF CORE PARTLY METAMORPHOSED COARSE GRAINED GRANITE.)
		64	94	NX		12.4'- 22.4' SAME AS ABOVE EXCEPT ALL GNEISS.
	20					
-34.4						
						END OF BORING AT 22.4'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

4	
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1	6/3/80 PBW

BORING LOG I-19A

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE STATION

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 49

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-20

TYPE OF BORING SPLIT SPOON/ NX CORE LOCATION 970 N - 692 W GROUND ELEV. -10.8'

DATE DRILLED OCTOBER 1, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
-10.8						
			3	1		TOP 6" SILTY SAND, UNIFORM, FINE, 30-40% NONPLASTIC FINES, VERY LOOSE, SATURATED, DARK GRAY. (SM) BOTTOM 5" GRAVELLY SAND, POORLY GRADED, 10-20% SUBROUNDED GRAVEL TO 0.75 IN.MAX., COARSE TO FINE SAND, MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, VERY LOOSE, SATURATED, GRAY BROWN, MICA. (SP)
			8	2		GRAVELLY SAND, SIMILAR TO ABOVE, EXCEPT ANGULAR GRAVEL TO 0.9 INCH MAXIMUM, (SP)
			18	3		GRAVELLY SAND, SIMILAR TO ABOVE EXCEPT COMPACT AND ANGULAR GRAVEL TO 0.5 INCH MAXIMUM. (SP)
			22	4		SILTY SAND, 5-8% SUBANGULAR GRAVEL TO 0.5 INCH MAXIMUM, UNIFORM, FINE SAND, 8-12% NONPLASTIC FINES, COMPACT, SATURATED, BROWN. (SP-SM)
	10		17	5		NO RECOVERY
			34	6		TOP 3" SANDY GRAVEL, WIDELY GRADED, GRAVEL TO 1.0 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 8-12% NONPLASTIC FINES, COMPACT, SATURATED, GRAY BROWN. (GP-GM) PIECE OF COBBLE CORED THROUGH BY SPOON. BOTTOM 4" SILTY SAND, UNIFORM, FINE, 20-30% NONPLASTIC FINES, COMPACT, MOIST, ORANGE BROWN, MICA. (SM)
			27	7		SILTY SAND, WIDELY GRADED, LESS THAN 5% ANGULAR GRAVEL TO 0.25 INCH MAXIMUM, COARSE TO FINE, MOSTLY FINE, 15-25% NONPLASTIC FINES, COMPACT, SATURATED, LIGHT GRAY, (SM) (TILL)
	20		31	8		SANDY GRAVEL, WIDELY GRADED, ANGULAR GRAVEL TO 0.75 INCH MAXIMUM, 30-40% COARSE TO FINE, 8-12% NONPLASTIC FINES, DENSE, SATURATED, LIGHT GRAY. (GP-GM) (TILL)
			70	9		GRAVELLY SAND, WIDELY GRADED, 5-8% ANGULAR GRAVEL TO 0.5 INCH MAXIMUM, COARSE TO FINE, MOSTLY FINE, 20-30% NONPLASTIC FINES, VERY DENSE, MOIST, GRAY BROWN. (SP-SM) (PIECES OF COBBLE TO 1.3 INCH MAXIMUM AT BOTTOM OF SAMPLE) (TILL)
	30		100/3"	10		SANDY GRAVEL, WIDELY GRADED, ANGULAR GRAVEL TO 0.6 INCH MAXIMUM, 20-30% COARSE TO FINE, MOSTLY FINE, 10-20% NONPLASTIC FINES, VERY DENSE, SATURATED, LIGHT GRAY. (GP-GM) (TILL)
			4"	NX		31.2'- 36.2' CORED THROUGH LIGHT GRAY GRANITE GNEISS BOULDER AND PIECES OF COBBLE.
-52.9	40		100/6"	11		NO RECOVERY (STILL WASHING TILL) TOP OF ROCK AT 42.1'
		92	92	NX		42.1'- 47.1' LIGHT GRAY BIOTITE GRANITE GNEISS, NO JOINTING, (ALL BREAKS ARE FRESH DRILLING BREAKS) FRESH WEATHERING, VERY HARD, MEDIUM GRAINED, (SOME COARSE GRAINED PINK GNEISSOSE GRANITE)
	50	71	71	NX		47.1'-55.1' SAME AS ABOVE.
-65.9						END OF BORING AT 55.1'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

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1	6/23/76 PSV

BORING LOG I-20

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 50

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING No. I-21.

TYPE OF BORING SPLIT SPOON/ NX CORE LOCATION 902 W - 574 W GROUND ELEV. -11.0'

DATE DRILLED SEPTEMBER 20-21, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS or RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
-11.0						
			5	1		TOP 6" SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY FINE, 15-20% SLIGHTLY PLASTIC FINES, LOOSE, MOIST, DARK BROWNISH GRAY. (SM) BOTTOM 4" SAND, SIMILAR TO ABOVE EXCEPT 5-8% NONPLASTIC FINES AND YELLOW BROWN, MICA. (SP)
			13	2		SAND, POORLY GRADED, COARSE TO FINE, MOSTLY FINE, 5-8% NONPLASTIC FINES, COMPACT, MOIST, YELLOW BROWN. (SP)
			30	3		SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY FINE, 10-15% NONPLASTIC FINES, COMPACT, DAMP, GRAY BROWN, MICA. (SM-SP)
	10		8	4		SILTY SAND, UNIFORM, FINE, 10-15% NONPLASTIC FINES, LOOSE, DAMP, YELLOWISH BROWN, MICA. (SM-SP)
			25	5		SANDY GRAVEL, POORLY GRADED, SUBROUNDED GRAVEL TO 1.25 INCH MAXIMUM, 30-40% COARSE TO FINE SAND, MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, COMPACT, SATURATED, GRAY BROWN, MICA. (GP)
			24	6		SAND, POORLY GRADED, COARSE TO FINE, MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, COMPACT, DAMP, GRAY BROWN, MICA. (SP)
	20		26	7		SILTY SAND, WIDELY GRADED, MEDIUM TO FINE, MOSTLY FINE, 25-30% NONPLASTIC FINES, COMPACT, DAMP, GRAY BROWN, MICA. (SM)
			20	8		SILTY SAND, UNIFORM, FINE, 8-12% NONPLASTIC FINES, COMPACT, DAMP, GRAY BROWN, MICA. (SM-SP)
			23	9		SILTY SAND, SAME AS ABOVE. (SM-SP)
			25	10		SILTY SAND, SAME AS ABOVE. (SM-SP)
	30		20	11		SILTY SAND, SAME AS ABOVE. (SM-SP)
			38	12		TOP 1" VARVED CLAY, SLIGHTLY TO MODERATELY PLASTIC, (CL-CH) MIDDLE 6" SAME AS SAMPLE #11. (SM-SP) BOTTOM 1" SAND, POORLY GRADED, COARSE TO FINE, MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, LOOSE, DAMP, YELLOW BROWN, MICA. (SP)
	40		84	13		TOP 5" SAND, POORLY GRADED, COARSE TO FINE, MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, VERY DENSE, DAMP, YELLOW BROWN (SP) BOTTOM 4" SILTY SAND, WIDELY GRADED, LESS THAN 5% GRAVEL TO 0.5 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 40-50% SLIGHTLY PLASTIC FINES, VERY DENSE, DAMP, GRAY. (BASAL TILL) (SM)
-57.0						TOP OF ROCK AT 46.0'
		38	88	NX		46.0'- 51.0' LIGHT GRAY BIOTITE GRANITE GNEISS, VERY CLOSE TO CLOSE JOINTING, FRESH WITH A 2 INCH SECTION OF SEVERE WEATHERING BY CHLORITIZATION, HARD TO VERY HARD, MEDIUM GRAINED.
	50	59	93	NX		51.0'- 61.0' TOP 21" SAME AS ABOVE EXCEPT FRESH - NO CHLORITIZATION. MIDDLE 42" SIMILAR TO ABOVE EXCEPT MOSTLY SEVERE WEATHERING BY CHLORITIZATION. BOTTOM 48" LIGHT GRAY BIOTITE GRANITE GNEISS, CLOSE JOINTING, SLIGHT TO FRESH WEATHERING, VERY HARD, MEDIUM GRAINED.
-72.0	60					
						END OF BORING AT 61.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. □ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

4	
3	
2	
1	6/23/80 FSV

BORING LOG I-21

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE STATION

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 51

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. No. 12179 BORING No. I-22

TYPE OF BORING SPLIT SPOON/ NX CORE LOCATION 814 N - 433 W GROUND ELEV. -20.0'

DATE DRILLED OCTOBER 3, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

SOIL OR ROCK DESCRIPTION

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS or RECOV.	SAMPLE: TYPE	GRAPHIC LOG	FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
-20.0						
			PRESSED 2.0'	(no recovery)		NO RECOVERY
			5	2		SILTY SAND, UNIFORM, VERY FINE, 15-20% NONPLASTIC FINES, VERY LOOSE, SATURATED, GRAY BROWN, MICA. (SM)(GRAY SILTY SAND TO 1.0 INCH MAXIMUM INTERBEDDED WITH YELLOW BROWN SILT TO 0.2 INCH MAXIMUM)
			11	3		SILTY SAND, SIMILAR TO ABOVE EXCEPT SOME MEDIUM SAND AND VERY LITTLE INTERBEDDING. (SM)
	10		11	4		SILTY SAND, SAME AS SAMPLE S#3. (SM)
			17	5		SILTY SAND, SIMILAR TO SAMPLE S#2 EXCEPT 2-3% COARSE AND MEDIUM SAND AND COMPACT. (SM)
	20		18	6		SILTY SAND, SIMILAR TO SAMPLE S#5 EXCEPT LESS THAN 5% SUBROUNDED GRAVEL TO 0.5 INCH MAXIMUM. (SM)
			24	7		SILTY SAND, POORLY GRADED, MEDIUM TO VERY FINE, MOSTLY FINE, 15-20% NONPLASTIC FINES, COMPACT, MOIST, GRAY BROWN, MICA. (SM)
	30		40	8		TOP 10" SANDY SILT, 8-12% UNIFORM, VERY FINE SAND, SLIGHTLY PLASTIC FINES, SOFT, DAMP, GRAY-BROWN AND YELLOW BROWN, MICA. (MS-ML)(INTERBEDDED GRAY SILT LAYERS TO 0.5 INCH MAXIMUM WITH GRAY-BROWN AND YELLOW SANDY SILT LAYERS TO 0.5 INCH). BOTTOM 6" SILTY SAND, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, 8-12% NONPLASTIC FINES, DENSE, MOIST, GRAY BROWN, MICA. (SP-SM)
-56.3			80-70 4"	9		TOP 6" SANDY GRAVEL, WIDELY GRADED, GRAVEL TO 0.75 IN.MAX., COARSE TO FINE, MOSTLY FINE, 10-15% NONPLASTIC FINES, VERY DENSE, DAMP, GRAY BROWN. (GP)(TILL) BOTTOM 6" SAPROLITE OF GRANITE GNEISS. TOP OF ROCK AT 36.3'
	40	52	85	NX		36.3'- 41.3' LIGHT GRAY BIOTITE GRANITE GNEISS, VERY CLOSE TO CLOSE JOINTING, FRESH TO SLIGHT WEATHERING, VERY HARD, MEDIUM GRAINED.
		54	83	NX		41.3'- 45.3' SAME AS ABOVE.
-65.3						END OF BORING AT 45.3'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

4	
3	
2	
1	

BORING LOG I-22

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 52

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-23

TYPE OF BORING SPLIT SPOON/NX CORE LOCATION 836 N - 766 W GROUND ELEV. -14.1'

DATE DRILLED SEPTEMBER 28, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE BLOWS OR RECOV.	SAMPLE TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
-14.1						
			5	1		TOP 5" SILTY SAND, UNIFORM, VERY FINE, 30-40% NONPLASTIC FINES, VERY LOOSE, SATURATED, DARK GRAY. (SM) BOTTOM 11" GRAVELLY SAND, 8-12% SUBANGULAR GRAVEL TO 0.5 INCH MAXIMUM, POORLY GRADED, MEDIUM TO FINE, MOSTLY FINE, VERY LOOSE, MOIST, YELLOW BROWN. (SP)
			10	2		SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY FINE, 8-12% NON-PLASTIC FINES, LOOSE, SATURATED, GRAY BROWN, MICA. (SP-SM)
			15	3		SILTY SAND, UNIFORM, FINE, 15-20% NONPLASTIC FINES, COMPACT, DAMP, GRAY BROWN, MICA. (SM)
			14	4		SILTY SAND, SAME AS ABOVE. (SM)
	10		4"	PB-1		SILTY SAND, SAME AS ABOVE (SM) (SAMPLE OBVIOUSLY DISTURBED- TUBE RUINED BY MOVEMENT OF BARGE)
-27.1						TOP OF ROCK AT 13.0'
		70	90	NX		13.0'- 17.5' LIGHT GRAY BIOTITE GRANITE GNEISS, CLOSE JOINTING, FRESH TO SLIGHT WEATHERING, VERY HARD TO HARD, MEDIUM GRAINED.
	20	40	95	NX		17.5'- 22.5' SIMILAR TO ABOVE, EXCEPT VERY CLOSE TO CLOSE JOINTING
-36.6						END OF BORING AT 22.5'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ≚ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. [] INDICATES DEPTH & LENGTH OF NX CORING RUN
6. DATUM IS

4	
3	
2	
1	6/25/74 BV

BORING LOG I-23

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 53

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE PT., WATERFORD, CONN. J.O. NO. 12179 BORING NO. I-24

TYPE OF BORING SPLIT SPOON/NX CORE LOCATION 708 N - 679 W GROUND ELEV. -17.7'

DATE DRILLED SEPTEMBER 24, 1973 DRILLED BY AMERICAN LOGGED BY J. GUSTIN

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	OVERALL WEATHERING AND RQD (0 25 50 75 100)	SAMPLE: BLOWS OR RECOV.	SAMPLE: TYPE	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
-17.7						
			8	1		SAND, POORLY GRADED, COARSE TO FINE, MOSTLY VERY FINE, LESS THAN 5% NONPLASTIC FINES, LOOSE, SATURATED, GRAY BROWN, MICA. (SP)
			9	2		SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY FINE, 40-50% SLIGHTLY PLASTIC FINES, LOOSE, SATURATED, GRAY. (SM)
			18	3		SILTY SAND, UNIFORM, VERY FINE, 8-12% NONPLASTIC FINES, COMPACT, DAMP, GRAY BROWN, MICA. (SM-SP)
	10		18	4		SAND, UNIFORM, FINE, LESS THAN 5% NONPLASTIC FINES, COMPACT, DAMP, BROWN, MICA. (SP)
			18	5		SILTY SAND, SAME AS SAMPLE #3. (SM-SP)
			35	6		TOP 7" CLAYEY SILT, 10-15% VERY FINE SAND, SLIGHT SOFTENING UPON REMOLDING, STIFF, DAMP, GRAY BROWN, MICA. (ML-MH) BOTTOM 8" SILTY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY FINE, 20-30% SLIGHTLY PLASTIC FINES, DENSE, DAMP, GRAY BROWN. (GRAVEL TO 1.0 INCH MAXIMUM CUT THROUGH BY SHOE IN BOTTOM OF SAMPLE) (TILL) (SM)
-40.9	20		50-100 / 2"	7		GRAVELLY SAND, POORLY GRADED, 15-20% ANGULAR GRAVEL TO 0.5 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, VERY DENSE, DAMP, GREEN, MICA, (GP) (SAPROLITE OF CHLORITIZED GNEISS)
						TOP OF ROCK AT 23.2'
		88	93	NX		23.2'- 28.2' LIGHT GRAY BIOTITE GRANITE GNEISS, CLOSE TO MODERATELY CLOSE JOINTING, FRESH TO SLIGHT WEATHERING VERY HARD, MEDIUM TO COARSE GRAINED, (TOP 20" OF CORE PARTLY METAMORPHOSED GRANITE.)
	30	86	100	NX		28.2'- 38.2' SIMILAR TO ABOVE EXCEPT FOR THREE 2 INCH SEAMS OF SEVERE WEATHERING BY CHLORITIZATION.
-55.9						END OF BORING AT 38.2'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 12" OR THE DISTANCE SHOWN. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD - ROCK QUALITY DESIGNATION.
5. ▯ INDICATES DEPTH & LENGTH OF NX CORING RUN.
6. DATUM IS

4		
3		
2		
1	6/25/76	

BORING LOG I-24

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

12179 - GSK - 54

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. P-1
TYPE OF BORING 4" OD CASING LOCATION N1037 W313 GROUND ELEV. 1.43'
DATE DRILLED 4/29/75 DRILLED BY AMERICAN LOGGED BY CAK
SUMMARY OF BORING SPLIT SPOON/NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS; SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND EL. AT 1.43'						
0		1	2-4-5			SAND, UNIFORM, FINE, LESS THAN 5% NONPLASTIC FINES, LIGHT BROWN, SOME BIOTITE. (SP)
		2	3-5-5			SAND, UNIFORM, FINE, 7% NONPLASTIC FINES, LIGHT BROWN, SOME BIOTITE. (SP-SM)
-10	10	3	4-3-5			SILTY SAND, UNIFORM, VERY FINE SAND, 26% NONPLASTIC FINES, GRAY TO ORANGE BROWN, SOME BIOTITE. (SM) TOP OF TILL AT 14.0'
		4	50-52-55			TILL: SILTY SAND, WIDELY GRADED, COARSE TO FINE SAND, 28% NON-PLASTIC FINES, GRAY. (SM)
-20	20	5	13-16-17			SAND, UNIFORM, FINE, 8% NONPLASTIC FINES, DARK BROWN, FRAGMENTED GRANITE COBBLE AT BOTTOM OF SAMPLE, SOME BIOTITE. (SP-SM) TOP OF ROCK AT 23.7'
22.3'		NX	98%	56		LT. GRAY GNEISS: CLOSE JOINT; VERY THIN TO MODERATELY THIN FOLIATION, SLIGHTLY WEATHERED; HARD TO MEDIUM HARD; MEDIUM TO COARSE GRAINED; 40° FOLIATION. 23.8', 20°, OPEN, SOME MATERIAL WASHED OUT DURING CORING, SLIGHTLY WEATHERED, BROKE ALONG FOLIATION. 24.3, 30°, MODERATELY OPEN, SLIGHTLY WEATHERED, BROKE ALONG FOLIATION. 24.6, 5°, SLIGHTLY OPEN, FRESH, SLIGHTLY IRON STAINED, BROKE ACROSS FOLIATION. 25.1, 5°, SLIGHTLY OPEN, FRESH, BROKE ACROSS PEGMATITE ZONE. 25.4, 10°, TIGHT, FRESH. 25.5, 30°, SLIGHTLY OPEN, SLIGHTLY WEATHERED, BROKE ALONG FOLIATION. 25.8, 5°, MODERATELY OPEN, SLIGHTLY WEATHERED, HEAVILY IRON STAINED. 26.2, 50°, OPEN, SLIGHTLY WEATHERED, PARTLY COATED WITH LIGHT GREEN CLAY, SLIGHTLY IRON STAINED. 26.5, 20°, SLIGHTLY OPEN, SLIGHTLY WEATHERED, PARTLY COATED WITH LIGHT GREEN CLAY, SLIGHTLY IRON STAINED 26.7, 20°, OPEN, SLIGHTLY WEATHERED, PARTLY COATED WITH LIGHT GREEN CLAY, SLIGHTLY IRON STAINED. 26.9, 40°, OPEN, SLIGHTLY WEATHERED. 28.3, 40°, TIGHT, SLIGHTLY WEATHERED, MODERATELY IRON STAINED.
27.3						

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ▮2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ∇ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1	6/10/75

BORING LOG
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NO. 12179-GSK-55

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. P-2
TYPE OF BORING 4" O.D. CASING LOCATION N1109 W415 GROUND ELEV. 2.95
DATE DRILLED 4/30/75 DRILLED BY AMERICAN LOGGED BY CAK
SUMMARY OF BORING SPLIT SPOON WITH NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS, OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION, LITHOLOGY AND TEXTURE)
GROUND EL. AT 2.95'						
0		1	1-4-9			SAND, UNIFORM, FINE, LIGHT BROWN, SOME BIOTITE (10 INCH RECOVERY) LAST 6 INCHES CONTAINED FRAGMENTS OF COBBLE. (SP)
		2	6-9-10			SAND, FINE, 12% NONPLASTIC FINES, LIGHT BROWN, SOME BIOTITE. (SM)
-10	10	3	5-5-5			SAND, POORLY GRADED, LESS THAN 1% SUBANGULAR GRAVEL TO 3/8", COARSE TO FINE SAND, LESS THAN 5% NONPLASTIC FINES, SOME BIOTITE, LIGHT BROWN. (SP)
		4	3-4-6			SAND, POORLY GRADED, COARSE TO FINE SAND, LIGHT BROWN, SOME BIOTITE, (SP)
-20	20	5	3-5-8			SAND, FINE, 14% NONPLASTIC FINES, LIGHT BROWN, BOTTOM 1 INCH RUST COLORED, SOME BIOTITE. (SM)
		6	4-7-8			SILTY SAND, VERY FINE, 38% NONPLASTIC FINES, SOME BIOTITE, LAST THREE INCHES OF SAMPLE BANDED WITH ALTERNATING LAYERS OF SOIL WITH LITTLE OR NO BIOTITE, SOIL WITH SOME BIOTITE, AND RUST COLORED SOIL. (SM)
-30	30	7	5-16-26			SAND, POORLY GRADED, FINE, LESS THAN 5% NONPLASTIC FINES, LIGHT BROWN, BOTTOM 4 INCHES RUST COLORED. (SP)
		8	17-16-17			SILTY SAND, MEDIUM TO FINE SAND, 5-15% NONPLASTIC FINES, LIGHT BROWN, SOME BIOTITE, BOTTOM 2 INCHES OF SAMPLE RUST COLORED. (SM) TOP OF TILL AT 39.0
-40	40	9	25*-57*-53*			TILL: SAND, POORLY GRADED, COARSE TO MEDIUM, LIGHT BROWN, GRADING TO SILTY SAND, UNIFORM, FINE, 5-15% NONPLASTIC FINES, LIGHT BROWN GRADING TO SILTY SAND, UNIFORM, FINE, 5-15% NONPLASTIC FINES, GRAY, SOME RUST STAINS.
-40.85		NX	98%	52		TOP OF ROCK AT 43.8'
-45.85						GRANITE, CLOSE JOINTING, HARD TO VERY HARD, JOINTS AT: 43.9, 50°, MODERATELY OPEN, SLIGHTLY WEATHERED. 44.4, 20°, OPEN, SLIGHTLY WEATHERED, SLIGHT IRON STAINED. 44.4-44.7 APPROXIMATELY 10 FRAGMENTS OF CORE - JOINT SURFACES COATED WITH GRAY SUBSTANCE, SLIGHTLY WEATHERED. 44.8, 30°, OPEN, SLIGHTLY WEATHERED, COATED WITH GRAY CLAY. 45.3, 10°, OPEN, SLIGHTLY WEATHERED, COATED WITH GRAY CLAY. 45.5 60°, MODERATELY OPEN, SLIGHTLY WEATHERED, SLIGHTLY COATED WITH GRAY CLAY, SLIGHTLY IRON STAINED. 45.9, 10°, OPEN, SLIGHTLY WEATHERED, SLIGHTLY IRON STAINED. 46.4, 20°, OPEN (CORE FRAGMENTED) FRESH. 46.5, 20°, OPEN, (CORE FRAGMENTED), SLIGHTLY WEATHERED, PARTIAL COATING WITH GRAY CLAY. 46.6, 20°, MODERATELY OPEN, FRESH. 46.8, 10°, OPEN, SLIGHTLY WEATHERED. 47.3, 30°, OPEN, SLIGHTLY WEATHERED, VERY SLIGHT IRON STAINED. 47.4, 40°, MODERATELY OPEN, SLIGHTLY WEATHERED, SLIGHT IRON STAINED, MODERATELY COATED WITH LIGHT GREEN CLAY. 47.5, 5°, OPEN, FRESH. 47.6, 50°, OPEN, SLIGHTLY WEATHERED, SLIGHT IRON STAINED. 47.2, 20°, TIGHT FRESH. 47.4, 5°, MODERATELY OPEN, SLIGHTLY WEATHERED, PARTLY COATED WITH LIGHT GREEN CLAY. 47.5, 40° MODERATELY OPEN, SLIGHTLY WEATHERED. 47.6, 40°, OPEN (CORE FRAGMENTED) SLIGHTLY WEATHERED, PARTLY COATED WITH GREEN YELLOW CLAY. 47.7, 40° OPEN (CORE FRAGMENTED) SLIGHTLY WEATHERED, SLIGHT IRON STAINED.
						END OF BORING AT 48.8'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO ~~DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN.~~ * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ▌2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   ☐◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. [NX] INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 6/10/75

BORING LOG

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-56

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 2

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. P-3
TYPE OF BORING 4" OD CASING LOCATION N1188 W383 GROUND ELEV. 13.35'
DATE DRILLED 5/1/75 DRILLED BY AMERICAN LOGGED BY CAK
SUMMARY OF BORING SPLIT SPOON/NX CORE

GROUND EL. AT 13.35

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
10		1	1-1-1			SAND, UNIFORM, FINE, SOME ROOTS AND BIOTITE, LIGHT BROWN. (SP)
		2	2-2-2			SILTY SAND, VERY FINE, 15% NONPLASTIC FINES, DARK BROWN. (SM)
	10	1				NO RECOVERY.
0		3	18-20-15			GRAVELLY SAND, POORLY GRADED, FRAGMENTS OF COBBLE, LESS THAN 10% SUBANGULAR GRAVEL, MEDIUM TO FINE SAND, 10% NONPLASTIC FINES, WITH BIOTITE, LIGHT BROWN TO ORANGE BROWN. (SP-SM)
		4	10-6-7			SAND, WELL GRADED, LESS THAN 5% SUBANGULAR GRAVEL, MEDIUM TO FINE SAND, LESS THAN 10% NONPLASTIC FINES, SOME BIOTITE, ORANGE-BROWN TO LIGHT BROWN. (SP-SW)
	20	2				NO RECOVERY.
-10		5	4-6-9			SAND, POORLY GRADED, SEVERAL PIECES SUBANGULAR GRAVEL TO 3/4", FINE SAND, LESS THAN 5% NONPLASTIC FINES, SOME BIOTITE, LIGHT BROWN. (SP)
		6	5-6-8			SAND, POORLY GRADED, FINE, LESS THAN 5% NONPLASTIC FINES, SOME BIOTITE, ORANGE BROWN. (SP)
		3				SAND, POORLY GRADED, MEDIUM TO FINE, SOME BIOTITE, ORANGE BROWN. (SP)
	30	7	5-8-10			SILTY SAND, VERY FINE, 28% NONPLASTIC FINES, SOME BIOTITE, DARK BROWN. (SM)
-20		4				SANDY SILT, 46% MEDIUM TO FINE SAND, NONPLASTIC FINES, SOME BIOTITE, LIGHT BROWN. (ML)
	40	8	9*-11*-23*/4"			TILL: GRAVELLY SAND, POORLY GRADED, FINE, 9% NONPLASTIC FINES, LIGHT BROWN. (SP-SM)
-30		9	25*-100*/1"			GRAVELLY SAND, POORLY GRADED, LESS THAN 10% SUBANGULAR GRAVEL, MEDIUM TO FINE, 6.4% NONPLASTIC FINES, SOME BIOTITE, LIGHT BROWN. (SW)
-40	50	10	21-17-21			CLAYEY SAND, VERY FINE, 29% NONPLASTIC FINES, SOME BIOTITE ORANGE BROWN TO LIGHT BROWN. (SC) TOP OF ROCK AT 53.6'
-40.3 to -45.3		NX	100%	40		LIGHT GRAY GNEISS: CLOSELY JOINTED, SLIGHTLY WEATHERED, HARD TO MEDIUM HARD, MEDIUM TO COARSE GRAINED, VERY THIN 40° FOLIATION. 54.0, 5°, OPEN, SLIGHTLY WEATHERED, MODERATE IRON STAIN. 54.2, 10°, OPEN, SLIGHTLY WEATHERED, MODERATE IRON STAIN. 54.2 TO 54.4 CORE SEVERELY FRACTURED, JOINTS, IRON STAIN. 54.7, 20°, MODERATELY OPEN, SLIGHTLY WEATHERED, MODERATELY COATED WITH IRON STAINED CLAY. 54.9, 10°, OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. 55.0, 10°, OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED, CORE FRACTURE AT JOINT 55.4, 5°, SLIGHTLY OPEN, VERY SLIGHTLY WEATHERED. 55.7 TO 56.2 CORE FRACTURE, MODERATELY WEATHERED, HEAVILY IRON STAINED. 56.5 10°, SLIGHTLY OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. 56.7, 10°, MODERATELY OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. 56.9, 20°, SLIGHTLY OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. 57.4, 20°, SLIGHTLY OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. 57.9, 20°, OPEN, SLIGHTLY WEATHERED, CORE FRACTURE AT JOINT.

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 6/10/75 BV

BORING LOG

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-57A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 2

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. P-3
TYPE OF BORING 4" OD CASING LOCATION N1188 W383 GROUND ELEV. 13.35'
DATE DRILLED 5/1/75 DRILLED BY AMERICAN LOGGED BY CAK
SUMMARY OF BORING SPLIT SPOON/NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
						58.0, 50°, MODERATELY OPEN, SLIGHTLY WEATHERED. 58.3, 30°, MODERATELY OPEN, SLIGHTLY WEATHERED.
						END OF BORING AT 58.6'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1	6/13/75	FSL

BORING LOG

MILLSTONE NUCLER POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-57B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. P-4
TYPE OF BORING 4" MUD LOCATION N1046 W270 GROUND ELEV. 3.87
DATE DRILLED 5/13/75 DRILLED BY AMERICAN LOGGED BY CAK
SUMMARY OF BORING SS/NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND EL. AT 3.87'						
0		1	1-7-13			SAND, UNIFORM, FINE, SOME BIOTITE, LIGHT BROWN. (SP)
		1				NO RECOVERY.
		2	16-12-20			SAND, POORLY GRADED, COARSE TO FINE, 8.5% NONPLASTIC FINES, ORANGE BROWN. (SW-SM)
	10	3	30-60-50			TILL: SILTY SAND, FRAGMENT OF COBBLE AT BOTTOM OF SAMPLE, LIGHT BROWN, COARSE TO FINE SAND, 31% NONPLASTIC FINES. (SM)
-10 -10.6		4	50/6"*			SILTY SAND, FRAGMENTS OF COBBLE, FINE SAND, 27% NONPLASTIC FINES, SOME BIOTITE, ORANGE BROWN. (SM) TOP OF ROCK AT 14.5'
		NX	38%	56%		LIGHT GRAY GNEISS: CLOSE JOINTS, SLIGHTLY WEATHERED, HARD TO MEDIUM HARD, MEDIUM TO COARSE GRAINED, VERY THIN, 40° FOLIATION. 14.8, 5°, SLIGHTLY OPEN, FRESH. 15.0, 10°, SLIGHTLY OPEN, FRESH. 15.8, 5°, MODERATELY OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. 16.6, 30°, OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. FROM 16.6 TO 16.7: 90°, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. 17.5, 5°, OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. 17.6, 5°, SLIGHTLY OPENED, FRESH, SLIGHTLY IRON STAINED. 17.8, 10°, OPEN, SLIGHTLY WEATHERED, SLIGHTLY IRON STAINED. 18.5, 5°, OPEN, SLIGHTLY WEATHERED, SLIGHTLY IRON STAINED (SPIN MARKS ON JOINT). 19.1, 30°, OPEN, SLIGHTLY WEATHERED, SLIGHTLY IRON STAINED.
-15.6						END OF BORING AT 19.5'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ▮ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ▼ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

BORING LOG

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK- 58

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. P-5

TYPE OF BORING 4" MUD LOCATION N1010 W218 GROUND ELEV. 5.57'

DATE DRILLED 5/14/75 DRILLED BY AMERICAN LOGGED BY CAK

SUMMARY OF BORING SPLIT SPOON/NX CORE

GROUND EL. 5.57

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
		1	13-18-17			SANDY GRAVEL, GAP GRADED, SUBANGULAR COARSE TO FINE GRAVEL, 49% MEDIUM TO FINE SAND, SOME BIOTITE, LIGHT BROWN. (GP) TOP OF TILL AT 4.4'
0		2	30-40-41			SILTY SAND, COARSE TO FINE SAND, 33% NONPLASTIC FINES, SOME BIOTITE, LIGHT BROWN. (SM) TILL
-5.4	10	3	23-21-74			SILTY SAND, MEDIUM TO FINE SAND, 23% NONPLASTIC FINES, SOME BIOTITE, LIGHT BROWN. (SM) TILL TOP OF ROCK AT 11.0'
-10.4		NX	90%	46%		LIGHT GRAY GNEISS: CLOSE JOINTS, SLIGHTLY WEATHERED, HARD TO MEDIUM HARD, MEDIUM TO COARSE GRAINED, VERY THIN 40° FOLIATION. 11.2, 10°, TIGHT, SLIGHTLY WEATHERED, MODERATE IRON STAINED. 11.6, 20°, SLIGHTLY OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. 11.8, 10°, MODERATELY OPEN, SLIGHTLY WEATHERED, HEAVY IRON STAINED. 12.2, 30°, MODERATELY OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. 12.6, 20°, TIGHT, FRESH. 12.9, 5°, MODERATELY OPEN, FRESH, SPIN MARKS ON JOINT. 13.6, 5°, OPEN, FRESH, SPIN MARKS ON JOINT. 13.9, 10°, OPEN, FRESH, SPIN MARKS ON JOINT. 14.1, 5°, OPEN, FRESH. 14.3, 5°, OPEN, FRESH. 14.5, 20°, OPEN FRESH. 14.7, 20°, MODERATELY OPEN, FRESH. 14.8, 20°, OPEN, FRESH. 15.0, 5°, OPEN, FRESH, SPIN MARKS ON JOINT. 15.1, 5°, OPEN, FRESH, SPIN MARKS ON JOINT. END OF BORING AT 16.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 6/10/75

BORING LOG

MILLSTONE NUCLEAR POWER STATION

UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-59

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. P-6

TYPE OF BORING 4" MUD LOCATION N1067.8 W207.2 GROUND ELEV. 17.72'

DATE DRILLED 5/15/75 DRILLED BY AMERICAN LOGGED BY CAK

SUMMARY OF BORING SPLIT SPOON SAMPLING, WITH NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND EL. AT 17.72'						
		1	1-3-3			SAND, POORLY GRADED, FINE, SOME BIOTITE, LIGHT BROWN. (SP)
		2	5-4-5			NO RECOVER.
		3	5-7-14			NO RECOVERY.
10		4	11-17-16			SAND, POORLY GRADED, COARSE TO FINE, 5% NONPLASTIC FINES, LIGHT BROWN. (SP)
	10	1				
		5	30-31-34			GRAVELLY SAND, WELL GRADED, 20% SUBANGULAR GRAVEL TO 0.75 INCHES., COARSE TO FINE SAND, LIGHT BROWN. (SP)
0		6	46-57			SILTY SAND, WIDELY GRADED, 12% SUBANGULAR GRAVEL TO 0.5 INCH, COARSE TO FINE SAND, 21% NONPLASTIC FINES, LIGHT BROWN. (SM)
-5.28'	20					TOP OF ROCK AT 23.0'
-10 / -10.28		NX	100%	56%		GRAY AND WHITE GNEISS, 0° TO 40° CLOSE TO VERY CLOSELY SPACED JOINTS, SLIGHTLY WEATHERED, HARD TO MEDIUM HARD, MEDIUM TO COARSE GRAINED, VERY THIN 45° FOLIATION. 23.0'-28.0' 0°-30° JOINTS, CLOSELY SPACED, CLEAN, SLIGHTLY ROUGH. AT 26.5 60° JOINT, CLEAN, FRESH, ROUGH. 26.9-27.2 BROKEN ZONE, SURFACES ROUGH AND CLEAN, MEDIUM HARD TO FRIABLE GNEISS. 27.1-27.9 PINK AND WHITE GRANITE PEGMATITE, VERY COARSE GRAIN, FRESH, VERY HARD.
						END OF BORING AT 28.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ▮ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 6/6/75 | [illegible]

BORING LOG

MILLSTONE NUCLEAR POWER STATION

UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-60

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION UNIT - 3 J.O. No. 12179 BORING No. P-7

TYPE OF BORING 4" MUD LOCATION N1165 W495 GROUND ELEV. 3.82'

DATE DRILLED 5/7/75 DRILLED BY AMERICAN LOGGED BY CAK

SUMMARY OF BORING SPLIT SPOON SAMPLING WITH NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND EL. AT 3.82'						
		1 (split spoon)	2-2-3			SAND, POORLY GRADED, FINE, SOME BIOTITE, LIGHT BROWN. (SP)
0						
		2 (split spoon)	5-8-10			GRAVELLY SAND, POORLY GRADED, PIECE OF COBBLE, 32% SUBROUNDED GRAVEL TO 0.75 INCHES, COARSE TO FINE SAND, SOME BIOTITE, LIGHT BROWN. (SP)
	10	3 (split spoon)	5-7-7			GRAVELLY SAND, POORLY GRADED, 32% SUBROUNDED GRAVEL, COARSE TO FINE SAND, SOME BIOTITE, LIGHT BROWN. (SP)
		1 (undisturbed)				
-10						
		4 (no recovery)	11-21-19			NO RECOVERY.
	20	2 (undisturbed)				
-20		5 (split spoon)	8-8-10			SILTY SAND, FINE, 17% NONPLASTIC FINES, LIGHT BROWN (NO SAMPLE PRESERVED FOR SPLIT SPOON 5). (SM)
		6 (split spoon)	8-7-9			SAME AS SAMPLE 5.
	30	3 (undisturbed)				
-30						
		7 (split spoon)	14-16-12			SILTY SAND, FINE, 12% NONPLASTIC FINES, GRAY BROWN. (SM)
-34.18						TOP OF ROCK AT 38.0'
	40	NX	84%	58%		LIGHT GRAY GNEISS: CLOSELY JOINTED, SLIGHTLY WEATHERED; HARD TO MEDIUM HARD, MEDIUM TO COARSE GRAINED, VERY THIN 40° FOLIATION. 38.5', 30°, SLIGHTLY OPEN, FRESH. 38.7, 5°, OPEN, SLIGHTLY WEATHERED, HEAVILY IRON STAINED, SPIN MARKS ON JOINT.
-39.18						39.1, 5°, OPEN, SLIHGLTY WEATHERED, HEAVILY IRON STAINED, SPIN MARKS ON JOINT. 39.2, 5°, OPEN, SLIGHTLY WEATHERED, HEAVILY IRON STAINED, SPIN MARKS ON JOINT. 39.4, 10°, MODERATELY OPEN, FRESH. 39.5, 10°, MODERATELY OPEN, FRESH. 39.6, 10°, OPEN, FRESH, SPIN MARKS ON JOINT. 39.8, 20°, OPEN, SLIGHTLY WEATHERED, HEAVILY IRON STAINED. 40.2, 20°, SLIGHTLY OPEN, SLIGHTLY WEATHERED. 40.7, 30°, MODERATELY OPEN, SLIGHTLY WEATHERED, HEAVILY IRON STAINED. 41.4, 30°, MODERATELY OPEN, SLIGHTLY WEATHERED, HEAVILY IRON STAINED. 41.4, 20°, TIGHT, SLIGHTLY WEATHERED, HEAVILY IRON STAINED.
						END OF BORING AT 43.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO ~~DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN.~~ * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. [NX] INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1	[initials]

BORING LOG

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-61

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE: MILLSTONE NUCLEAR POWER STATION - UNIT 3   J.O. No. 12179   BORING No. P-8

TYPE OF BORING: 4" MUD   LOCATION: N1315 W705   GROUND ELEV. 10.52

DATE DRILLED: 5/8/75   DRILLED BY: AMERICAN   LOGGED BY: CAK

SUMMARY OF BORING: SPLIT SPOON/NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND EL. AT 10.52						
10		1 (split spoon)	2-3-3			SAND, POORLY GRADED, FINE; SOME BIOTITE, GRASS ROOTS, LIGHT BROWN. (SP)
		2 (split spoon)	1-2-2			SILTY SAND, FINE, 32% NONPLASTIC FINES, DARK BROWN. (SC)
0	10	3 (split spoon)	11-13-10			SANDY SILT, 40% MEDIUM TO FINE SAND, SOME BIOTITE, LIGHT BROWN. (ML)
		1 (undisturbed)				SILTY SAND, COARSE TO FINE, 34% NONPLASTIC FINES, SOME BIOTITE, LIGHT BROWN. (ML)
		4 (split spoon)	14-23-20			SAND, POORLY GRADED, MEDIUM TO FINE, SOME BIOTITE, LIGHT BROWN. (SP)
-10	20	5 (split spoon)	10-11-12			SAND, POORLY GRADED, COARSE TO FINE, LIGHT BROWN. (SP)
		2 (undisturbed)				SILTY SAND, LESS THAN 10% GRAVEL TO 1/2 IN., COARSE TO FINE SAND, 23% NONPLASTIC FINES, SOME BIOTITE, YELLOWISH BROWN. (SM)
-20	30	6 (split spoon)	45-36-23			TILL: GRAVELLY SAND, POORLY GRADED, 26% SUBANGULAR GRAVEL TO 1.0 INCH, COARSE TO FINE SAND, SAMPLE GRADED FROM FINE SAND WITH BIOTITE AT TOP TO COARSE TO FINE WITH NO BIOTITE AT BOTTOM, LIGHT BROWN GRADING TO ORANGE BROWN. (SP)
		7 (split spoon)	84-32-17			SILTY SAND, FINE, 13%, NONPLASTIC FINES, SOME BIOTITE (SP)
-29.98	40	8 (split spoon)	41-50-49			GRAVELLY SAND, POORLY GRADED, 24% SUBANGULAR GRAVEL TO 1.0 INCH, COARSE TO FINE SAND, 11% NONPLASTIC FINES, LIGHT BROWN. (SP-SM) TOP OF ROCK AT 40.5'
		NX	96%	80%		LIGHT GRAY GNEISS: CLOSELY JOINTED, SLIGHTLY WEATHERED. 41.6, 5°, MODERATELY OPEN, FRESH. 43.3, 10°, OPEN, SLIGHTLY WEATHERED, MODERATE IRON STAINED, SPIN MARKS ON JOINT. 43.4, 5°, OPEN, SLIGHTLY WEATHERED, MODERATE IRON STAINED, SPIN MARKS ON JOINT. 43.6, 5°, OPEN, SLIGHTLY WEATHERED, MODERATE IRON STAINED, SPIN MARKS ON JOINT. 43.7, 5°, OPEN, SLIGHTLY WEATHERED, MODERATE IRON STAINED, SPIN MARKS ON JOINT. 44.1, 5°, OPEN, FRESH, SPIN MARKS ON JOINT. 44.6, 5°, OPEN, FRESH, SPIN MARKS ON JOINT. 44.9, 5°, OPEN, FRESH. 45.0, 10°, OPEN, FRESH, SPIN MARKS ON JOINT. 45.2, 10°, OPEN, SLIGHTLY WEATHERED, SPIN MARKS ON JOINT.
-34.98						END OF BORING AT 45.5'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES ~~USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE~~ ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. [NX] INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 6/9/75

BORING LOG

MILLSTONE NUCLEAR POWER STATION

UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-62

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. P-9
TYPE OF BORING 4" MUD LOCATION N1292 W825 GROUND ELEV. 7.19'
DATE DRILLED 5/9/75 DRILLED BY AMERICAN LOGGED BY CAK
SUMMARY OF BORING SPLIT SPOON SAMPING WITH NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND EL. AT 7.19'						
		1 (split spoon)	3-9-13			SAND, UNIFORM, FINE, SOME BIOTITE, LIGHT BROWN. (SP)
0		2 (no recovery)	32-17-24			NO RECOVERY. TOP OF ROCK AT 7.5'
-0.31'	10	NX	100%	88%		LIGHT GRAY GNEISS: CLOSELY JOINTED; SLIGHTLY WEATHERED; HARD TO MEDIUM HARD, MEDIUM TO COARSE GRAINED, VERY THIN 40° FOLIATION. 7.7, 20°, OPEN, SLIGHTLY WEATHERED, HEAVILY IRON STAINED, SPIN MARKS ON JOINT. 7.9, 20°, OPEN, SLIGHTLY WEATHERED, SPIN MARKS ON JOINT. 8.1, 5°, OPEN, FRESH, SPIN MARKS ON JOINT. 9.6, 40°, OPEN, FRESH, SPIN MARKS ON JOINT. 10.5, 5°, MODERATELY OPEN, FRESH, SPIN MARKS ON JOINT. 11.7, 5°, MODERATELY OPEN, FRESH, SPIN MARKS ON JOINT.
-5.31'						END OF BORING AT 12.5'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 6/07 | ?81

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NO. 12179-GSK-63

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. P-10

TYPE OF BORING 4" MUD LOCATION N1254.1 W770.1 GROUND ELEV. 4.38

DATE DRILLED 5/12/75 DRILLED BY AMERICAN LOGGED BY CAK

SUMMARY OF BORING SPLIT SPOON SAMPLING WITH NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND EL. 4.38						
		Split spoon 1	1-5-7			SAND, UNIFORM, FINE, SOME BIOTITE, ORANGE BROWN. (SP)
0		No recovery 2	13-20-31			NO RECOVERY.
	10	Split spoon 3	16-14-11			SAND, POORLY GRADED, FRAGMENTS OF COBBLE, MEDIUM TO FINE SAND, LESS THAN 5% NONPLASTIC FINES, ORANGE BROWN. (SP)
		Undisturbed 1				SILTY SAND, COARSE TO MEDIUM, 39% NONPLASTIC FINES, W/BIOTITE, LIGHT BROWN. (SM)
-10		Split spoon 4	8-9-11			SILTY SAND, MEDIUM TO FINE, 10-15% NONPLASTIC FINES, SOME BIOTITE, LIGHT BROWN. (SM)
-12.28						TOP OF ROCK AT 16.66'
	20	NX	86%	66%		LT. GRAY GNEISS: CLOSELY JOINTED; SLIGHTLY WEATHERED; HARD TO MEDIUM HARD, MEDIUM TO COARSE GRAINED, VERY THIN 40° FOLIATION. 17.3, 20°, OPEN, SLIGHTLY WEATHERED, MODERATELY IRON STAINED. 17.5, 30°, OPEN, SLIGHTLY WEATHERED, SPIN MARKS ON JOINT. 18.7, 5°, TIGHT, FRESH, SPIN MARKS ON JOINT. 19.0, 5°, OPEN, SLIGHLTY WEATHERED, SLIGHLTY IRON STAINED, SPIN MARKS ON JOINT. 19.5, 5°, OPEN, FRESH, SPIN MARKS ON JOINT. 19.6, 5°, TIGHT, FRESH. 19.7, 60°, SLIGHTLY WEATHERED. 19.8, 5°, OPEN, FRESH, SPIN MARKS ON JOINT. 20.2, 5°; OPEN, FRESH, SPIN MARKS ON JOINT.
-17.28						END OF BORING AT 21.66'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ▼ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ∇ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. [NX] INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 6/4/75 | 18V

BORING LOG

MILLSTONE NUCLER POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-64

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE UNIT 3 J.O. No. 12179 BORING No. B-1
TYPE OF BORING WASH/CORE LOCATION N 1174.70 E 60.50 GROUND ELEV. 19.3'
DATE DRILLED JANUARY 27, 1975 DRILLED BY AMERICAN LOGGED BY G.J.Z./R.T.D.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD (25 50 75)	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE ELEVATION +19.3'							
+15	5	1	13-18-32			SILTY SAND, WELL GRADED, COARSE TO FINE, LESS THAN 5% MEDIUM GRAVEL, 5-10% SLIGHTLY PLASTIC FINES, MEDIUM BROWN. (SW)	
+10	10	2	19-27-33			CLAYEY SAND, WELL GRADED, COARSE TO FINE, 10-15% MODERATELY PLASTIC FINES, MEDIUM GRAY AND BROWN. (SC)	
+5	15	3	40-50/2"			SILTY SAND, WELL GRADED, COARSE TO FINE, 10-15% SLIGHTLY TO MODERATELY PLASTIC FINES, MEDIUM BROWN. (TILL) (SM)	
0	20	4	100/6"			SILTY SAND, WELL GRADED, COARSE TO FINE, 5-10% MEDIUM TO FINE GRAVEL, 5-10% NON TO SLIGHTLY PLASTIC FINES, MEDIUM BROWN. (TILL) (SW)	
-5	25	5	50/4"			SILTY SAND, WELL GRADED, COARSE TO FINE, 5-10% NON TO SLIGHTLY PLASTIC FINES, MEDIUM GRAY TO BROWN. (TILL) (SW)	
						TOP OF ROCK AT ELEVATION -8.2'	
						SEVERELY WEATHERED ROCK.	
-10	30		98	96		JT.@ 30.0' 50° SL. IRREG. SURF., ROUGH, W/SL. FeOx STN. JT.@ 30.8' 50° SURF.IRREG.,ROUGH, W/ SL. FeOx STN. JT.@ 32.8' HORIZ.,SURF. SL. IRREG. W/ SL. FeOx STN. JT.@ 33.7' HORIZ.,SURF. ROUGH, CLEAN, FRESH	PINK PEGMATITE, HARD,FRESH,SL. WX. W/ABUNDANT LARGE PINK& WHITE ORTHOCLASE CRYSTALS OFTEN STN. LT.GREEN, BIOT. 10%,QTZ.20%, ORTHOCLASE 60%, JOINTING CLOSE SPACED. PINK GRAY GRANITE CONTACT @ 31.5' HARD,FRESH,MEDIUM GRAINED EQUIGRANULAR,SUBHEDRAL GRAY GNEISS CONTACT 50° AT 34.3' MOD.HARD,MOD.WX.,MED.GR.,QUARTZO-FELDSPATHIC, W/BIOT.DEFINING THIN FOL.
						END OF BORING AT ELEVATION -15.2'	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ▮ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 3/75 FSL

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NO. 12179-GSK-80

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 2

SITE MILLSTONE UNIT 3 J.O. No. 12179 BORING No. B-2
TYPE OF BORING WASH/CORE LOCATION N 1774.70 E 60.50 GROUND ELEV. 19.8'
DATE DRILLED JANUARY 27-28, 1975 DRILLED BY AMERICAN LOGGED BY G.J.Z./R.T.D.
SUMMARY OF BORING

GROUND SURFACE ELEVATION +19.8'

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD (25 50 75)	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
15	5	1	17-20-32			GRAVELLY SAND, WELL GRADED, COARSE TO FINE, 20-30% MEDIUM TO FINE GRAVEL, 3-8% NON TO SLIGHTLY PLASTIC FINES, MEDIUM BROWN AND GRAY. (SW)
10	10	2	25-50/6"			CLAYEY SAND, WELL GRADED, COARSE TO FINE, LESS THAN 5% FINE GRAVEL 10-15% SLIGHLTY TO MODERATELY PLASTIC FINES, MEDIUM GRAY-BROWN, WITH SLIGHT ORANGE STAINING. (TILL) (SC)
5	15	3	60/6"			SILTY SAND, SIMILAR TO S2 BUT NO GRAVEL, NON TO SLIGHTLY PLASTIC FINES. (TILL) (SM)
0	20	4	66/6"			SILTY SAND, WELL GRADED, COARSE TO FINE, 5-10% NON TO SLIGHTLY PLASTIC FINES, MEDIUM GRAY-BROWN. (TILL) (SM)
-5	25	5	100/4"			SILTY SAND, SIMILAR TO S4 EXCEPT 10-15% NON TO MODERATELY PLASTIC FINES. (TILL) (SM)
-10	30	6	138/6"			SILTY SAND, SIMILAR TO S-5 (TILL) (SM)
-15	35					

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ▮ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 3/77 | RGL

BORING LOG
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NO. 12179-GSK-81A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 2

SITE MILLSTONE UNIT 3 J.O. No. 12179 BORING No. B-2
TYPE OF BORING WASH/CORE LOCATION N 1774.70 E 60.50 GROUND ELEV. 19.8'
DATE DRILLED JANUARY 27-28, 1975 DRILLED BY AMERICAN LOGGED BY G.J.Z./R.T.D.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD (25 50 75)	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
		7	128/6"			SILTY SAND, SIMILAR TO S-5 (TILL) (SM)	
-20	40	8	52/6"			SILTY SAND, SIMILAR TO S-5 (TILL) (SM)	
-25	45		100	60		TOP OF ROCK AT ELEVATION -25.2' JT.@ 45.2' HORIZ.,ROUGH.SURF.,SL.WX. W/THIN BROWN CLAY COAT.(TILL)&DK.GR. CHL.STN. JT.@ 45.5' 60° SURF.SM.,W/DK.GR.CHL. CTG.,SLICKS PLUNGING DOWN DIP JT.@ 45.9' 70° SURF.SM.,W/DK.GR.CHL. STN.&OCC.MED.HARD,WHITE SILICEOUS COAT.LESS THAN .10" THICK JT.@ 46.2' 5° SURF.SM.,MOD.WX.TO .02" DEEP W/HEAVY CHL. STN. & OCC BROWN CLAY FILL. JT.@ 46.8' 5° SURF.SM.,MOD.WX.TO .2" DEEP,SL.CHL.STN. JT.@ 47.4' 50° PARALLEL TO FOL.,SURF. SM.,MOD. SOFT,HEAVY CHL.STN. JT.@ 48.0' 45° PARALLEL TO FOL.,SURF. V.SM., W/HEAVY CHL.STN.,PROMINENT SLICKS PLUNGING DOWN DIP JT.@ 48.9' 30° SURF.SM.,MOD.SOFT, WX. TO .2" DEEP,HEAVY CHL.STN. PARALLEL TO FOL.,SLICKS PLUNGING 25° JT.@ 49.2' 50° PARALLEL TO FOL.,SURF. V.SM.,MOD.WX. TO .10" DEEP W/HEAVY CHL.STN., SLICKS PLUNGING 40° JT.@ 49.7' 45° PARALLEL TO FOL.,SURF. SM.,MOD.WX. TO .2" DEEP,SLICKS.	GRAY GNEISS, QUARTZO FELDSPATHIC BIOT.GN.,MOD.HARD,SL. WX.,MED.TO COARSE GR.,THINLY FOL.W/WEAK OR INDISTINCT LAYERING,W/LT.GR.STN.THROUGHOUT AT 48.8' CONTACT W/BIOTITE CONCENTRATION, SLIGHT WX., MOD. SOFT. AT 49.5' CONTACT WITH GNEISS.
-30						END OF BORING AT ELEVATION -30.2'	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1

BORING LOG
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NO. 12179-GSK-81B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE: MILLSTONE UNIT 3 — J.O. No. 12179 — BORING No. B-3
TYPE OF BORING: WASH/CORE — LOCATION: N 1109.1 E 151.5 — GROUND ELEV. 14.8'
DATE DRILLED: JANUARY 31, 1975 — DRILLED BY: AMERICAN — LOGGED BY: G.J.Z./R.T.D.
SUMMARY OF BORING:

GROUND SURFACE ELEVATION +14.8'

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD (25 50 75)	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
10	5	1	15-16-21				SILTY SAND, WELL GRADED, COARSE TO FINE, 5-10% NON TO MODERATELY PLASTIC FINES, MEDIUM GRAY-BROWN. (SM)
5	10	2	23-38-46				SILTY SAND, POORLY GRADED, COARSE TO FINE, MOSTLY MEDIUM AND FINE, 5-10% NON TO SLIGHTLY PLASTIC FINES, MEDIUM GRAY-BROWN. (SM)
0	15	3	45-50/4"				SILTY SAND, SIMILAR TO S2 EXCEPT WELL GRADED, MEDIUM GRAY. (TILL) (SM)
-5	20	4	60/6"				CLAYEY SAND, POORLY GRADED, COARSE TO FINE, MOSTLY MEDIUM AND FINE, 5-10% SLIGHTLY TO MODERATELY PLASTIC FINES, MEDIUM GRAY-BROWN. (TILL) (SC)
-10	25	5	90/6"				CLAYEY SAND, SIMILAR TO S4. (TILL) (SC)
						TOP OF ROCK AT ELEVATION -13/7'	
-15	30		100	84		JT.@ 28.75' 20°SL.OP TO .10" WIDE, SURF.IRREG. W/OCC.LT.GR.WAXY CHL. COAT. JT.@ 29.4' HORIZ.SURF.IRREG.,SL.WX. W/OCC.WHITE-YELLOW COAT. JT.@ 29.6' 40° SURF.SM.,SL.IRREG., FR.,CLEAN, JT.@ 29.9' 60° SURF.SM.,SL.WX.,W/ THIN COAT. TO.10"THICK OF PALE YELLOW CLAY. JT.@ 30.2' 30° SURF.SM.,CLEAN,FR. JT.ALONG FOL.PLANE AT 31.2',50° MOD.WX. W/CHL.TO .20" THICK JT.ALONG FOL.PLANE AT 32.6' 60° SM.,SL.IRREG.,CLEAN,FRESH	PINK-WHITE GRANITE, MOD.HARD, SL.-MOD,WX.,COARSE GR.,PEGAN-HEDRAL,CLOSELY SPACED.JTG., BIOT. 10%, QTZ. 20-30%, FELD. 50-60%. GRAY BLACK-BIOTITE GNEISS CONTACT AT 30.8', 50°, MED. HARD TO MOD.SOFT,MED.GR., THINLY LAYERED W/FLD. & QTZ., JTG.CL.SP.ALONG FOL.PLANES W/ALT. OF BIOT.TO CHL. TO .20" THICK, FLD.(PLAGIOCLASE) 10%, QTZ. 20-30%,BIOT. 60%. PINK-WHITE GRANITE 50° AT 33.3' HARD, FRESH, SL.FOL.
						END OF BORING AT ELEVATION -18.7'	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 9/7/75 | BJ

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NO. 12179-GSK-82

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 2

SITE MILLSTONE UNIT 3 J.O. No. 12179 BORING No. B-4
TYPE OF BORING WASH/CORE LOCATION N 1058.6 E 151.8 GROUND ELEV. +16.9'
DATE DRILLED JANUARY 30, 1975 DRILLED BY AMERICAN LOGGED BY G.J.Z./R.T.D.
SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD 25 50 75	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION, LITHOLOGY AND TEXTURE)
						GROUND SURFACE ELEVATION +16.9'
15						
	5	1	12-7-8			SILTY SAND, WELL GRADED, COARSE TO FINE, 5-10% NON TO SLIGHTLY PLASTIC FINES, 10-20% FINE TO MEDIUM GRAVEL, MEDIUM BROWN. (SW)
10						
	10	2	1-4-7			NO RECOVERY
5		3	11-50-25			CLAYEY SAND, POORLY GRADED, COARSE TO FINE, MOSTLY MEDIUM AND FINE, 10-15% SLIGHTLY TO MODERATELY PLASTIC FINES, MEDIUM BROWN AND GRAY. (TILL) (SC)
	15	4	40-55/5"			SILTY SAND, SIMILAR TO SS3 EXCEPT NON TO SLIGHTLY PLASTIC FINES, MEDIUM GRAY. (TILL) (SM)
0						
	20	5	80/6"			SILTY SAND, SIMILAR TO SS4 EXCEPT LESS GRAVEL (5-10%) MEDIUM GRAY AND BROWN. (TILL) (SM)
-5						
	25	6	50/4"			SILTY SAND, WELL GRADED, COARSE TO FINE, 5-10% NON TO SLIGHTLY PLASTIC FINES, LESS THAN 5% MEDIUM GRAVEL, MEDIUM BROWN AND GRAY. (TILL) (SM)
-10						
	30	7	89/6"			SILTY SAND, SIMILAR TO SS6 EXCEPT NON TO MODERATELY PLASTIC FINES, MEDIUM BROWN-GRAY. (TILL) (SM)
-15						
						TOP OF ROCK AT ELEVATION -17.6'
	35	8	50/3"			WEATHERED ROCK

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ▮ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

BORING LOG
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NO. 12179-GSK-83A

NORTHEAST UTILITIES SERVICE COMPANY

SH 2 OF 2

SITE MILLSTONE UNIT 3 J.O. No. 12179 BORING No. B-4

TYPE OF BORING WASH/CORE LOCATION N 1058.6 E 151.8 GROUND ELEV. +16.9'

DATE DRILLED JANUARY 30, 1975 DRILLED BY AMERICAN LOGGED BY G.J.Z./R.T.D.

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD 25 50 75	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
-20	40		86	11		JT.@ 36.0' 80° SURF.SM.,HIGHLY WX., W/THIN CHL.COAT..TO .10" THICK JT.@ 36.4' 10° X-CUTS HIGH ANGLE JT.,SURF.SM.,HIGHLY WX.,W/HEAVY CHL. STN. JT.@ 36.9' 15° SURF.HIGHLY WX.,W/ THIN YELLOW CLAY COAT. < .10" JT.@ 37.2' 20° SURF. SM.,SL.IRREG. W/OCC.COAT.OF YELLOW CLAY JT.@ 37.5' 30° SURF.IRREG.W/ALT.OF BIOT.TO CHL. JT.@ 38.3' 30° FOL.SURF.SM.,HIGHLY WX. W/THIN CHL.COAT.TO .10"THICK JT.@ 38.4' 85° SURF.SM.,MOD.WX.,W/ CHL. AND HEMATITE STN. JT.@ 39.2' 45° SURF. V.SM.,W/HEAVY CHL.STN. & OCC.HEMATITE,PROMINENT SLICKS PLUNGING ABOUT 40° JT.@ 40.4'45° SURF.V.SM.,W/OCC. YELLOW CLAY COAT.,ALT.FLD.STN.W/ CHL. JT.@ 40.8' 30° SURF.SM.,SL.WX. W/ LT.YELLOW THIN WAXY CLAY COAT. TO .10" THICK END OF BORING AT ELEVATION -24.1'	GRAY GREEN GNEISS, SOFT BROKEN, HIGHLY WX.,MED.GR.,THINLY FOL., W/HEAVY CHL.STN. THROUGHOUT (ALT.OF BIOTITE) JTG.CL.SPACED BOTH HIGH&LOW ANGLE,20% BIOT., 30% QTZ.,50% FLD. W/MINOR SULFIDES(CHALCOPYRITE) QTZ.VEIN CONTACT @ 37.0' MINOR ORTHOCLASE GEISS CONTACT @37.8' HORIZ. WHITE GRANITE @ 40.4' MODERATELY HARD,MODERATELY WEATHERED, COARSE GRAINED.

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ▼6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □▽ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 3/7/75 FSL

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NO. 12179-GSK-83B

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE UNIT 3 J.O. No. 12179 BORING No. B-5
TYPE OF BORING WASH/CORE LOCATION N 1012.4 E 120 GROUND ELEV. 16.6'
DATE DRILLED JANUARY 31, 1975 DRILLED BY AMERICAN LOGGED BY G.J.Z./R.T.D.
SUMMARY OF BORING

GROUND SURFACE ELEVATION +16.6'

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD (25 50 75)	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS, OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION, LITHOLOGY AND TEXTURE
+15							
+10	5	1	15-13-26			SAND, WELL GRADED, COARSE TO FINE, LESS THAN 10% FINE TO MEDIUM GRAVEL, LESS THAN 5% NONPLASTIC FINES, MEDIUM BROWN. (SW)	
+5	10	2	17-11-31			SILTY SAND, WELL GRADED, COARSE TO FINE, 25-30% GRAVEL. FINE TO MEDIUM, 3-10% NONPLASTIC FINES, MEDIUM BROWN. (SM-SW)	
0	15	3	17-50/4"			SILTY SAND, POORLY GRADED, FINE TO MEDIUM, 5-15% FINE GRAVEL, 10-20% SLIGHTLY PLASTIC FINES, LIGHT GRAY. (SM)	
						TOP OF ROCK AT ELEVATION	
	20		88	78		JT.@ 17.5' 5° SURF.CLEAN,FRESH,ROUGH. BREAKING ON ORTHOCLASE CLEAVAGE JT.@ 18.2' HORIZ.,SURF.CLEAN,FRESH, ROUGH JT.@ 18.8' 20-30° SURF.SL.IRREG.,SL. ROUGH,FeOx STN.,MOD.FeOx STN. JT.@ 19.4' 5-10° SURF.IRREG.&ROUGH W/ SL.FeOx STN. JT.@ 20.1' 60° SURF.SL.ROUGH W/SL. FeOx STN.	PINK PEGMATITE, HARD,SL.WX., LG.PINK XTALS.,OCC.GRADES TO A COARSE PINK GRANITE,JTG. CLOSELY SPACED & GENERALLY LOW ANGLE,10% BIOT.& MUSC., 40% QTZ.,50% FLD. PINK GRAY GRANITE,HARD, SL. WX.,COARSE GR.,EQUIGRANULAR, SUBHEDRAL AT 18.3' PEGMATITE CONTACT AT 19.0'
						END OF BORING AT ELEVATION	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ☳ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 3/7/75 | RJ

BORING LOG
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NO. 12179-GSK-84

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE UNIT 3 J.O. No. 12179 BORING No. B-6

TYPE OF BORING WASH/CORE LOCATION N 1065.6 E 61 GROUND ELEV. 17.0'

DATE DRILLED JANUARY 29, 1975 DRILLED BY AMERICAN LOGGED BY G.J.Z./R.T.D.

SUMMARY OF BORING

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD (25 50 75)	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL OR ROCK DESCRIPTION: SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND SURFACE ELEVATION +17.0'							
15							
	5	1	INVALID			SILTY SAND, POORLY GRADED, COARSE TO FINE, MOSTLY MEDIUM TO FINE, LESS THAN 5% NONPLASTIC FINES, MEDIUM BROWN. (SP)	
10							
		2	17-17-20			SILTY SAND, SIMILAR TO SS1, MEDIUM BROWN. (SP)	
	10	3	20-33-52			CLAYEY SAND, FAIRLY WELL GRADED, COARSE TO FINE, 10-15% SLIGHTLY TO MODERATELY PLASTIC FINES, MEDIUM GRAY AND BROWN. (TILL) (SC)	
5							
		4	53/6"			CLAYEY SAND, SIMILAR TO SS3 WITH 10-20% FINE TO MEDIUM GRAVEL, MEDIUM GRAY. (TILL) (SC)	
						TOP OF ROCK AT ELEVATION +2.5'	
	15					SEVERLY WEATHERED ROCK	
0			100	98		JT.@ 17.8' 30° SURF.CLEAN,SM.,SL. ROUGH JT.@ 18.35' 10° SURF.,SL.IRREG., HEAVILY FeOx STN.,WX. TO 0.1" DEEP JT. @ 18.5' HORIZ. SURF. SM.,MOD. FeOx STN. JT.@ 19.0' 10° SURF.SM.,CLEAN,FRESH JT.@ 19.3' 25° SURF. CLEAN,ROUGH, FRESH JT.@ 19.7' 55° FOL.SURF.,SM.MOD.WX. TO .20" DEEP,SL.FeOx STN. JT.@ 20.4' 20° SL.ROUGH,CONCAVE SURF.,CLEAN, FRESH.	GRAY GNEISS, MOD.HARD,GENERALLY SL.WX., MED.GR.,THINLY FOL.,JOINTS CL.SP. W/SL. TO MOD. FeOx STN.,30% FLD.,30% BIOT., 40% QTZ.
	20						
						END OF BORING AT ELEVATION -4.0'	

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 3/77 | FBV

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE CO.

STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NO. 12179-GSK-85

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. T-1
TYPE OF BORING CASED, 4" O.D. LOCATION N1286.9 E247.5 GROUND ELEV. 21.1'
DATE DRILLED 5/14/75 DRILLED BY AMERICAN LOGGED BY REH
SUMMARY OF BORING SPLIT SPOON/NX CORE

GROUND EL. AT 21.1'

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
20		1	4-7-13			SAND, WELL GRADED, LESS THAN 10% GRAVEL TO 1.0 INCH MAXIMUM, COARSE TO FINE SAND, 5-10% NONPLASTIC FINES, DRY TO SLIGHTLY DAMP, LIGHT BROWN. (SW-SM)
		2	8-6-4			SAND, POORLY GRADED, 10-20% COARSE SAND, MOSTLY FINE SAND, LESS THAN 5% NONPLASTIC FINES, DAMP GRAYISH-BROWN. (SP) TOP OF TILL 8.5'
10	10		120/5"			NO RECOVERY.
		3	13-45-51			SAND, POORLY GRADED, LESS THAN 10% GRAVEL TO 0.5 INCH MAXIMUM, COARSE TO FINE SAND, 5-10% NONPLASTIC FINES, MOIST, BROWN, TILL. (SP-SM)
0 -1.4'	20	4	61/6"			SILTY SAND, 25-35% GRAVEL (WEATHERED GRANITE), COARSE TO FINE SAND, 10-15% SLIGHTLY PLASTIC FINES, MOIST, REDDISH BROWN, GRAY SILT WASHED IN FROM TILL ABOVE. (SM) TOP OF ROCK AT 22.5'
		NX 1	75%	37%		22.5-23.7 27.5-29.0 PINK & WHITE GRANITE PEGMATITE, CLOSE JOINTS, FRESH TO SLIGHTLY WEATHERED, SLIGHT IRON STAIN TO CLEAN, VERY COARSE GRAIN, VERY HARD, MAJOR MINERALS ARE QUARTZ, K-SPAR, AND PLAGIOCLASE 23.7-27.5 29.0-31.5 GRAY & WHITE GNEISS, CLOSE TO VERY CLOSE JOINTS, SLIGHTLY TO MODERATELY WEATHERED, HARD TO MODERATELY HARD, VERY THIN 50-60° FOLIATION, MAJOR MINERALS: QUARTZ, PLAG., BIOTITE, PYROXENE. 23.6-24.2 25.1-25.4 COMPLETE WEATHERED GNEISS, FRIABLE AND SOFT, MUCH CHLORITE, IRON STAINING.
-10 -10.4	30	NX 2	80%	36%		@24.3 0° JOINT, @24.8 20° JOINT - CLEAN, ROUGH. @ 24.5 20° JOINT WITH SLIGHT CALCITE COATING. @ 26.7 50° JOINT - SLIGHT CLAY COATED. @ 27.3 60° JOINT - CLEAN. 27.5 - 29.4 0°-20° JOINTS, CLOSE TO VERY CLOSE, CLEAN TO SLIGHT CLAY FILM, SLIGHTLY ROUGH. 29.8-31.5 MODERATELY TO SEVERELY WEATHERED GNEISS, VERY CLOSE, 0° JOINTS, HEAVY CLAY AND CHLORITE COATINGS, MEDIUM HARD TO SOFT.

END OF BORING AT 31.5'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ▮ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ☿ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NO. 12179-GSK-86

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. T-2

TYPE OF BORING 4" MUD. LOCATION N1233.5 E465.0 GROUND ELEV. 19.2'

DATE DRILLED 5/13/75 DRILLED BY AMERICAN LOGGED BY RFH

SUMMARY OF BORING SPLIT SPOON SAMPLING WITH NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND EL. AT 19.2'						
		1 (split spoon)	12-21-19			SAND, WIDELY GRADED, 15-20% GRAVEL TO 1.5 INCH MAXIMUM, COARSE TO FINE SAND, LESS THAN 10% NONPLASTIC FINES, DRY TO SLIGHTLY DAMP, BROWN, YARD FILL. (SP-SM)
		(no recovery)				NO RECOVERY.
10	10	2 (split spoon)	10-12-12			SAND, UNIFORM, FINE TO VERY FINE, LESS THAN 5% NONPLASTIC, VERY MICACEOUS, WITH VERY THIN LAYERS OF SILTY SAND WITH 20-30% NON-PLASTIC FINES, DAMP, BROWN. (SP)
		3 (split spoon)	7-15-22			SAND, POORLY GRADED, 10-15% COARSE SAND AND GRAVEL TO 3/4 INCH MAXIMUM, MOSTLY FINE SAND, LESS THAN 5% NONPLASTIC FINES, MOIST, REDDISH BROWN TO BROWN. (SP) TOP OF FILL AT 12.5'
		4 (split spoon)	23-62-87			TILL, SAND, WELL GRADED, LESS THAN 10% COARSE SAND, MOSTLY FINE TO MEDIUM SAND, LESS THAN 5% NONPLASTIC FINES, MOIST, GRAY. (SW)
0	20	NX 1	34%	0%		18.5-22.5 COBBLES OF MILKY WHITE QUARTZ AND PINK AND GRAY GRANITE, FRAGMENTED, FRESH TO SLIGHTLY WEATHERED.
-3.3'						TOP OF ROCK AT 22.5
		NX 2	27%	0%		22.3-3.10 GRAY AND WHITE GNEISS, VERY CLOSE TO CLOSE 0°-10° JOINTS, HARD, FRESH TO SLIGHTLY WEATHERED, MEDIUM GRAINED, VERY THIN 50° FOLIATION, MAJOR MINERALS: QUARTZ, PLAGIOCLASE, BIOTITE, PYROXENE, LOW ANGLE JOINTS, HAVE SLIGHT IRON STAINING.
-10		NX 3	71%	28%		23.3-24.2 VAGUE FOLIATION DUE TO DECREASE IN BIOTITE. 27.5-31.0 0°-10° JOINTS, CLOSE TO VERY CLOSE, SLIGHT CHLORITE. 30.3-30.6 QUARTZ SEAM. 30.7-31.0 SLIGHTLY TO MODERATELY WEATHERED GNEISS, 0° VERY CLOSE JOINTS, CHLORITE COATING, SLIGHT CLAY.
-11.8	30					END OF BORING AT 31.0

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. ✱ INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ▮ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ♀ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 6/10/75 | RH

BORING LOG
MILLSTONE NUCLEAR POWER STATION
UNIT 3
NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK- 87

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. T-3
TYPE OF BORING 4" MUD LOCATION N1233.6 E428.2 GROUND ELEV. 19.8'
DATE DRILLED 5/12/75 DRILLED BY AMERICAN LOGGED BY REH
SUMMARY OF BORING SPLIT SPOON SAMPLING WITH NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND EL. AT 19.8'						
		1	6-7-8			SAND, POORLY GRADED, FINE TO COARSE, LESS THAN 5% GRAVEL TO 0.5 INCH MAXIMUM, MOSTLY FINE TO MEDIUM SAND, LESS THAN 5% NONPLASTIC FINES, DAMP, LIGHT BROWN. (SP)
		2	46-52-42			SAND, WIDELY GRADED, 20-30% GRAVEL TO 1.0 INCH MAXIMUM, COARSE TO FINE SAND, 5-10% NONPLASTIC FINES, MOIST, MEDIUM BROWN, (SP-SM)
10	10	3	12-16-20			SAND, POORLY GRADED, 10-15% COARSE AND MEDIUM SAND, MOSTLY FINE SAND, 5-10% NONPLASTIC FINES, MOIST, DARK BROWN WITH ORANGE-BROWN LAYERS, MICACEOUS. (SP-SM) TOP OF TILL AT 12.5'
		4	37-42-90			SAND, POORLY GRADED, 5-10% COARSE AND MEDIUM SAND, MOSTLY FINE SAND, LESS THAN 5% NONPLASTIC FINES, MOIST, MEDIUM GRAY, TILL. (SP)
0	20	5	38- 45/3"			SILTY SAND, WIDELY GRADED, LESS THAN 10% GRAVEL TO .75 INCH MAXIMUM, COARSE TO FINE SAND, 15-20% NONPLASTIC FINES, MOIST, MOTTLED ORANGE AND DARK BROWN, TILL. (SM)
-8.2'		6	109			DECOMPOSED GNEISS, GREENISH GRAY, SEVERE TO COMPLETELY WEATHERED, FRIABLE, SOFT. TOP OF ROCK AT 28.0'
-10	30	NX	30%	0%		28.0-38.0 GRAY AND WHITE GNEISS, VERY CLOSE TO CLOSELY SPACED JOINTS, SLIGHTLY TO SEVERELY WEATHERED, HARD TO MODERATELY HARD, VERY THIN, 40-60° FOLIATION, MAJOR MINERALS: QUARTZ, PLAGIOCLASE, BIOTITE, PYROXENE. 28.0-33.2 SEVERELY WEATHERED AND BROKEN ZONE, PITTED, CHLORITE AND LIGHT GREEN CLAY COATINGS ON JOINTS. 33.1-37.6 0-15° CLOSELY SPACED JOINTS, SLIGHT CHLORITE FILM TO CLEAN
-18.2		NX	100%	38%		AT 33.2 60° JOINT - HEAVY CHLORITE COATING, LIGHT GREEN CLAY, VAGUE SLICKS-DOWN DIP AT 34.3 60° JOINT - HEAVY CHLORITE COATING, LIGHT GREEN CLAY, VAGUE SLICKS - DOWN DIP 34.5-34.9 BROKEN ZONE - MUCH CHLORITE ON HIGH ANGLE JOINTS. 35.3 50° JOINT - SLIGHT CHLORITE CLAY. 35.7 0° JOINT - FRESH 37.3 ?-60° JOINTS - HEAVY CHLORITE COATING 37.7-38.0 BROKEN ZONE - HEAVY CHLORITE COAT ON HIGH ANGLE JOINTS.
						END OF BORING AT 38.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
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   □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1	6/6/75

BORING LOG

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-88

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. T-4
TYPE OF BORING 4" MUD LOCATION N1159.1 E388.4 GROUND ELEV. 16.9'
DATE DRILLED 5/16/75 DRILLED BY AMERICAN LOGGED BY RTD
SUMMARY OF BORING SPLIT SPOON SAMPLING WITH NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	SAMPLE BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND EL. AT 16.9'						
		1	5-11-22			SAND, WIDELY GRADED, GRAVEL 25-30% TO 7.0" MOSTLY FINE TO MEDIUM SAND, 5-10% NONPLASTIC FINES, ASPHALT AND OCCASIONAL WOOD, GRAY BROWN, DAMP. (SP)
10		2	23-42-39			SAND, WIDELY GRADED, GRAVEL 25-35% TO 1.0", MOSTLY FINE TO MEDIUM SAND, 5-15% NONPLASTIC FINES, SILT OCCURS IN THIN LIGHT BLUE LENSES, LIGHT GRAY BROWN, DAMP. (SP-SM)
	10	3	10-19-19			SAND, WIDELY GRADED, GRAVEL 5-10% TO 4", FINE TO MEDIUM SAND, MOSTLY FINE, 5-15% NONPLASTIC FINES, LIGHT GRAY BROWN, DAMP, TILL (SP-SM)
0		4	27-17-28			SANDY GRAVEL, SUBROUNDED TO 1.25", 20-30% FINE - MEDIUM SAND, LESS THAN 5% NONPLASTIC FINES, LIGHT GRAY BROWN, DAMP, TILL. (SW)
	20	5	17-120-100/3"			SAND, WIDELY GRADED, GRAVEL SUBROUNDED 20-30% TO 1.0", MOSTLY FINE TO MEDIUM SAND, LESS THAN 5% NONPLASTIC FINES, GRAY BROWN, DAMP, MOIST, TILL. (SP)
-10		6	31-39-46			SAND, WELL GRADED, GRAVEL 5-10% TO .75", FINE TO MEDIUM SAND MOSTLY FINE, LESS THAN 5% NONPLASTIC FINES, GRAY, MOIST. (SW)
-16.88	30	7	17-43-43			SAPROLITE - LIGHT GREEN GNEISS - FINE TO MEDIUM GRAINED, SHOWS REMNANT FOLIATION, SLIGHTLY WEATHERED; SOFT, WEATHERED, CLAYEY; OVERALL CHLORITE STAINING, OCCASIONAL YELLOW AND WHITE MOTTLING. TOP OF ROCK AT 33.7'
-20 -21.88		NX	100%	50%		HIGHLY WX., BROKEN ZONE TO 38.1', GNEISS SOFT FRIABLE, WITH HEAVY CHLORITE STAIN, 80° JOINT AT 34.8', ROUGH, SURFACE, SLIGHTLY TO MODERATELY WEATHERED WITH OCCASIONAL LIGHT GREEN CLAY COATING LESS THAN 0,1" THICK. END OF BORING AT 38.7' GRAY GNEISS: MEDIUM GRAINED; THIN, STRONG FOLIATION, CLOSE TO CLOSE 5° TO 30° JOINTING, ROUGH SURFACE, GENERALLY CLEAN WITH OCCASIONAL BROWN CLAYEY (TILL) FILLING AND/OR GREEN CLAY COATING, MAJOR MINERALS: BIOTITE, QUARTZ, FELDSPAR.

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO ~~DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER.~~ FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ▮ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. [NX] INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 6/10/75 | 18

BORING LOG

MILLSTONE NUCLEAR POWER STATION
UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-89

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. T-5

TYPE OF BORING CASED, 4" O.D. LOCATION N1207.5 E308.3 GROUND ELEV. 17.9

DATE DRILLED 5/15/75 DRILLED BY AMERICAN LOGGED BY RTD

SUMMARY OF BORING SPLIT SPOON WITH NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION: FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS	SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE
GROUND EL. AT 17.9'							
		1	10-27-32				SAND; WIDELY GRADED, GRAVEL 20%-25% TO 80", MOSTLY FINE TO MEDIUM SAND, LESS THAN 10% NONPLASTIC FINES, OCCASIONAL LENSES OF YELLOW BROWN SILT, LIGHT GRAY BROWN, DAMP. (SP-SM)
10		2	27-35-38				SILTY SAND, GRAVEL LESS THAN 5% TO .33", FINE TO MEDIUM SAND, MOSTLY FINE, 20%-30% NONPLASTIC FINES, LIGHT GRAY BROWN, DAMP. (SM) TOP OF TILL AT 9.9'
	10	3	51-87-52/6"*				SILTY SAND, FINE TO MEDIUM MOSTLY FINE, 10%-20% NONPLASTIC FINES, LIGHT GRAY BROWN, DAMP. (SM)
		4	72/6 93/12*				SILTY SAND, GRAVEL 5%-10% TO 0.7", FINE TO MEDIUM SAND, MOSTLY FINE, 10%-20% NONPLASTIC FINES, LIGHT GRAY, MOTTLED WITH IRON STAINING, MOIST. (SM)
0	20						SAPROLITE: GRAY GNEISS: - MEDIUM GRAINED, MODERATELY SOFT - SOFT, HIGHLY TO SEVERELY WEATHERED, EASILY FRIABLE WITH LIGHT GREEN CHLORITE STAINING, FELDSPAR ALTERED TO CLAYS.
-4.1		5	57*-60*				TOP OF ROCK AT 22.0'
		NX 1	70%	20%		JOINT AT 23.0, 10° SURFACE ROUGH, SLIGHTLY WEATHERED, MODERATE IRON STAINED. JOINT AT 23.4°, 20° SURFACE ROUGH, IRON STAINED WITH THIN CLAY COATING TO 10". JOINT AT 23.6' 45°; SURFACE ROUGH, FRESH, SLIGHTLY WEATHERED, GREEN GNEISS BROKEN ZONE AT 23.8'.	PINK GRANITE: MEDIUM TO COARSE GRAINED, MODERATE HARD - HARD, EQUIGRANULAR SUBHEDRAL BIOTITE, QUARTZ, FELD., SLIGHTLY WEATHERED WITH LIGHT IRON STAINING, CLOSE - VERY CLOSE JOINTING; SURFACE SLIGHTLY ROUGH AND SLIGHT-MODERATE IRON STAINING.
-10		NX 2	28%	0%			GREEN GNEISS: AT 23.8 FINE TO MEDIUM GRAINED, SOFT EASILY FRIABLE, HIGHLY SEVERELY WEATHERED, WITH HEAVY CHLORITE STAINING, BROKEN, MUCH OF SAMPLE, WASHED OUT.
	30	NX 3	55%	0%			GRAY GNEISS: MEDIUM GRAINED, MEDIUM HARD, 45-75° FOLIATION THIN AND STRONG, MODERATELY WEATHERED, GENERALLY BROKEN INTO 1-2" FRAGMENTS SHOWING IRON AND CHLORITE STAINING, LARGEST FRAGMENT 3" LONG DISPLAYING 75° JOINT ALONG FOLIATION PLANE.
-18.1							PINK PEGMATITE - VERY COARSE, HARD, SLIGHTLY WEATHERED, BROKEN INTO 1" FRAGMENTS, LARGEST 3" MAXIMUM SURFACE, IRON STAINING AND OCCASIONAL COATED WITH A THIN LIGHT GREEN WHITE CLAY COATING; QTZ. AND FELD. MINOR BIOTITE
							GRAY GNEISS - 32.7' MEDIUM GRAINED, WELL FOLIATED NEARLY VERTICAL; GEN. BROKEN INTO 2-3" FRAGMENTS, SURFACE ROUGH, MODERATELY WEATHERED WITH OCCASIONAL CHOCLATE BROWN CLAY FILLING, GEN. LIGHT IRON STAINED.

END OF BORING AT 36.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ▮ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE.
   ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE.
   ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ⊻ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

1 | 637 | 781

BORING LOG

MILLSTONE NUCLER POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-90

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE MILLSTONE NUCLEAR POWER STATION - UNIT 3 J.O. No. 12179 BORING No. T-6

TYPE OF BORING CASING 4" MUD LOCATION N1249.7 E309.0 GROUND ELEV. 20.2

DATE DRILLED 5/14/75 DRILLED BY AMERICAN LOGGED BY REH

SUMMARY OF BORING SPLIT SPOON WITH NX CORE

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
GROUND EL. AT 20.2'						
20		1	23-27-30			SILTY SAND, LESS THAN 10% COARSE TO MEDIUM SAND, MOSTLY VERY FINE SAND, 10-20% NONPLASTIC FINES, DRY TO SLIGHTLY DAMP, BROWN, CONTAINS ONE THIN LAYER OF GRAYISH BROWN NONPLASTIC SILT. (SM)
						TOP OF TILL AT 4.5
		2	13-17-29			SILTY SAND, LESS THAN 10% COARSE TO MEDIUM SAND, MOSTLY VERY FINE SAND, 20-40% NONPLASTIC FINES, DAMP, BROWN, CONTAINS FEW VERY THIN LAYERS AT SLIGHTLY PLASTIC GRAY SILT, TILL (SM).
10	10	3	58/6" *104/12"			SAND, UNIFORM, 10-20% COARSE AND MEDIUM SAND, MOSTLY FINE SAND, LESS THAN 5% NONPLASTIC FINES IN TOP 3" OF SAMPLE, BOTTOM IS 5-10% NONPLASTIC FINES, MOIST, BROWN TO GRAYISH BROWN, TILL. (SP-SM)
		4	25/4" *134/12"			SAND, UNIFORM, 10-20% COARSE AND MEDIUM SAND, MOSTLY FINE SAND, LESS THAN 5% NONPLASTIC FINES, SATURATED, GRAYISH BROWN, TILL. (SP)
0						
-1.8		5	120/6"			NO RECOVERY. TOP OF ROCK AT 22.0'
-6.8		NX	100	76%		22.0-27.0 GRAY AND WHITE GNEISS, CLOSE TO VERY CLOSE JOINTS, SLIGHTLY WEATHERED, MODERATELY HARD, BANDING IS VERY THIN WITH 45-60° DIP, MEDIUM TO COARSE GRAINED, MAJOR CONSTITUENTS: QUARTZ, FELSPAR, BIOTITE, PYROCENE 22.7 15° JOINTS, CLEAN AND FRESH 23.9-24.3 BROKEN ZONE, HIGH AND LOW ANGLE JOINTS, HEAVY IRON STAINING, GRAY CLAY FILLING PERCOLATED FROM TILL. 24.8-25.6 3-45° JOINTS, CLEAN TO SLIGHTLY IRON STAINED, ROUGH, BROKEN ALONG FOLIATION AT 25.8 2-20° JOINTS, HEAVY IRON STAIN. AT 26.5 60° JOINT, FRESH, CLEAN, ROUGH. AT 26.8 2-40° JOINTS - SLIGHTLY IRON STAINED, SLIGHTLY ROUGH.
						END OF BORING AT 27.0

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
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   ▯◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY.
   SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ▽ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. [NX] INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

BORING LOG

MILLSTONE NUCLER POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-91

AMENDMENT 15

SEPTEMBER 1985

NORTHEAST UTILITIES SERVICE COMPANY

SH 1 OF 1

SITE: MILLSTONE NUCLEAR POWER STATION - UNIT 3 | J.O. No. 12179 | BORING No. T-7

TYPE OF BORING: CASED, 4" O.D. | LOCATION: N1186.4 E220.3 | GROUND ELEV. 20.6

DATE DRILLED: 5/16/75 | DRILLED BY: AMERICAN | LOGGED BY: REH

SUMMARY OF BORING: SS/NX CORE

GROUND EL. AT 20.6'

ELEV. FEET	DEPTH FEET	SAMPLE TYPE	BLOWS OR RECOV.	OVERALL WEATHERING AND RQD	SOIL OR ROCK DESCRIPTION (FIELD AND LABORATORY TEST RESULTS; OR JOINTING, BEDDING AND FAULTING DESCRIPTIONS / SOIL STRATA DESCRIPTION; LITHOLOGY AND TEXTURE)
20					
					TOP OF TILL AT 6.0'
		Split-spoon 1	16-16-25		SAND, WIDELY GRADED, 15-25% GRAVEL TO 1.5 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE SAND, LESS THAN 5% NONPLASTIC FINES, DAMP, BROWN TO ORANGE-BROWN, LENSE OF SILTY SAND AND GRAY SILT IN BOTTOM OF SAMPLE. (SP)
10	10	Split-spoon 2	17-25-45		SAND, UNIFORM, LESS THAN 5% GRAVEL TO 1.5 INCH MAXIMUM, MOSTLY FINE AND VERY FINE SAND, 5-10% NONPLASTIC FINES, MOIST, GRAY, TILL. (SP-SM)
		Split-spoon 3	50-57-70		SILTY SAND, LESS THAN 15% GRAVEL TO 1.25 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE SAND, 10-15% SLIGHTLY PLASTIC FINES, MOIST, GRAY, TILL. (SM)
0	20	Split-spoon 4	38-64-78		SAND, WELL GRADED, LESS THAN 10% GRAVEL TO 0.5 INCH MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE SAND, LESS THAN 3% NONPLASTIC FINES, SATURATED, GRAY, LENSE OF SILTY SAND, TILL. (SW)
-7.4		Split-spoon 5	50-70-78		SAND, POORLY GRADED, 5-15% COARSE SAND AND GRAVEL TO 0.5 INCH MAXIMUM, MOSTLY FINE SAND, 5-10% NONPLASTIC FINES, SATURATED, TILL GRAY. (SP-SM) TOP OF ROCK AT 28.0'
-10	30	NX 1	20%	0%	28.0-35.0 SAPROLITE, GREENISH GRAY GNEISS, SOFT AND FRIABLE, SEVERE TO COMPLETELY WEATHERED, RETAINS RELIC STRUCTURE, FINE GRAINED, MUCH GREENISH-GRAY CLAY.
		NX 2	48%	0%	34.5-35.0 GRAY COMPLETELY WEATHERED GNEISS-POWDER FORM, DRY, QUARTZ PEBBLES, CHUNKS OF SEVERELY WEATHERED SOFT GNEISS, VERY THIN LENSE OF GRAY CLAY.
-20 / -21.4	40	NX 3	60%	10%	35.0-42.0 GRAY AND WHITE GNEISS, 0-20° CLOSELY TO VERY CLOSELY SPACED JOINTS, SLIGHTLY WEATHERED, SLIGHTLY PITTED, HARD, MEDIUM GRAINED, VERY THIN 60° FOLIATION, JOINTS HAVE SLIGHT CLAY FILM TO CLEAN.
					END OF BORING AT 42.0'

1. FIGURES IN BLOW OR RECOVERY COLUMN OPPOSITE SOIL SAMPLE DENOTE THE NUMBER OF BLOWS OF A 140 LB. HAMMER FALLING 30" REQUIRED TO DRIVE A 2" OD. SAMPLE SPOON 6" OR THE DISTANCE SHOWN. * INDICATES USE OF 300 LB. HAMMER. FIGURES SHOWN OPPOSITE ROCK CORES DENOTE THE PERCENT OF CORE RECOVERED.
2. ■ 2 INDICATES LOCATION OF UNDISTURBED SAMPLE. ◤ 6 INDICATES LOCATION OF SPLIT-SPOON SAMPLE. □◸ INDICATES LOCATION OF SAMPLING ATTEMPT WITH NO RECOVERY. SUBSCRIPT NEXT TO SYMBOL INDICATES SAMPLE NUMBER.
3. ☿ INDICATES LOCATION OF NATURAL GROUND WATER TABLE.
4. RQD-ROCK QUALITY DESIGNATION.
5. NX INDICATES DEPTH, LENGTH, AND SIZE CORING RUN.
6. DATUM IS M.S.L.

BORING LOG

MILLSTONE NUCLEAR POWER STATION UNIT 3

NORTHEAST UTILITIES SERVICE COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NO. 12179-GSK-92

APPENDIX 2.5K

SEISMIC SURVEY

April 1972

Weston Geophysical Engineers, Inc.
Weston, Massachusetts

WESTON GEOPHYSICAL ENGINEERS, INC.
POST OFFICE BOX 306
WESTON, MASSACHUSETTS 02193
617 899 0060

April 24, 1972

Northeast Utilities Service Company
Post Office Box 270
Hartford, Connecticut 06101

Gentlemen:

A seismic refraction survey was conducted at the site of the proposed Millstone Nuclear Power Plant in Connecticut in accordance with your Purchase Order Number 202144, dated September 2, 1971. The field work for this investigation was performed during the period of August 9, through 30, 1971.

This investigation was coordinated in the field by Mr. Ralph Borjeson, Soils Engineer, Stone & Webster Engineering Corporation, and directed by our supervising geophysicist, Mr. Edward N. Levine.

Preliminary data have been submitted; this is a formal presentation of our findings.

Sincerely,

WESTON GEOPHYSICAL ENGINEERS, INC.

Vincent J. Murphy

VJM/ct

SEISMIC SURVEY

MILLSTONE NUCLEAR POWER PLANT

for

NORTHEAST UTILITIES SERVICE COMPANY

under the direction of

STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

WESTON, MASSACHUSETTS

SEISMIC SURVEY

MILLSTONE NUCLEAR POWER PLANT

INTRODUCTION

This seismic survey took place to investigate subsurface conditions at the site of the proposed Millstone Nuclear Power Plant at Millstone Point in the Town of Waterford, Connecticut. Lines of investigation were located in the proposed plant area, along the proposed cooling water intake, and proposed discharge alignments.

PURPOSE AND LOCATION

The purpose of this study was to determine velocities and depths of subsurface materials and to prepare a map of bedrock contours in the site area, based on seismic survey data.

The locations of the seismic lines in the plant site area, shown on Sheet 1, were affected by buildings and construction equipment. The locationing of the seismic lines in the field was accomplished by Weston Geophysical Engineers, Inc. using the buildings and other landmarks shown on plans of the site provided by the Northeast Utilities Service Company. Seismic field work in the plant site area was conducted at night to avoid the noise caused by construction activity on Unit No. 2.

The locations of the seismic lines along the intake and discharge areas, shown on Sheet 2, were based on survey alignments provided by the Northeast Utilities Service Company. The amount of field work which could be accomplished along the discharge line was limited by buildings, construction equipment,and underground utilities in the proposed plant site area.

FIELD PROCEDURES

A twelve-channel, photographic recording seismic refraction system with continuous profiling technique was used in this study. Seismic energy was generated with explosives along the intake and discharge areas and along those lines designated "SD" in the plant site area. Augered shot holes were used in the plant site area, in the parking lot portion of the intake, and along the portion of the discharge nearest to the site. Seismic energy for those lines designated "S" or "W" in the plant site area was generated by using a drill rig to drop a 600 pound weight from a height of 20 to 25 feet.

Seismic spreads 200 feet in length with 20-foot geophone intervals and three 10-foot intervals on each end of the geophone cable were used for more accurate overburden control. Because of the existing utilities, parking lot, etc., in the plant site, discharge and intake areas, overlapped spreads and crosslines were used rather than the normally employed quarter shots.

RESULTS

The results of the seismic survey are shown on the profile plates of this report. Ground surface profiles were constructed from topographic data supplied by the Northeast Utilities Service Company and from field observations. Shown on the profile sections are depths to seismic discontinuities based on measured seismic velocities. The seismic bedrock profiles were used to construct the bedrock contour map.

Discussion of Results

Using seismic data alone, materials are placed into broad classifications based on the velocity of the seismic wave transmitted through them. Each velocity value does not have a unique material correlation, but most overburden and bedrock types fall within particular velocity ranges.

Since the seismic velocity is determined by the modulus of elasticity and the density of the material, the magnitude of velocity is an indicator to some extent of the "behavior" of the material for design and excavation purposes.

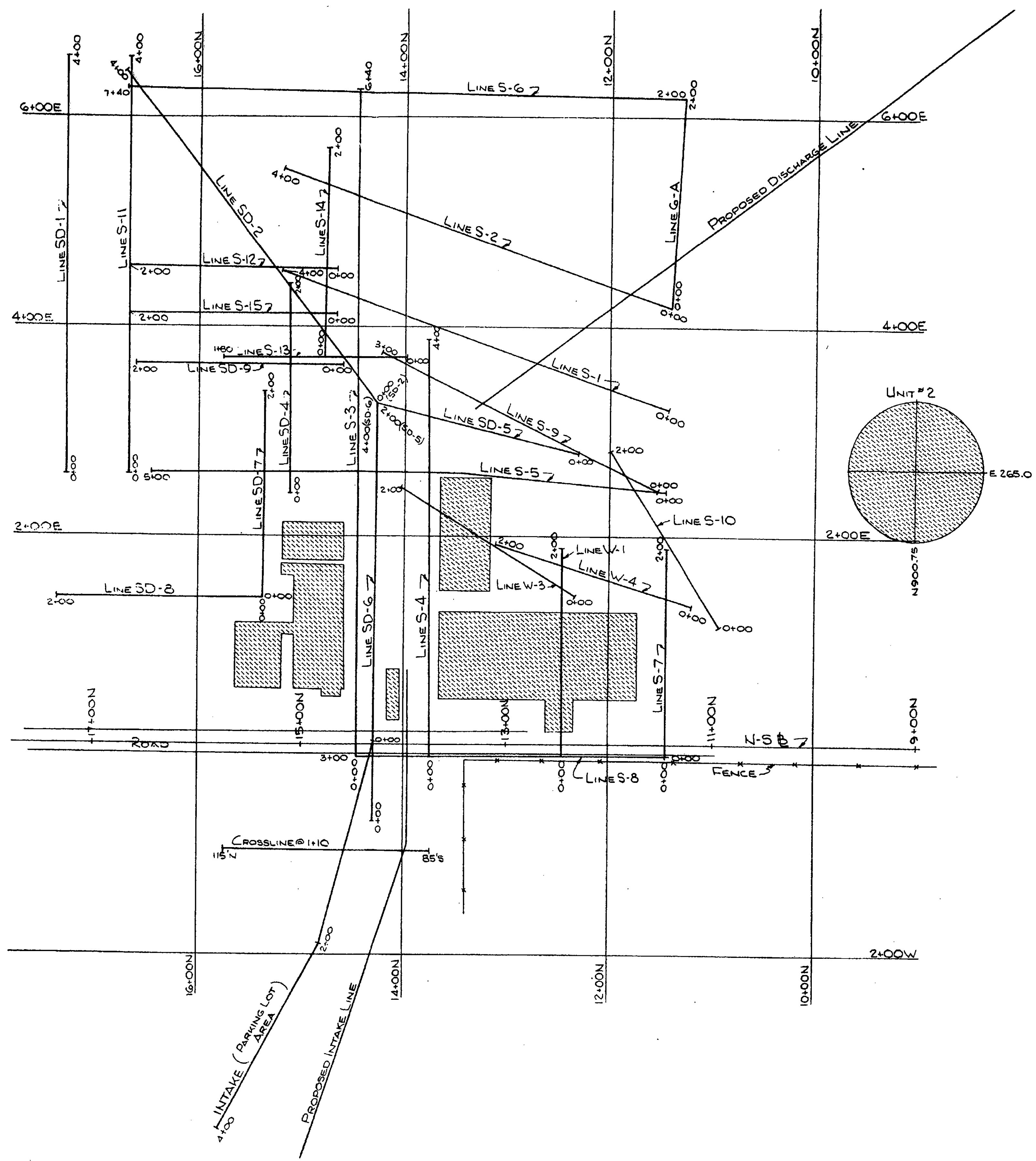
The seismic velocity of the near-surface, overburden material is 1,500 ft./sec. to 2,000 ft./sec. (V_1) which is indicative of a loose, unconsolidated material.

The seismic velocity range of 5,000 ft./sec. to 5,600 ft./sec. (V_{2a}) is indicative of two types of overburden materials: water saturated overburden material; moderately dense glacial till. The seismic velocity of 6,700 ft./sec. (V_{2b}) is indicative of a very dense glacial till.

The velocity values of the till were determined by the closely spaced seismic cross hole velocity measurements in a series of test borings in the vicinity of 14 + 00 N. 1 + 00 E. Boring data should be referred to for more accurate identification of these overburden materials.

Locations where the recorded seismic data did not allow for a straightforward interpretation are indicated on the profile sections by dashed lines.

Since seismic methods present average conditions over 200-foot segments, localized rises and depressions may be undetected. For the preparation of the bedrock contour map, it was necessary to generalize and interpolate data; accordingly, the contour map should be used judiciously.

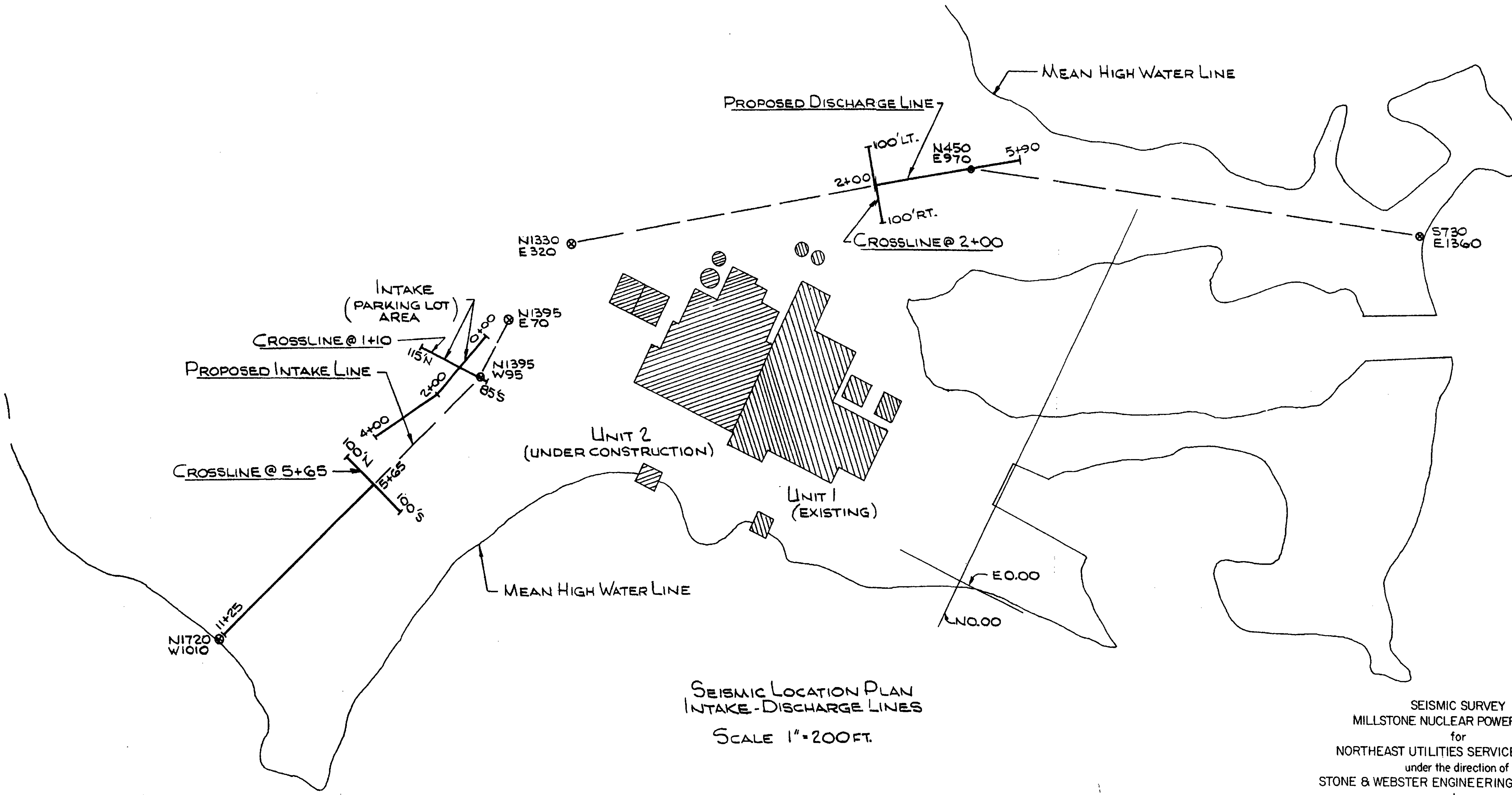


0 50 100 150 200 FT

SCALE

SEISMIC SURVEY
MILLSTONE NUCLEAR POWER PLANT
for
NORTHEAST UTILITIES SERVICE COMPANY
under the direction of
STONE & WEBSTER ENGINEERING CORPORATION
by
WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 1 OF 8



Seismic Location Plan
Intake - Discharge Lines

Scale 1" = 200 ft.

SEISMIC SURVEY
MILLSTONE NUCLEAR POWER PLANT
for
NORTHEAST UTILITIES SERVICE COMPANY
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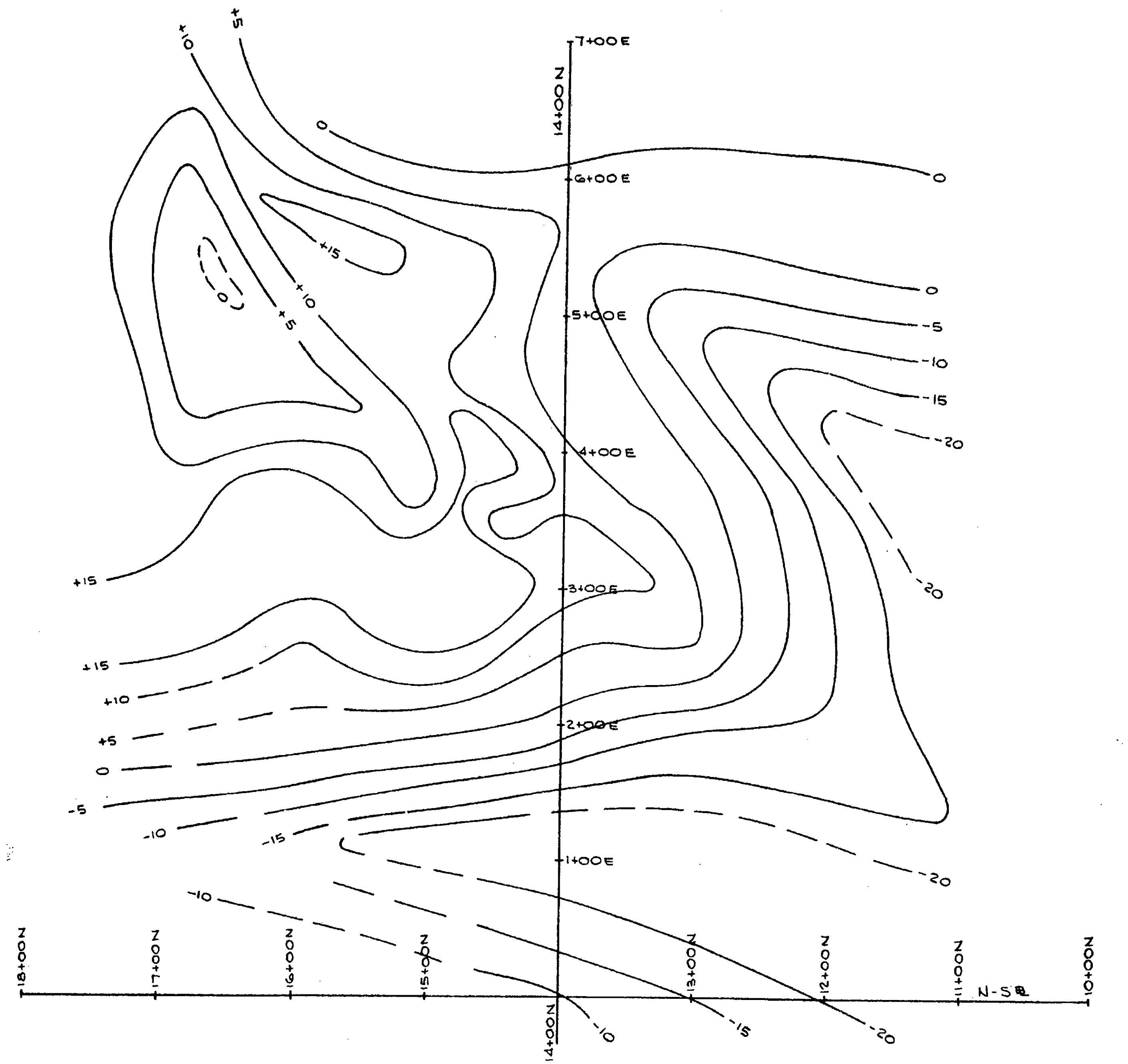
by
WESTON GEOPHYSICAL ENGINEERS, INC.

Sheet 2 of 8



LEGEND

Contour of top of rock. (Vel. = 12,000± ft/sec)

Signifies uncertain data where rock could be deeper than shown.

<u>Note</u>: Contours are based on seismic survey profiling.

SEISMIC SURVEY
MILLSTONE NUCLEAR POWER PLANT
for
NORTHEAST UTILITIES SERVICE COMPANY
under the direction of
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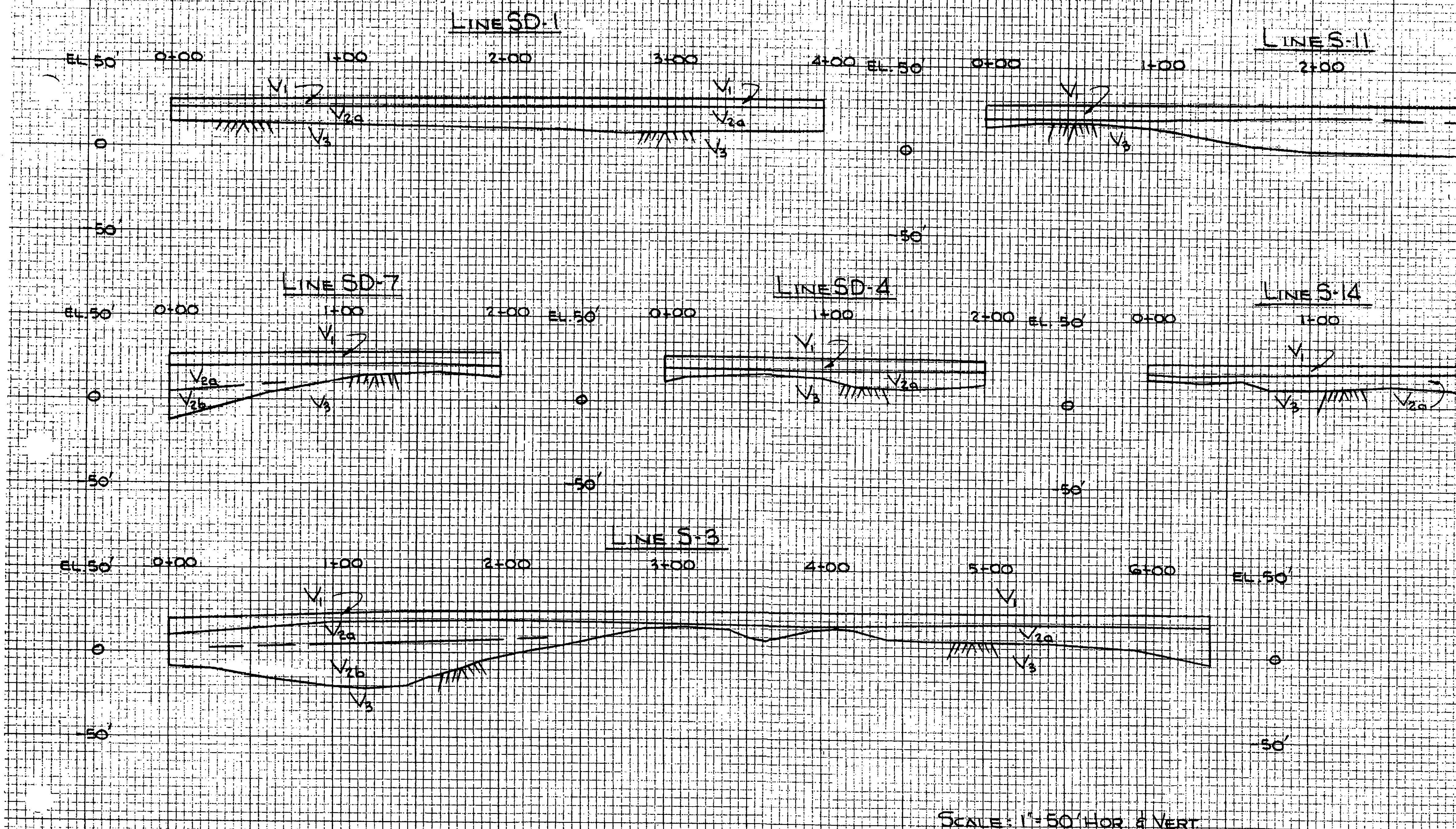
by
WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 3 OF 8



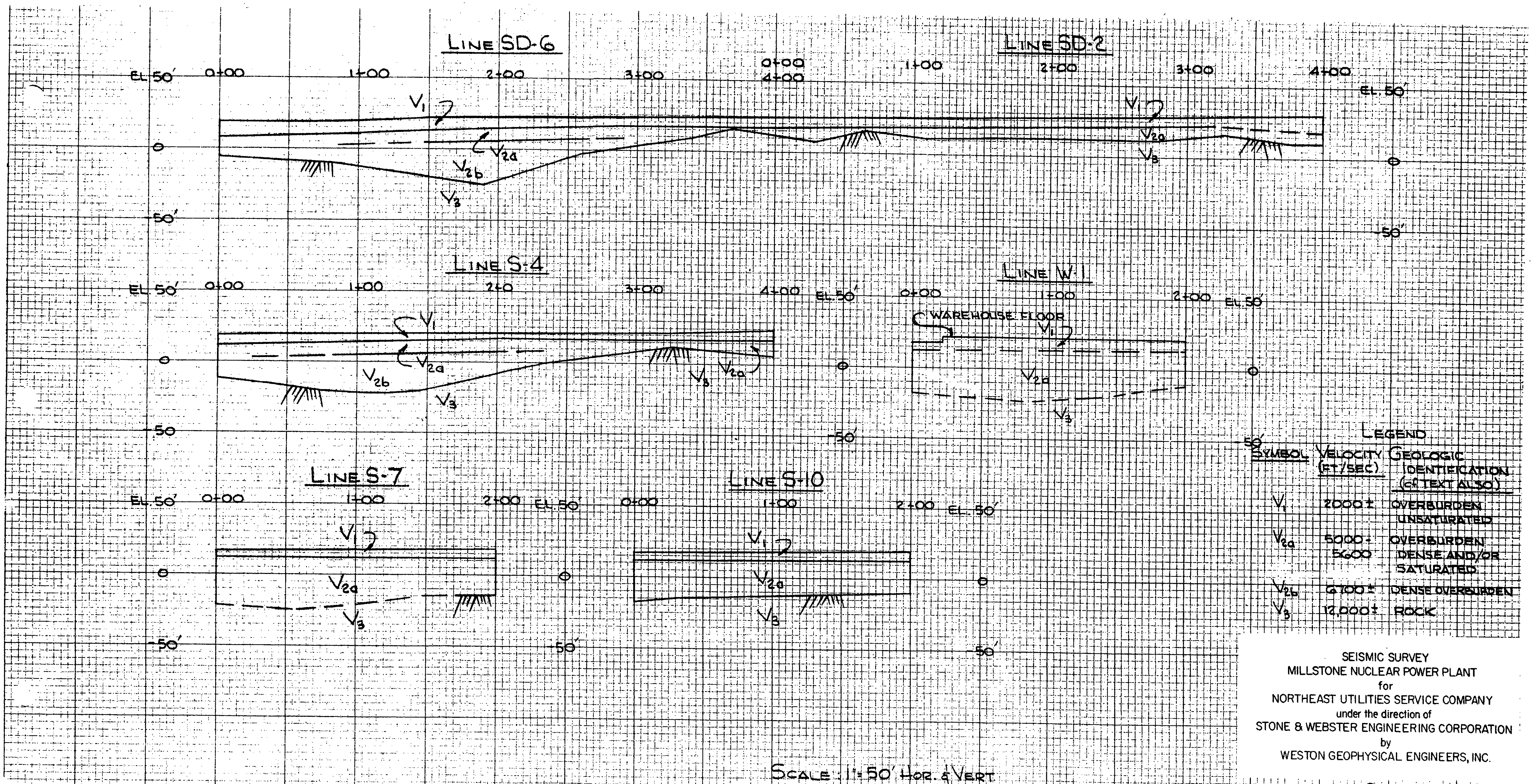
LEGEND

SYMBOL	VELOCITY (FT/SEC)	GEOLOGIC IDENTIFICATION (cf. TEXT ALSO)
V_1	2000±	OVERBURDEN UNSATURATED
V_{2a}	5000-5600	OVERBURDEN DENSE AND/OR SATURATED
V_{2b}	6700±	DENSE OVERBURDEN
V_3	12,000±	ROCK

SCALE: 1"=50' HOR & VERT.

SEISMIC SURVEY
MILLSTONE NUCLEAR POWER PLANT
for
NORTHEAST UTILITIES SERVICE COMPANY
under the direction of
STONE & WEBSTER ENGINEERING CORPORATION
by
WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 4 OF 8



SEISMIC SURVEY
MILLSTONE NUCLEAR POWER PLANT
for
NORTHEAST UTILITIES SERVICE COMPANY
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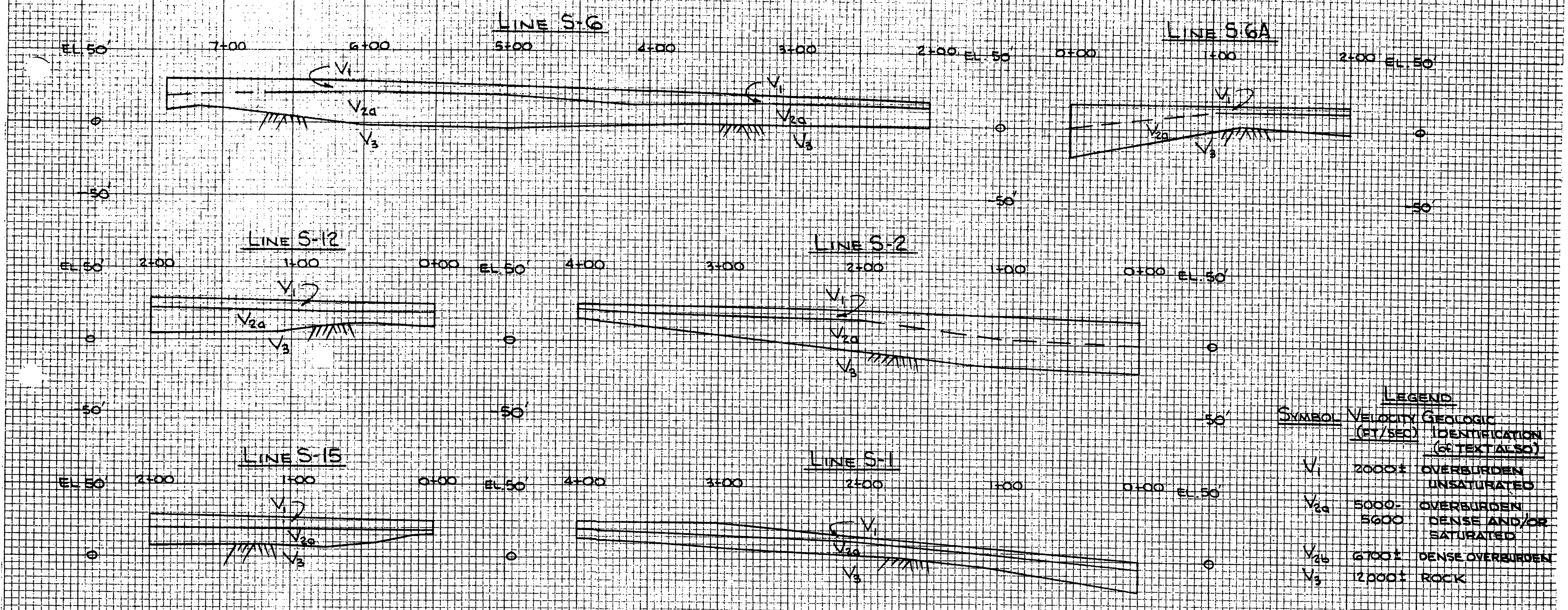
SHEET 5 OF 8



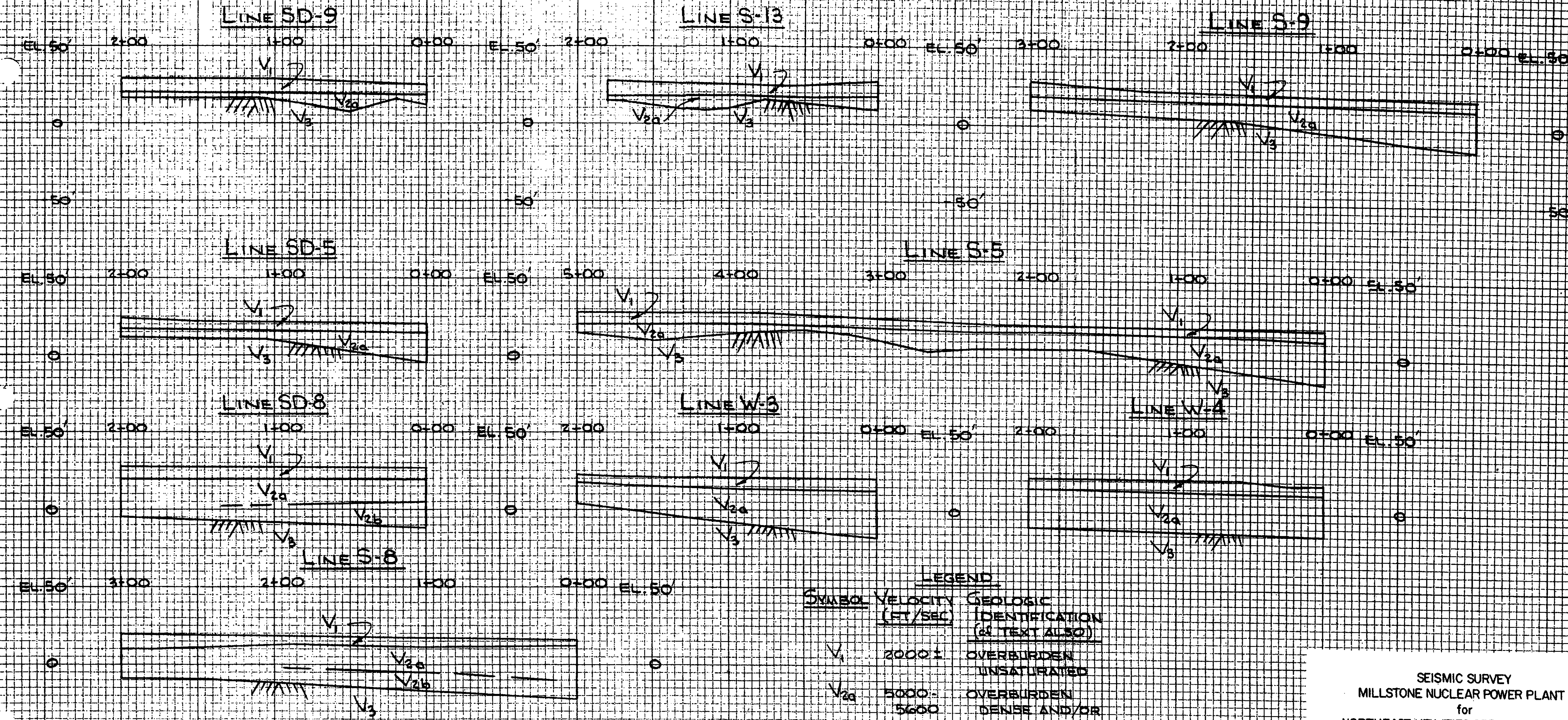
LEGEND

SYMBOL	VELOCITY (FT/SEC)	GEOLOGIC IDENTIFICATION (SEE TEXT ALSO)
V_1	2000±	OVERBURDEN UNSATURATED
V_{2a}	5000-5600	OVERBURDEN DENSE AND/OR SATURATED
V_{2b}	6700±	DENSE OVERBURDEN
V_3	12000±	ROCK

SCALE: 1" = 50' HOR. & VERT.

SEISMIC SURVEY
MILLSTONE NUCLEAR POWER PLANT
for
NORTHEAST UTILITIES SERVICE COMPANY
under the direction of
STONE & WEBSTER ENGINEERING CORPORATION
by
WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 6 OF 8



LEGEND

SYMBOL	VELOCITY (FT/SEC)	GEOLOGIC IDENTIFICATION (& TEXT ALSO)
V_1	2000 ±	OVERBURDEN UNSATURATED
V_{2a}	5000-5600	OVERBURDEN DENSE AND/OR SATURATED
V_{2b}	6700 ±	DENSE OVERBURDEN
V_3	12,000 ±	ROCK

SCALE: 1" = 50' HOR. & VERT.

SEISMIC SURVEY
MILLSTONE NUCLEAR POWER PLANT
for
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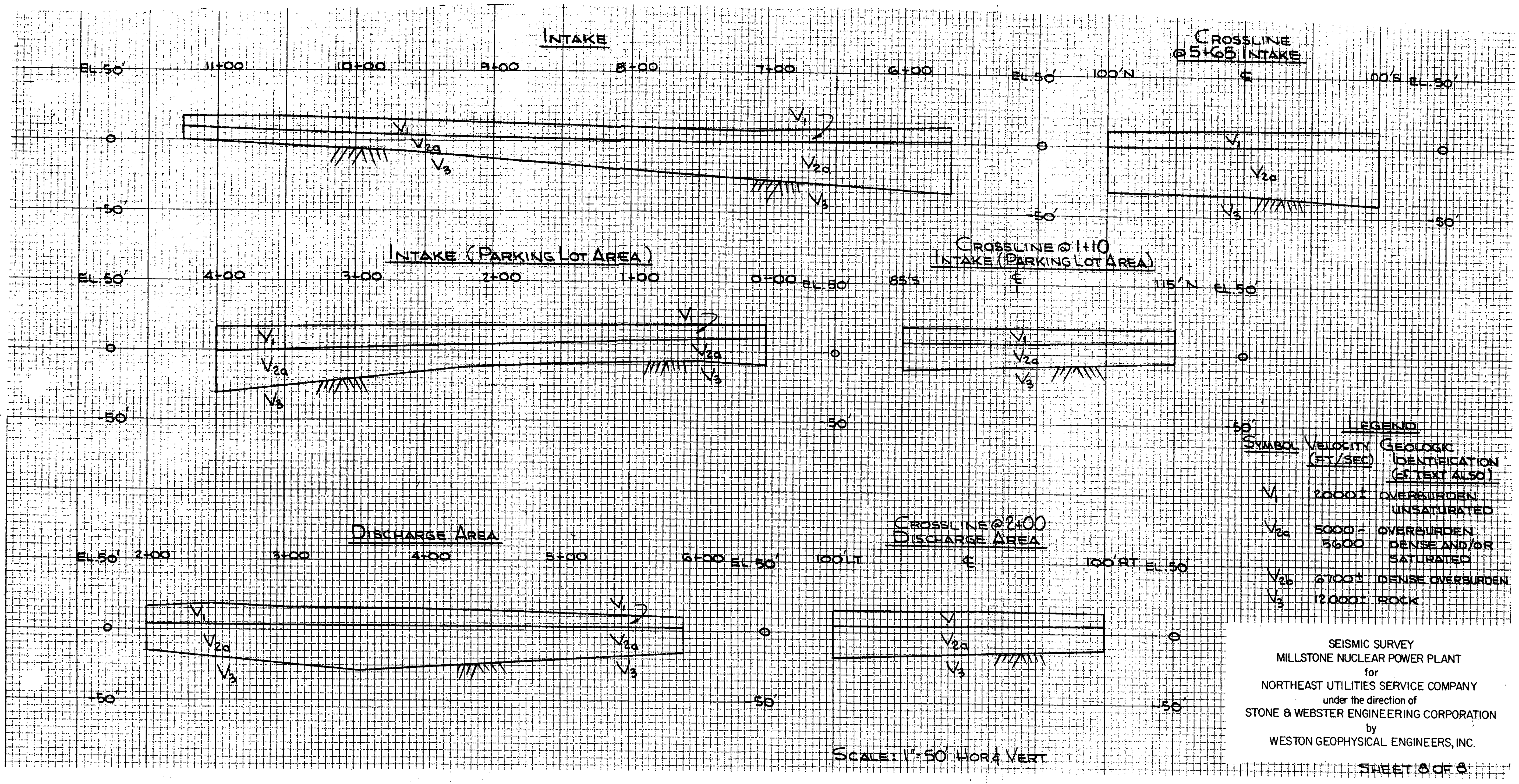
WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 7 OF 8



INTAKE
EL 50'
11+00
10+00
9+00
8+00
7+00
6+00
V1
V2a
V3
V2a
-50'
CROSSLINE @5+65 INTAKE
EL 50'
100'N
100'S EL 50'
V1
V2a
V3
INTAKE (PARKING LOT AREA)
EL 50'
4+00
3+00
2+00
1+00
0+00 EL 50'
CROSSLINE @1+10 INTAKE (PARKING LOT AREA)
85'S
115'N EL 50'
DISCHARGE AREA
EL 50' 2+00
3+00
4+00
5+00
6+00 EL 50'
CROSSLINE @2+00 DISCHARGE AREA
100'LT
100'RT EL 50'
SCALE: 1"=50' HOR & VERT
LEGEND
SYMBOL VELOCITY (FT/SEC) GEOLOGIC IDENTIFICATION (Cf. TEXT ALSO)
V1 2000± OVERBURDEN UNSATURATED
V2a 5000-5600 OVERBURDEN DENSE AND/OR SATURATED
V2b 6700± DENSE OVERBURDEN
V3 12000± ROCK
SEISMIC SURVEY
MILLSTONE NUCLEAR POWER PLANT
for
NORTHEAST UTILITIES SERVICE COMPANY
under the direction of
STONE & WEBSTER ENGINEERING CORPORATION
by
WESTON GEOPHYSICAL ENGINEERS, INC.
SHEET 8 OF 8

APPENDIX 2.5L

SEISMIC AND BATHYMETRIC SURVEY

June 1972

Weston Geophysical Engineers, Inc.
Weston, Massachusetts

WESTON GEOPHYSICAL ENGINEERS, INC.
POST OFFICE BOX 306
WESTON, MASSACHUSETTS 02193
617 899 0060

June 13, 1972

Stone & Webster Engineering Corporation
225 Franklin Street
Boston, Massachusetts 02107

Gentlemen:

In accordance with your Purchase Order Number E-9909, Job Number 12179, dated October 15, 1971, a seismic and bathymetric survey was conducted in the vicinity of Millstone Point, Connecticut, during the period of November 1971 through February 1972.

Preliminary data have been submitted; this is a formal presentation of our findings.

Very truly yours,

WESTON GEOPHYSICAL ENGINEERS, INC.

Richard J. Holt

Richard J. Holt

RJH:jh

SEISMIC AND BATHYMETRIC SURVEY

MILLSTONE POINT, CONNECTICUT

for

STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

WESTON, MASSACHUSETTS

SEISMIC AND BATHYMETRIC SURVEY

MILLSTONE POINT, CONNECTICUT

INTRODUCTION AND PURPOSE

A seismic and bathymetric survey was completed during the period of November, 1971 through February, 1972, in the vicinity of Millstone Point, Connecticut.

The purpose of the survey was to contour the bottom and the bedrock surface in areas of possible future intake and discharge structures.

DESCRIPTION OF SURVEY

The bathymetric survey was conducted using a continuous recording fathometer. Calibration was constantly checked during the period of this survey. The instrument error is less than 0.5 percent. The continuous recordings of this instrumentation, adjusted for tidal variations, were used to construct the bottom contour maps included in this report.

The seismic survey was conducted using both seismic refraction and seismic reflection techniques. Detailed profiling of the bedrock surface was obtained in some of the area using continuous reflection techniques. This method provides measurements of the elapsed travel time for a sound wave to travel to and return from a reflecting horizon.

Velocity values for the different materials, as determined from the seismic refraction survey, were used to compute depths to the reflecting horizons. Those areas where the continuous reflection profiling technique could not penetrate bottom materials are discussed in the following section of this report. The seismic refraction method yields velocity data for use in computing depths from the reflection data as well as indicating the type of overburden material and quality characteristics of the bedrock. The thicknesses of the overburden material above the bedrock are computed based on the relative velocities of the overburden and bedrock.

Seismic energy for the refraction survey was generated by means of an air gun in order to avoid danger to aquatic life. Energy for the continuous reflection survey was generated by means of an electromechanical device.

The approximate locations of the four areas of investigation as outlined by Stone & Webster Engineering Corporation are shown on Figure 1. Positioning for the bathymetric and seismic surveys was provided by Offshore Navigation, Inc., using a radio-navigation system consisting of a mobile base station on board the survey boat and transponders located at a combination of two or more fixed transponder stations as shown on Figures 2 through 5. The base station control for stations Bay Pcint, Millstone and Fox were provided by Northeast Utilities Service Company using the Millstone Plant grid system. The coordinates of station Attawan to an accuracy of ±9 feet were determined by Offshore Navigation, Inc. using the other three transponder stations and a number of Shoran three-way fixes.

RESULTS

The results of the bathymetric and seismic surveys for each of the four areas are shown on the contour maps included with this report. Also included in this report are location (track) maps for each of the four areas, describing the amount and density of the seismic coverage. The maps included in this report are indexed as follows:

Area	Bottom Contour Map	Generalized Bedrock Contour Map	Track Map
I	Sheet 1	Sheet 2	Sheet 3
II	Sheet 4	Sheet 5	Sheet 6
III	Sheet 7	Sheet 8	Sheet 9 & 9A
IV	Sheet 10	Sheet 11	Sheet 12

Velocities of the overburden material range from 5,000 ft./sec. to 5,400 ft./sec. which is indicative of saturated granular or silt-clay overburden material. Identification of this material should be made from borings since the seismic compressional wave velocity is indicative of the water media and not of the overburden material. The seismic velocities of the bedrock range from 11,000 ft./sec. to 13,000 ft./sec. which is indicative of sound bedrock. A seismic velocity of 7,000 ft./sec. to 8,000 ft./sec. was noted in a small section of Area IV. This velocity range can be indicative of weathered bedrock or dense glacial till.

The generalized bedrock contour maps were constructed from both seismic reflection and seismic refraction data in Area I as well as around and to the west of the 2,000 W. grid line in Area III. The continuous reflection profiler could not penetrate the bottom materials in the remainder of Area III and Areas II and IV. A relatively dense, near-surface overburden layer probably prevented penetration by the low energy continuous reflection method. The poor reflection areas were profiled by the seismic refraction method. The refraction data did not indicate any changes in the velocity of the overburden materials.

Shallow bedrock is indicated on the contour maps by hachured areas. Judicious use of the bedrock contour maps is warranted in those areas of shallow bedrock since the contours represent an "average" bedrock surface.

AREA OF OPERATIONS (APPROXIMATE)

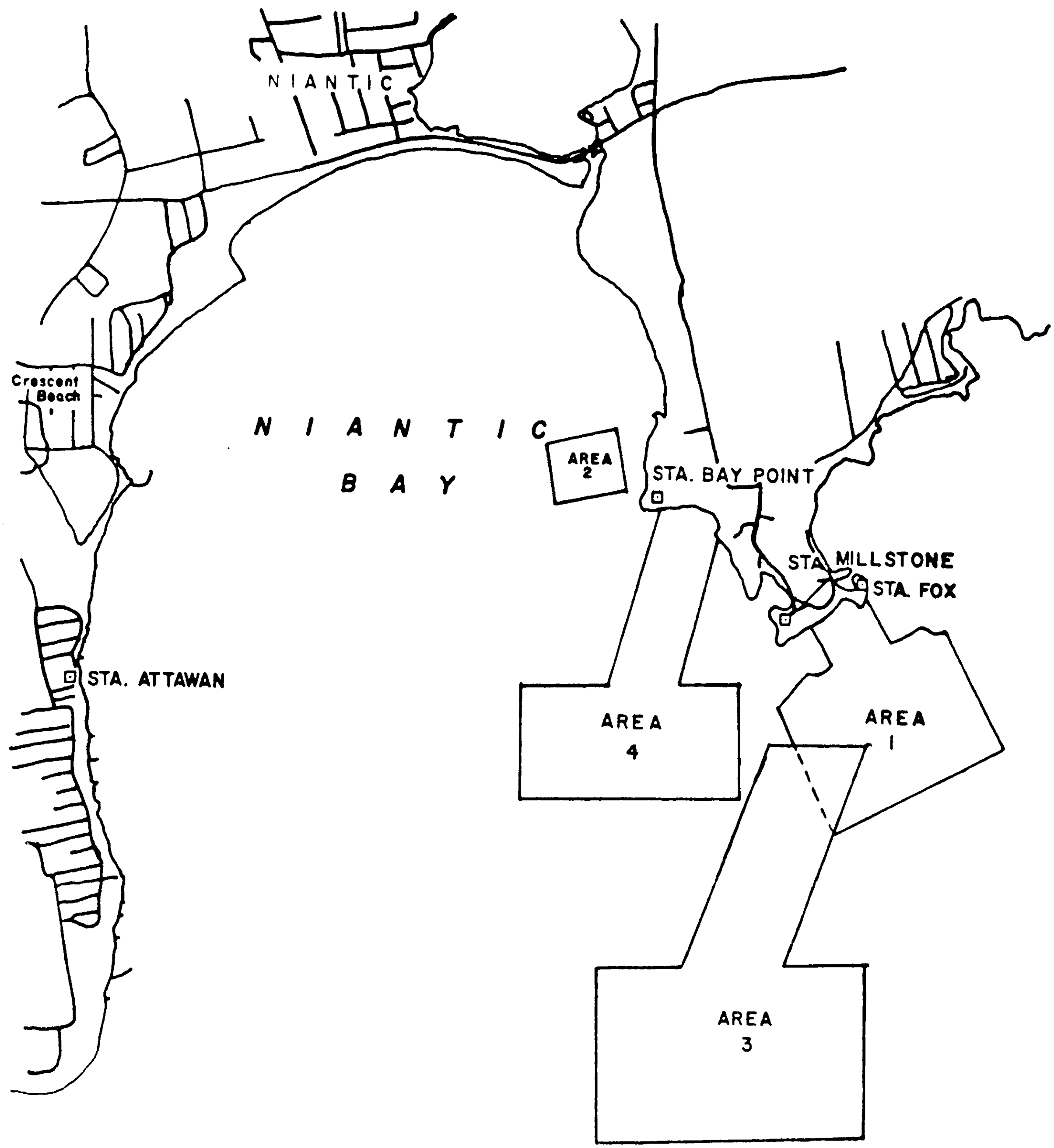


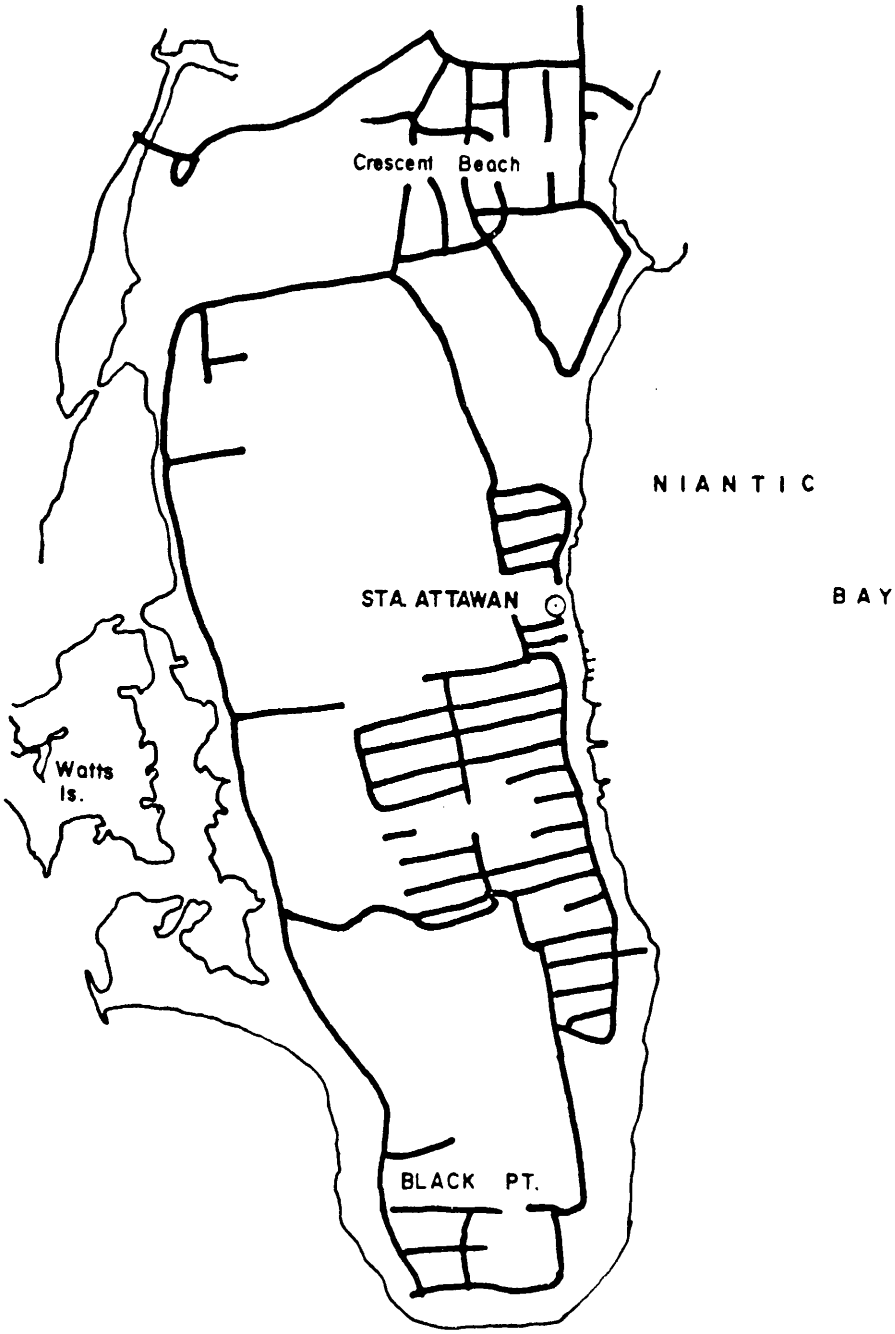
Figure 1

STA. ATTAWAN ——— CONNECTICUT

X = (–) 10,331 feet
Y = (+) 1,119 feet

ELEVATION: 20 feet

NORTHEAST UTILITIES GRID SYSTEM



LOCATION: Station Attawan is located near Niantic, Connecticut at the residence of Mr. Steve Toth, resident engineer of Northeast Utilities.

The station marker is the TV antenna located on the south side of the residence of Mr. Toth. The Hirex transponder was raised on a 20 foot aluminum pole and strapped to the TV antenna.

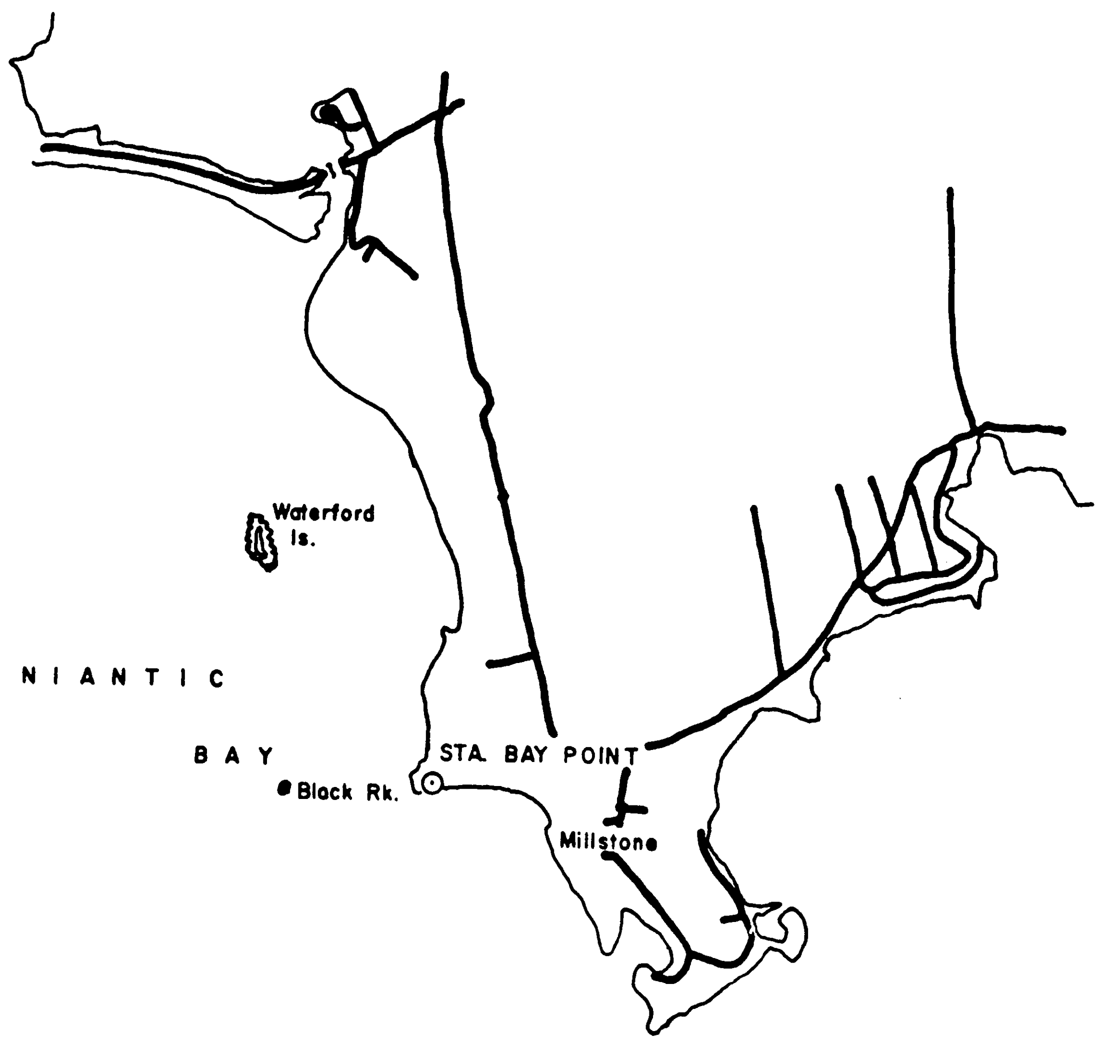
Figure 2

STA. BAY POINT——— CONNECTICUT

X = (–) 1,185 feet
Y = (+) 1,317 feet

ELEVATION: 60 feet

NORTHEAST UTILITIES GRID SYSTEM



LOCATION: Station Bay Point is located at Bay Point, Connecticut near the Millstone Point Power Station.

The station marker is a brown four by four that extends 18 inches above the ground. It is located adjacent to the last manhole cover on Bay Point on the southern tip of the point.

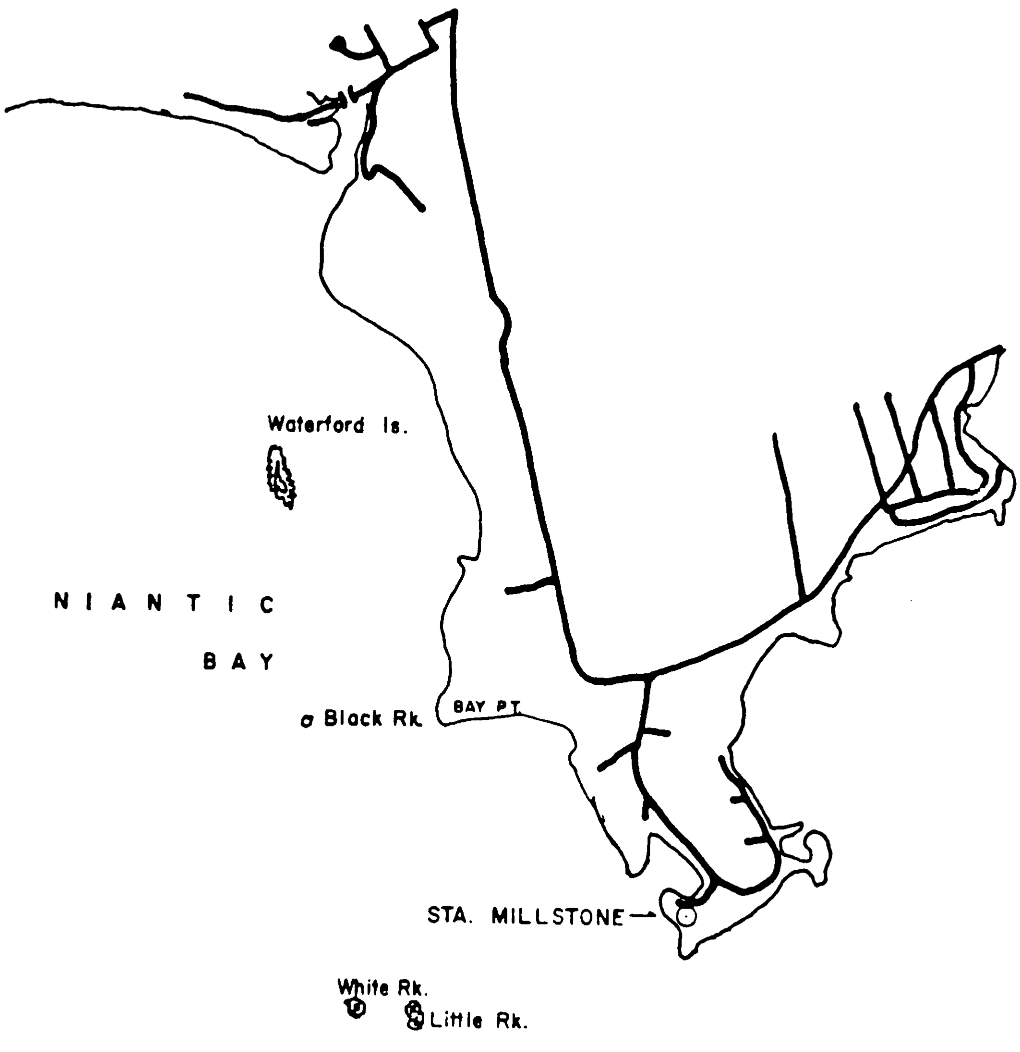
Figure 3

STA. MILLSTONE —— CONNECTICUT

X = (+) 441 feet
Y = (−) 894 feet

ELEVATION: 50 feet

NORTHEAST UTILITIES GRID SYSTEM



LOCATION: Station Millstone is located at Millstone Point, Connecticut on the 150 foot weather tower.

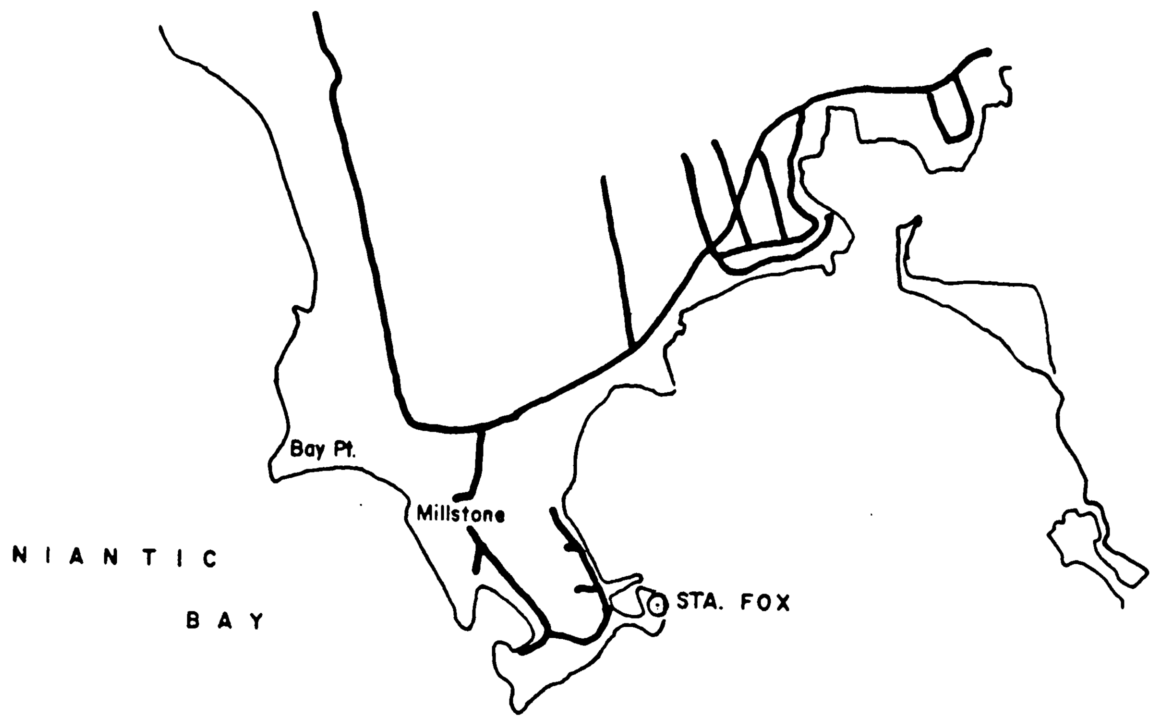
Figure 4

STA. FOX —————— CONNECTICUT

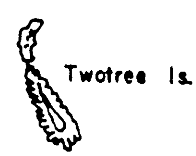
X = (+) 1,741 feet
Y = (–) 705 feet

ELEVATION: 25 feet

NORTHEAST UTILITIES GRID SYSTEM

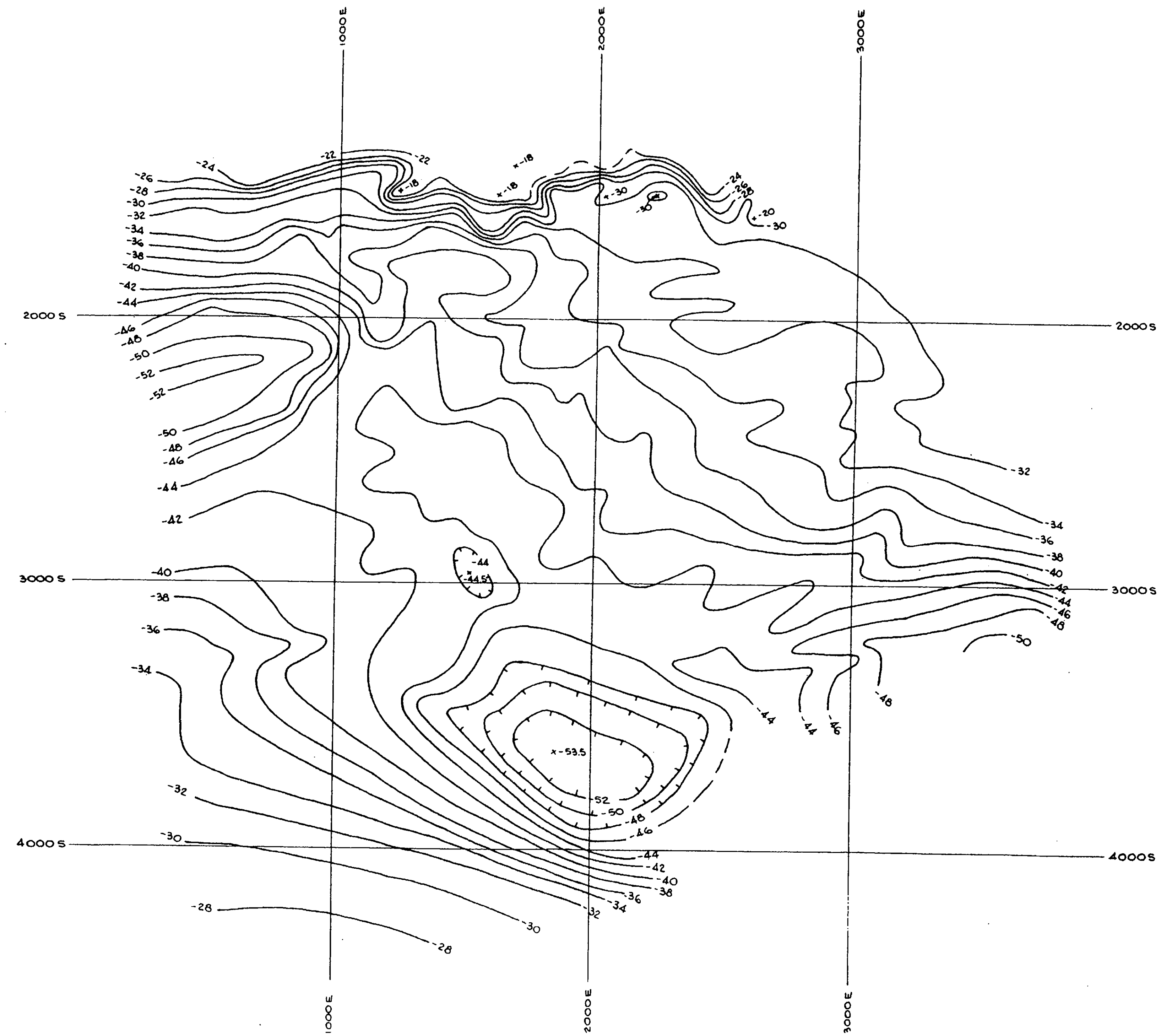


LOCATION: Station Fox is located on Fox Island, near Millstone Point, Connecticut. Fox Island and Millstone Point are now one land mass.



The station is marked by a concrete disk 6 inches in diameter flush with the ground with a half inch bolt protruding 4 inches above the surface of the ground. The marker is inscribed "ONI 72".

Figure 5



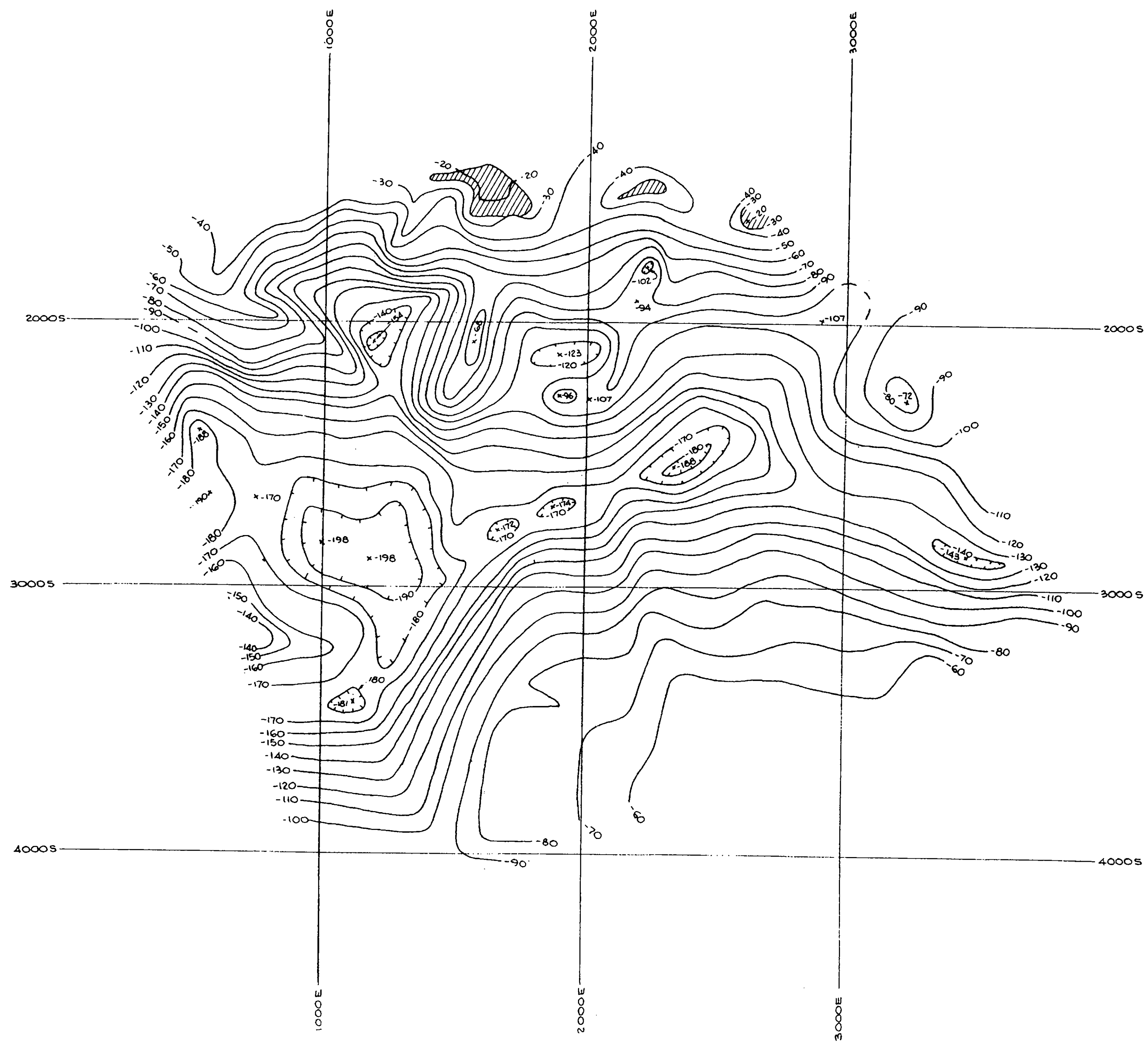
ELEVATIONS BASED ON MEAN LOW WATER DATUM.

CO-ORDINATES IN TERMS OF MILLSTONE PLANT GRID SYSTEM.

CONTOUR INTERVAL: 2 FEET.

0 500 1000 FEET

BOTTOM CONTOUR MAP
AREA I
BATHYMETRIC SURVEY
MILLSTONE POINT, CONNECTICUT
for
STONE & WEBSTER ENGINEERING CORPORATION
by
WESTON GEOPHYSICAL ENGINEERS, INC.
SHEET 1 OF 12



OVERBURDEN THICKNESS 0-5 FT.

ELEVATIONS BASED ON MEAN LOW WATER DATUM.

CO-ORDINATES IN TERMS OF MILLSTONE PLANT GRID SYSTEM.

CONTOUR INTERVAL: 10 FEET.

0 500 1000 FEET

GENERALIZED BEDROCK CONTOUR MAP

AREA I

SEISMIC SURVEY

MILLSTONE POINT, CONNECTICUT

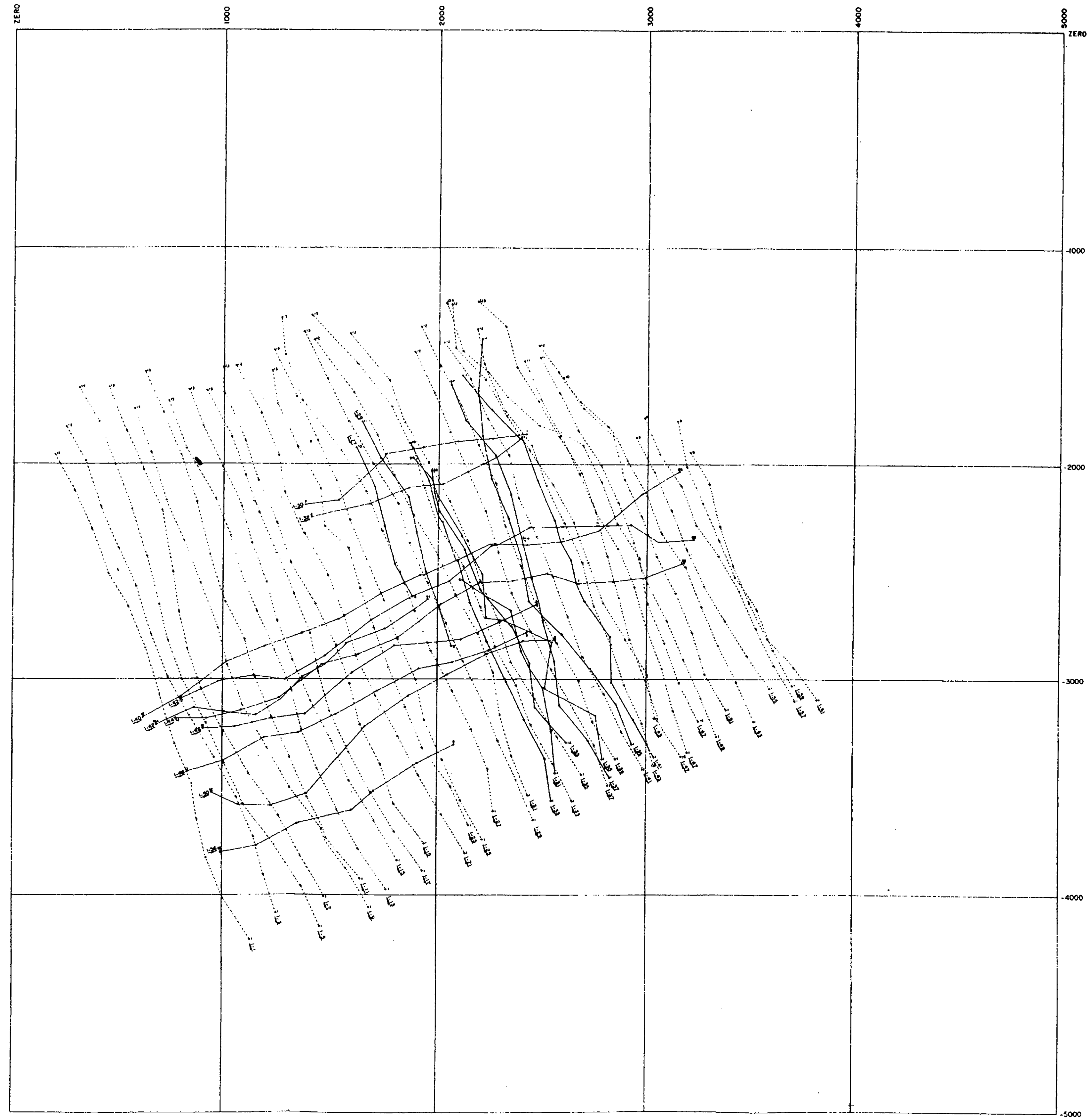
for

STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 2 OF 12



0 500 1000 FT.

Sta. ATTAWAN X= -10,331 Y= 1,119
Sta. FOX X= 1,741 Y= -703
— REFRACTION SURVEY 16.5 FT. STEPBACK APPLIED.
— REFLECTION SURVEY 50.0 FT. STEPBACK APPLIED.

TRACK MAP

BATHYMETRIC AND SEISMIC SURVEY

AREA I

MILLSTONE POINT, CONNECTICUT

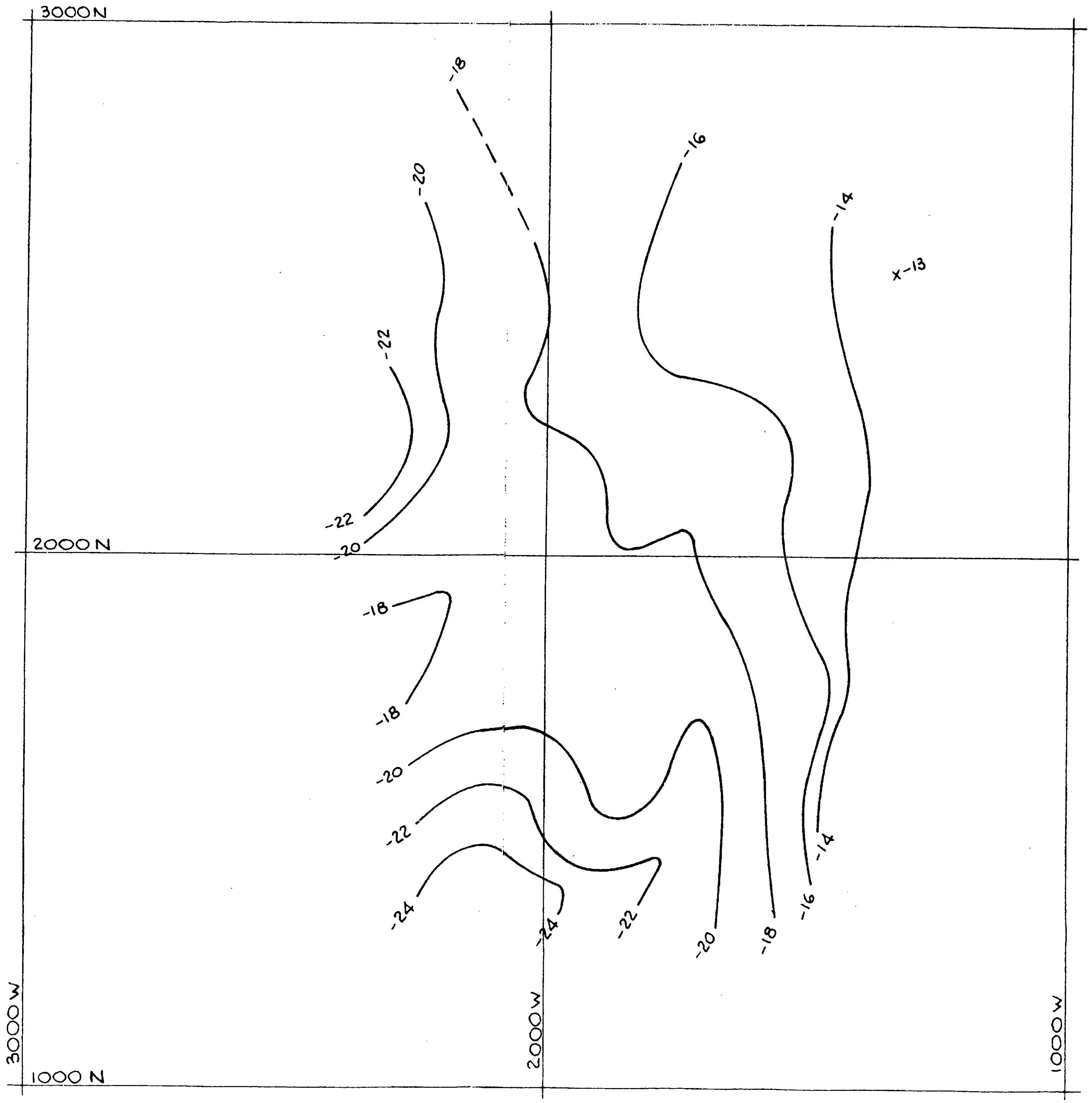
for

STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 3 OF 12



ELEVATIONS BASED ON MEAN LOW WATER DATUM.

CO-ORDINATES IN TERMS OF MILLSTONE PLANT GRID SYSTEM.

CONTOUR INTERVAL: 2 FEET.

BOTTOM CONTOUR MAP

AREA II

BATHYMETRIC SURVEY

MILLSTONE POINT, CONNECTICUT

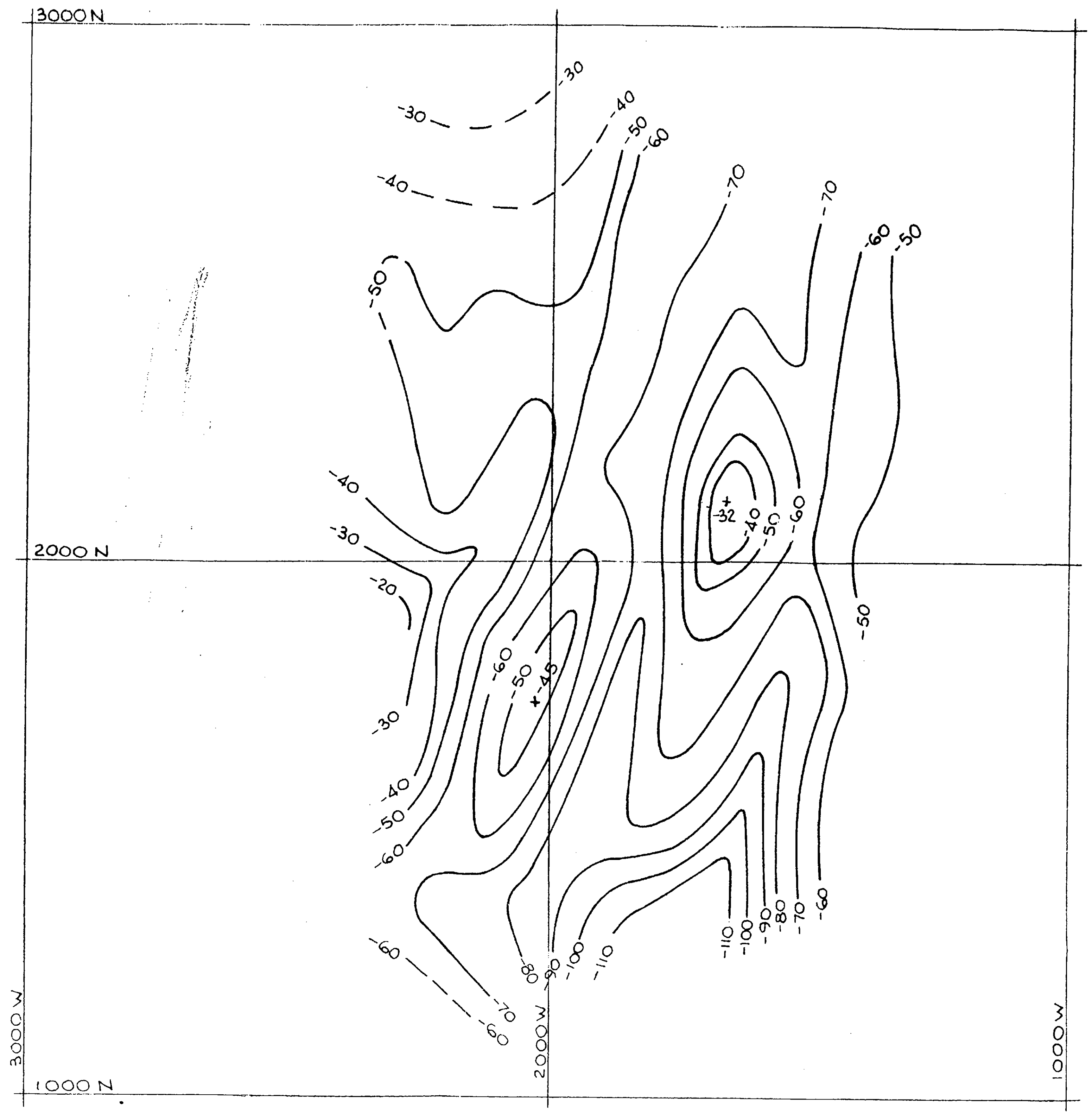
for

STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 4 OF 12



ELEVATIONS BASED ON MEAN LOW WATER DATUM.

CO-ORDINATES IN TERMS OF MILLSTONE PLANT GRID SYSTEM.

CONTOUR INTERVAL: 10 FEET.

GENERALIZED BEDROCK CONTOUR MAP

AREA II

SEISMIC SURVEY

MILLSTONE POINT, CONNECTICUT

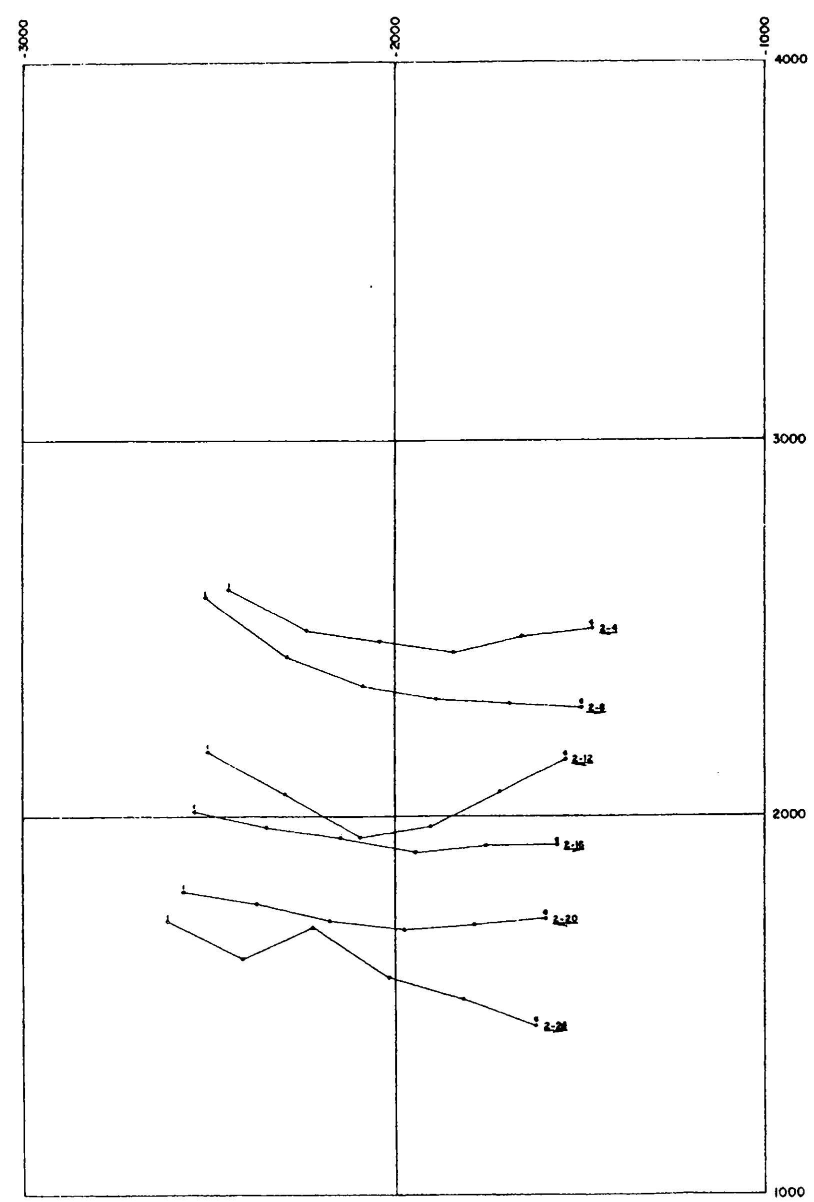
for

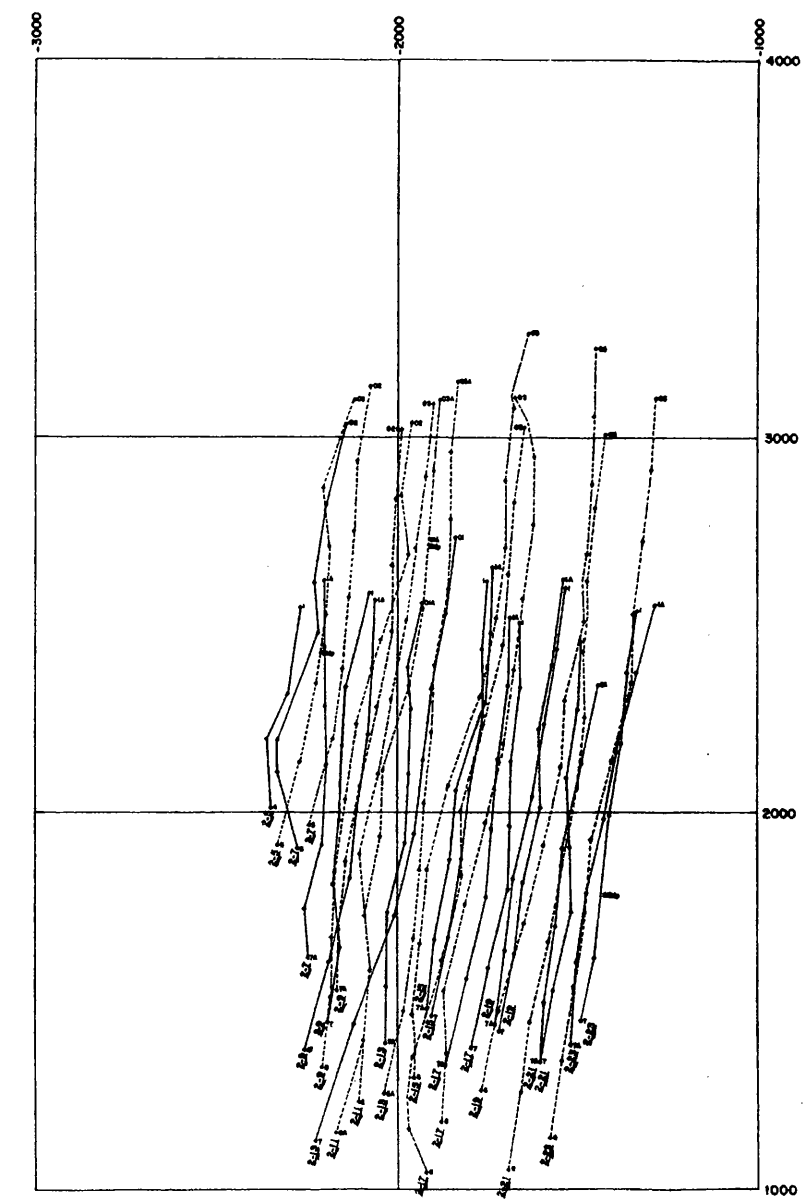
STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 5 OF 12





0 500 1000 FT

Sta. ATTAWAN X= -10,331 Y= 1,119

Sta. MILLSTONE X= 441 Y= -694

—•— FATHOMETER SURVEY NO STEP-BACK APPLIED.
—•— REFRACTION SURVEY 16.6 FT STEP-BACK APPLIED.
--•-- REFLECTION SURVEY 500 FT STEP-BACK APPLIED.

TRACK MAP

BATHYMETRIC AND SEISMIC SURVEY

AREA II

MILLSTONE POINT, CONNECTICUT

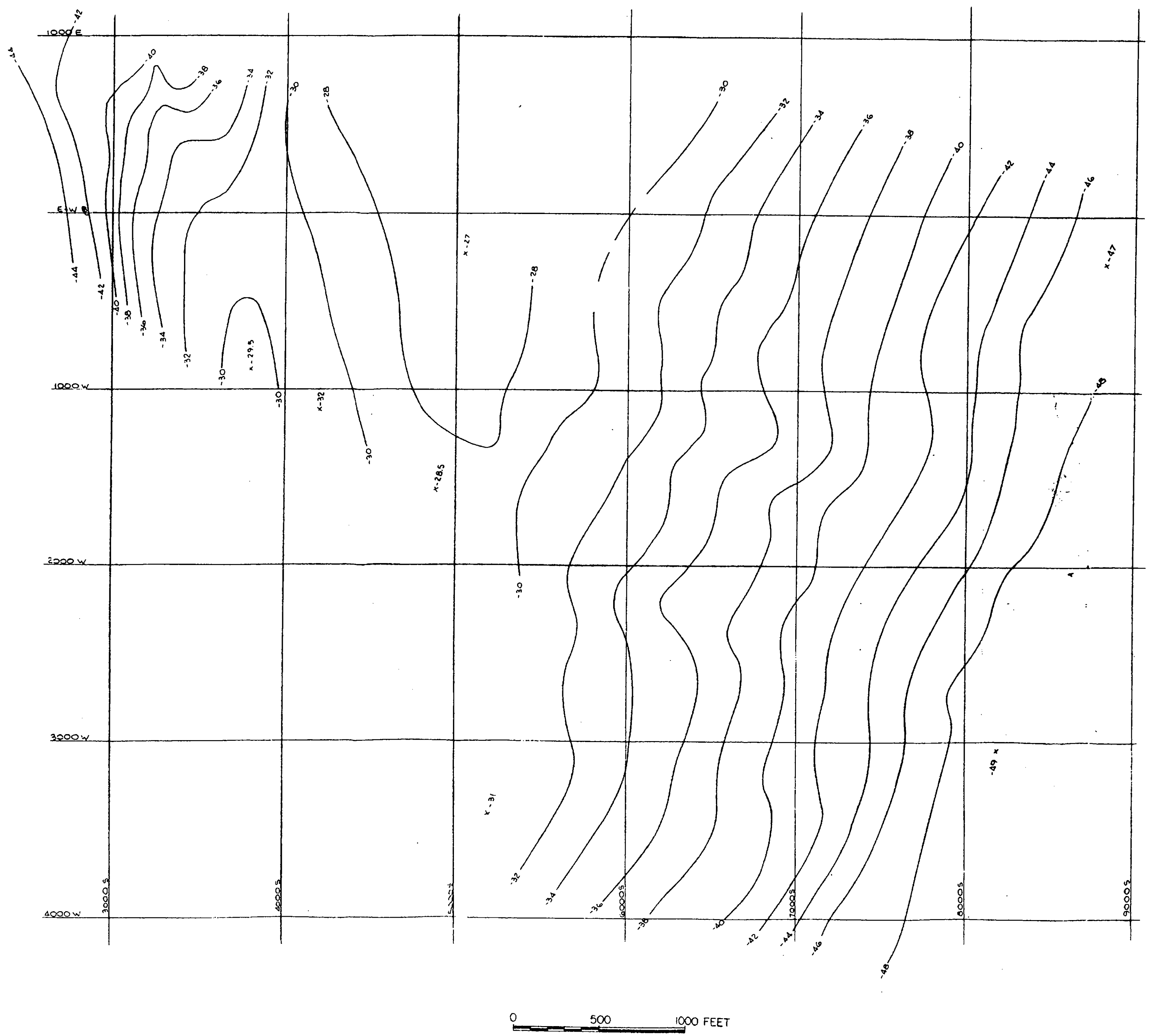
for

STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 6 OF 12



ELEVATIONS BASED ON MEAN LOW WATER DATUM.

CO-ORDINATES IN TERMS OF MILLSTONE PLANT GRID SYSTEM.

CONTOUR INTERVAL: 2 FEET.

BOTTOM CONTOUR MAP

AREA III

BATHYMETRIC SURVEY

MILLSTONE POINT, CONNECTICUT

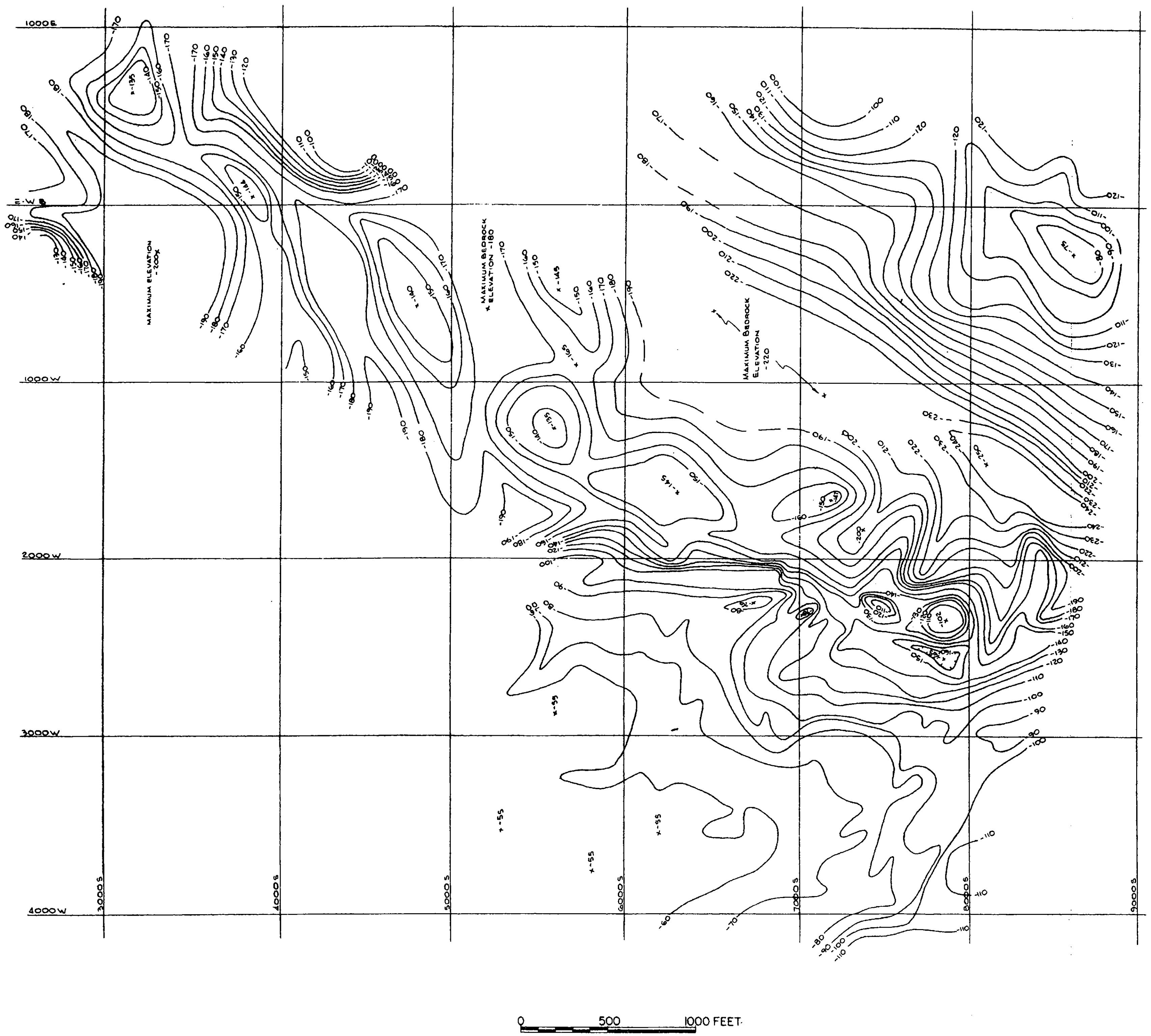
for

STONE & WEBSTER ENGINEERING CORPORAT,

by

WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 7 OF 12



ELEVATIONS BASED ON MEAN LOW WATER DATUM.

CO-ORDINATES IN TERMS OF MILLSTONE PLANT GRID SYSTEM.

CONTOUR INTERVAL: 10 FEET.

GENERALIZED BEDROCK CONTOUR MAP

AREA III

SEISMIC SURVEY

MILLSTONE POINT, CONNECTICUT

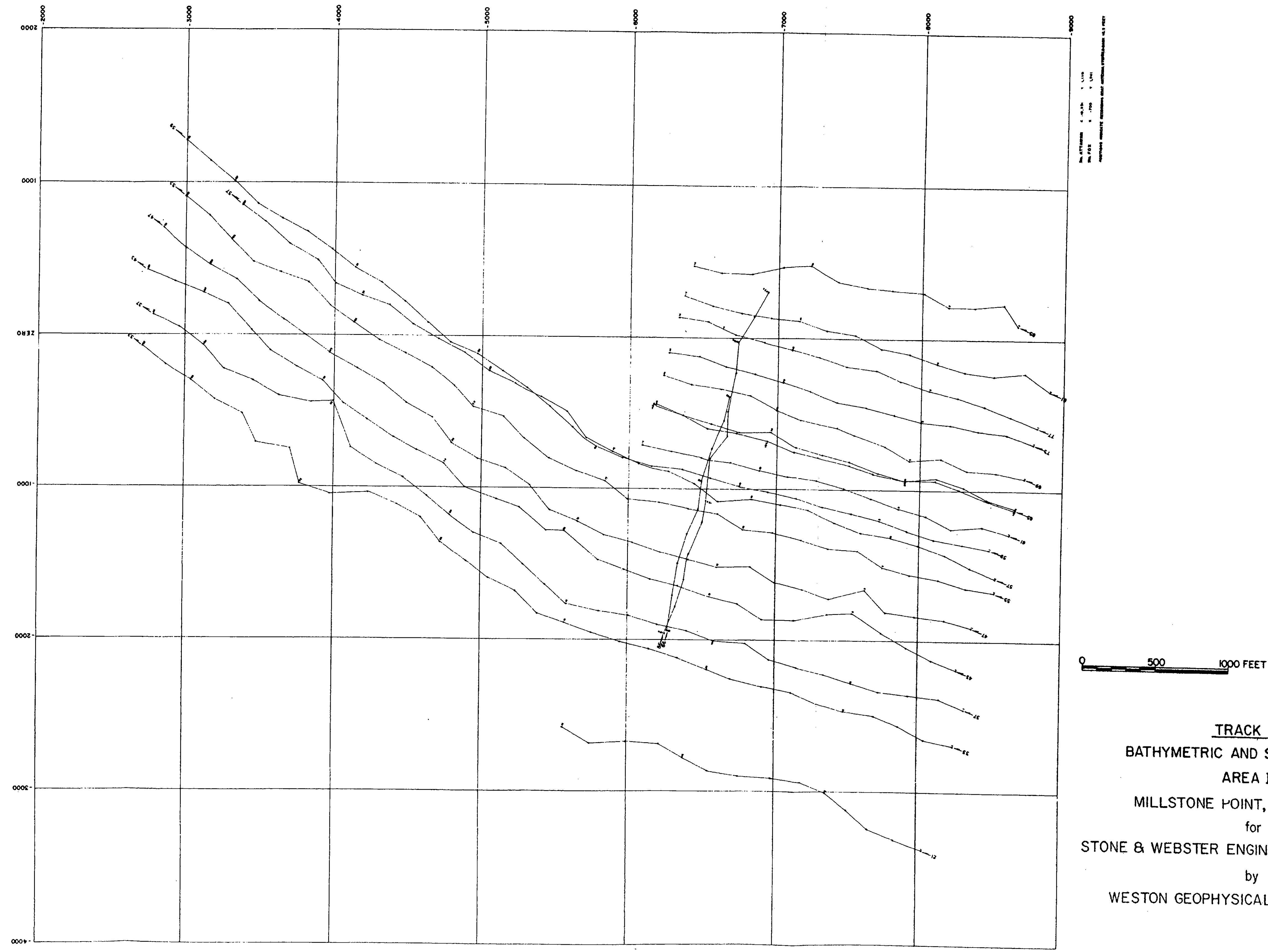
for

STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 8 OF 12



TRACK MAP

BATHYMETRIC AND SEISMIC SURVEY

AREA III

MILLSTONE POINT, CONNECTICUT

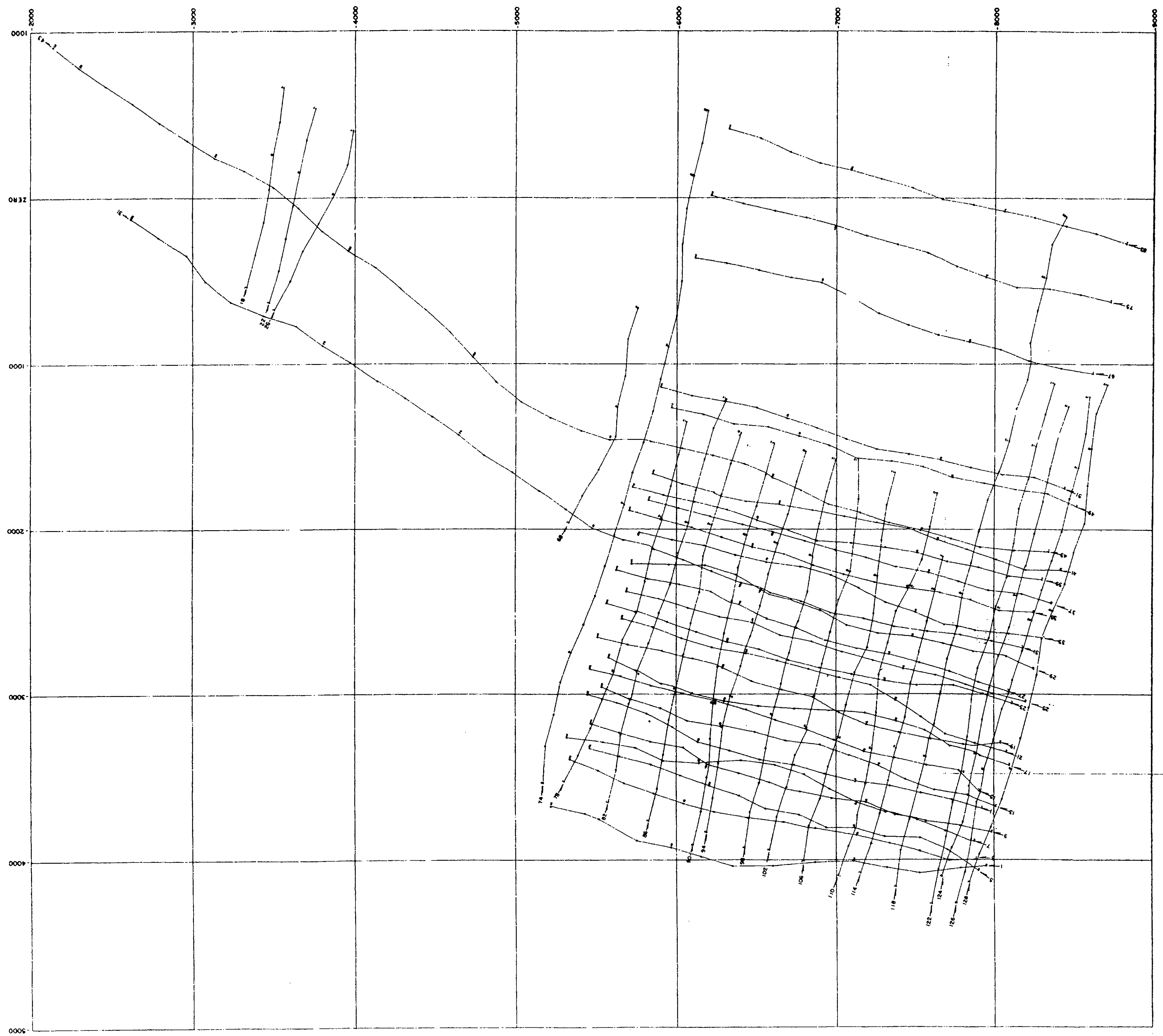
for

STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 9 OF 12



0 500 1000 FT.

TRACK MAP

BATHYMETRIC AND SEISMIC SURVEY

AREA III

MILLSTONE POINT, CONNECTICUT

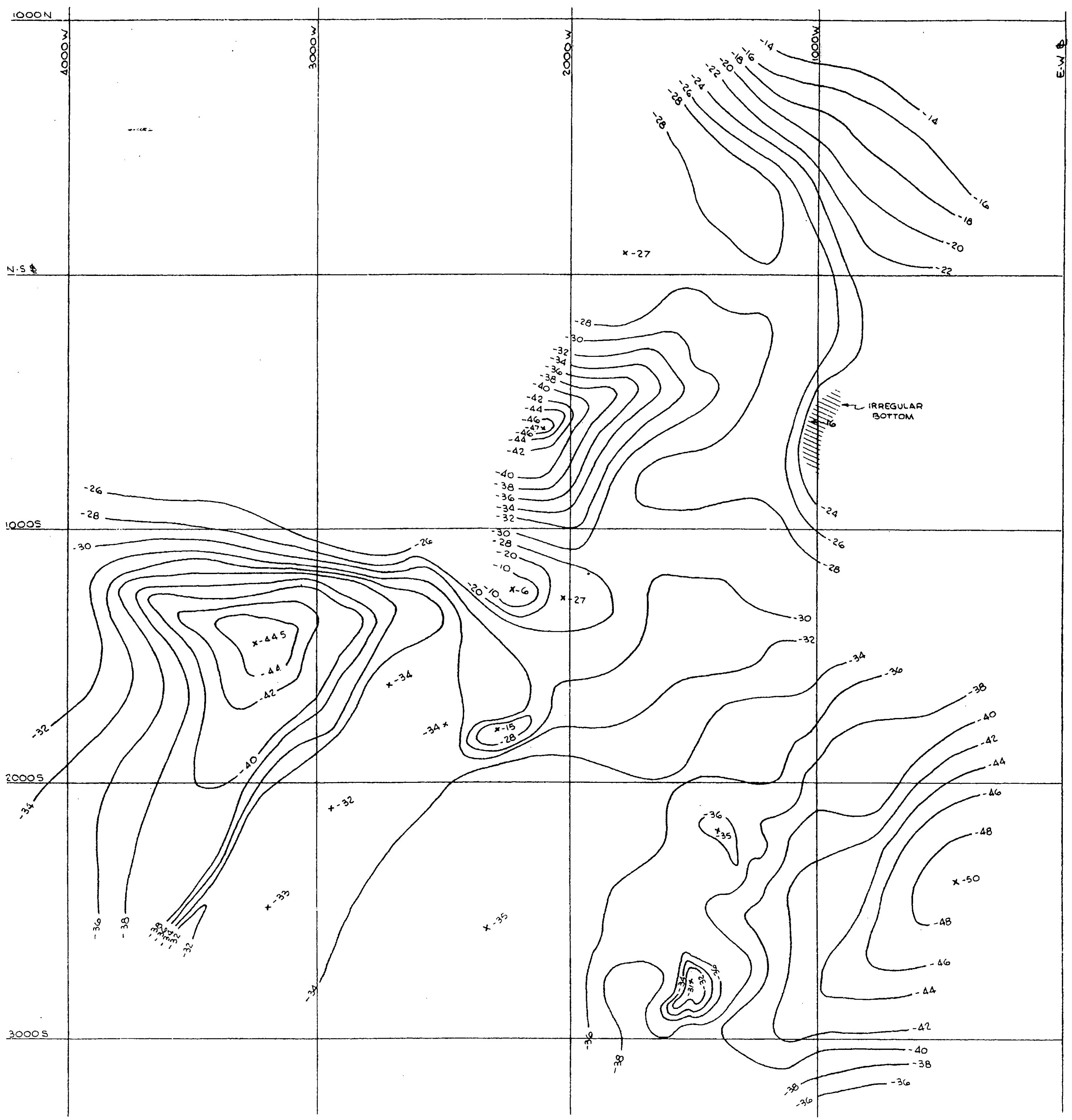
for

STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 9A OF 12



ELEVATIONS BASED ON MEAN LOW WATER DATUM.

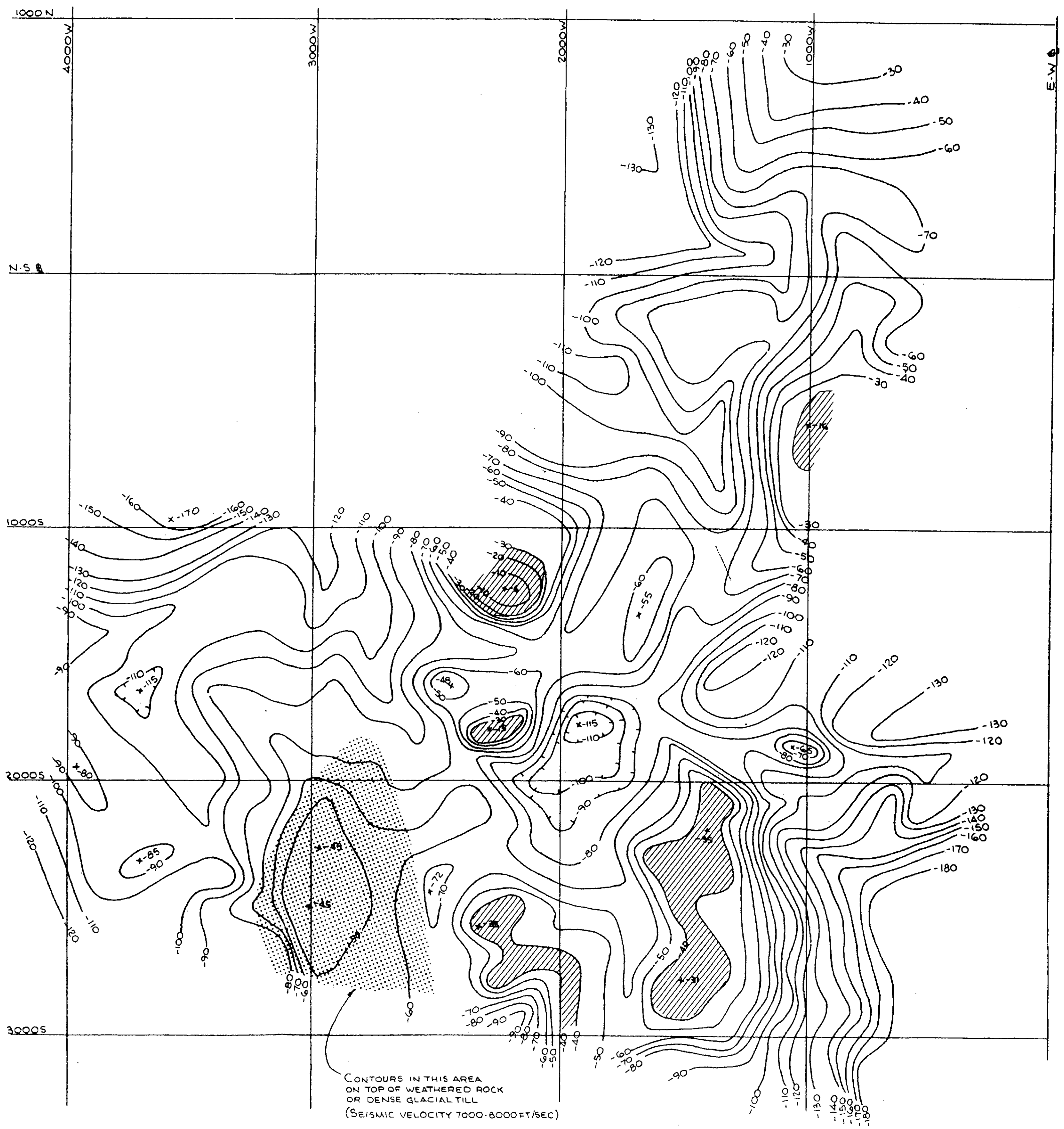
CO-ORDINATES IN TERMS OF MILLSTONE PLANT GRID SYSTEM.

CONTOUR INTERVAL: 2 FEET.

0 500 1000 FEET

BOTTOM CONTOUR MAP
AREA IV
BATHYMETRIC SURVEY
MILLSTONE POINT, CONNECTICUT
for
STONE & WEBSTER ENGINEERING CORPORATION
by
WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 10 OF 12



OVERBURDEN THICKNESS 0-5 FT.

ELEVATIONS BASED ON MEAN LOW WATER DATUM.

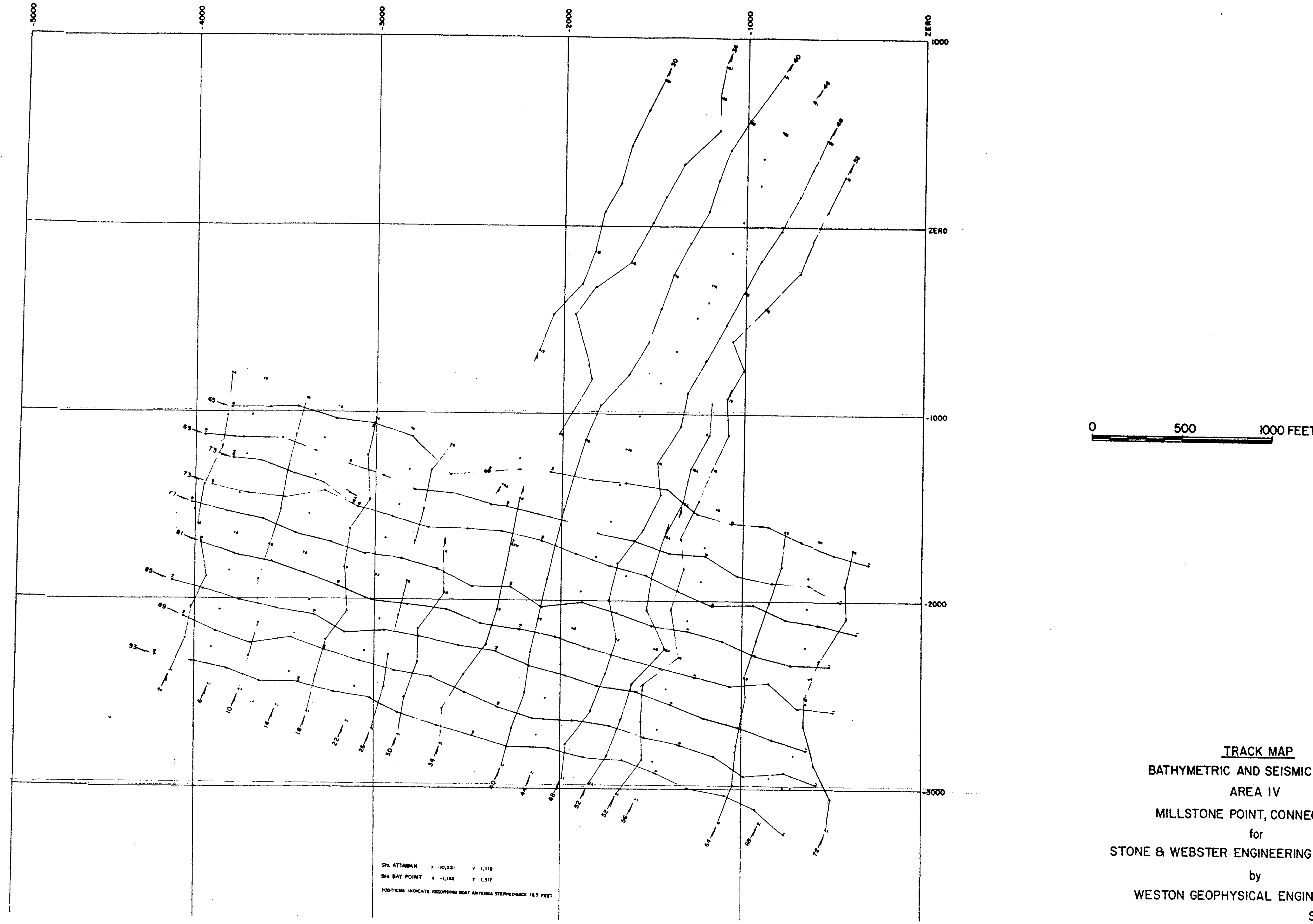
CO-ORDINATES IN TERMS OF MILLSTONE PLANT GRID SYSTEM.

CONTOUR INTERVAL: 10 FEET.

0 500 1000 FEET

GENERALIZED BEDROCK CONTOUR MAP
AREA IV
SEISMIC SURVEY
MILLSTONE POINT, CONNECTICUT
for
STONE & WEBSTER ENGINEERING CORPORATION
by
WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 11 OF 12



TRACK MAP

BATHYMETRIC AND SEISMIC SURVEY

AREA IV

MILLSTONE POINT, CONNECTICUT

for

STONE & WEBSTER ENGINEERING CORPORATION

by

WESTON GEOPHYSICAL ENGINEERS, INC.

SHEET 12 OF 12

APPENDIX 2.5M

LABORATORY TEST PROGRAM FOR PROPOSED ADDITIONAL STRUCTURAL BACKFILL SOURCES

Stone & Webster Engineering Corp.
Boston, Massachusetts

Report On

LABORATORY TEST PROGRAM FOR PROPOSED ADDITIONAL STRUCTURAL BACKFILL SOURCES

Millstone Nuclear Power Station, Unit 3
Docket No. 50-423

June, 1976

Written by:

F.S. Vetere
Soils Engineer

Reviewed by:

A.S. Lucks
Sr. Soils Engineer

S.C. Rossier
Asst. Chief Geotechnical Engineer

Approved by:

S.B. Jacobs
Project Engineer

INTRODUCTION

In accordance with the commitment made in the Millstone Unit 3 Preliminary Safety Analysis Report, Section 2.5.4.6.9.1,[1] a "Report on Laboratory Tests and Bearing Capacity Determination of Proposed Select Granular (Structural) Backfill," dated July, 1974, and the subsequent addendum dated November, 1974,[2] were submitted to the NRC. That report and addendum document the required testing necessary to certify suitable structural backfill material sources. The material reported on, and subsequently approved, for use as structural fill was from the Romanella property in North Stonington, Connecticut, designated therein as Sample "R." To date, this material has been used as structural fill for all nuclear safety-related structures and pipelines. Recently, material represented by Sample "R" has been in short supply due to a natural change in gradation of the soils at the borrow pit, requiring a search for additional sources for structural backfill. Presented herein are the results of a similar testing program performed on three proposed alternate fill sources, located in the towns of Preston, Canterbury, and North Stonington, Connecticut. Backfill from all three of these sources meets the criteria for structural fill described in the Millstone 3 PSAR. It is proposed that these fill sources be approved as an alternate material to the Romanella source.

MATERIALS AND TESTS

Structural backfill materials described in this report were obtained from three different borrow pits in the vicinity of the Millstone site:

1. The Preston pit, located in the Town of Preston, approximately 25 miles northeast of the site,

2. The Canterbury pit, located in the Town of Canterbury, approximately 30 miles north of the site, and

3. The North Stonington pit, located in the Town of North Stonington, approximately 25 miles northeast of the site.

The locations of the pits are shown in Figure 1. Each of the three backfill materials is processed at the respective pit by means of passing the soil through a screen, ensuring that the maximum particle size is within acceptable limits for a backfill material.[3]

For this test program, samples from each pit were obtained from a stockpile delivered to the Millstone site; the samples tested are thus representative of the processed borrow material as it would be delivered to the site. The test program specified that samples from each stockpile be tested in accordance with the following procedures:

1. Grain Size Analysis of Soils - ASTM D422, no hydrometer test required

2. Moisture Density Relations of Soils Using 10 Lb Hammmer and 18 In. Drop - ASTM D1557, on material finer than the U.S. Standard Sieve No. 4 fraction of the sample

3. Drained Direct Shear Tests, on specimens 10 cm square by 3 cm high at a 10 cm/hr rate of displacement, on material finer than the U.S. Standard Sieve No. 4 fraction of the sample, compacted to 90 percent and 95 percent of maximum density determined from the minus No. 4 fraction of the sample

For information and comparison, results of earlier tests on samples from the three borrow sources are included in this report. These tests are as follows:

1. Specific Gravity of Soils - ASTM D854

2. Moisture Density Relations of Soils Using 10 Lb Hammer and 18 In. Drop - ASTM D1557, on material finer than U.S. Standard 3/4 in. sieve

The results of all tests are shown in Figures 2 through 14.

DISCUSSION OF TEST RESULTS

Grain Size

Grain size analyses of samples from the three pits indicate that each soil is a well-graded sand and gravel, with a maximum particle size of 3 in. and having less than 12 percent by weight passing the No. 200 sieve. As shown in Figure 2, each sample is similar in gradation with the limits represented in Section 2.5.4.6.9.1 and Figure 2.5.4-16 of the Millstone 3 PSAR. The coefficient of uniformity, Cu, for all samples varies from 38 to 50, indicating a widely graded soil, and the coefficient of curvature, Cc, varies from 0.50 to 1.10. Due to limitations imposed by the size of the direct shear box, samples used for strength testing consist of only the minus No. 4 fraction of the backfill. The resulting shear strengths are therefore lower than the actual value would be in the field. Table 1 presents the proposed gradation for Seismic Category I structural backfill. These limits have been expanded from those specified in the addendum of November, 1974,[2] to account for the natural gradation variations which naturally exist between different borrow sites.

Density

The results of the modified Proctor moisture-density tests are presented in Figures 3, 7, and 11 for the minus No. 4 fractions and in Figures 4, 8, and 12 for the minus 3/4 in. fractions for the Canterbury, Preston, and North Stonington pits, respectively. Each soil is characterized by a well-defined moisture-density curve typical of granular materials. Consistently high values of maximum density, similar to the maximum density of 137.5 pcf for Romanella material reported in Figure 2.5.4-18 of the PSAR and 136.4 pcf reported for Sample "R," on July, 1974, were obtained in the test program. The maximum density for the minus No. 4 fraction tests is consistently less for equal compactive efforts, by approximately

5 to 12 pcf, than the maximum density of minus 3/4 in. fractions, and it can be assumed that the minus No. 4 maximum density is also less than the maximum density attainable at the site on the whole sample. Consequently, testing the minus No. 4 fraction results in values of shear strength more conservative than would be expected for the whole soil fraction. A comparison of the maximum densities for each fraction is presented in Table 2.

Shear Strength

Drained direct shear tests were conducted on 10 cm square by 3 cm high samples of the minus No. 4 fractions of the respective borrow soils compacted to 90 percent and 95 percent of the maximum densities determined from the modified Proctor tests on the minus No. 4 fraction. Consequently, the total densities of the samples at the start of testing were lower than the total densities expected at the site, making the test program more conservative than the actual site conditions. Results of the direct shear tests are shown in Figures 5, 9, and 13 for the Canterbury, Preston, and North Stonington pits, respectively, and the fraction angles are tabulated in Table 1. Each failure envelope is based on tests run at normal pressures of 2.0 and 4.0 tsf.

The minimum shear strength values at 95 percent of maximum density varied from 35.0 degrees for the Preston pit to 39.4 degrees for the Canterbury pit. For 90 percent of maximum density, the minimum shear values varied from 34.0 degrees for the Canterbury and North Stonington pits to 34.6 degrees for the Preston pit. Every value reported equaled or exceeded the design criteria established in the Millstone 3 PSAR, i.e., a shear strength equal to or greater than 34 degrees, and all of the values tested at 95 percent compaction were greater than or equal to the design values reported in July, 1974.[2]

CONCLUSIONS

Based on the results of tests and discussions presented herein, processed soil from the Canterbury, North Stonington, and Preston pits is suitable for use as backfill for Seismic Category I structures and pipelines for the following reasons:

1. Material from these pits satisfies the gradation requirements for structural fill represented by Figure 2.5.4-16 and Section 2.5.4.6.9.1 of the Millstone 3 PSAR.

2. The maximum dry density of material from the Canterbury, North Stonington, and Preston pits is within the range of maximum densities reported in the Millstone 3 PSAR and a subsequent report dated July, 1974, describing the currently used structural fill, represented by Sample "R".

3. The material from the Canterbury, North Stonington, and Preston pits, when compacted to 95 percent of the maximum density determined by ASTM D1557, exhibits higher shear

strength values than previously assumed in the Millstone 3 PSAR and subsequently established as a basis for design in the report of July, 1974.

4. The shear values reported in Table 1 from direct shear test results are conservative estimates of the shear strength of the structural backfill because:

   a. The minimum value for each direct shear test failure envelope is reported

   b. The direct shear tests are run on the more uniform minus No. 4 portions of each sample, giving lower values of shear strength than for the widely graded sand and gravel which would be used in the field as structural backfill.

REFERENCES

1. Millstone Nuclear Power Station - Unit 3, Preliminary Safety Analysis Report, Docket No. 50-423.

2. Millstone Nuclear Power Station - Unit 3, "Report on Laboratory Tests and Bearing Capacity Determination of Proposed Select Granular (Structural) Backfill, July, 1974, and Addendum, November, 1974, Docket No. 50-423.

3. Stone & Webster Engineering Corporation, "Placement of Structural and Random Fill," Millstone Nuclear Power Station - Unit 3, Specification No. 2199.101-967, January 15, 1976.

Table 1
Representative Maximum Density and Shear Strength Values for Proposed Fill Sources

Backfill Source	$\gamma_d$max (-3/4")	$\gamma_d$max (-#4)	ϕ@ 95% $\gamma_d$max (-#4)	ϕ@ 90% $\gamma_d$max (-#4)
Preston Pit	135.8 pcf	131.0 pcf	35.0°	34.6°
No. Stonington Pit	148.0 pcf	136.1 pcf	37.9°	34.0°
Canterbury Pit	140.0 pcf	131.6 pcf	39.4°	34.0°
Sample "R"	136.4 pcf	129.5 pcf	41.5°	---

Table 2
Proposed Gradation Limits for Category I Structural Backfill

U.S. Standard Sieve Size	% Passing by Weight
3"	100
3/4"	70-100
3/8"	60-90
#10	35-65
#40	15-40
#100	0-25
#200	0-15

Coefficient of Uniformity, Cu = $D_{60}/D_{10} \geq 10$

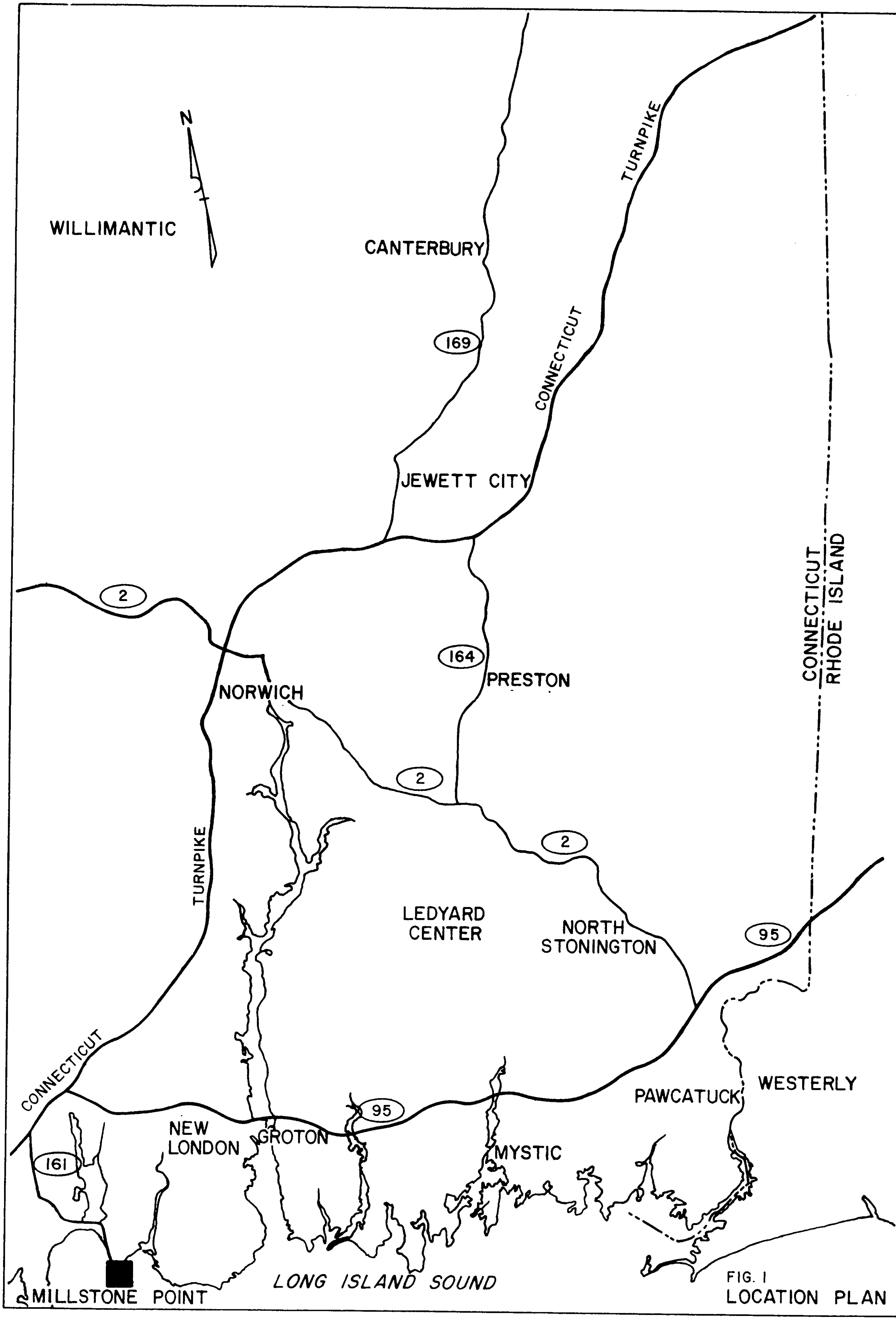
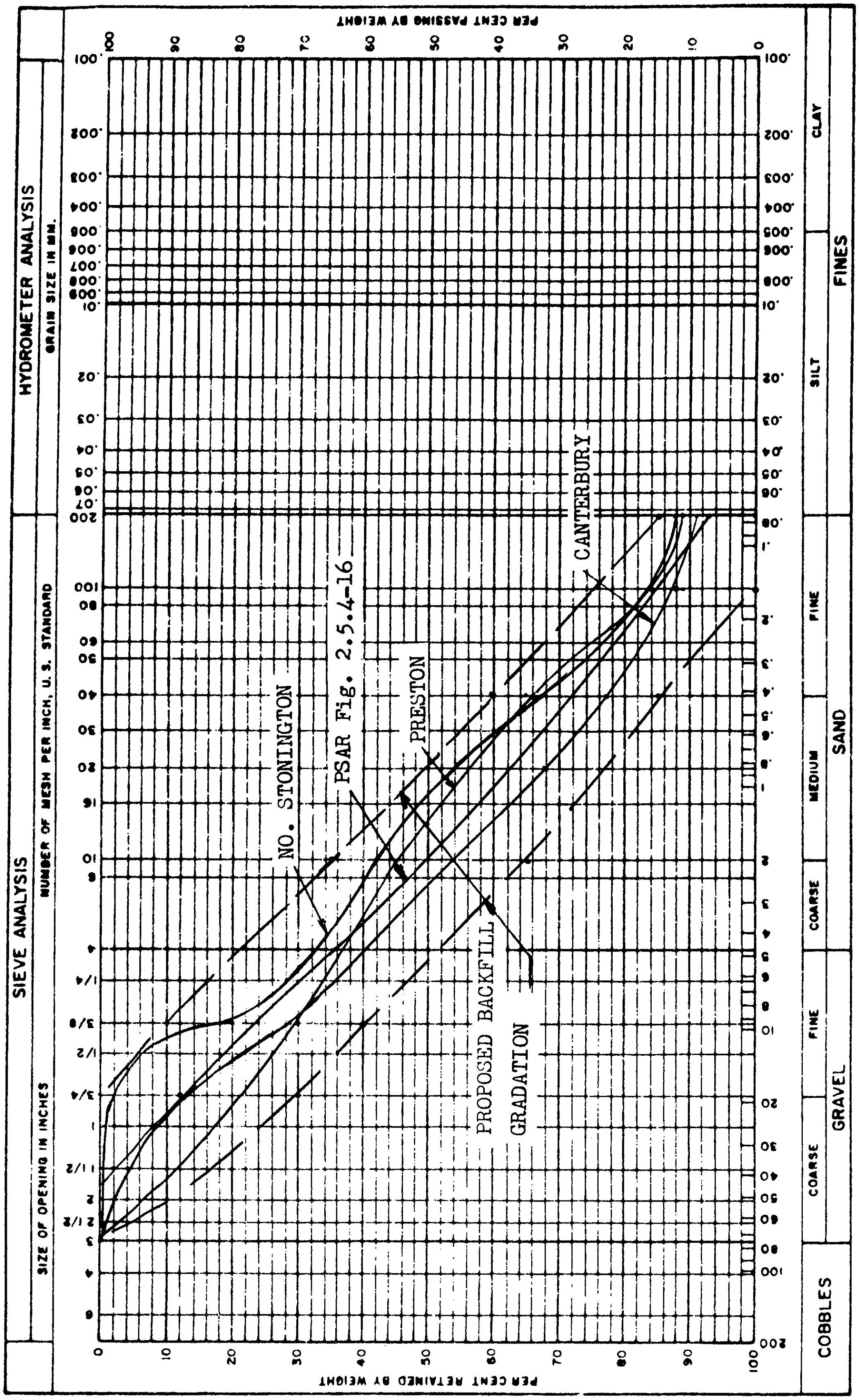


FIG. I
LOCATION PLAN

STONE & WEBSTER ENGINEERING CORPORATION

GRADATION CURVES

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
Northeast Utilities (NUSCO)	12179	Borrow Pit Bag Samples
SITE	**DATE**	**SAMPLE NUMBERS**
Millstone -	1 Feb 1976	Canterbury No. Stonington, Preston



SAMPLE	% GRAVEL	% < #200	D_{60} (MM)	D_{30} (MM)	D_{10} (MM)	Cu	Cc	Classification
Canterbury	40	9	4.7	.70	.095	49	1.10	Gravelly Sand (SW - SM)
No. Stonington	30	12	2.3	.38	.06	38	1.05	Gravelly Sand (SW - SM)
Preston	38	11	3.5	.35	.07	50	0.50	Gravelly Sand (SW - SM)

Fig. 2

STONE & WEBSTER ENGINEERING CORPORATION

COMPACTION TEST REPORT

CLIENT: Northeast Utilities (NUSCo)	J.O. NUMBER: 12179	TEST NUMBER: MD-SFM - 170
SITE: Millstone		DATE: 14 Jan 1976
EXPLORATION TYPE AND NUMBER: Bag Sample from Canterbury Pit		SAMPLE NUMBER: Canterbury

TYPE OF COMPACTION: ASTM D1557, Method D, -#4 Fraction	DIAMETER OF MOLD: 6.0 IN.		
WEIGHT OF HAMMER: 10.0 LB	CLASSIFICATION OF SOIL: SP-SM		
FALL OF HAMMER: 18.0 IN.			
NUMBER OF LAYERS: 5	LL:	PL:	PI:
BLOWS PER LAYER: 56	SPECIFIC GRAVITY: 2.78		

MAXIMUM DRY UNIT WEIGHT:	131.6	PCF
OPTIMUM WATER CONTENT:	7.1	%
NATURAL WATER CONTENT:		%

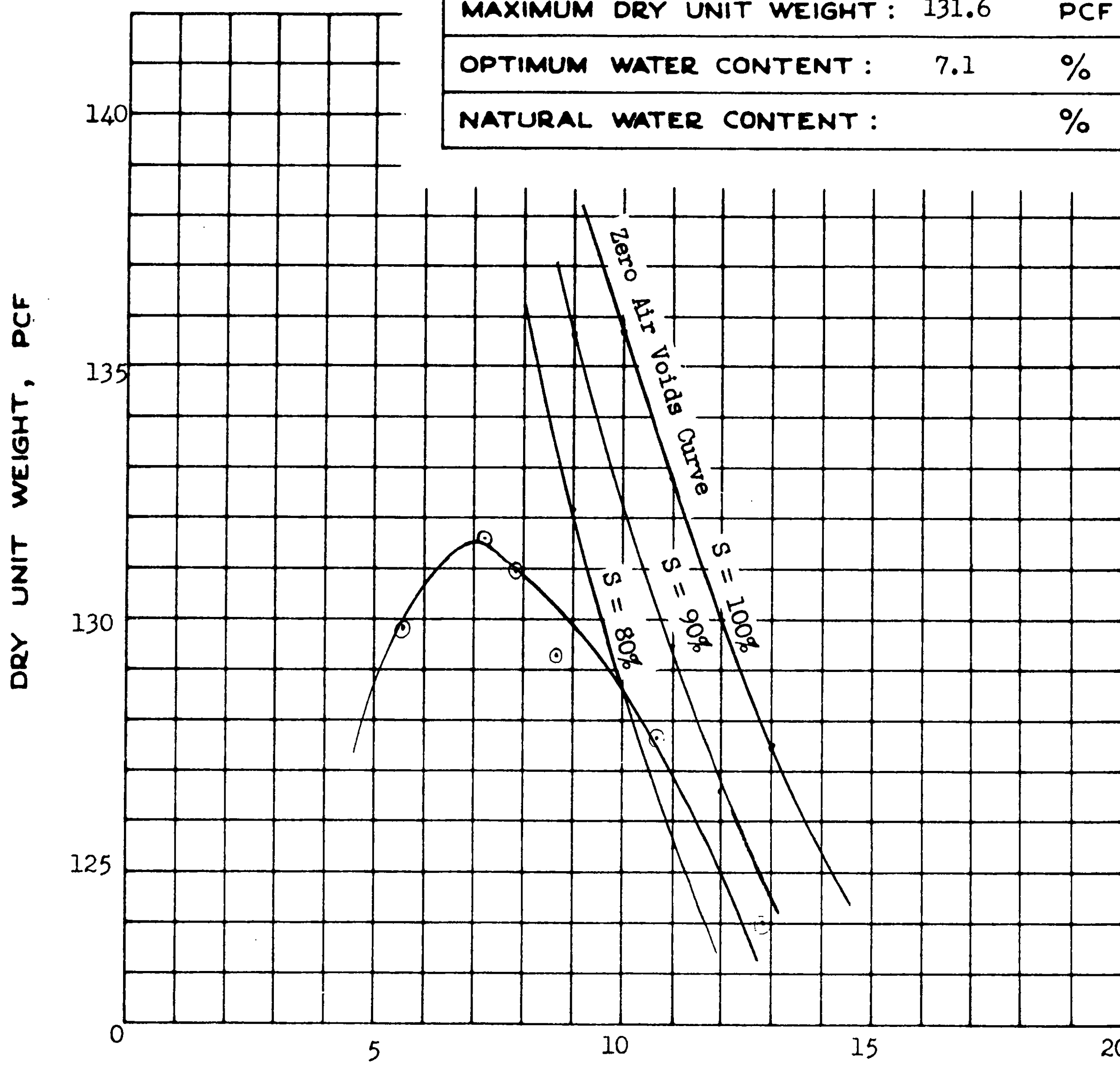


Fig. 3

STONE & WEBSTER ENGINEERING CORPORATION

COMPACTION TEST REPORT

CLIENT: NORTHEAST UTILITIES (NUSCO)	J.O. NUMBER: 12179	TEST NUMBER: -
SITE: MILLSTONE 3		DATE: 9 SEPT 75
EXPLORATION TYPE AND: BAG SAMPLE FROM CANTERBURY PIT		SAMPLE: CANTERBURY PIT

TYPE OF COMPACTION: ASTM D1557 (D) -3/4" Fraction	DIAMETER OF MOLD: 6.0 IN.		
WEIGHT OF HAMMER: 10.0 LB	CLASSIFICATION OF SOIL:		
FALL OF HAMMER: 18 IN.	SANDY GRAVEL (GW)		
NUMBER OF LAYERS: 5	LL:	PL:	PI:
BLOWS PER LAYER: 56	SPECIFIC GRAVITY: 2.78 (DET.)		

MAXIMUM DRY UNIT WEIGHT:	139.98 PCF
OPTIMUM WATER CONTENT:	7.0 %
NATURAL WATER CONTENT:	- %

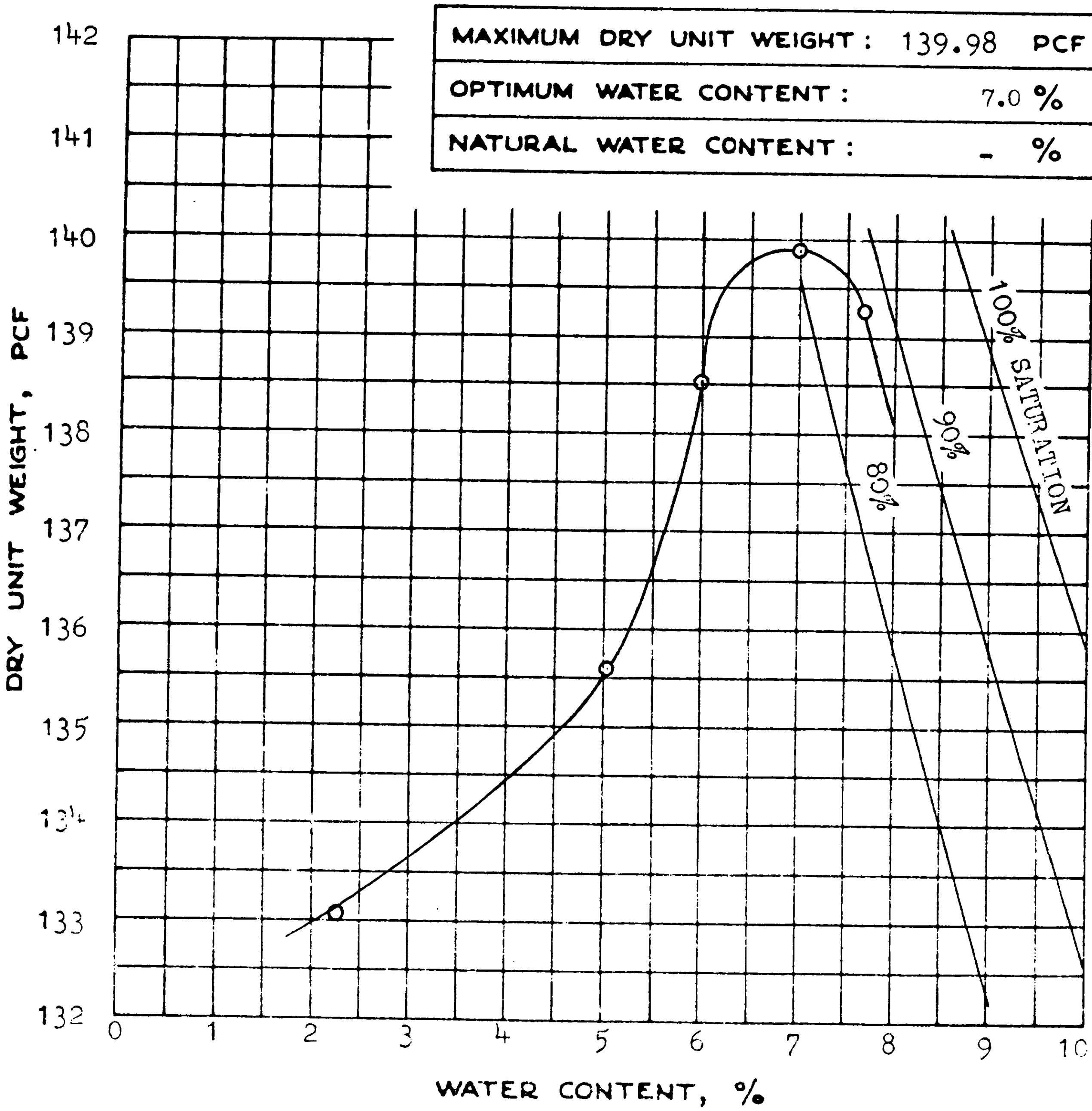


Fig. 4

STONE & WEBSTER ENGINEERING CORPORATION

DIRECT SHEAR TEST SUMMARY

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO)	12179	BAG SAMPLE
SITE	**DATE**	**SAMPLE NUMBERS**
MILLSTONE POINT	22 JAN 76	CANTERBURY

TYPE OF TEST : DRAINED — SPECIMEN SIZE : 10 SQ CM BY 3 CM HIGH

TYPE OF SPECIMEN : COMPACTED — RATE OF DISPLACEMENT : 10.0 MM/HR

	SAMPLE NUMBER	1	2	3	4
INITIAL	PERCENT COMPACTION	90*	90*	95*	95*
INITIAL	DRY UNIT WEIGHT, γ_d (PCF)	121.1	121.3	127.8	127.8
INITIAL	VOID RATIO, e_o	0.382	0.380	0.309	0.309
AFTER CONSOL.	NORMAL STRESS, $\bar{\sigma}_n$ (TSF)	2.0	4.0	2.0	4.0
AFTER CONSOL.	VOID RATIO, e_c	0.357	0.346	0.297	0.288
AT FAILURE	SHEAR STRESS, τ_f (TSF)	1.59	2.70	1.69	3.28
AT FAILURE	STRESS RATIO, $\tau_f / \bar{\sigma}_n$	0.795	0.675	0.845	0.820
AT FAILURE	$\phi' = $ ARC TAN $\tau_f / \bar{\sigma}_n$ (DEG)	38.4	34.0	40.2	39.4
AT FAILURE	VOID RATIO, e_f	0.361	0.342	0.312	0.300

* Maximum density 134.6 PCF determined on the fraction of soil passing a No.4 sieve.

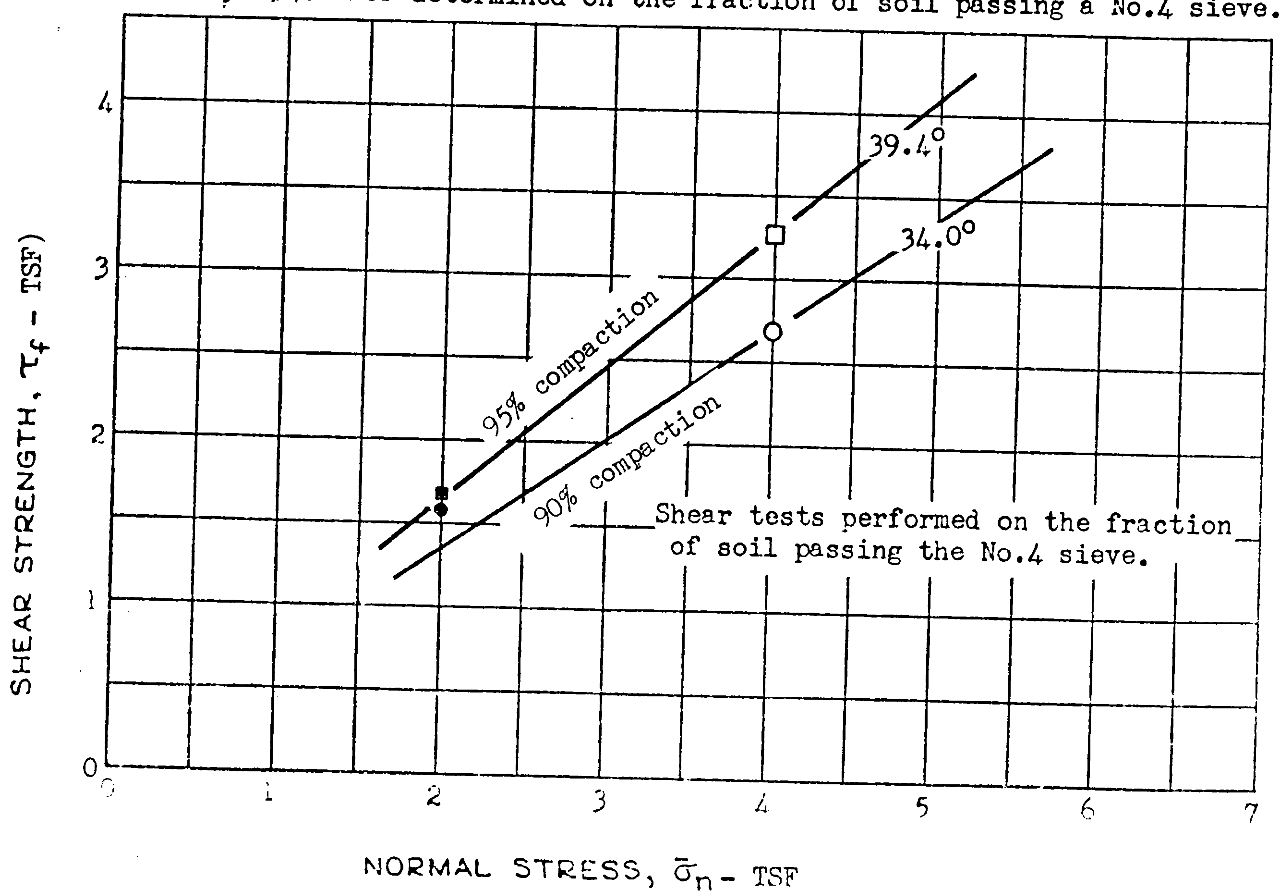


Fig. 5

STONE & WEBSTER ENGINEERING CORPORATION

DIRECT SHEAR TEST REPORT

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO	12179	BAG SAMPLE
SITE	DATE	SAMPLE NUMBERS
MILLSTONE	22 JAN 76	CANTERBURY

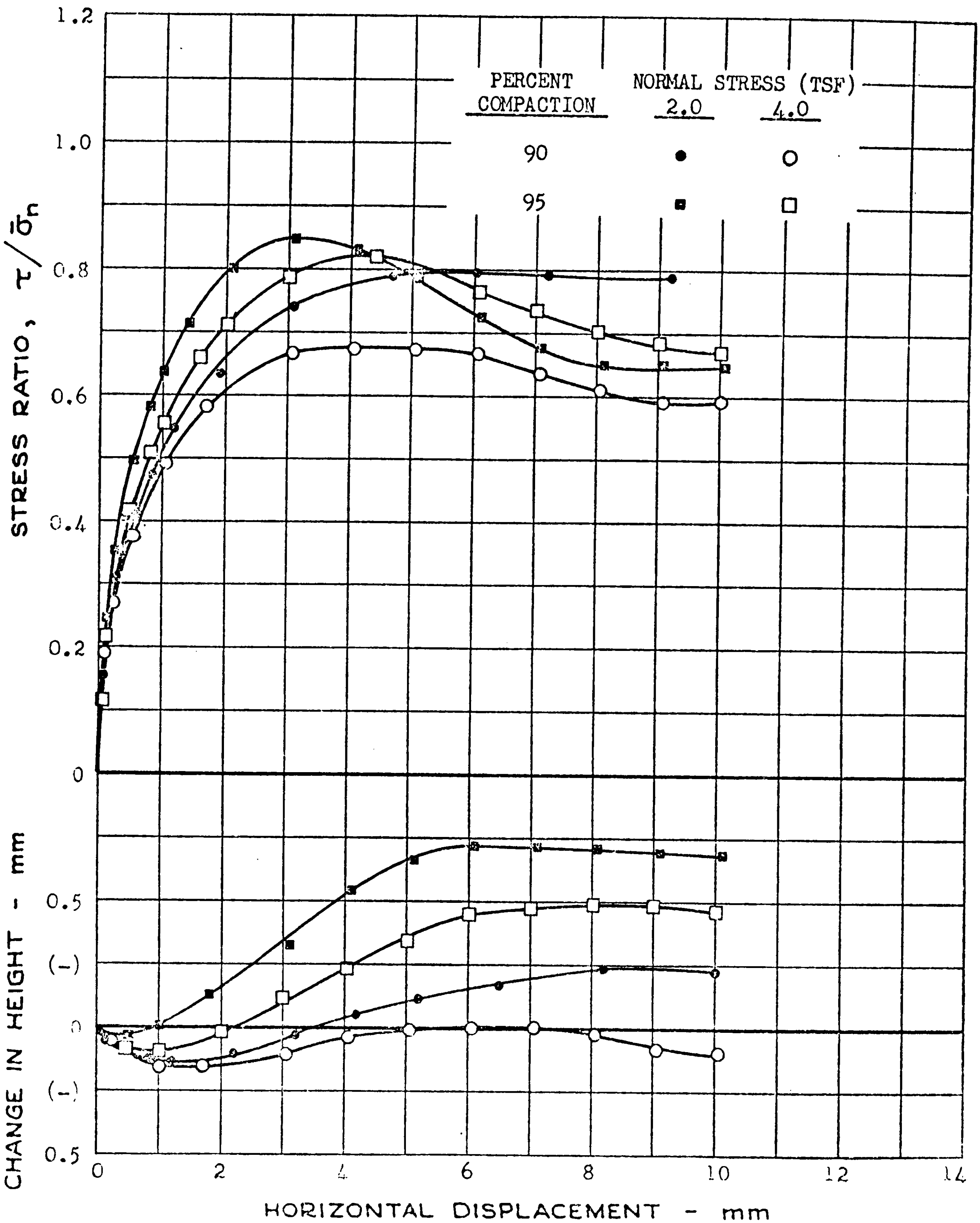


Fig. 6 2.5M-12

STONE & WEBSTER ENGINEERING CORPORATION

COMPACTION TEST REPORT

CLIENT: Northeast Utilities (NUSCo)	J.O. NUMBER: 12179	TEST NUMBER: MD - SFM - 168
SITE: Millstone		DATE: 12 Jan 1976
EXPLORATION TYPE AND NUMBER: Bag Sample From Preston Pit		SAMPLE NUMBER: Preston

TYPE OF COMPACTION: ASTM D1557, Method D - #4 Fraction	DIAMETER OF MOLD: 6.0 IN.
WEIGHT OF HAMMER: 10.0 LB	CLASSIFICATION OF SOIL: SP - SM
FALL OF HAMMER: 18.0 IN.	
NUMBER OF LAYERS: 5	LL: -- PL: -- PI: --
BLOWS PER LAYER: 56	SPECIFIC GRAVITY: 2.78

MAXIMUM DRY UNIT WEIGHT:	131.0	PCF
OPTIMUM WATER CONTENT:	8.0	%
NATURAL WATER CONTENT:	--	%

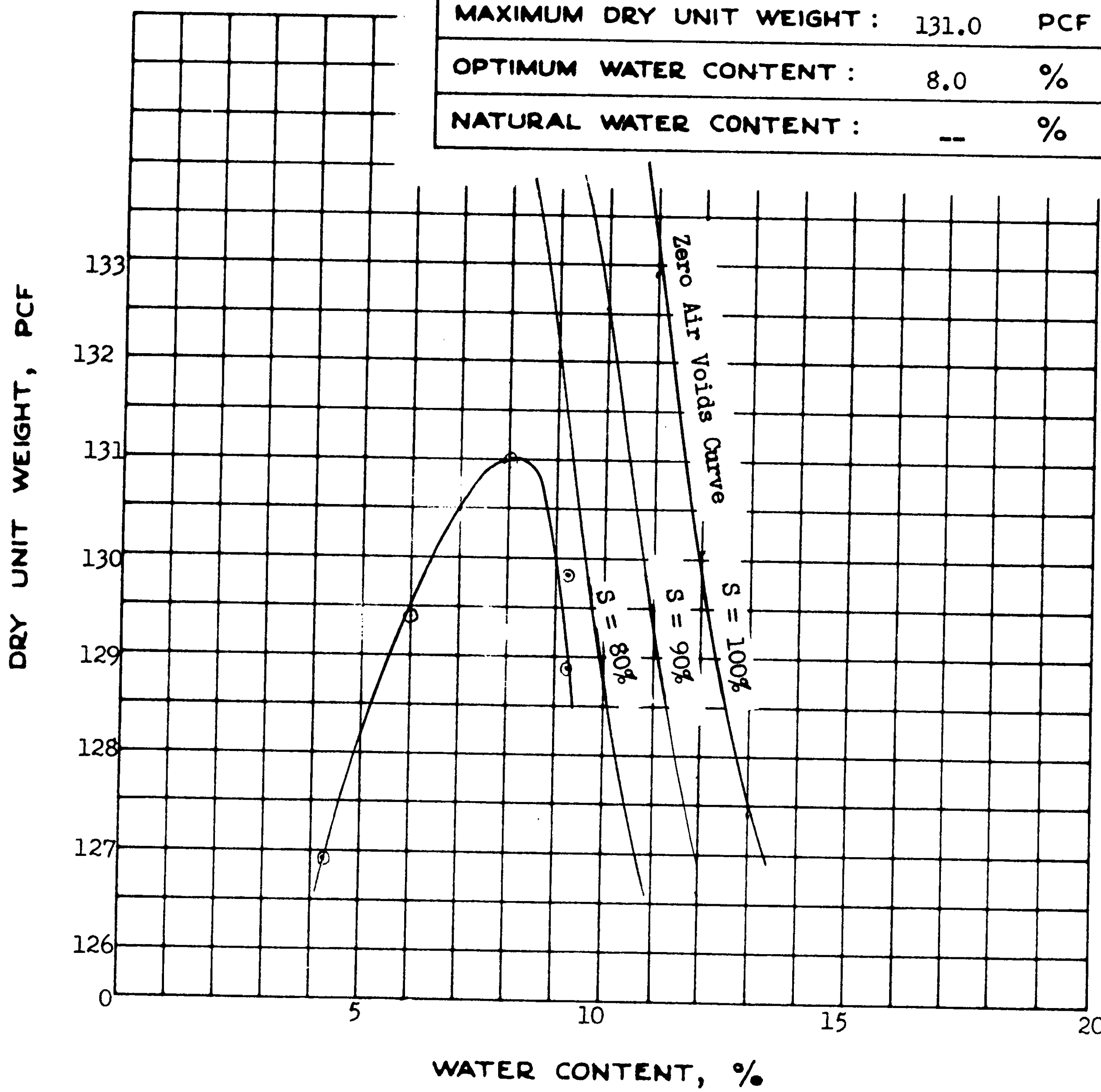


Fig. 7

STONE & WEBSTER ENGINEERING CORPORATION

COMPACTION TEST REPORT

CLIENT NORTHEAST UTILITIES (NUSCO)	J.O. NUMBER 12179	TEST NUMBER -
SITE MILLSTONE		DATE 12 SEP 74
EXPLORATION TYPE AND NUMBER BAG SAMPLE FROM PRESTON PIT		SAMPLE NUMBER Preston

TYPE OF COMPACTION: ASTM D1557 (D) -3/4" Fraction	DIAMETER OF MOLD: 6.0 IN.
WEIGHT OF HAMMER: 10.0 LB	CLASSIFICATION OF SOIL: SP-SM
FALL OF HAMMER: 18.0 IN.	GRAVELLY SAND
NUMBER OF LAYERS: 5	LL: - PL: - PI: -
BLOWS PER LAYER: 56	SPECIFIC GRAVITY: 2.78 (DET.)

MAXIMUM DRY UNIT WEIGHT:	135.8 PCF
OPTIMUM WATER CONTENT:	8.9 %
NATURAL WATER CONTENT:	- %

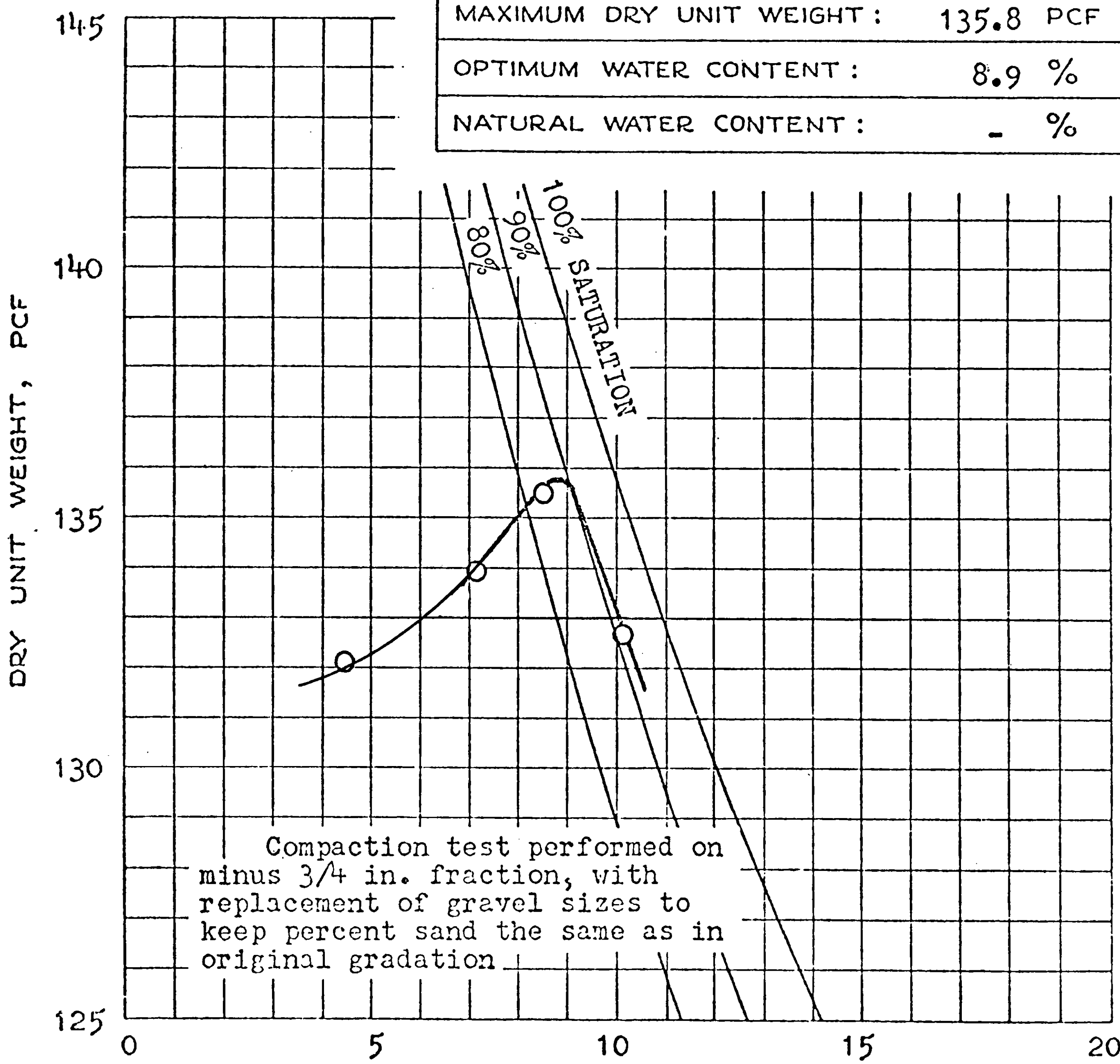


Fig. 8

DIRECT SHEAR TEST SUMMARY

CLIENT: NORTHEAST UTILITIES (NUSCO)	J.O. NUMBER: 12179	EXPLORATION TYPE AND NUMBER: BAG SAMPLE
SITE: MILLSTONE	DATE: 21 JAN 76	SAMPLE NUMBERS: PRESTON

TYPE OF TEST : DRAINED — SPECIMEN SIZE : 10 SQ CM BY 3 CM HIGH

TYPE OF SPECIMEN : COMPACTED — RATE OF DISPLACEMENT : 10.0 MM PER HR

	TEST NUMBER	1	2	3	4
INITIAL	PERCENT COMPACTION *	90	90	95	95
	DRY UNIT WEIGHT, γ_d (PCF)	118.1	117.9	124.5	124.6
	VOID RATIO, e_o	0.417	0.419	0.343	0.343
AFTER CONSOL.	NORMAL STRESS, $\bar{\sigma}_n$ (TSF)	2.0	4.0	2.0	4.0
	VOID RATIO, e_c	0.377	0.359	0.296	0.308
AT FAILURE	SHEAR STRESS, τ_f (TSF)	1.38	2.78	1.40	2.92
	STRESS RATIO, $\tau_f / \bar{\sigma}_n$	0.689	0.695	0.701	0.729
	ϕ' = ARC TAN $\tau_f / \bar{\sigma}_n$ (DEG)	34.6	34.8	35.0	36.1
	VOID RATIO, e_f	0.376	0.299	0.294	0.312

*Maximum density 131.0 PCF determined on -#4 fraction using modified effort

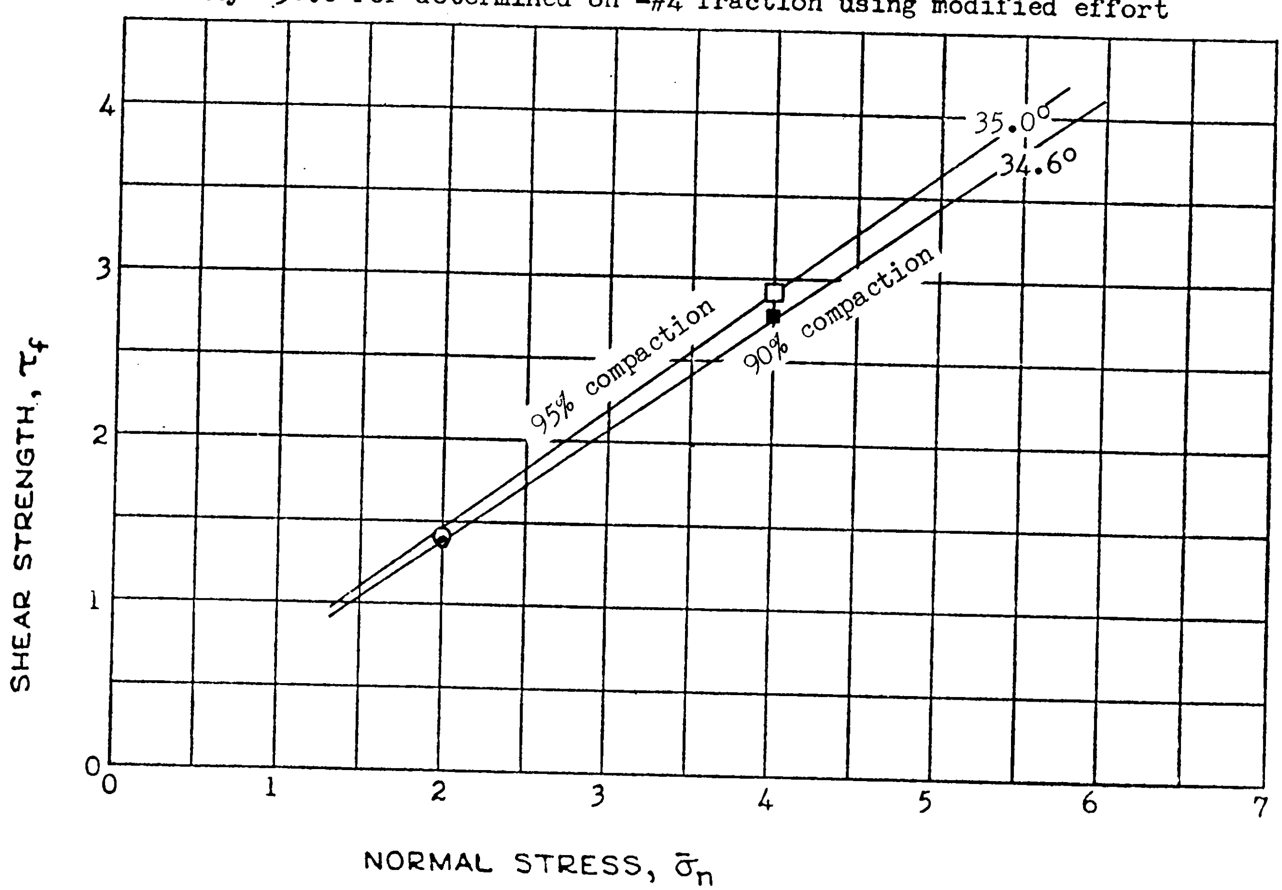


Fig. 9

STONE & WEBSTER ENGINEERING CORPORATION

DIRECT SHEAR TEST REPORT

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO)	12179	BAG SAMPLE
SITE	DATE	SAMPLE NUMBERS
MILLSTONE	21 JAN 76	PRESTON

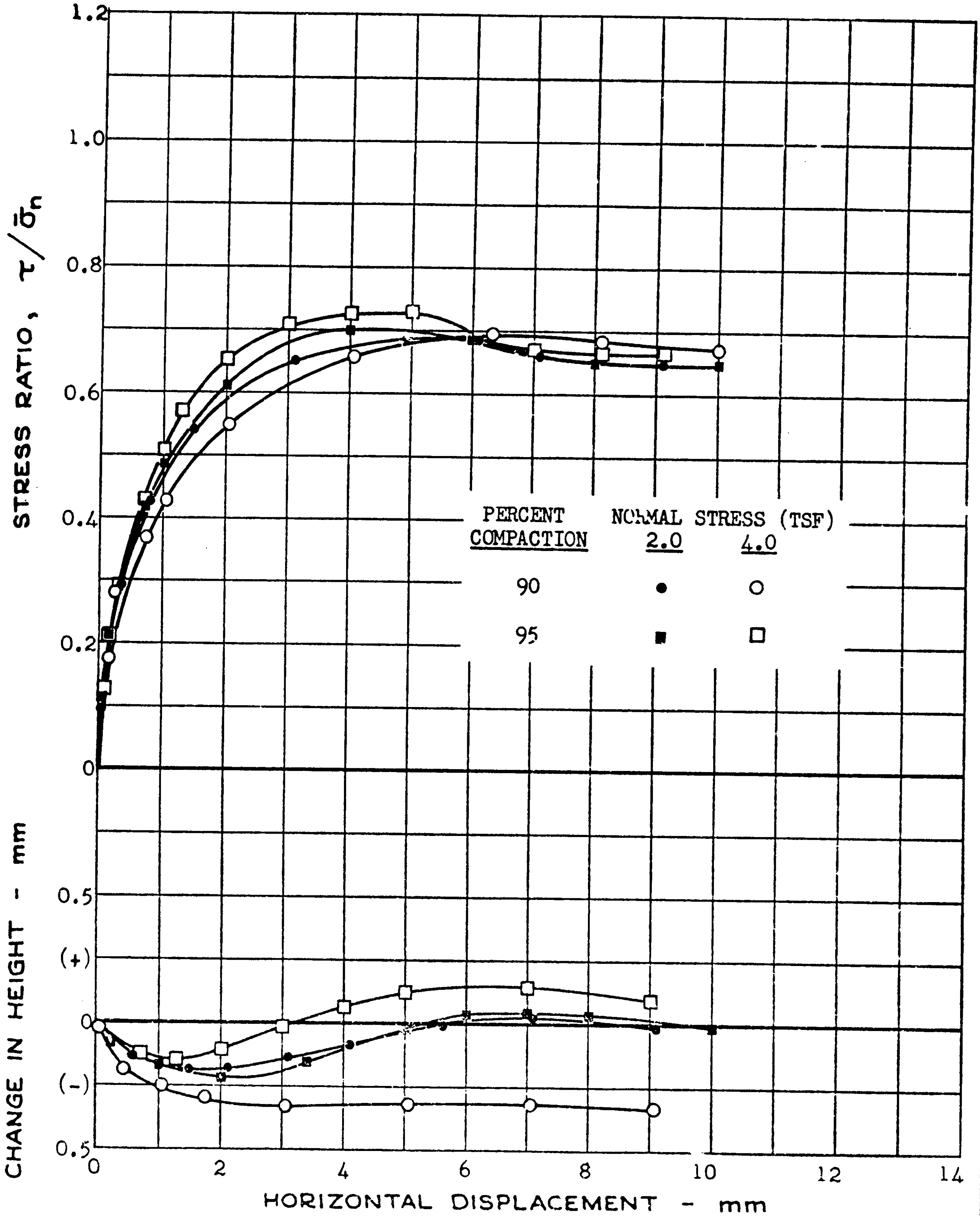


Fig. 10 2.5M-16

STONE & WEBSTER ENGINEERING CORPORATION

COMPACTION TEST REPORT

CLIENT: Northeast Utilities (NUSCo)	J.O. NUMBER: 12179	TEST NUMBER: MD - SFM - 169
SITE: Millstone		DATE: 8 Jan 1976
EXPLORATION TYPE AND NUMBER: Bag Sample from No. Stonington Pit		SAMPLE NUMBER: No. Stonington

TYPE OF COMPACTION: ASTM D1557, Method D, -#4 Fraction	DIAMETER OF MOLD: 6.0 IN.		
WEIGHT OF HAMMER: 10.0 LB	CLASSIFICATION OF SOIL: SP - SM		
FALL OF HAMMER: 18.0 IN.			
NUMBER OF LAYERS: 5	LL:	PL:	PI:
BLOWS PER LAYER: 56	SPECIFIC GRAVITY: 2.86		

MAXIMUM DRY UNIT WEIGHT:	136.1	PCF
OPTIMUM WATER CONTENT:	6.6	%
NATURAL WATER CONTENT:	-	%

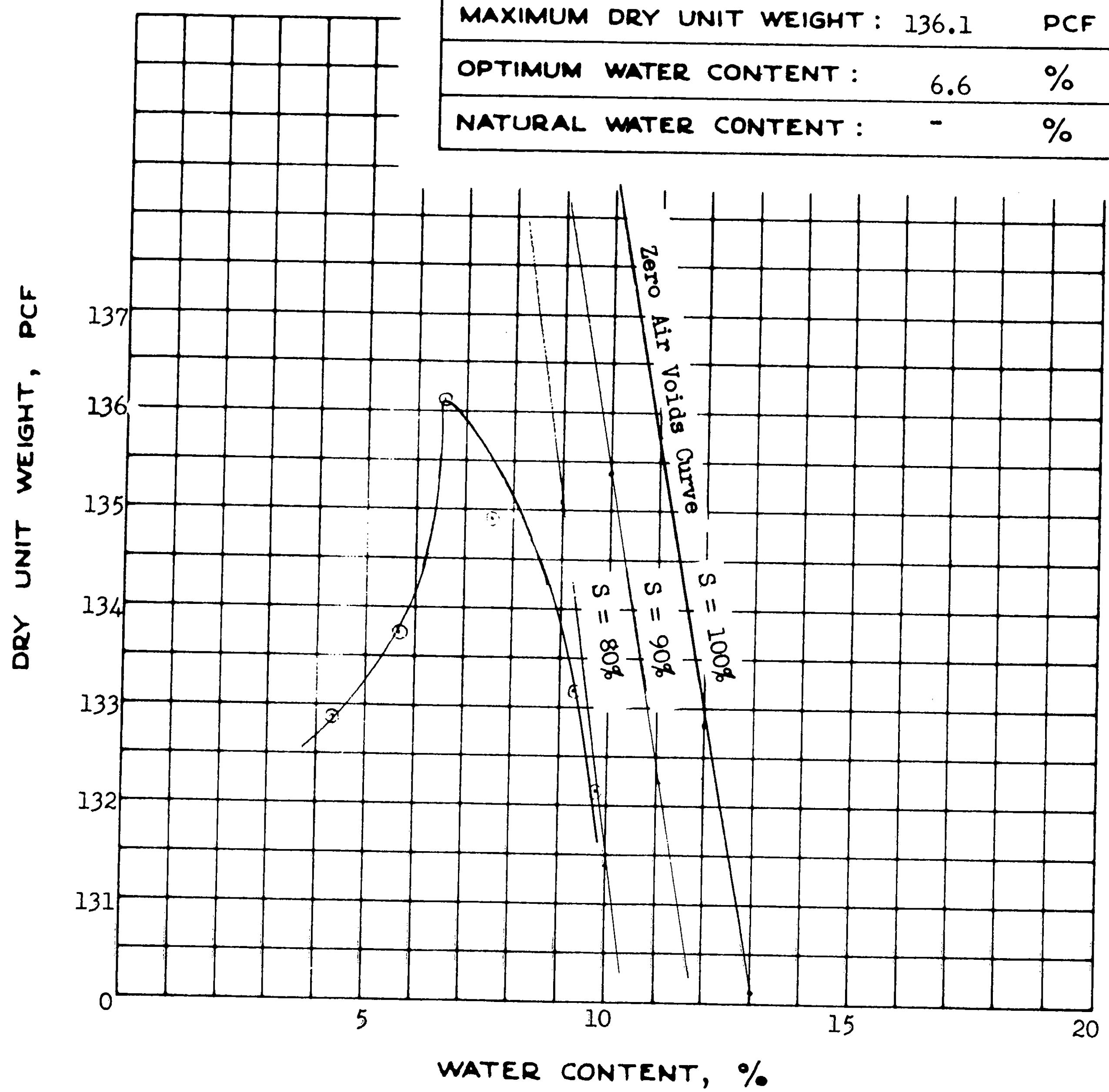


Fig. 11

STONE & WEBSTER ENGINEERING CORPORATION

COMPACTION TEST REPORT

CLIENT NORTHEAST UTILITIES (NUSCO)	J.O. NUMBER 12179	TEST NUMBER 1
SITE MILLSTONE		DATE 31 JUL 75
EXPLORATION TYPE AND NUMBER NORTH STONINGTON BAG SAMPLE		SAMPLE NUMBER No. Stonington

TYPE OF COMPACTION: ASTM D1557 (D) -3/4" Fraction	DIAMETER OF MOLD: 6.0 IN.		
WEIGHT OF HAMMER: 10.0 LB	CLASSIFICATION OF SOIL:		
FALL OF HAMMER: 18 IN.	SANDY GRAVEL (GW - GM)		
NUMBER OF LAYERS: 5	LL: -	PL: -	PI: -
BLOWS PER LAYER: 56	SPECIFIC GRAVITY: 2.86		

MAXIMUM DRY UNIT WEIGHT:	148.0 PCF
OPTIMUM WATER CONTENT:	5.9 %
NATURAL WATER CONTENT:	- %

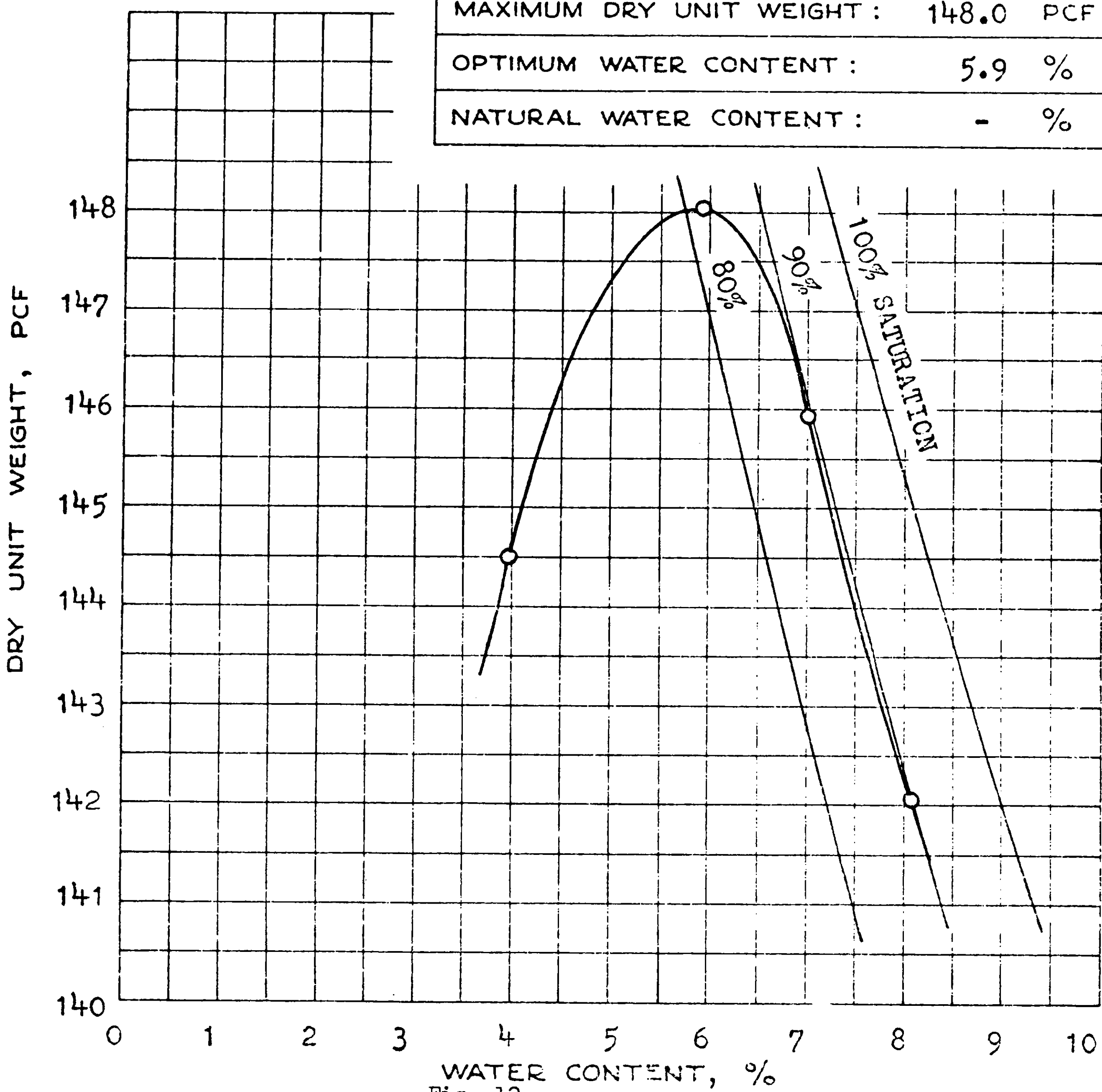


Fig. 12

2.5M-18

DIRECT SHEAR TEST SUMMARY

CLIENT: NORTHEAST UTILITIES (NUSCO)	J.O. NUMBER: 12179	EXPLORATION TYPE AND NUMBER: BAG SAMPLE
SITE: MILLSTONE	DATE: 19 JAN 76	SAMPLE NUMBERS: NORTH STONINGTON

TYPE OF TEST : DRAINED — SPECIMEN SIZE : 10 CM SQUARE BY 3 CM HIGH

TYPE OF SPECIMEN : COMPACTED — RATE OF DISPLACEMENT : 10.0 MM/HR

	TEST NUMBER	1	2	3	4
INITIAL	PERCENT COMPACTION	90*	90*	95*	95*
	DRY UNIT WEIGHT, γ_d (PCF)	122.7	122.6	129.3	129.3
	VOID RATIO, e_o	0.363	0.366	0.294	0.294
AFTER CONSOL.	NORMAL STRESS, $\bar{\sigma}_n$ (TSF)	2.0	4.0	2.0	4.0
	VOID RATIO, e_c	0.273	0.311	0.274	0.234
AT FAILURE	SHEAR STRESS, τ_f (TSF)	1.41	2.70	1.62	3.11
	STRESS RATIO, $\tau_f / \bar{\sigma}_n$	0.704	0.675	0.808	0.778
	$\phi' =$ ARC TAN $\tau_f / \bar{\sigma}_n$ (DEG)	35.1	34.0	38.9	37.9
	VOID RATIO, e_f	0.261	0.296	0.280	0.214

*Maximum density 136.1 PCF determined on -#4 fraction using modified effort

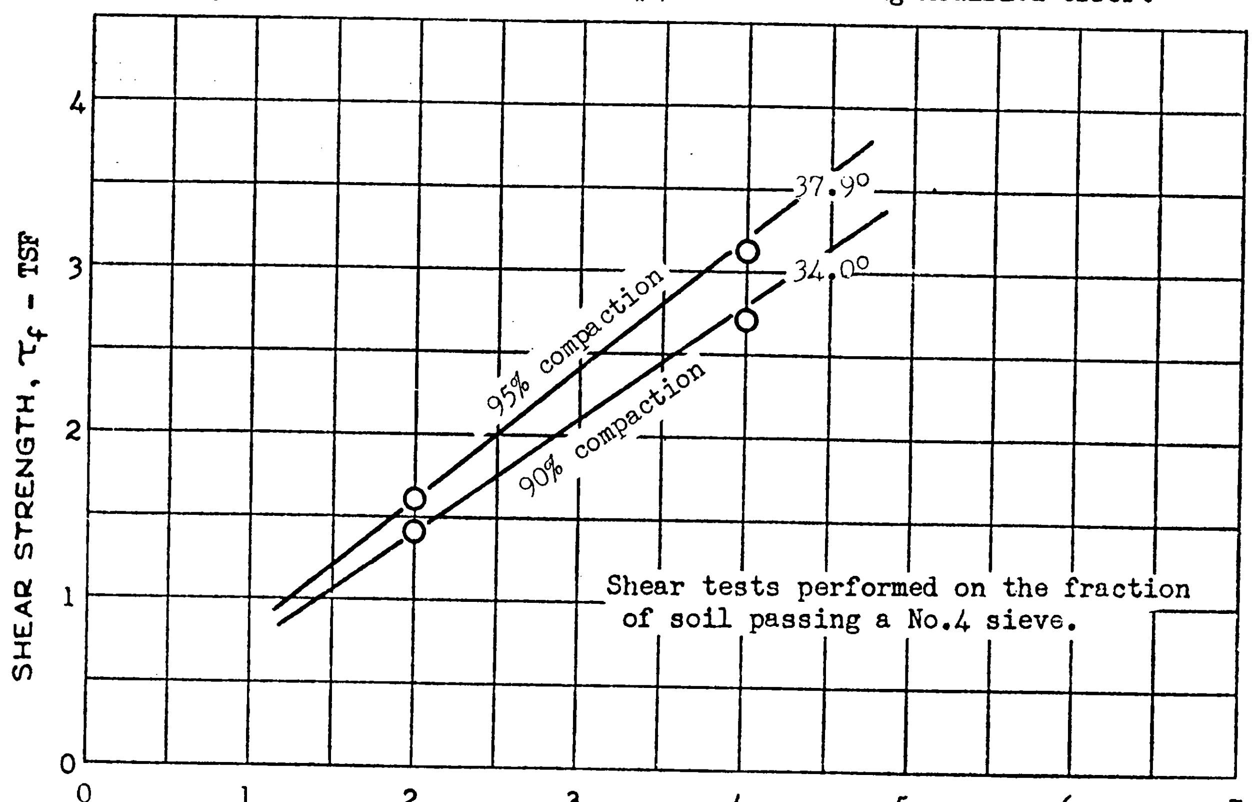


Fig. 13

STONE & WEBSTER ENGINEERING CORPORATION

DIRECT SHEAR TEST REPORT

CLIENT	J.O. NUMBER	EXPLORATION TYPE AND NUMBER
NORTHEAST UTILITIES (NUSCO)	12179	BAG SAMPLE
SITE	DATE	SAMPLE NUMBERS
MILLSTONE	19 JAN 76	NORTH STONINGTON

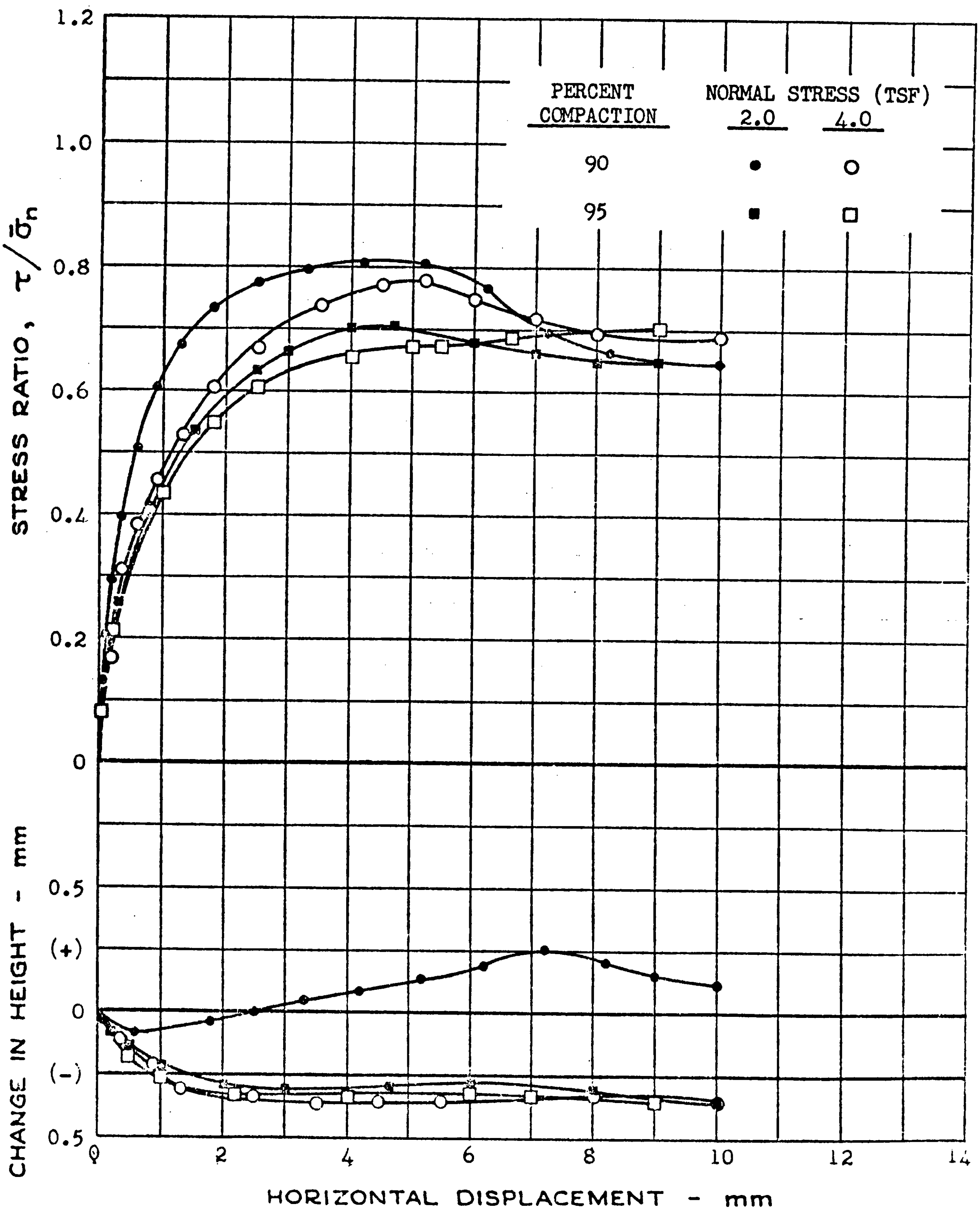


Fig. 14 2.5M-20