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GEOLOGY AND SEISMOLOGY
YANKEE ROWE NUCLEAR POWER PLANT

prepared for

YANKEE ATOMIC ELECTRIC COMPANY

January 29, 1979

Weston Geophysical
CORPORATION

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GEOLOGY AND SEISMOLOGY

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SUMMARY OF CONCLUSIONS

The site is located in the Green Mountain Section of the New England Physiographic Province (Fenneman, 1938). Tectonically, the site is located on the east flank of the Berkshire-Green Mountain anticlinorium in the central axial zone of the Western New England Foldbelt. The historical seismicity in the site province is of very low frequency and intensity.

The maximum earthquake potential for the Rowe site is specified by considering both site intensities experienced in the past during large historical events, and by calculating site intensities associated with the hypothetical reoccurrences of some large historical earthquakes within each of the surrounding tectonic provinces, but with epicenters migrated to the points of closest approach to the site.

From these considerations, both of historical and hypothetical site intensities, it is concluded that an Intensity VI(MM) is an appropriately conservative estimate of the Safe Shutdown Earthquake. Such an intensity would result in a ground acceleration .06g to .07g using either Neumann's (1954) or Trifunac and Brady's (1975) curves.

G1 REGIONAL GEOLOGY AND TECTONICS

G1.1 REGIONAL GEOLOGY

G1.1.1 SUBREGIONAL PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The site is located in the Green Mountain Section of the New England Physiographic Province (Fenneman, 1938). The fabric of the land area in the New England Province is characterized by a series of subparallel belts of lowlands, uplands, and mountain groups elongated to the north and northeast. These distinctive physiographic belts reflect, due to differential weathering and erosion, regional variations in the structure or lithology of the underlying bedrock; the bedrock ranges in age from Precambrian to Mesozoic, and ranges in competence from crystalline, well-bonded igneous and metamorphic rocks to little-metamorphosed shales and sandstones. The topography has been subdued by the scouring action of continental glaciers which moved over the area intermittently during the Pleistocene epoch.

The Green Mountain Section of the New England Physiographic Province is a narrow, north-trending, dissected upland which ranges to 25 miles in width and extends for about 250 miles through western New England from southwestern Massachusetts through west-central Vermont into southeastern Quebec. Elevations in the Section range from about 1,000 to 3,000 feet above sea level, supported by crystalline rocks of Precambrian and Lower Paleozoic age. The north-trending fabric of the Section closely follows a continuous bedrock structure of anticlinal folding and westerly-directed thrust faulting of Early and Middle Paleozoic ages.

Surficial geologic deposits in the Green Mountain Section (Flint et al, 1959) consist, on hillsides and in upland areas, of thin Late Pleistocene ground moraine till, with frequent bedrock exposures. Local deposits of granular glacial ice-contact, outwash and fluvial sediments occur along valley bottoms. Thick deposits of dense lodgment till lie in the troughs of deep bedrock valleys, and also locally rise to upland elevations on north-facing hillsides. Talus deposits occur below some bedrock cliffs.

G1.1.2 REGIONAL BEDROCK GEOLOGY AND HISTORY

Figure G1-1 is a specialized bedrock geologic map which has been constructed to show the distribution of the five distinctive blocks of crystalline basement which were created and joined by pre-Mesozoic compressional tectonic forces to form the present continental crust of the land area in the site region. The site is located in the exact center of Figure G1-1 and other regional tectonic and seismicity maps.

Block I - Grenvillian Crustal Consolidation

Upper Precambrian geosynclinal formations now located in areas to the west of the site were consolidated to a regionally-extensive crustal block of gneisses, schists, marbles, and intrusive igneous rocks during the Grenvillian orogeny, about 1,100 million years ago (King, 1976). The block constitutes the crustal basement beneath Cambrian-to-

Permian platform sedimentary formations throughout a broad area in New York, Pennsylvania, Ohio, and southern Ontario, and terminates against an older Precambrian crustal block along the Grenville front, about 500 miles west of the site (King, 1976).

Block II - Avalonian Crustal Consolidation

Late Precambrian rocks which now lie to the east of the site were consolidated and widely intruded by igneous rocks during the Avalonian orogeny, about 600 million years ago (Cameron and Naylor, 1976). The block constitutes the basement in southeastern New England, made up largely of little-deformed granitic rocks, and is also exposed as a remobilized gneiss dome and an apparent thrust slice, respectively, in central Massachusetts and southeastern New Hampshire (Naylor, 1976).

Block III - Penobscot(?) Crustal Consolidation

Early Paleozoic geosynclinal and volcano-clastic rocks having island arc affinities now occur discontinuously along the Maine coast and in northeastern Massachusetts and eastern Connecticut. Radiometric dating suggests that these rocks were apparently consolidated as a crustal block by orogenic forces about 480 to 500 million years ago, temporally associated with the Penobscot orogenic event in northern Maine (Brookins and Hussey, 1978; Hall, 1969; Neuman, 1967).

Block IV (The Site Block) - Taconic Crustal Consolidation

Cambrian and Early Ordovician geosynclinal rocks which trend northerly through western New England, and the site from southeastern Pennsylvania into southeastern Quebec were consolidated into a crustal block by westerly-directed compression during the Taconic orogeny, culminating about 450 million years ago (Fisher and McLelland, 1975; Bence and Rajamani, 1972).

Briefly to summarize the history of formation of this basement block, the Taconic orogeny completed a sequence of events which started in Late Precambrian time with a continental separation and ocean opening along an axis trending north through the site area (Rankin et al, 1977; Dewey and Kidd, 1974). Miogeosynclinal sands and carbonate shelf deposits formed to the west of the site, while eugeosynclinal sands and muds were deposited on oceanic crust from the site area easterly toward an oceanic ridge-island arc chain. In Early Ordovician time, the drift of crustal plates was reversed and, as the plates converged, the shelf sequence to the west was block-faulted and warped downward; the axial zone near the site was anticlinally elevated; huge masses of eugeosynclinal sediments moved westerly as gravity slides off the anticline down into the depressed former shelf zone; slices of consolidated eugeosynclinal rocks were thrust westerly; Grenvillian basement gneisses were remobilized and thrust in imbricate fashion into the anticlinal zone; and ultramafic masses of oceanic crust were kneaded upward into the overlying water-saturated sediments on the east flank of the anticlinal zone (Bird and Dewey, 1970). To the east of the site, the island arc chain, with its distinctive Late Precambrian (Avalonian?) and Ordovician plutonic gneiss basement, converged over a subduction zone against the former eugeosynclinal trough to its west, and the entire Cambro-Ordovician crustal block was consolidated at the end of Taconic time and annexed as part of the North American continent (Robinson, 1978).

Block V - Acadian Crustal Consolidation

Silurian and Devonian rocks to the east of the site in Massachusetts, New Hampshire, and Maine were deposited largely as thick sequences of eugeosynclinal sands and muds in an oceanic trench to the east of the Taconic crustal block (Billings, 1956). Miogeosynclinal and eugeosynclinal sediments with minor volcanic members were contemporaneously deposited also in a narrow north-trending trough on downwarped Taconic basement in west-central Massachusetts through eastern Vermont into southeastern Quebec (Cady, 1969).

The easternmost eugeosynclinal/oceanic depositional site was then compressed and uplifted between the Taconic block to the west and a northwesterly-advancing continental block to the east. In the salient defined by the wide part of the eugeosynclinal basin in central New Hampshire and southwestern Maine, Englund (1976) has proposed that the large central mass of uplifted sediments flowed under gravitational forces into the southwestern and northeastern gaps between the two continental plates, producing (at depth) recumbent folds with northwest-trending axes. Upon continued plate convergence, rocks of the geosyncline were successively deformed into large-scale nappes and upright folds, and with intense metamorphism, faulting, and wide-spread granitic plutonism were consolidated to form the terminal crustal block of the region, during the Acadian orogeny, culminating about 360 million years ago.

In the narrow Siluro-Devonian trough on the downwarped Taconic basement, extending northerly through eastern Vermont from just east of the site, compressional effects of the Acadian orogeny produced successively uplift, recumbent folding, mafic to calc-alkaline plutonism, gravitational uplift of domes and arches, thrust faults and finally, discordant calc-alkaline plutonic activity (Cady, 1969).

Post-Acadian Bedrock Geology

Sedimentary formations of Upper Devonian to Permian age overlie a thick blanket of Cambrian to Middle Devonian sedimentary formations (not defined on Figure Gl-1), resting on the gently south-dipping Grenvillian basement to the west of the site in New York and Pennsylvania. Sedimentary formations of predominantly Carboniferous age occur as intermontane deposits on the Avalonian basement east-southeast of the site in Massachusetts and Rhode Island. Sedimentary formations and intercalated basaltic flows and sills of

Triassic and Jurassic age occur as continental deposits in rifted basins on the Cambro-Ordovician basement to the southeast, south and southwest of the site in central Massachusetts and Connecticut (the Connecticut Basin); in southeastern New York, and northeastern New Jersey (the Newark Basin); and southeastern Pennsylvania (the Gettysburg Basin).

Alkaline ring complexes of Permian to Middle Cretaceous age, the White Mountain Plutonic Series, discordantly intrude both Cambro-Ordovician and Siluro-Devonian basement blocks to the northeast of the site, in a zone which trends south-southeasterly through New Hampshire and southwestern Maine to offshore northeastern Massachusetts. Isolated plutons with White Mountain Plutonic Series affinities also occur in these basement blocks in southeastern Vermont, southwest-central Maine, and near the Maine border in southeastern Quebec. Alkaline plutons of Middle Cretaceous age, the Monteregian Hills Plutonic Series, intrude both Cambro-Ordovician and Grenvillian basement blocks in and adjacent to a block-faulted embayment in southern Quebec, and at two or more isolated localities in western Vermont and northeastern New York. Prominent mafic dike swarms, predominantly of Triassic age, strike northeasterly through Cambro-Ordovician and Siluro-Devonian basement blocks to the southeast and east of the site in Connecticut, Massachusetts, New Hampshire, and southern Maine. Numerous small mafic dikes of both Triassic and Middle Cretaceous age occur throughout the region to the east, northeast and north of the site, in western Maine, New Hampshire, central and northern Vermont, and southeastern Quebec. Mafic dikes of Mesozoic tectonic origin have not been found in the site area.

Bedrock formations younger than Middle Cretaceous are rarely found on land areas in the region. Offshore to the south of New England, the continental shelf is comprised of Cretaceous and Tertiary Coastal Plain sediments overlying Mesozoic or older basement rocks (not defined in Figure G1-1). Patches of Tertiary Coastal Plain sediments occur on Triassic and older basement rocks in the Gulf of Maine. The entire 200-mile region around the site, with the exception of a small area in northern New Jersey and southeastern Pennsylvania, has been overridden by Pleistocene continental glaciers, and a variable, thin veneer of glacial and post-glacial sediments occurs throughout the region on the bedrock surface.

G1.2 REGIONAL TECTONICS

Precambrian and Early-Middle Paleozoic Compressional Tectonics

The major tectonic elements of the site region are defined on Figure G1-1. As summarized in Section G1.1.2 above, the essential crustal-tectonic framework of the region is constructed of five distinctive basement blocks which were initially formed and consolidated by compressional orogenic episodes which culminated successively at about 1,100, 600, 480, 450 and 360 million years ago. The common boundaries of all blocks are marked by basement fault zones and inherent zones of crustal weakness, and some of these boundary zones have experienced renewed or repeated fault deformations in response to subsequent tectonic stresses. To varying degrees of intensity, the forces of successive orogenic episodes have also superimposed younger deformational features within portions of earlier-consolidated crustal blocks.

Late Paleozoic Compressional Tectonics

In addition to the fundamental Precambrian and Early-to-Middle Paleozoic tectonic episodes which created the basic crustal blocks of the region, a final sequence of compressional events near the close of Paleozoic time superimposed or re-activated deep-seated fault structures on several of the crustal blocks in the coastal regions to the east, southeast, south, and southwest of the site.

In southeastern Maine and to the northeast into Maritime Canada, Middle Devonian to Late Carboniferous tectonic history is characterized by rifting followed by southwesterly-directed, right-lateral, strike-slip faulting (Belt, 1968; Dewey and Kidd, 1974; Wones and Stewart, 1976) along the general boundary zone of the Siluro-Devonian and coastal Cambro-Ordovician crustal blocks. The Avalonian basement in southeastern New England, which was not in its present position there in Acadian time (Schutts et al, 1976), was transported into place adjacent to the Siluro-Devonian crustal block along a major transcurrent fault system, of which the Bloody Bluff fault zone in northeastern Massachusetts (Nelson, 1976) is a primary feature.

The close of the Paleozoic in the eastern and southeastern coastal regions is characterized tectonically by: (1) the emplacement in southwestern Maine of two alkaline intrusives of White Mountain Plutonic Series affinities 297 to 244 million years ago (K-Ar dating by Stone & Webster Engineering Corporation, Montague PSAR, Appendix 27, 1974); (2) the development in northeastern Massachusetts of a complex of closely-spaced thrust faults between the Clinton-Newbury fault and the north edge of the Carboniferous Boston Basin, along the boundary of the Avalonian and Acadian crustal blocks in mid-Permian time (Public Service Company of New Hampshire, Seabrook PSAR, 1974); (3) the compressional folding and thrust faulting in the Carboniferous rocks of the Boston Basin (Billings, 1976) and Narragansett Basin (Skehan et al, 1976); (4) the emplacement of the Narragansett Pier and Westerly granites in southern Rhode Island (Quinn, 1971); and (5) the numerous determinations of Permian radiometric ages on basement rocks known to have substantially older geologic ages (Zartman et al, 1970).

To the south and southwest of the site, Late Paleozoic compressional events which deformed the older crustal blocks are evidenced by: (1) a 255-million year old metamorphic imprint in southern and southwestern Connecticut; (2) the emplacement of pegmatites and a discordant acid porphyry intrusion having an age of about 250 million years (Clark and Kulp, 1968); (3) right-lateral normal faulting and pseudotachylite development on the Ramapo fault system in northern New Jersey, dated at 259 million years (Ratcliffe, 1977); and (4) widespread folding, cleavage development, northwesterly-directed thrust faulting and Grenvillian basement remobilization in and to the northwest of the Reading Prong in easternmost Pennsylvania (Drake, 1970).

This Late Paleozoic compressional tectonic sequence has been generally defined as the "Allegheny disturbance" by Woodward (1957), and attributed by McKerrow and Ziegler (1972) and Dewey and Kidd (1974) to a collision of northern Africa with Europe and the Canadian Maritime provinces in Late Carboniferous time (Variscan orogeny), followed by the collision of Africa south of the South Atlas fault with North America south of New York during the Alleghenian orogeny in Early Permian time.

Mesozoic Extensional Tectonics

Attendant with the last closing of a proto-Atlantic Ocean and the resultant compressional fracturing and metamorphic deformations derived from Late Paleozoic continent-to-continent plate collisions, the site region was uplifted and subject to subaerial erosion. The area of the Siluro-Devonian crustal block in central New Hampshire and south-western Maine appears to have been particularly elevated and subjected to rapid erosional uncovering, in that K-Ar radiometric dating of micas from Acadian-age rocks in this wide area show Permian ages (Zartman et al, 1970), which Dallmeyer and VanBreeman (1978) have determined to reflect a time of cooling of these rocks, and not an episode of thermal metamorphism.

After the start of the Mesozoic era, a discontinuous chain of rift basins developed in the zones of Alleghenian continental suturing, generally along the eastern edge of the present continental landmass from Alabama to Nova Scotia. These basins locally accumulated more than 20,000 feet of terrestrial clastic sediments, including coal seams, and basin development was accompanied, in Late Triassic and Jurassic times, by extrusions of basalt flows and intrusions of basalt and diabase dikes and sills (Houlik and Laird, 1977; de Boer, 1968). Toward the end of Jurassic time, following three episodes of folding and strike-slip faulting in the Juro-Triassic basins (Sanders, 1977; Dewey, 1977), extensional tectonics in the southernmost part of the site region intensified with the initiation of the opening of the present Atlantic Ocean to the south of the present shoreline. Final opening and separation of North America from northern Africa and Europe was achieved in Middle to Late Cretaceous time (Smith, 1976; Pitman and Talwani, 1972). Successive episodes of alkaline ring complex volcanic-plutonic activity of the White Mountain Plutonic Series coincide first with

Triassic and Jurassic intrusive activity in the rift basins, and then with the Middle Cretaceous final separation of the continental masses, and represent the last important tectonic deformations to have affected the site region (Boston Edison Company, Pilgrim II PSAR, 1976).

G1.3 REGIONAL TECTONIC PROVINCES

Introduction

As shown on Figure G1-2, the region within 200 miles of the site is divisible into twelve major tectonic provinces. The site is located in the exact center of the map. The division is defined first, by the geographic distribution of the five fundamental crustal blocks which, as discussed above, were separately created by orogenic episodes approximately 1,100, 600, 480, 450 and 360 million years ago. Each of these five basic crustal blocks is characterized by geologic, lithologic, and structural features which are unique to it, and which terminate abruptly, commonly along faulted boundaries, against the neighboring crustal blocks.

The basic province divisions are then modified to delineate those areas or regions in which portions of the basic crustal blocks or their overlying platform deposits have been substantially altered and deformed by subsequent major tectonic forces. These superimposed tectonic provinces geographically delineate the areas in which portions of the basic crustal blocks have been extensively broken by post-consolidation transcurrent faulting, or by deep-seated block faulting associated with repeated crustal uplift or subsidence, or where sedimentary formations above the crust have been faulted and/or folded.

In some of the major tectonic provinces, it is possible, as shown on Figure G1-2, to define provincial subdivisions on the basis of specialized subregional structural or historical geologic features. These specialized geologic features may either have been intimately associated with the overall historical and structural development of a given crustal block or province itself, or have developed in response to localized stress regimes.

With reference to Figure G1-2, the site region is partitioned into the following twelve tectonic provinces, with geologic subprovinces as shown:

1. Western New England Foldbelt - Site Province

    Middlebury Sync. rium
    Berkshire - Gree ntain Anticlinorium
    Connecticut Valle nclinorium
    Bronson Hill Antic. rium

2. Merrimack Synclinorium

    White Mountain Plutonic Series

3. Coastal Anticlinorium

4. Northeastern Massachusetts Thrust Fault Complex

5. Southeastern New England Platform

    Long Island Shelf

6. Long Island Platform

7. New York Recess

8. Valley and Ridge

9. Appalachian Plateau

10. Eastern Stable Platform

11. Adirondack Uplift

12. Western Quebec Seismic Zone

Ottawa-Bonnechere Graben
Monteregian Hills Plutonic Series

1. Western New England Foldbelt - Site Province

The site is located on the east flank of the Berkshire-Green Mountain anticlinorium in the central axial zone of the Western New England Foldbelt (Figure G1-2). Other geologic subdivisions of the Province include the Middlebury synclinorium, the Connecticut Valley synclinorium, and the Bronson Hill anticlinorium, as discussed in Section G1.1.2 above. The foldbelt was formed as a crustal block during the Taconic orogeny, and was subsequently locally deformed by: (1) thrust faulting, folding, and metamorphism during the Acadian orogeny; (2) localized minor folding and metamorphic effects during the Alleghenian orogeny; and (3) normal faulting rift basin development, and volcanic-plutonic activity along the eastern sector during Triassic to Middle Cretaceous extensional tectonics associated with the last opening of the Atlantic Ocean. In the site area, post-Acadian deformations are minor, consisting of Alleghenian(?) "kink-band" crinkling and small Triassic extensional displacements. With the exception of simple, widely-spaced, Mesozoic normal faults along and within the Bronson Hill anticlinorium, the foldbelt province has experienced no known post-metamorphic fracture deformation of major crustal influence.

2. Merrimack Synclinorium

The Merrimack Synclinorium province was formed as a crustal block, predominantly from eugeosynclinal sediments, during the Acadian orogeny, and was subsequently deformed by Late Paleozoic transcurrent faulting and Permo-Triassic to Middle Cretaceous volcanism and pluton emplacement of the White Mountain Plutonic Series. The province is characterized by distinctly different major structural features than those of the surrounding provinces, particularly with respect to its transverse, northwest-striking, fold trends, northwest-trending elongations of many Devonian granitic plutons, and northwest-trending gravity patterns (Englund, 1976). In central New Hampshire, the province contains a large physiographic-geologic-aeromagnetic anomaly, enclosing the Ossipee, Belknap, and Merrymeeting Lake Mesozoic plutons, which has been interpreted as a collapsed volcanic caldera (Boston Edison Company, Pilgrim II PSAR, 1976). In southwestern Maine, the Lewiston-Pittsfield fault zone experienced substantial post-Acadian transcurrent movement (Dallmeyer and VanBreeman, 1978); similar offsets of metamorphic isograds (Morgan, 1972) on mapped fault zones about 30 miles to the northwest of the Lewiston-Pittsfield structure suggests a similar style of transcurrent crustal deformation in that area. Two Late Paleozoic alkaline plutons of White Mountain Plutonic Series affinities occur in close spatial association with the Lewiston-Pittsfield structure.

3. Coastal Anticlinorium

Rocks of the Coastal Anticlinorium are predominantly of Cambro-Ordovician or older ages, and have been subjected to both pre-Silurian (Penobscot?) and Acadian orogenic fold, intrusive and metamorphic deformations, followed by post-metamorphic, left-lateral kink banding (Hussey, 1978). Along the Norumbega fault system, Wones and Stewart (1976) have mapped post-metamorphic, right-lateral, strike-slip faults whose relative displacements are measured in miles. Foliation fabric of the province strikes quite uniformly to the northeast, parallel to the post- and pre-metamorphic faults in the province.

4. Northeastern Massachusetts Thrust Fault Complex

The Northeastern Massachusetts Thrust Fault Complex is readily distinguished from neighboring provinces by its style and high frequency of post-Acadian faulting. The Complex is bounded on the northwest by the Clinton-Newbury fault, dated at Middle Permian (Public Service Company of New Hampshire, Seabrook PSAR, 1974), and is delimited on the southeast by the North Border fault of the Boston Basin. The Complex narrows and dies to the southwest, but can be projected for tens of miles to the east beneath the Gulf of Maine by extension of aeromagnetic patterns. The predominant style of deformation in the Complex is moderately- to steeply-northwest-dipping thrust faulting, commonly with right-lateral, west-over-east displacements (Skehan, 1968; Dennen, 1978). The Complex is a superimposed tectonic structural feature which exhibits extreme mechanical deformation of rocks both of Coastal Anticlinorium affinities (Hussey, 1978, personal communication; Goldsmith, 1978) to the north and of Avalonian affinities to the south. The boundary between these two distinctive terranes is the Bloody Bluff fault system, the principal deep crustal fault of the Complex (Nelson, 1976). Marine and airborne magnetic surveys (Boston Edison Company, Pilgrim II PSAR, 1976) indicate the presence of a probable Middle Cretaceous cylindrical mafic pluton offshore to the north of Cape Ann, located adjacent to the offshore trace of the Bloody Bluff fault system.

5. Southeastern New England Platform

To the south of the North Border fault of the Boston Basin, the Southeastern New England Platform consists largely of Late Precambrian-Early Paleozoic granitic basement, with supracrustal basins containing continental sedimentary rocks (with minor volcanic members) which range in age from older Paleozoic in the Boston Basin to Carboniferous in the Narragansett and neighboring basins in Rhode Island and southeastern Massachusetts. The Platform is relatively little deformed, and does not show evidence of Acadian orogenic deformation. In the Boston Basin, the sedimentary rocks have been folded and thrust faulted from the south, with apparently thin-skinned tectonic deformation (Billings, 1976).

In the southwestern part of the Narragansett Basin, in southeastern Rhode Island, deformation of the Carboniferous sedimentary rocks includes folding, metamorphism, and two episodes of east-west thrusting. In eastern Connecticut, the Precambrian rocks of the Southeastern Platform underlie a thin cover of pre-Silurian rocks beneath the Lake Char and Honey Hill fault surfaces. Most of the Platform rocks have been affected by an Alleghenian thermal or metamorphic event, locally including granitic plutonism. The Platform has not, however, been deformed internally by throughgoing crustal fault structures.

The basement offshore to the south, in the area of the Long Island Shelf (Schlee, 1977), slopes to the south and is blanketed by a seaward-thickening wedge of loosely-consolidated Coastal Plain sediments of Cretaceous and Tertiary age. Sheridan (1974) interprets the basement of the Southeastern Platform to extend roughly 100 kilometers south of the southern New England shoreline.

Aeromagnetic patterns (United States Geological Survey, 1976) suggest that in wide areas of the Long Island Shelf, Mesozoic volcanic rocks immediately underlie the Coastal Plain sediments (Valentine, 1978).

The only mapped fault structure in the Coastal Plain sediments in the site region is the New Shoreham fault (McMaster, 1971). Detailed seismic surveys by Weston Geophysical Corporation (New England Power Company, NEP

1 & 2 PSAR, 1978) reveal clearly that Cretaceous and presumed Tertiary sediments have been deformed along the zone, and that the underlying "basement" reflector is offset, down to the east, by as much as 130 feet. Although these geophysical surveys were not able to discern whether deformation of the sediments was related to tectonic faulting or merely to differential settlement of the sediment across a buried topographic escarpment, they were able to demonstrate that sediment deformation along the feature occurred more than 120,000 years ago, and possibly as much as 20 million years ago.

6. Long Island Platform

The northern boundary of the Long Island Platform (Klitgord and Schouten, 1977; Schlee, 1977) is defined by sharp offsets in the continental crust along a zone of block faulting. The southern boundary (beyond the southern edge of Figure G1-2) is defined by the "east coast magnetic anomaly" (Taylor et al, 1968). The Platform itself is considered to be a series of graben/horsts whose axes are parallel to the Baltimore Canyon trough and the Georges Bank trough (Klitgord and Schouten, 1977). Sheridan (1974) has interpreted the younger basement beneath Coastal Plain sediments in the Platform area to be Jurassic evaporite, carbonate, and terrigenous deposits, more than 20,000 feet thick, overlying Triassic sedimentary rocks in a down-faulted basin in the older-basement crystalline rocks.

The location of the inferred northern boundary of the Province as shown on Figure G1-2 is only approximate, having been estimated from very small-scale regional maps of Sheridan (1974).

7. The New York Recess

Burke and Dewey (1973) described a mechanism for continental separation at angular junctions over plume-generated "hot-spots". They suggested that "bends in continental margins commonly mark the sites of triple junctions and, further, that these bends... are inherited from irregularities in the continental margin formed at (earlier) opening..." of ocean basins. They cited the area of Long Island, New York, as a four-armed junction consisting of the Connecticut and Newark graben and two continent margin flexures.

Rodgers (1975) pointed out that salients (bends convex toward the craton) and recesses (bends concave toward the craton) are prominent features along the cratonal margin of the Appalachian Mountain chain, further noting that the recesses are relatively angular bends where structural trends from the two sides intersect, and that few individual structures continue through from one side of a recess to the other.

The term "New York Recess" was first used by Rankin (1976) to describe a triple junction there whose arms have been carried away; he further noted that the area between western Massachusetts and eastern Pennsylvania stood structurally high during most of the early Paleozoic, and coincides with the New York Recess.

As delineated on Figure G1-2, the New York Recess tectonic province includes that area of the Taconic crustal block which has been subjected to major fault deformation at recurring intervals from Late Precambrian to Middle Mesozoic time. No other area of the site region has experienced comparable deformations, nor has any other area the geometric characteristics of a continental recess, subjected repeatedly to the most extreme strains as a sequence of continental collisions were driven against it intermittently throughout Paleozoic time.

The structural history of the New York Recess dates from the time of its formation as a continental "headland" with the opening of Iapetus, a proto-Atlantic Ocean, in Late Precambrian time. Ratcliffe (1971, 1977) has reported repeated movements, both compressional and extensional, on the Ramapo fault system in southeastern New York in Late Precambrian, Ordovician to pre-Middle Devonian, Carboniferous, Triassic, and Jurassic times (the latter two, only west of the Hudson River). Long and Kulp (1962) report a "true" age of the Precambrian rocks in the Hudson Highlands of a southeastern New York at 1,150 million years, with a pronounced metamorphic event at about 840 million years, and immediately south of the Ramapo-Canapus fault system, a resetting of ages at about 360 million years, a time when Mose et al (1976) reported igneous activity and brittle fracture.

In the region of northeast New Jersey and eastern Pennsylvania, Drake (1970) has reported Alleghenian folding, faulting, and northwestward transport of Precambrian rocks in the Reading Prong. Pronounced Alleghenian metamorphism and igneous activity in southern and southwestern Connecticut, following Acadian and Taconic metamorphic events, has been documented by Clark and Kulp (1968). Juro-Triassic faulting and volcanism, associated with rift development of the Connecticut Valley Basin, are particularly pronounced in the southern part of the basin, in south-central and southwestern Connecticut (de Boer, 1968). The final known compressional deformation in the Newark and Connecticut rift basins and their basement rocks occurred between mid- and final Jurassic time, with three large-scale, left-lateral, strike-slip couples (Sanders, 1977; Dewey, 1977).

The northwestern boundary of the province is taken along the northwestern edge of high-angle block faulting in the Hudson and New Jersey Highlands where clastic rocks Mid to Late Devonian age are folded and infaulted (Drake, 1970). The southeastern boundary is taken on the prominent Higganum Jurassic dike swarm in southeastern Connecticut (de Boer, 1968), and is projected southwesterly beneath Long Island and northeastern New Jersey along a distinctive magnetic linear anomaly (Taylor et al, 1968).

The "jagged" northeast boundary drawn for the New York Recess encloses both the closely-faulted southern end of the

Connecticut Valley and the prominent fault structures which extend northeast across the Hudson River from the New Jersey Highlands. Mapping of the Manhattan Prong rocks in southeasternmost New York, 10 to 50 miles northeast of New York City, has reported ambiguous conclusions as to the time of last crustal deformation there, and that area has, accordingly, been tentatively placed with the tectonically older Western New England Foldbelt province.

Some evidence is emerging, however, that this southernmost arm of the foldbelt (as drawn) may have been subjected to a major post-Acadian deformational event (Brock and Brueckner, 1978), which, if confirmed, would cause it to be reassigned to the geologically younger New York Recess tectonic province.

8. Valley and Ridge

The Valley and Ridge tectonic province involves Cambro-Ordovician miogeosynclinal sedimentary rocks on the southeast, and Cambrian to Pennsylvanian platform sedimentary rocks to the northwest, all of which have been folded and thrust-faulted toward the northwest. These fold and thrust tectonics are thin-skinned, and are not believed to have involved remobilization of the underlying Grenvillian basement block, more than 30,000 feet beneath the surface rocks. The Blue Mountain Structural front in this area is marked both by a Taconic angular unconformity (Woodward, 1957; Rodgers, 1970) and by cleavage associated with folding during the Alleghenian orogeny (Drake, 1970). The major deformation in the northwestern part of the province is of apparent Alleghenian age.

In the narrow northeastern arm of the province delineated on Figure G1-2 along the Hudson River and eastern edge of the Appalachian Plateau (Catskill Mountains), from Albany southward, a chain of fold-and-thrust structures has been variously defined as of Acadian age (Woodward, 1957; Bird and Dewey, 1975; Ratcliffe et al, 1975), or of Alleghenian age (Sanders, 1969). Sanders noted that this fold-thrust zone dies out northward in the area of Clarksville, New York, west of Albany.

In the "Little Mountains" (about 55 miles south of Albany), Sanders (1969) described thrust faults which are not only folded themselves, but which dip westward, apparently passing beneath strata which underlie the gently east-west folded Devonian deposits of the Catskill Mountains. Sanders has also noted the effects of vertical folding of Triassic deposits in southeastern Pennsylvania, and suggested that a major compressional deformation may have been imparted to Valley and Ridge rocks after Late Triassic and prior to Late Cretaceous time. Fisher et al (1971) describes a graben of Silurian-Devonian strata in the Valley and Ridge about 70 miles south-southwest of Albany as probably a fault trough of Triassic age.

Regardless of age, the general style of compressional fold and thrust deformation in this narrow northeastern arm of the province is comparable to that of the classic Alleghenian deformation in the Valley and Ridge farther to the southwest, and it, in turn, is broken here by numerous normal faults (Sanders, 1969; Fisher et al, 1970), unlike structural features reported in neighboring provinces.

9. Appalachian Plateau

The Appalachian Plateau province in the site region consists of little-deformed Paleozoic platform sedimentary formations of Cambrian to Pennsylvanian age resting on a south-dipping Precambrian crystalline basement block of Grenvillian age. Several normal faults of pre-Devonian age have been inferred to cut Ordovician and older rocks beneath unfaulted Middle Paleozoic sedimentary cover in the northern part of the province (Isachsen and McKendree, 1977). The boundaries of the province on Figure G1-2 are defined by topographic (erosional) escarpments along the north and northeast sides, and by a general zone along the irregular south edge where the more prominent fold and thrust structures of the Valley and Ridge die out northward.

In the western part of the province in the site region, about 110 to 140 miles west of Albany, small swarms of predominantly north-northwest-striking kimberlite and lamprophyre dikes are exposed near Ithaca and Syracuse, New York, and are dated at 136 to 150 million years old (Fisher et al, 1971). Structural deformation of the province is apparently limited to mild, east-west, open folding, generally ascribed to Alleghenian compressional forces. The alignment of the Mesozoic dikes may have been controlled by tension openings normal to the fold axes, with intrusive activity initiated at a time of localized crustal uplift following erosional unloading of the sedimentary cover.

10. Eastern Stable Platform

The Eastern Stable Platform consists of a south-sloping Precambrian crystalline basement of Grenvillian age, widely overlain by little-deformed platform sedimentary formations ranging from Cambrian to Permian in age. The basement is exposed to the north, in southern Ontario, and consists of Lower and Middle Proterozoic gneisses, migmatites, and metamorphic rocks locally intruded by granites and syenites of the Grenvillian orogeny. Radiometric dates for the crystalline terrane run between 1,100-1,200 million years (King, 1977). The western boundary of the province is defined by the Grenville front, about 500 miles west of the site. The eastern boundary with the Adirondack Uplift is along the Highland Boundary fault, downthrown to the west (King, 1976).

Structural deformation of the platform sedimentary rocks overlying the Grenvillian basement within the site region appears restricted to south-trending normal faults of pre-Devonian age (Isachsen and McKendree, 1977).

11. Adirondack Uplift

The Adirondack Uplift province is a domical region of exposed high-grade (granulite facies) gneisses, syenite, and anorthosite, overlapped on the east and south by Cambrian and Ordovician platform sedimentary rocks. Radiometric dates of rocks on the province range between 1,020 to 1,100 million years, about 100 million years younger than Grenville Group metasedimentary and meta-intrusive rocks of the lowlands to the west, and record the age of magmatic crystallization and granulite metamorphism in the Uplift (King, 1976). The province boundaries are delineated on: (1) the northwest by the Highland Boundary fault; (2) the north by the Western Quebec Seismic Zone; (3) the east by the termination of block faulting against the Cambro-Ordovician Taconic block; and (4) the south and west by the apparent termination of exposed pre-Devonian normal fault structures in Ordovician sedimentary rocks. The structural feature of essential significance in defining the tectonic province, and in differentiating it from its neighboring provinces is the character of closely-spaced, north- to northeast-trending block faulting of the crystalline mass.

The crystalline rocks of the Uplift are closely faulted internally, and some of the faults extend through Cambrian-Ordovician sedimentary rocks which lap onto the Uplift on the southwest, south and east sides. Block faulting in the Mohawk, Hudson and Champlain valleys, to the south and east of the Uplift, is interpreted to be of Early Silurian(?) age, associated with a doming episode of the Uplift, and subsequent doming may have occurred in Late Silurian through Lower Devonian time (Fisher et al, 1971).

Fault movements younger than Middle Paleozoic have not been reported for areas within the central part of the Uplift. In the eastern part of the province, however, Cady (1969) described east-west cross faults of the Champlain fault system as at least of Mesozoic age, and Fisher et al (1971) and McHone (1977) report the emplacement there of Mesozoic dikes, some of which are themselves faulted. Burke (1977) has hypothesized that a 2 km uplift of the Adirondacks in Miocene-Pliocene time could have reactivated the "Champlain-Lake George rift system". Isachsen et al (1978) reported that releveling surveys suggest that the Adirondack Mountains Dome, which formed sometime later than Upper Devonian time, is currently undergoing uplift at the rate of 3-4 mm/year, although investigations specifically to detect recent surface movements on faults within the Uplift have not yet been successful.

12. Western Quebec Seismic Zone

For much of its area, the Western Quebec Seismic Zone is defined as a tectonic province on the basis of its modern, anomalous seismicity. In the site region, however, the province is characterized by crystalline basement rocks of Grenvillian age block-faulted in a central rift basin which contains faulted platform sedimentary rocks of Cambrian and Ordovician ages. The trend of major faulting extends east southeasterly from the Ottawa-Bonnechere graben, in which Kay (1942) described normal faults having post-Ordovician displacements of as much as 1,500 feet. In the eastern part of the rift basin, the trend of faulting curves to assume a south-southwest strike fabric, parallel to the eastern margin of the province.

In this eastern area, a series of plug-like alkaline plutons of Middle Cretaceous age (Currie, 1976), the Monteregian Hills Plutonic Series, have forcefully intruded the basement and Lower Paleozoic sedimentary rocks along an 80-mile east-west belt near Montreal. Diment (1968) has suggested that a series of gravity anomalies along a parallel 40-mile belt in northeasternmost New York state, about 50 miles south of the Monteregian plutons, may reflect a belt of buried mafic plutons along an east-southeast-trending rift or sedimentary basin.

These fault/intrusive structural features of the province in the site region are distinctive, and are unlike those of neighboring provinces. The precise ages of fault activity in the basin are not known. Kay (1942) inferred an Early Tertiary age, largely from wide-area geomorphologic considerations. Kumarapeli and Saull (1966) noted that the younger faulting followed zones of weakness on older Precambrian faults, with post-Silurian and probably Cretaceous activity. They recounted reported post-Pleistocene fault movement in the Timiskaming region of Ontario and Quebec, about 275 miles west-northwest of Montreal. Rankin (1976) discussed the rift basin in terms of a Late Precambrian failed-arm trough (aulacogen), and noted that it was a zone of diabase dike emplacement in Late Precambrian time, of alkaline ring complex intrusion in Cambrian time, and of Monteregian Hills plutonic activity in Cretaceous time.

Beyond the site region, the Western Quebec Seismic Zone constitutes a northwest-trending region of Grenvillian crystalline rocks ranging to about 150 miles in width, bounded on the southwest by the northwesterly continuation of the Ottawa-Bonnechere block fault system, and on the northwest by the Grenville Front, 250 to 320 miles northwesterly from Montreal. Geologic control for the northeastern boundary of the province is not well-defined, although there is a partial relationship of the northeastern cessation of recorded seismicity with the northeastern limit of Grenville series metasedimentary rocks (Doig, 1977), and with the northeastern slope of a broad gravity anomaly (Canadian Observatories Branch, 1969). Much of the province in the Grenvillian crystalline terrane beyond the site region has not yet been mapped in sufficient detail to define patterns and ages of post-orogenic faulting.

G1.4 REGIONAL SEISMICITY

A cummulative seismicity map was prepared for the region contained between 39.0°N and 46.0°N, 68.7°W and 77.0°W (Figure G1-3), using Weston Geophysical's earthquake data base. This data base has been developed over the past decade by incorporating data from many published sources with many man years of original research by Weston Geophysical. It includes data from all major catalogs and listings, such as the Earthquake History of the United States; the United States Earthquake Series; the Publications of the Dominion Observatory and the Seismological Series of Earth Physics Branch, both of Canada; the Seismological Bulletins of the Lamont-Doherty Observatory, of the New England Seismological Association and the Northeastern United States Seismic Network; and the listings of Mather and Godfrey, Brigham, Brook, and Pomeroy. It contains numerous revisions and additions founded on other historical sources, such as newspapers, diaries, scientific bulletins, etc. A more complete description of the sources and a review of the completeness and reliability can be found in New York State Electric & Gas Corporation, NYSE&G 1 and 2, PSAR (1978). Table G1.1 lists all events included in Figure G1-3.

G1.5 GEOLOGIC STRUCTURES AND TECTONIC ACTIVITY

Introduction

As shown on Figure G1-4, historical seismicity in the region tends to "cluster" in areas or regions also characterized by the presence of high-angle fault systems. These fault systems have crustal dimensions and relatively "young" post-orogenic mechanical displacements, and may be of either transcurrent compressional origin or of block-fault extensional origin. There is no apparent association in the region of anomalous earthquake activity with pre- or syn-metamorphic fault structures.

In several instances, an apparent higher <u>frequency</u> of seismic activity is spacially associated with areas having a greater frequency of mapped brittle-fracture deformation. It appears also that relatively higher <u>intensity</u> seismic activity is generally associated with systems of brittle-fracture deformation which have the relatively longer lateral strike lengths. Some large earthquakes are spatially associated with distinctive, individual tectonic structures defined by discordant, post-metamorphic mafic intrusives lying within crustal fault systems or immediately adjacent to individual major crustal faults.

Conversely, broad areas in the region characterized by their infrequent, widely-spaced and low-intensity historical earthquake activity are also characterized tectonically by the absence of deep-crustal, post-metamorphic mechanical deformation.

Published geologic reports are not of uniform quality and detail from place to place throughout the region. Where detailed information does exist, however, there appears to be a direct relationship between the degree of post-metamorphic mechanical deformation and the level of seismic activity. Seismicity in the region results from modern stress regimes which accumulate strain in distinct zones of rock weakness, or at specific locations where there is a marked discontinuity in rock density, rigidity or geometry. The orientation of the contemporary crustal stress field relative to the orientation of zones of weakness or discontinuity influences the degree of seismicity and the type of earthquake mechanism at those locations. There is no reason to assume that earthquakes which have occurred on anomalous tectonic structural features in one part of a broad regional tectonic province might, in the future, occur in some other part of that province where no comparable structural features exist.

1. Western New England Foldbelt - Site Province

The site prov[illegible]onsists of Lower Paleozoic rocks with included Precambrian thrust slices which were consolidated to a crustal block about 450 million years ago during the Taconic orogeny; locally metamorphosed and thrust faulted during the Acadian orogeny; and broken by simple, widely-spaced normal faults and locally intruded by a few ring complex plutons along the eastern margin during Mesozoic time.

As shown on Figure G1-4A, historical seismicity in the province is of very low frequency and is, with two exceptions, limited to Intensity V(MM) or smaller earthquakes. The network of faults in the aseismic western part of the province is predominantly comprised of gravity-slide and thrust faults of Taconic age, welded by Taconic and Acadian metamorphic processes. A substantial portion of the historical earthquakes within the province has occurred along the

Bronson Hill anticlinorium in the eastern part, in spatial association with simple, widely-spaced, normal fault structures of Mesozoic age.

The first exception to the low-intensity characteristic of the province is the Intensity VI(MM), Magnitude $m_b = 4.8$ event of June 15, 1973 near Woburn, Quebec, about 210 miles north-northeast of the site (Wetmiller, 1975). This event is spatially correlated with an anomalous and localized tectonic structure, consisting of a large cylindrical mafic plug of Middle Cretaceous age, the Megantic complex, (Boston Edison Company, Pilgrim II PSAR, 1976) emplaced within a swarm of closely-spaced, northwest-dipping normal faults of apparent post-Devonian age (St. Julien and Hubert, 1975, Page 343, Section E-E'). The faults of St. Julien and Hubert (1975) are not defined in plan view in their paper, and are not, accordingly, shown on Figure G1-1 and following maps herein. The epicenter is also coincident with the southwesterly projection of the Northern Border fault of the Boundary Mountain Anticlinorium in Maine (Westerman, 1978a), which has been interpreted as a high-angle, post-Devonian normal fault with thousands of feet of displacement, down to the northwest (Westerman, 1978b).

The second exception is a peculiar Intensity VI event which occurred on January 30, 1952, in Burlington, Vermont. Cracks at the surface of frozen ground near the Winooski River as well as cracks in pavement and basement walls were reported. The event was given its Intensity VI most likely because of these reports. This event remains anomalous in nature because of its extremely small felt area, 50 square miles, certainly not characteristic of a true Intensity VI event. Other factors such as extreme, shallow focal depth of a smaller magnitude event and frozen, saturated overburden could be envisaged as principal causes of the observed cracks and explosive noises.

2. Merrimack Synclinorium

The province consists of Silurian and Devonian eugeosynclinal sediments which were consolidated to a crustal block about 360 million years ago during the Acadian orogeny; locally deformed by transcurrent right-lateral crustal faulting around 280-240 million years ago during the Variscan orogeny; and invaded by discordant White Mountain series volcanic-plutonic complexes at discrete intervals from Late Paleozoic to Middle Cretaceous time, about 300 to 110 million years ago.

A substantial portion of the historical seismicity in the province (Figure G1-4A) is associated with one of three anomalous structural features:

A. In southwestern Maine, the most prominent and repeated seismicity, including two Intensity VI(MM) events of December 23, 1857 and July 15, 1905, lies in close spatial correlation with the northeast-trending Lewiston-Pittsfield fault zone. Similarly, diffuse seismicity appears to correlate with a broad northeast-trending fault system to the northwest of the Lewiston-Pittsfield zone, and with the Norumbega fault system along the southeast boundary of the province. All of these fault systems are post-metamorphic, and are interpreted to be of Carboniferous (Variscan) age.

B. In central New Hampshire, a cluster of earthquakes, including two Intensity VII(MM) events, is spatially correlated with an 850 square mile physiographic-geologic-aeromagnetic anomaly which encloses at least five Mesozoic central complex intrusives, and which may reflect a collapsed volcanic caldera. The two Intensity VII(MM) events occurred in December, 1940, and are spatially correlated with a tectonic structure in which an east northeast-trending border fault of the apparent collapse structure passes tangent to the north rim of a large cylindrical mafic pluton of Middle Cretaceous age, the Ossipee complex (Boston Edison Company Pilgrim II PSAR, 1976).

C. In south central New Hampshire, a diffuse grouping of earthquakes of Intensity V(MM) and smaller occurs in a region in which a few presumed Triassic silicified zones have been mapped, but where extensive post-metamorphic mechanical deformation has not yet been identified. The grouping of epicenters here is very closely contained within a discrete area of sillimanite + orthoclase low P/T granulite facies metamorphism (Morgan, 1972), where gravity patterns (Kane et al, 1972; Nielson et al, 1976) and aeromagnetic patterns (Boston Edison Company, Pilgrim II PSAR, 1976) display both prominent northwest- and northeast-trending anomalies. The post-Acadian Concord granite pluton (possible age 330 million years, Lyons and Livingston, 1977) is centrally located in the epicentral grouping, and the Late Carboniferous Milford Granite (275 ± 10 M.Y.: Aleinikoff and Zartman, 1978) is located in association with silicified fault zones of Triassic(?) age at the southwestern end of the epicentral grouping. This combination of intersecting geophysical and geological features is not known to occur elsewhere in the region.

3. Coastal Anticlinorium

The province consists of Cambro-Ordovician volcano-clastic rocks consolidated by Early Paleozoic orogenic forces; deformed and intruded during the Acadian orogeny; broken by transcurrent faulting during the Variscan orogeny; and locally intruded by mafic dikes at intervals during Mesozoic time.

Historical seismicity in the province (Figure G1-4A) is of low frequency and low intensity, with a substantial portion of the historical events having occurred in spatial correlation with the post-metamorphic Norumbega right-lateral, strike-slip fault system. The largest event in the province is the Intensity VI(MM), Magnitude 4.8 event of April 26, 1957, offshore to the east of Portland, Maine. Partial aeromagnetic coverage (Boston Edison Company, Pilgrim II PSAR, 1976) in the southern part of this area suggests, but cannot demonstrate, that a mafic pluton of

White Mountain series affinity may occur in very close spatial association with the epicentral location of this event.

4. Northeastern Massachusetts Thrust Fault Complex

The province consists of Late Precambrian and Early Paleozoic plutonic and volcanic rocks which have been extensively fractured by thrust faulting associated with Late Paleozoic continent-to-continent collision tectonics, possibly successively during both the Variscan and Alleghenian orogenies. A cylindrical mafic pluton has been interpreted from magnetic surveys to lie within the fault complex, adjacent to its major crustal fault, about one mile offshore to the north of Cape Ann, Massachusetts.

Historical seismicity within the fault complex (Figure G1-4A) is the greatest in New England, with one Intensity VIII(MM) event in 1755, one Intensity VII(MM) event in 1727, three Intensity VI(MM) events, and numerous Intensity V(MM) and smaller events. The two largest earthquakes are considered to have occurred in the area offshore of Cape Ann. The larger offshore events have been correlated with a localized tectonic structure consisting of the geophysically-inferred, cylindrical mafic pluton tangent to the Bloody Bluff fault, the major fault system of the Complex (Boston Edison Company, Pilgrim II PSAR, 1976). All of the lower level seismicity is spatially correlated with the zone of intense post-metamorphic faulting, and dies out to the southwest as the frequency of faulting diminishes.

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5. Southeastern New England Platform

The province consists of a little-deformed Late Precambrian (Avalonian) granitic basement complex, containing Early and Late Paleozoic intrusive masses, Early to Late Paleozoic supracrustal basins, and, to the southeast, north-trending mafic dikes of presumed Triassic age. The supracrustal basins have been open-folded and broken by shallow thrust and normal faults. There are no known major crustal fault zones within the province.

Historical seismicity of the province (Figure G1-4A) is of generally low frequency and low intensity, the largest earthquake having been an Intensity VI-VII(MM) event near East Haddam, Connecticut on May 16, 1791. Most of the remaining earthquakes in the province appear to have occurred in general spatial association with the relatively more faulted portions of the Boston and Narragansett supracrustal basins. The faulting in these areas is not considered to have deep crustal dimensions, and all earthquakes have been small.

6. Long Island Platform

The province is interpreted to consist of down-faulted basins in Early Paleozoic or Precambrian basement, filled with Mesozoic sediments, and overlain by loosely-consolidated Coastal Plain sediments of Cretaceous and Tertiary ages.

No seismic activity has been detected in the province of the site region (Figure G1-4A).

7. New York Recess

The province consists of Cambro-Ordovician geosynclinal deposits and included Precambrian thrust slices which were consolidated to a crustal block during the Taconic orogeny; locally deformed and metamorphosed by the Acadian orogeny; compressionally faulted, intruded and thermally altered by the Alleghenian orogeny; broken by normal faulting and intruded by mafic dikes during Triassic continental rifting; and finally, subjected to three episodes of large-scale, left-lateral folding and strike-slip faulting in Late Jurassic time.

Historical seismicity in the province (Figure Gl-4A) in the site region includes events listed as Intensity VII(MM) in New Jersey and southernmost New York; several Intensity VI(MM) events in eastern Pennsylvania, New Jersey, southernmost New York, and southwestern Connecticut; and numerous Intensity V(MM) and smaller events. In areas for which detailed geologic mapping has been published, as along the Ramapo fault system, it appears that the higher frequency of seismic activity can be correlated with zones of relatively greater frequency of brittle-fracture faulting.

8. Valley and Ridge

The province consists of Cambrian to Pennsylvanian sedimentary rocks which were deformed by thin-skinned folding and thrust faulting during the Alleghenian orogeny, and apparently further slightly deformed by Mesozoic compressional and extensional tectonic forces. Grenvillian basement lies at great depth and is not believed to have been remobilized during deformation of the sedimentary rocks, although it may have been broadly warped (Rodgers, 1970).

Historical seismicity in the province (Figure G1-4A) is of generally low frequency and intensity in the site region. There is a scattering of small events to the southwest along the Blue Mountain Structural Front, and to the west in the closely-folded and structurally anomalous north-northeast-trending Lackawanna syncline in northeastern Pennsylvania.

9. Appalachian Plateau

The province consists of Cambrian to Pennsylvanian platform sedimentary rocks which were mildly deformed into east-northeast-trending open folds during the Alleghenian orogeny, and then locally broken by small, discontinuous normal faults of probable Mesozoic age and intruded by mafic dikes of Upper Jurassic age. A south-sloping Grenvillian basement surface underlies the sedimentary rocks at depths of from about 1,000 feet to 25,000 feet, and is probably broken locally in the northeastern part of the province by pre-Devonian normal faults.

Historical seismicity in the province (Figure G1-4A) is clearly of very low frequency and intensity; a single event is shown in the site region, located in north-central Pennsylvania about 210 miles southwest of the site.

10. Eastern Stable Platform

The province consists of a gently south-sloping basement of Grenvillian rocks overlain from southern Ontario southward by very little-deformed platform sedimentary rocks of Cambrian to Permian ages. In and beyond the site region to the west, province rocks to the south of Lake Ontario are locally broken by north-south normal faults of pre-Devonian age.

Historical seismicity in the province (Figure G1-4A) within 200 miles of the site is very low. One earthquake of Intensity VI(MM) and some smaller ones have occurred in an area along the St. Lawrence River 180 to 200 miles northwest of the site in this area. Detailed structural geologic mapping has not been performed in this area.

Beyond the site region in west-central New York state, a tight cluster of earthquakes, including one Intensity VIII(MM) event, has been correlated to the Clarendon-Linden north-south normal fault structure near Attica, 270 miles west of the site (Fletcher and Sykes, 1977).

11. Adirondack Uplift

The province consists of Grenvillian-age crystalline rocks overlapped in southern and eastern areas by Cambrian and Ordovician sedimentary rocks. The crystalline rocks are broken by numerous north-northeast-trending normal faults which, in some instances, extend into the sedimentary rocks to the south and east. The age of block faulting is predominantly pre-Middle Devonian, but faulting may have been reactivated in Mesozoic and possibly Late Tertiary times along the Champlain-Lake George rift system in the eastern part of the province.

Historical seismicity has generally been associated with the peripheral regions of the province, in areas where overlapping sedimentary rocks are broken by normal faults trending out from the exposed basement massif (Figure Gl-4A). A cluster of small, shallow earthquakes has recently been reported in the central part of the Uplift in the area of Blue Mountain Lake.

The largest historical earthquake in the province is an Intensity VII(MM) event which occurred on April 20, 1931 near Lake George, New York, about 62 miles northwest of the site. In detail, the epicentral area is characterized geologically by a network of closely-spaced northeast- and northwest-trending normal faults whose displacement is commonly down toward the long, central Lake George rift structure.

12. Western Quebec Seismic Zone

The province is broadly defined on the basis of the distribution of anomalously frequent and occasionally high intensity earthquake activity. In the site region, the province consists of a block-faulted basin in Grenvillian-age crystalline rocks with faulted Cambrian and Ordovician platform sedimentary rocks resting on the basement in the basin. The major normal faults trend east southeasterly through much of the basin and turn to parallel the north-northeast-trending margin of the province on the east. Middle Cretaceous mafic plugs occur in the eastern part of the province, scattered along east-southeast trends parallel with the major block faulting.

The seismicity of this zone is relatively higher in frequency than that of other provinces. Recently acquired instrumental data confirm the spatial distribution and higher frequency of occurrences suggested in the historical data. Besides frequent smaller events in the Magnitude 2 to 4 range, the zone includes three larger events in the Magnitude 5.5 to 6.0 range. The 1935 Timiskaming earthquake (Intensity VII) and the 1944 Cornwall-Massena earthquake (Intensity VIII) are the most recent ones; another large event, poorly documented, occurred in 1732, very likely near Montreal, where damages corresponding to an Intensity VIII(MM) were reported. Even though a large portion of the zone shows spatial correlation with geological and topographical features (Forsyth, 1977), it is not yet clear to what extent the larger events can be related to individual structures without more intensive geophysical investigations.

G1.6 MAXIMUM EARTHQUAKE POTENTIAL

The maximum earthquake potential for the Rowe site is specified by considering both site intensities experienced in the past during large historical events and by calculating site intensities associated with the hypothetical reoccurrences of some large historical earthquakes within each of the surrounding tectonic provinces described above, but with epicenters migrated to the points of closest approach to the site.

1. Site Intensities From Historical Events

Table Gl.2 lists known large events of northeastern America with their epicentral coordinates and distances to the Rowe site, their epicentral intensities, and finally the Rowe site intensities calculated according to Gupta and Nuttli's (1976) attenuation relationship. The largest estimate of these site intensities is "5.6", associated with an historical event that occurred near La Malbaie, Quebec, in 1663; this event has been conservatively assigned an epicentral intensity of X. In numerous cases where comparison was possible, calculated values have been found to be in good agreement with observed values. (New York State Electric & Gas PSAR, Units 1 and 2, 1978).

2. Site Intensities From Hypothetical Events

The maximum earthquake potential is also estimated from site intensitiies associated with the occurrences of hypothetical events. The most important historical events of each of the twelve tectonic provinces are examined.

The site is located in the Green Mountain anticlincrium, a distinct part of the Western New England Foldbelt. An

Intensity V event is considered as the largest intensity not correlated with a tectonic structure. Such an intensity, if assumed to migrate to the site, remains an Intensity V. The Quebec-Maine earthquake of June 1973 has been assigned an Intensity VI; however, this event is specifically correlated with a tectonic structure, the Megantic mafic intrusive, and associated post-Devonian normal faults. This earthquake can also be correlated with the White Mountain Plutonic Series structure accepted by the Nuclear Regulatory Commission (Boston Edison Company, Pilgrim II SER, 1977).

In the Merrimack Synclinorium province, the two Ossipee Intensity VII events of 1940 are considered related to a tectonic structure, approximately 175 km from the site (Boston Edison Company, Pilgrim II PSAR, 1976). Because it can be argued that the two Intensity VII events and some of the Intensity VI and even Intensity V events are related to structures, an Intensity VI assumed to occur at the closest boundary point of this province (68 km) is considered as a conservative estimate.

Within the Coastal Anticlinorium province, the single Intensity VI(m_b=4.8) April 16, 1957, event is migrated to a site distance of 215 km.

Two larger events that occurred near Cape Ann, Massachusetts, in 1727 and 1755, are considered constrained to the conjunction of a cylindrical mafic intrusive and the Bloody Bluff fault. The remaining historical seismicity within the Northeastern Massachusetts Thrust Fault Complex province is upper-bounded by an Intensity VI, which can be migrated to its closest distance to the site (105 km).

In the Southeastern New England Platform province, the migration of the East Haddam Intensity VII event of 1791 to the closest boundary approach is conservative since, in that area, the province appears to be historically aseismic.

No seismic effect is expected from the Long Island Platform.

The Intensity VII, characteristic of the New York City-New Jersey region, is migrated to the closest point, although an Intensity IV-V appears to be prevalent in this northeastern area of the New York Recess province.

An Intensity V is accepted as characteristic of the low-level seismicity recorded in the Valley and Ridge province. The closest approach is 75 km away from the site.

A very low-level seismicity is typical of the Appalachian Plateau province, and an Intensity V migrated to a point 90 km from the site is a conservative estimate.

In the Eastern Stable Platform, an Intensity VI is taken to the point of closest approach. In this province, the largest earthquake near Attica, New York, in 1929, with an Intensity VIII has been correlated to the Clarendon-Linden fault (Van Tyne, 1975; Fletcher and Sykes, 1977).

An Intensity VII, similar to that of the Lake George event is taken to the nearest point along the Adirondack Uplift province boundary, 68 km from the site.

An Intensity VIII is taken to the borders of the Western Quebec Seismic Zone, 200 km away from the site.

Using Gupta and Nuttli (1976), the site intensities corresponding to these hypothetical occurrences are calculated. Table G1.3 summarizes the results. The largest value (Intensity "5.6") is associated with the largest historical event of the Adirondack Uplift, postulated at 68 km. This is of the same order as site intensities calculated for large, distant historical earthquakes, such as the 1663 La Malbaie Intensity X and 1811 New Madrid Intensity XII event.

From these considerations of both historical and hypothetical site intensities, it is concluded that an Intensity VI(MM) is an appropriately conservative estimate of the Safe Shutdown Earthquake. Such an intensity would result in a ground acceleration of .06g to .07g using either Neumann's (1954) or Trifunac and Brady's (1975) curves.

G2 SITE GEOLOGY

Introduction

The site is situated on the eastern edge of the Deerfield River valley on very dense glacial till of Late Pleistocene age. The till, which blankets crystalline gneiss bedrock of Cambrian age, ranges from 0 to about 80 feet in thickness beneath the site area, and from about 70 to 80 feet in thickness immediately beneath the reactor containment vessel. Underlying the till above bedrock in the southwestern part of the containment is a 0 to 40 feet sequence of interbedded till, compact clay-silt and very compact sand. Bedrock underlying the glacial sediments is composed of hard, medium-grained, quartz-albite-biotite gneiss with an evenly-layered foliation structure which dips 30°-35° to the southeast. No cavernous lithologies or throughgoing fault structures have been detected in the site area.

Topography - Site Locale (Figure G2-1(A))

The site lies at about Elevation 1,120-1,140 feet above mean sea level. The topography of the site locale is defined by the valley of the Deerfield River, deeply dissected into an upland plateau of Early Paleozoic crystalline bedrock. Immediately adjacent to the site, the Deerfield River drainage has been impounded by the Sherman Dam to form Sherman Reservoir with a nominal surface elevation of 1,102 feet. From the edge of the river/reservoir valley, hillsides climb steeply to the plateau elevations ranging from 1,800 to 2,000 feet. Hillside slopes range up to about 35°, locally interrupted by bedrock cliffs. The site is located in a small low-elevation reentrant in the eastern hillside slopes of the Deerfield River valley.

Surficial Geology - Site Locale (Figure G2-1(B))

Hillsides in the site locale above Elevation 1,200 feet are commonly characterized by a thin cover of stony ground moraine and numerous bedrock exposures. The valley of the Deerfield River below Elevation 1,200 feet contains scattered deposits of late-glacial sand and gravel outwash and alluvium, overlying dense Late Pleistocene lodgement till (Chidester et al, 1967). The till is olive gray in color, fine-grained, and contains numerous pebbles and few large fragments. The surficial stratigraphy in the immediate site area prior to plant construction comprised an upper layer of up to 30 feet of sand and gravel outwash (Figures G2-3(A) and G2-4(B)), overlying up to about 80 feet of dense lodgment till. In the southwestern part of the site area, where the bedrock surface lies at low elevations, the lodgment till is in turn underlain by an interbedded sequence of compact varved (lacustrine) clay-silt, till and very compact fine-to-coarse sand, ranging to about 80 feet in combined thickness (Figures G2-3(B) and G2-4(B)).

Although the hillsides above Elevation 1,200 feet in the site locale are commonly characterized by thin ground moraine and numerous bedrock outcrops, a wide area of hillside rising to the south-southeast from the site to Elevation 1,800 feet lacks bedrock exposures. Reconnaissance geologic observations (Figure G2-1(A)) and seismic refraction surveys (Figure G2-1(B)) indicate that a relatively thick blanket of till rests here on a bedrock surface having slopes ranging from about 17° to (very locally) as much as 32°. The thickest till section measured is at the west end of seismic line No. 7, about 500 feet south of the site, with a total thickness of about 200 feet. A series of five backhoe test pits in the area (Figure G2-1(B)), ranging to 10-foot depths, encountered fairly compact lodgment till with a developed A and B soil horizon averaging 30-40 percent gravel and cobbles by volume, with a silty sand to sand-silt matrix and a faintly fissile fabric oriented parallel to the ground surface.

The hillside slopes on till are relatively dry and well drained except in those areas where seeps or small springs occur (Figure G2-1(B)). Although some seeps occur relatively high on the hillside, most are near the transition from steep to gentle slopes.

Bedrock Geology - Site Locale (Figure G2-2)

1. Stratigraphy and Structure

The bedrock in the site locale (Figure G2-2(A)) is comprised of a succession of Lower Cambrian(?) gneiss, schist, and dolomitic marble and Lower Cambrian gneiss which form a local south-plunging anticlinal structure (Figure G2-4(A)) along the axis of Sherman Reservoir (Chidester et al, 1967; Skehan, 1961). The site is situated over the uniformly southeast-dipping flank of this anticline, on quartz-albite-biotite gneiss of the Hoosac Formation. With the possible (but not apparent) exception of the dolomitic marble member of the Cavendish Formation, all bedrock formations in the site locale are hard, internally welded, and not notably subject to degradation by groundwater solution effects.

Where exposed in outcrop and quarry excavations, 3,800 to 7,400 feet north-northeast of the site, the dolomitic marble does not exhibit solution cavities. The structure of the south-plunging anticlinal warping in the site locale is such that the dolomitic marble, if it is continuous in the region, would pass beneath the site, below a thick column of crystalline gneisses and schists, at a depth greater than 800 feet.

2. Faulting and Jointing

Fracturing of the bedrock in the site locale (Figure G2-2(B)) is not a prominent structural feature, and numerous outcrops exhibit either no joints or only minor discontinuous joint surfaces. In reconnaissance geologic mapping, 74 joints or joint sets and five faults were measured. Two of the faults show left-lateral displacement, and the other three appear to define normal offsets. None of the five faults displays fracturing, brecciation, or gouge indicative of significant fault movement.

Details of the five faults (as numbered 1 through 5 on Figure G2-2(B)) are as follows:

1. (East of Reservoir) Strike N25°W, Dip about 80°NE, with slickensides which plunge 26° to the southeast, apparently reflecting left-lateral displacement. The single exposed fault surface is moderately curved and scalloped, with no associated fracturing in either wall, and cannot be traced laterally beneath the soil cover;
2. (East of Reservoir) Strike N28°E, Dip 76°NW, may simply be a prominent joint. The single surface is not polished or slickensided, and no offset can be ascertained. There is no associated fracturing in adjacent walls, and the feature cannot be traced laterally.

3. (East of Reservoir) Strike N10°E, Dip 60°E, defined by a quartz filling 1 to 2 inches thick. Displacement appears to be normal, about 6 inches down on the east. The quartz filling is tight, welded to the enclosing walls. The fault cannot be traced on strike.

4. (West of Reservoir) Strike N50°E, Dip 75°SE. Quartz-feldspar pegmatite zone in thinly-layered gneiss appears to have about 12-15 inches of normal displacement, down on the southeast. The fracture surface is weathered, displays no slickensides, and cannot be traced on strike.

5. (West of Reservoir) Strike N30°W, Dip 88°NE. A N65°W, 85°NE quartz vein is offset on the fault by 1 to 2 inches of apparent left-lateral displacement. Exposure is on a smooth bedrock surface in a stream bed, and the true sense of movement (whether left-lateral or normal) cannot be ascertained. The fault is tight with no brecciation or adjacent fracturing.

The distribution of all fracture orientations measured in the site locale is shown on a stereo net plot beside the legend on Figure G2-2(B). For purposes of analysis, symbols for joints and faults to the east of Sherman Reservoir are graphically differentiated on the plot from those to the west of the reservoir. The stereo net plot indicates generally that almost all fractures dip steeply at about 70° or greater. There is no apparent difference in fracture orientations to the west of the reservoir from those to the east. Showing no anomalously-preferred orientation of fracturing in the area, the plot further suggests the absence of any throughgoing zones of post-metamorphic faulting or shear.

Site Geology - Soils Layering (Figures G2-3 and G2-4)

Geologic Profile A-A' for the site locale (Figure G2-4(A)) shows the site to be situated on glacial sediments in the lower elevation of a broad bedrock valley, with bedrock layering beneath the site dipping 30°-50° to the southeast. A blanket of till overlies bedrock for about two-thirds of the distance up the valley slope to the southeast. To the northwest, above the west abutment of Sherman Dam, the hillside is supported by bedrock whose layering nearly parallels the hillside surface.

Geologic Profiles B-B' and C-C' (at 90° to B-B') show the glacial stratigraphy beneath the site, as estimated from seismic refraction profiles obtained in 1956, eight borings put down at the site in 1956 and 1977, and six borings put down in 1978 (see Appendix A). Three-dimensional depictions of the estimated soils layering at the site are presented on Figure G2-3 showing A., estimated thickness of the upper sand and gravel layer outwash; B., estimated thickness of the lower lodgment till and varved clay-silt sequence; C., estimated combined total thickness of the soils overburden column; and D., estimated topography (USGS Sea-Level Datum) of the underlying bedrock surface. The estimated thickness of the upper sand and gravel outwash layer is shown in its original, pre-construction configuration.

The plant structures are founded on very dense glacial till.

Seismic Survey

A seismic refraction survey was conducted at the Rowe Nuclear Power Plant site to obtain subsurface information on the thickness of overburden materials and the seismic wave velocities of the various overburden materials and bedrock. Seismic refraction data were obtained along the valley wall in the vicinity of the plant site and on the eastern valley wall of the Sherman Reservoir just north of the Vermont-Massachusetts border (see Figure G2-1).

The results of the seismic survey are presented in profile form (Figures G2-5 and G2-6) and show that overburden cover becomes thinner at high elevations. Near the base of the valley adjacent to the power plant, overburden thickensses are as great as 200 feet. Almost all of the overburden material has seismic velocities ranging from 5,500 fps to 7,000 fps, indicative of a dense glacial till. Maximum thicknesses of 25 to 35 feet of lower velocity overburden materials (1,500 to 3,000 fps) exist at some locations. This velocity range indicates loosely-consolidated surficial deposits. Bedrock velocity values range from 12,000 to 16,000 fps, indicative of fresh competent bedrock.

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TABLE G1.1

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME		LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1661	02	10	12		45.500N	73.000W		VII				
1727	11	9	2240	L	42.800N	70.600W*		VII				
1727	11	14	1700	L	42.800N	70.600W*		IV-V				
1728	1	4	2300	L	42.800N	70.600W*		IV-V				
1728	2	10	1530	L	42.800N	70.600W*		V				
1732	09	16	1600		45.500N	73.600W		VIII				
1737	12	18			40.800N	74.000W		VII				
1744	6	14	1015	L	42.500N	70.900W*		VI				
1755	11	18	0412	L	42.700N	70.300W*		VIII				
1755	11	22	2027	L	42.700N	70.300W*		V				
1783	11	29	1050	L	41.000N	74.500W		VI				
1791	5	16	0800	L	41.500N	72.500W		VI-VII				
1810	11	9	2115	L	43.000N	70.800W*		V				
1814	11	28	1914	L	43.700N	70.300W*		IV-V				

L=LOCAL TIME
*=COORDINATES BY WGC

PREPARED BY WESTON GEOPHYSICAL CORPORATION

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME		LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1816	09	09			45.500N	73.600W		VII				
1816	09	16			45.500N	73.600W		VI				
1817	10	5	1145	L	42.500N	71.200W		V-VI				
1821	5	5	0730	L	44.800N	68.800W*		V				
1823	6	10			44.800N	68.800W*		V				
1823	7	23	0655	L	42.900N	70.600W*		IV-V				
1837	4	12			41.700N	72.700W		IV-V				
1840	01	16	2000		43.000N	75.000W		V-VI				
1840	8	9	1530	L	41.500N	72.900W		V				
1840	11	11			39.800N	75.200W		VII				
1842	11	09			46.000N	73.200W		VI				
1845	10	26	1815	L	41.200N	73.300W*		V-VI				
1846	8	25	0445	L	42.500N	70.800W*		V				
1847	8	8	1000	L	41.700N	70.100W*		V-VI				

L=LOCAL TIME
*=COORDINATES BY WGC

TABLE G1.1 (Cont'd)

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME		LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1847	09	29			40.500N	74.000W		V				
1848	09	08	2200	L	40.400N	74.000W		V				
1852	11	27	2345	L	43.000N	70.900W*		V				
1853	03	12	0700		43.700N	75.500W		VI				
1854	12	11	0030	L	43.000N	70.800W		IV-V				
1855	1	16	1800	L	44.000N	71.000W		V				
1855	02	06	2330		42.000N	74.000W		V				
1857	12	23	1330	L	44.100N	70.200W*		VI				
1858	6	30	2245	L	41.300N	73.000W		IV-V				
1861	07	12	2100	L	45.400N	75.400W		VII				
1861	10				45.600N	73.700W		V				
1867	12	18	0300		44.650N	75.150W		VI				
1871	01	03			45.600N	74.600W		V				
1871	10	09	0940	L	39.700N	75.500W		VII				

L=LOCAL TIME
*=COORDINATES BY WGC

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EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME		LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1872	07	11	0525	L	40.900N	73.800W		V				
1872	11	18	1400	L	43.200N	71.600W		IV-V				
1873	04	25	1900		44.800N	74.200W		V				
1874	12	10	2225	L	40.900N	73.800W		VI				
1875	7	28	0410	L	41.900N	73.000W*		V				
1876	9	21	2330	L	41.530N	71.280W*		IV-V				
1877	09	10	0959	L	40.300N	74.900W		IV-V				
1877	11	04	0156	L	45.200N	73.900W		VI				
1877	12	18	1000		45.700N	76.850W		V				
1878	02	05	1120	L	40.000N	73.800W		V				
1878	10	04	0230	L	41.500N	74.000W		V				
1879	03	26	0030		39.200N	75.500W		IV-V				
1880	5	12	0745	L	42.700N	71.000W*		IV-V				
1882	12	19	1724	L	43.200N	71.400W		V				

L=LOCAL TIME
*=COORDINATES BY WGC

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME		LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM	SCALE	MAGNITUDE MB	MN	ML	REMARKS
1883	2	27	2330	L	41.500N	71.300W*		V					
1883	03	11	2357		39.500N	76.400W		IV-V					
1883	03	12	0500	L	39.500N	76.400W		IV-V					
1883	03	12	0600	L	39.500N	76.400W		IV-V					
1884	05	31			40.600N	75.500W		V					
1884	08	10	1907		40.600N	74.000W		VII					
1884	08	11			40.600N	74.000W		IV-V					
1884	11	23	1230	L	43.200N	71.700W		V					
1889	03	08	1840	L	40.000N	76.000W		V					
1891	5	1	1910	L	43.200N	71.600W		V					
1893	03	09	0030	L	40.600N	74.300W		V					
1893	11	27	1650		45.500N	73.300W		VII					
1895	09	01	0609	L	40.700N	74.800W		VI					
1897	03	23	1807	L	45.500N	73.600W		VII					

L=LOCAL TIME
*=COORDINATES BY WGC

TABLE G1.1 (Cont'd)

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME		LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1897	05	27	2216	L	44.500N	73.500W		VI				
1897	9	25	1305	L	44.700N	68.700W		V				
1899	05	16	2015	L	41.600N	72.600W*		V				
1903	12	25	1230		44.700N	75.500W		V				
1905	7	15	0510		44.200N	70.000W*		V-VI				
1905	08	30	1040		43.100N	70.700W*		V				
1907	10	16	0010		42.800N	71.000W		V				
1908	05	31	1742		40.600N	75.500W		VI				
1908	06	16	204152		45.100N	74.800W		V				
1913	04	29	002857		44.870N	75.330W		VI				
1914	02	10	1831		46.000N	75.000W		VII				
1916	01	05	1356		43.700N	73.700W		V				
1916	02	03	0420		43.000N	74.000W		V				

L=LOCAL TIME
*=COORDINATES BY WGC

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TABLE G1.1 (Cont'd)

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME	LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM	INTENSITY SCALE	MAGNITUDE MB	MAGNITUDE MN	MAGNITUDE ML	REMARKS
1916	11	02	0232	43.300N	73.700W		V					
1917	05	22	090026	45.100N	75.600W		IV-V					
1918	8	21	0515	44.200N	70.500W*		VI					
1921	01	26	2340	40.000N	75.000W		V					
1922	12	08	1624	44.350N	75.120W		V					
1924	07	15	0010	45.700N	76.500W		V-VI					
1925	01	07	1307	42.600N	70.600W		V					
1925	4	24	0756	41.700N	70.800W*		IV-V					
1925	10	9	1355	43.700N	71.100W		VI					
1925	11	14	1304	41.700N	72.400W*		V					
1926	01	26	2340	40.000N	75.000W		V					
1926	3	18	2109	42.800N	71.800W*		V					
1926	05	12	0330	40.900N	73.900W		V					
1927	3	9	0408	43.300N	71.400W		IV-V					

L=LOCAL TIME
*=COORDINATES BY WGC

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME	LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1927	06	01	1223	40.300N	74.000W		VII				
1927	10	24	110000	44.730N	73.750W						
1928	2	8		45.300N	69.000W		VI				
1928	03	18	1525	44.500N	74.300W		V-VI				
1928	4	25	2338	44.500N	71.200W		V				
1930	06	19	120656	45.730N	71.220W					3.6	
1931	04	20	1954	43.400N	73.700W		VII		4.7	5.[illegible]	
1933	01	21	160439.5	45.300N	74.650W					3.8	
1933	01	25	0200	40.200N	74.700W		V				
1933	07	14	044840	45.420N	75.700W					3.9	
1934	04	15	025813	44.670N	73.800W		V-VI			4.5	
1935	01	28	090132	44.800N	74.300W		III			3.2	
1936	11	10	0246	43.550N	71.430W		V				
1937	11	12	144344.3	45.920N	74.330W					3.6	

L=LOCAL TIME
*=COORDINATES BY WGC

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EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME	LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM	SCALE	MAGNITUDE MB	MN	ML	REMARKS
1937	11	12	165732.5	45.920N	74.330W						3.7	
1938	01	06	132842.2	44.900N	75.180W						3.2	
1938	8	22	0748	44.700N	68.800W		IV-V				4.1	
1938	08	23	033634	40.100N	74.500W		V			3.9	4.6	
1938	08	23	050455	40.250N	74.250W					4.0	4.8	
1938	08	23	070329	40.250N	74.250W					3.7	4.6	
1938	09	07	231818.9	45.870N	74.900W						3.4	
1938	11	18	221906	44.750N	75.250W		IV-V					
1939	11	15	0254	39.600N	75.200W		V					
1940	1	28	231151	41.630N	70.800W		V			2.6	4.3	
1940	03	28	114234.5	44.700N	69.900W						3.8	
1940	05	16	140017.1	45.800N	73.200W						3.6	
1940	12	20	072726	43.800N	71.300W		VII			5.4	5.8	
1940	12	24	134344	43.800N	71.300W		VII			5.4	5.8	

L=LOCAL TIME
*=COORDINATES BY WGC

TABLE G1.1 (Cont'd)

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME	LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1940	12	25	050343	43.800N	71.300W				3.7	4.0	
1940	12	27	195609	43.800N	71.300W				3.8	3.9	
1941	04	04	081043.7	44.730N	73.920W					3.7	
1941	10	21	061041	44.770N	74.800W					3.3	
1941	10	24	141359.3	45.700N	74.300W					3.6	
1942	05	20	121922.8	45.770N	74.670W					4.4	
1942	05	24	113357	44.730N	73.830W					3.9	
1942	10	24	172703.6	40.970N	75.250W					3.4	
1943	1	14	213238	45.300N	69.600W		V		4.4	5.4	
1943	03	14	140227.5	43.700N	71.570W					3.9	
1943	05	09	110312.5	44.770N	73.830W					3.2	
1943	07	06	221014.8	44.920N	73.130W					4.1	
1944	01	22	215509.1	45.830N	76.780W					4.3	
1944	02	05	162200.5	40.800N	76.200W					3.7	

L=LOCAL TIME
*=COORDINATES BY WGC

TABLE G1.1 (Cont'd)

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME	LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1944	06	24	234838.5	46.000N	74.250W					3.7	
1944	09	05	043845	44.970N	74.900W		VIII		5.8	5.9	
1944	09	05	083049	44.980N	74.900W					3.4	
1944	09	05	085106	44.980N	74.900W					4.6	
1944	09	05	105651	44.980N	74.900W					3.3	
1944	09	09	232448	44.980N	74.900W					4.1	
1944	10	31	084225	44.980N	74.900W					4.0	
1946	04	21	050555.5	45.730N	73.430W					3.6	
1946	10	28	203606.	41.500N	76.600W					3.6	
1946	11	24	102047.2	45.170N	74.680W					3.1	
1946	12	25	044802.7	44.900N	74.900W					3.3	
1947	12	28	195820	45.200N	69.200W		V		4.4	4.5	
1948	01	06	204651	45.400N	69.280W		IV			4.0	
1948	05	07	120226	45.750N	73.630W					4.0	

L=LOCAL TIME
*=COORDINATES BY WGC

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME	LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1948	06	09	030412.2	45.230N	73.870W					3.7	
1948	07	07	073801.4	45.180N	73.900W					3.5	
1949	10	5	023347	44.800N	70.500W		V		4.5	4.0	
1949	10	16	233342.3	45.300N	74.830W		V			4.2	
1950	03	06	161411.8	46.000N	74.500W					4.0	
1950	03	20	225511.5	41.500N	75.800W					3.3	
1950	08	04	142928.7	45.200N	74.720W					4.0	
1950	08	05	235907.0	45.070N	74.750W					3.5	
1951	08	08	093624.1	45.930N	74.670W					3.3	
1951	09	03	212624.5	41.250N	74.250W		V		3.8	4.4	
1951	10	25	070752.8	45.270N	74.730W					3.8	
1951	11	06	175441.5	45.000N	73.600W		IV			3.7	
1952	1	30	0400	44.500N	73.200W		VI				
1952	08	25	0007	43.000N	74.500W		V				

L=LOCAL TIME
*=COORDINATES BY WGC

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TABLE G1.1 (Cont'd)

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME	LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM	INTENSITY SCALE	MAGNITUDE MB	MAGNITUDE MN	MAGNITUDE ML	REMARKS
1952	10	08	2140	41.700N	74.000W		V					
1953	3	27	0850	41.100N	73.500W		V					
1953	3	31	125834.3	43.700N	73.000W		V				4.0	
1953	04	26	0120	44.720N	73.450W		IV				3.7	
1954	01	07	0725	40.300N	76.000W		VI					
1954	02	01	003750	43.030N	76.650W						3.3	
1954	7	29	195706	42.700N	70.700W*		V				4.0	
1954	12	13	035352	44.600N	74.600W		IV				3.6	
1955	01	21	0840	42.970N	73.780W		V					
1955	2	3	0230	44.500N	73.200W		V					
1955	10	07	180952	45.220N	73.900W						3.5	
1956	01	10	120818	45.670N	75.470W						3.3	
1956	02	02	192416	45.450N	74.820W						3.1	
1956	03	06	233810	44.850N	75.380W						3.1	

L=LOCAL TIME
*=COORDINATES BY WGC

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EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME		LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1956	07	27	013444		44.700N	73.780W					3.4	
1957	03	23	1902		40.630N	74.830W		VI				
1957	4	24	004159		44.400N	72.000W		V				
1957	4	26	114006		43.600N	69.800W		VI		4.8	4.7	
1958	9	19	1745		43.600N	70.200W*		V				
1958	09	30	001358		45.180N	73.730W					3.7	
1959	04	13	212019		41.920N	73.270W					3.4	
1960	01	22	205322		41.590N	75.500W					3.4	
1961	03	13	105545		45.170N	75.280W					3.2	
1961	04	20	131300		45.000N	74.780W		V			2.0	
1961	09	14	2117	L	40.750N	75.500W		V			4.3	
1961	12	27	1706		40.500N	74.750W		V			4.3	
1962	01	27	121117		45.920N	74.850W					4.3	
1962	4	10	143048.1		44.100N	73.400W		V			5.0	

L=LOCAL TIME
*=COORDINATES BY WGC

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TABLE G1.1 (Cont'd)

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME	LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1962	06	21	020648	45.370N	72.700W		V			3.9	
1962	12	29	061910	42.800N	71.700W		V			4.7	
1963	03	02	202432	41.510N	75.730W					3.4	
1963	05	19	191418	43.500N	75.230W					3.5	
1963	07	01	195912	42.570N	73.750W					3.3	
1963	08	26	162935	45.180N	73.350W					3.5	
1963	10	16	153101.8	42.500N	70.800W		V		3.9	4.2	
1963	10	30	173657.9	42.700N	70.800W		IV-V		2.4	5.0	
1963	12	4	213234.9	43.600N	71.600W		IV-V			3.7	
1964	03	29	0416	44.900N	74.900W		V			4.3	
1964	05	12	094514.1	40.200N	76.500W		VI			4.5	
1964	6	26	110446	43.300N	71.900W		V	2.6		3.6	
1964	11	17	1708	41.200N	73.700W		V			4.3	
1965	10	24	1745	41.300N	70.100W		V			4.3	

L=LOCAL TIME
*=COORDINATES BY WGC

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME	LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM	INTENSITY SCALE	MAGNITUDE MB	MAGNITUDE MN	MAGNITUDE ML	REMARKS
1965	12	8	0303	41.700N	71.400W		IV-V				4.3	
1966	06	25	000551	45.160N	73.830W						3.4	
1966	10	23	230534	43.000N	71.800W		IV-V				3.1	
1967	2	2	134009	41.400N	71.400W		V				2.4	
1967	05	15	224712	42.300N	69.900W						3.2	
1967	07	01	153332	44.400N	69.900W						3.2	
1967	07	01	155558.2	44.380N	69.860W						3.3	
1967	07	01	160540	44.380N	69.870W		V			3.4	3.8	
1967	07	01	161118.9	44.380N	69.860W						3.5	
1967	11	22	2210	41.200N	73.800W		V					
1968	09	23	153850	45.170N	69.450W	18				3.3		
1968	10	19	103718	45.300N	74.120W	18	V			3.2		
1968	11	3	083352.5	41.400N	72.500W*		V					
1968	12	10	041244.9	39.700N	74.600W		V				2.5	

L=LOCAL TIME
*=COORDINATES BY WGC

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME	LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM	INTENSITY SCALE	MAGNITUDE MB	MAGNITUDE MN	MAGNITUDE ML	REMARKS
1969	8	6	1603	43.800N	71.400W			V				
1970	06	25	160854.6	39.600N	71.000W				5.0		4.7	
1971	05	14	062009	45.100N	73.370W	18				3.2		
1971	05	23	062427	43.820N	74.540W	1				3.7		
1971	05	23	092959	43.940N	74.550W					3.6		
1971	06	21	024834	43.990N	74.530W	1					3.3	
1971	07	10	081502	43.930N	74.530W	1				3.4		
1971	09	27	084723	45.710N	75.170W	18				3.2		
1971	10	21	005446.2	42.700N	71.150W*			V				
1972	12	16	190136	45.790N	75.210W	18				3.9		
1973	02	28	082132	39.720N	75.440W	14		V		3.8		
1973	06	15	010905	45.390N	71.030W	10				4.9		
1973	07	15	082031	43.970N	74.490W	18				3.4		
1973	07	15	103238	43.960N	74.430W	18				3.2		

L=LOCAL TIME
*=COORDINATES BY WGC

PREPARED BY WESTON GEOPHYSICAL CORPORATION

EARTHQUAKES LOCATED IN THE NORTHEAST REGION
LATITUDE 39.0N TO 46.0N
LONGITUDE 68.7W TO 77.0W

YEAR	MO	DA	ORIGIN TIME	LATITUDE	LONGITUDE	DEPTH KM.	INTENSITY MM SCALE	MAGNITUDE MB	MN	ML	REMARKS
1973	07	16	084158	43.760N	74.470W	1			3.3		
1974	06	07	194537	41.570N	73.940W	5			3.3		
1974	08	08	115533	45.930N	76.380W	18				3.2	
1975	04	03	190317	45.730N	74.240W	5			3.1		
1975	06	09	183922	44.940N	73.650W	10			3.5		
1975	11	3	205455.9	43.890N	74.640W				3.9		
1975	11	3	210640.6	43.890N	74.650W				4.0		
1976	03	11	082932.2	41.560N	71.210W				3.5		
1976	04	13	153912.9	40.800N	74.030W				3.1		
1976	05	10	013420.5	41.540N	71.010W		V		2.7		
1977	12	20	174424.9	41.822N	70.758 W	5	IV		3.1		
1977	12	25	153553.4	43.200N	71.641W	2	IV		3.2		

L=LOCAL TIME
*=COORDINATES BY WGC

THIS CATALOG LISTS 249 EARTHQUAKES

PREPARED BY WESTON GEOPHYSICAL CORPORATION

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TABLE G1.2

ESTIMATED SITE INTENSITIES

DATE YR MO DA	HR MN SEC	L*	LAT. (N)	LONG. (W)	EPICENTRAL INTENSITY	MAGNITUDE m_b	m_{bLg}	M_L	DIST. TO SITE(MI)	SITE INTENSITY A^1	B^2
1638 06 11	20		47.65	70.17	IX				365.0	4.6	
1661 02 10	12		45.5	73.0	VII				191.3	3.6	
1663 02 05	17 30		47.6	70.1	X				363.1	5.6	
1727 11 09	22 40	L	42.8	70.6	VII				118.0	4.3	
1732 09 16	16 00		45.5	73.6	VIII				194.1	4.6	
1737 12 18			40.8	74.0	VII				143.9	4.1	
1744 06 14	10 15	L	42.5	70.9	VI				104.1	3.5	
1755 11 18	04 12	L	42.7	70.3	VIII				133.2	5.2	
1783 11 29	10 50	L	41.0	74.5	VI				143.9	3.1	
1791 05 16	08 00	L	41.5	72.5	VI-VII				87.5	4.7	
1811 12 16	08 00		36.6	89.6	XII				980.6	5.3	<IV
1816 09 09			45.5	73.6	VII				194.1	3.6	
1817 10 05	11 45	L	42.5	71.2	V-VI				89.1	3.7	
1840 01 16	20 00		43.0	75.0	V-VI				106.4	3.5	
1840 11 11			39.8	75.2	VII				233.7	3.3	
1845 10 26	18 15	L	41.2	73.3	V-VI				107.1	3.5	
1861 07 12	21 00	L	45.4	75.4	VII				221.3	3.4	
1870 10 20	16 30		47.4	70.5	IX				343.3	4.7	
1871 10 09	09 40	L	39.7	75.5	VII				247.8	3.2	
1874 12 10	22 25	L	40.9	73.8	VI				133.8	3.2	
1875 07 28	04 10	L	41.9	73.0	V				57 2	3.3	
1884 08 10	19 07		40.6	74.0	VII				156.	3.9	
1886 09 01	02 51		32.9	80.0	X				779.7	4.0	II-III
1893 03 14			42.35	72.66	IV				29.5	3.1	
1893 11 27	16 50		45.5	73.3	VII				192.1	3.6	
1897 03 23	18 07	L	45.5	73.6	VII				194.1	3.6	
1897 05 27	22 16	L	44.5	73.5	VI				125.5	3.3	
1898 06 11	01 45	L	42.83	72.56	IV				15.9	3.6	
1914 02 10	18 31		46.0	75.0	VII				247.7	3.2	

*L = Local time.

[1]Site intensity derived using: $I_{site}=I_o+3.7-.0011(\Delta km.)-2.7\ Log_{10}(\Delta km.)$ (Gupta and Nuttli, 1976).
[2]Site intensity observed from isoseismal maps.

Weston Geophysical

TABLE G1.2

ESTIMATED SITE INTENSITIES
(Continued)

DATE YR MO DA	HR MN SEC	L*	LAT. (N)	LONG. (W)	EPICENTRAL INTENSITY	MAGNITUDE m_b	m_{bLg}	M_L	DIST. TO SITE(MI)	SITE INTENSITY A[1]	B[2]
1916 02 03	04 26		43.0	74.0	V				57.3	3.3	
1916 11 02	02 32		43.3	73.7	V				55.4	3.3	
1924 09 30	08 52 30		47.60	69.70	VII-VIII		5.5		370.9	3.5	
1925 03 01	02 19 20		47.6	70.1	IX		6.6	7.0	363.1	4.6	III
1925 10 09	13 55		43.7	71.1	VI				113.8	3.4	
1926 03 18	21 09		42.8	71.8	V				57.3	3.3	
1927 06 01	12 23		40.3	74.0	VII				176.4	3.8	
1928 03 18	15 25		44.5	74.3	V-VI			4.1	140.1	3.1	
1929 08 12	11 24 48		42.87	78.35	VIII				274.4	4.1	I-IV
1929 11 18	20 32 00.7		44.5	56.3	X			7.2	839.0	3.8	II
1931 01 08	00 13 36.5		47.63	70.17				5.4	363.7	3.3	
1931 04 20	19 54		43.4	73.7	VII		4.7	5.0	60.5	5.2	
1934 04 15	02 58 13.		44.67	73.80	V-VI			4.5	140.8	3.1	
1935 11 02	14 31 58		47.23	78.17				5.4	402.2	3.1	
1938 08 23	05 04 55		40.25	74.25				4.8	184.1	3.6	
1938 08 23	07 03 29		40.25	74.25				4.6	184.1	3.3	
1940 12 20	07 27 26		43.8	71.3	VII		5.4	5.8	110.3	4.4	IV
1940 12 24	13 43 44		43.8	71.3	VII		5.4	5.8	110.3	4.4	IV
1943 03 14	14 02 27.5		43.70	71.57				3.9	95.7	3.3	
1944 09 05	04 38 45		44.97	74.90	VIII		5.8	5.9	183.1	4.7	IV
1944 09 05	08 51 06		44.98	74.90				4.6	183.7	3.3	
1952 01 30	04 00		44.50	73.20	VI				123.0	3.3	
1953 03 31	12 58 34.3		43.7	73.0	V			4.0	67.2	3.1	
1955 01 21	08 40		42.97	73.78	V				46.2	3.6	
1958 05 14	17 41 21		46.97	76.55				5.4	342.0	3.4	

*L = Local time.

[1]Site intensity derived using: $I_{site}=I_o+3.7-.0011(\Delta km.)-2.7\ Log_{10}(\Delta km.)$ (Gupta and Nuttli, 1976).
[2]Site intensity observed from isoseismal maps.

TABLE G1.2

ESTIMATED SITE INTENSITIES
(Continued)

DATE YR MO DA	HR MN SEC	L*	LAT. (N)	LONG. (W)	EPICENTRAL INTENSITY	MAGNITUDE m_b	m_{bLg}	M_L	DIST. TO SITE(MI)	SITE INTENSITY A^1	B^2
1959 04 13	21 20 19		41.92	73.27				3.4	58.4	3.3	
1962 12 29	06 19 10		42.8	71.7	V			4.3	62.4	3.2	
1963 07 01	19 59 12		42.57	73.75				3.3	43.1	3.5	
1964 02 13	19 46 42		40.4	78.2				5.2	315.8	3.2	
1964 06 26	11 04 46		43.3	71.9	V	2.6		3.6	65.2	3.1	
1966 10 23	23 05 34		43.0	71.8	IV-V			3.1	60.0	3.2	
1970 06 25	16 08 54.6		39.6	71.0		5.0		4.7	237.8	3.4	
1973 06 15	01 09 05		45.39	71.03			4.9		206.3	3.4	
1976 03 11	08 29 32.2		41.56	71.21	VI		3.5		119.2	3.3	

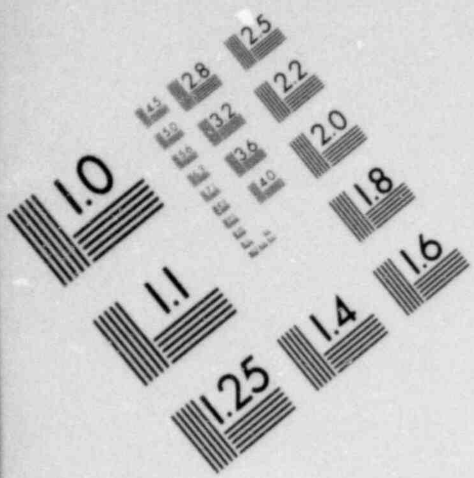
*L = Local time.

[1]Site intensity derived using: $I_{site}=I_o+3.7-.0011(\Delta km.)-2.7\ Log_{10}(\Delta km.)$ (Gupta and Nuttli, 1976).
[2]Site intensity observed from isoseismal maps.

Weston Geophysical

IMAGE EVALUATION
TEST TARGET (MT-3)

6″



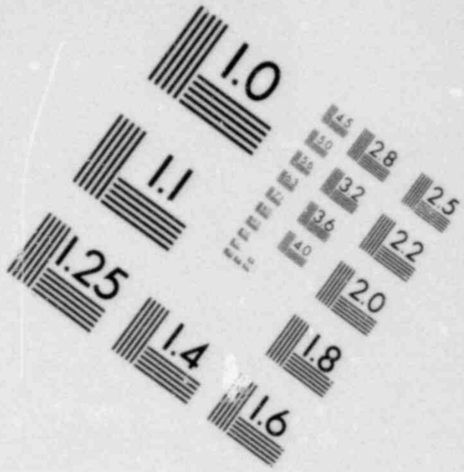
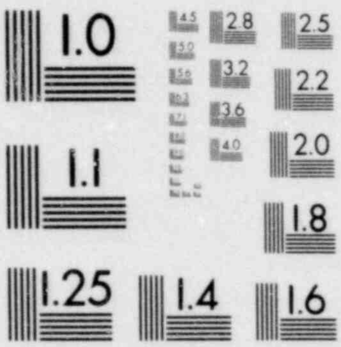


IMAGE EVALUATION TEST TARGET (MT-3)



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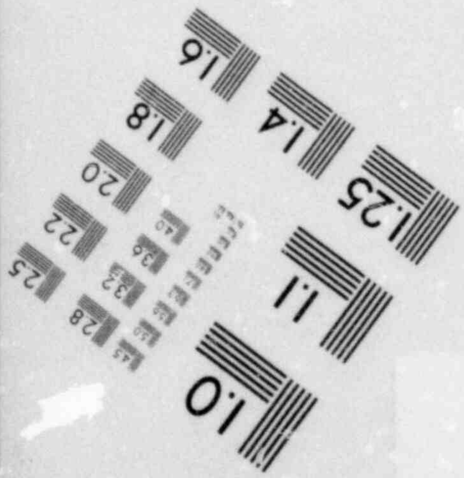


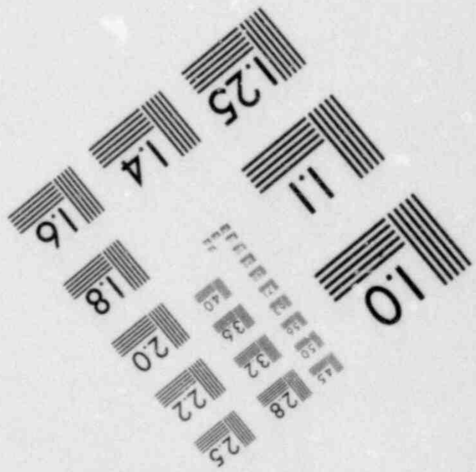


TABLE G1.[illegible]

SITE INTENSITIES FROM HYPOTHETICALLY REPEATED EVENTS

PROVINCE NO.	PROVINCE NAME	EVENTS	EPICENTRAL INTENSITY		DISTANCE TO SITE KM	SITE INTENSITY
1	Western New England Foldbelt - Site Province	June 15, 1973	VI	F	332	3.4
			V	M_1	15	V
2	Merrimack Synclinorium	Dec. 20, 1940	VII	F	175	4.4
			VI	M_2	68	4.6
3	Coastal Anticlinorium	Apr. 26, 1957	VI	M_2	215	3.2
4	Northeastern Massachusetts Thrust Fault Complex	Nov. 9, 1727	VII	F	189	4.3
		Nov. 18, 1755	VIII	F	214	5.2
			VI	M_2	105	4.2
5	Southeastern New England Platform	May 16, 1791	VII	M_2	110	5.1
6	Long Island Platform		0		--	--
7	New York Recess		VII	M_2	104	5.1
8	Valley and Ridge		V	M_2	75	3.5
9	Appalachian Plateau		V	M_2	90	3.3
10	Eastern Stable Platform	Aug. 12, 1929	VIII	F	441	4.1
			VI	M_2	180	3.4
11	Adirondack Uplift	Apr. 20, 1931	VII	M_2	68	5.6
12	Western Quebec Seismic Zone	Sept. 4, 1944	VIII	M_2	200	5.3

F = Fixed to structure.
M_1 = Migrated adjacent to site.
M_2 = Migrated to province border.

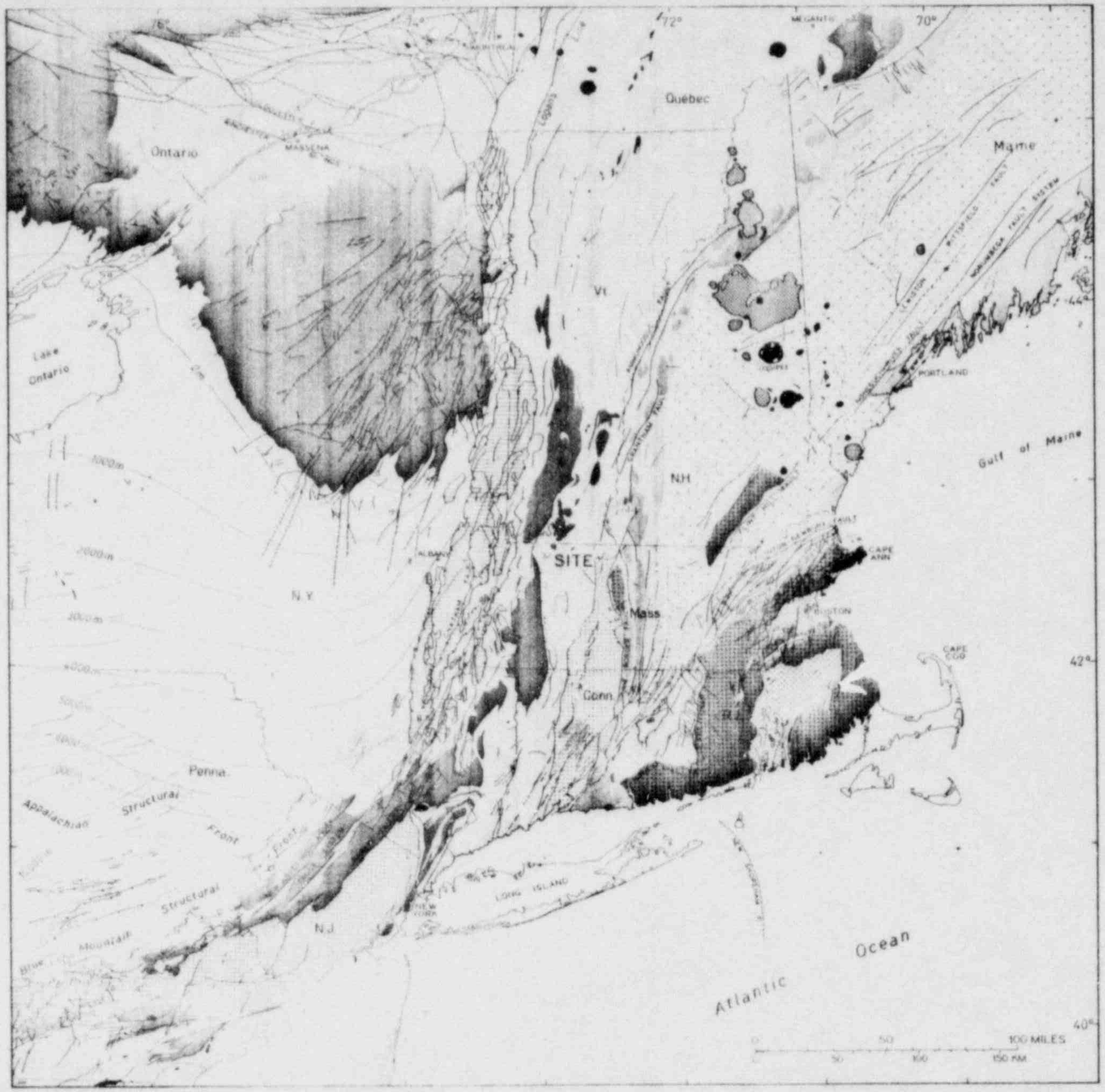
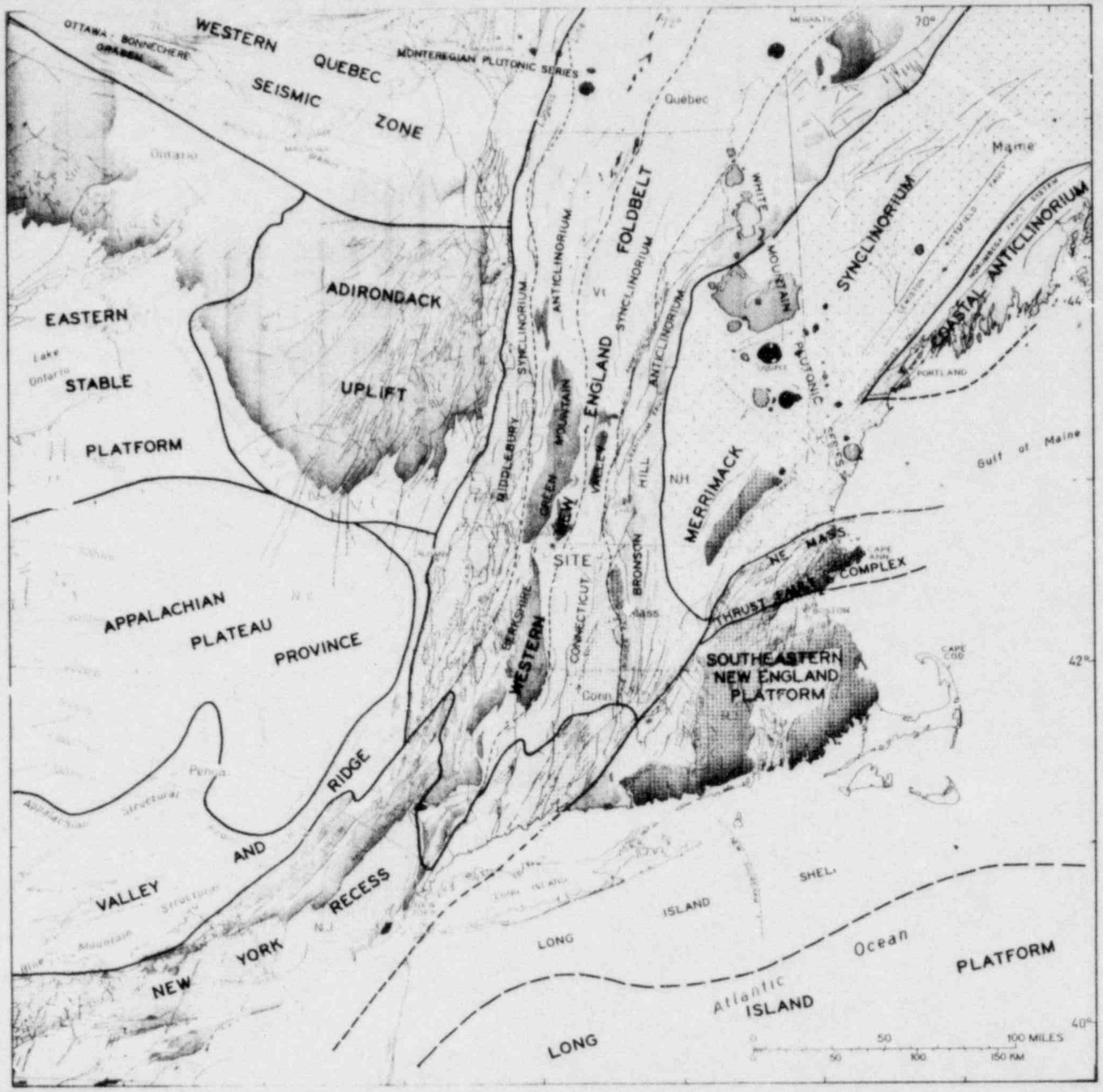


FIGURE G1-1

REGIONAL TECTONIC MAP

YANKEE NUCLEAR POWER STATION
Rowe, Massachusetts



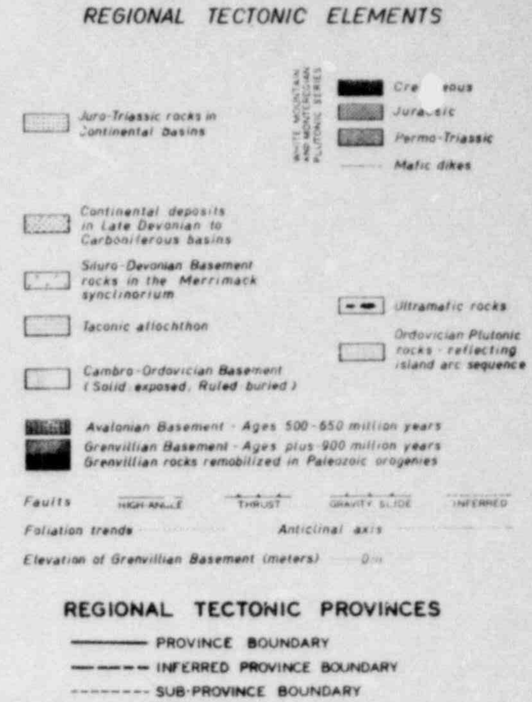


FIGURE G1-2

REGIONAL TECTONIC PROVINCES

YANKEE NUCLEAR POWER STATION
Rowe, Massachusetts

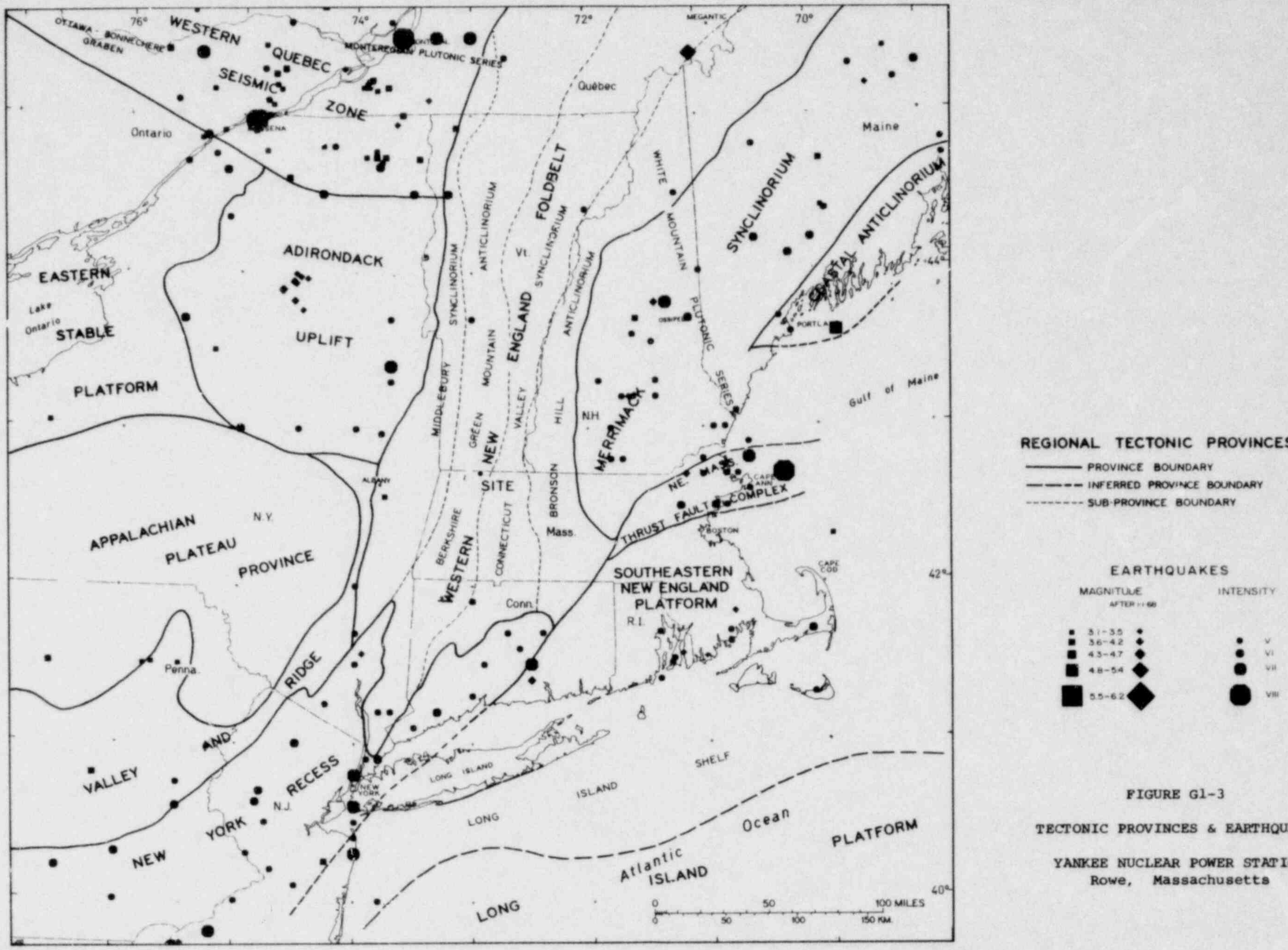


FIGURE G1-3

TECTONIC PROVINCES & EARTHQUAKES

YANKEE NUCLEAR POWER STATION
Rowe, Massachusetts

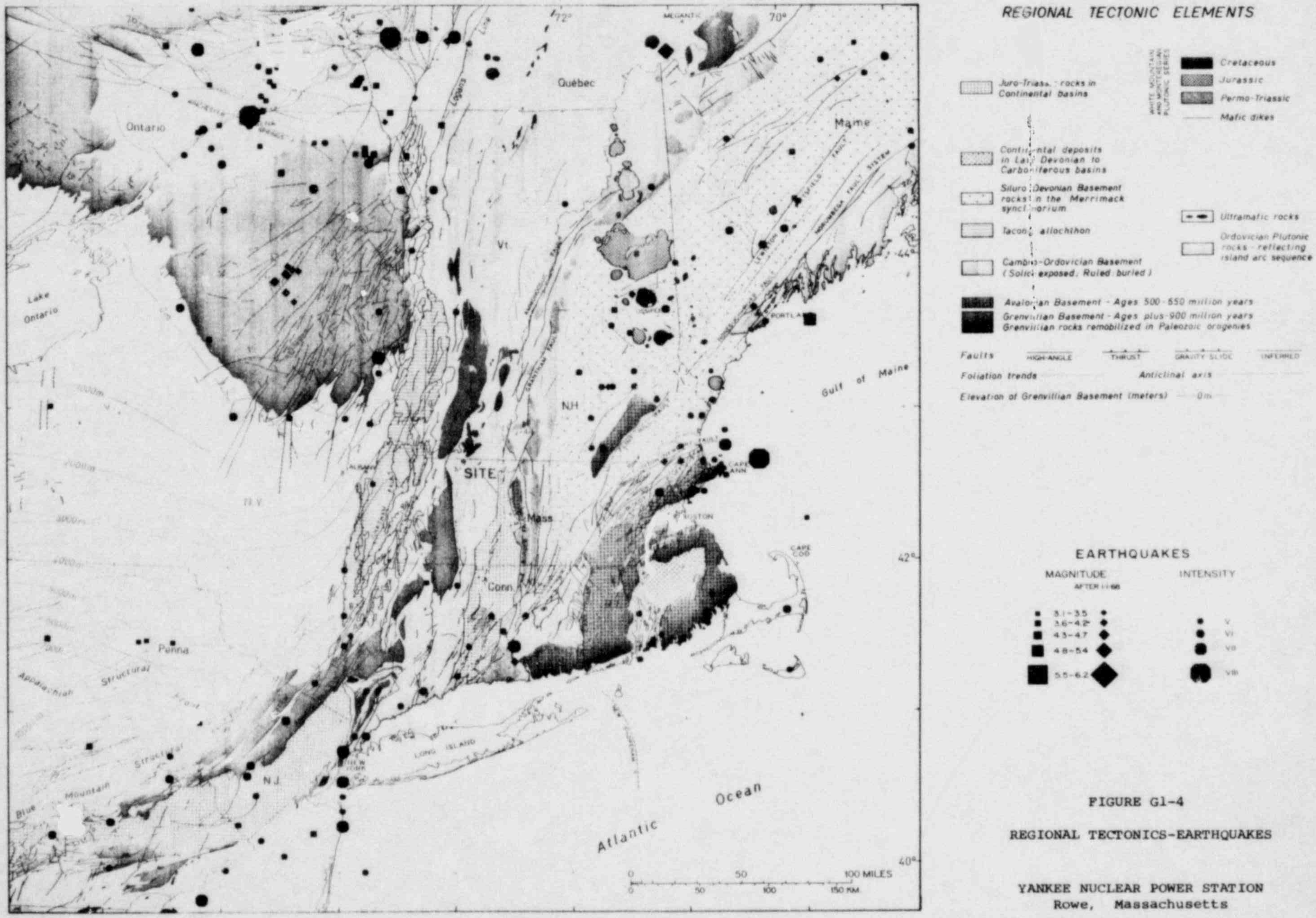


FIGURE G1-4

REGIONAL TECTONICS-EARTHQUAKES

YANKEE NUCLEAR POWER STATION
Rowe, Massachusetts

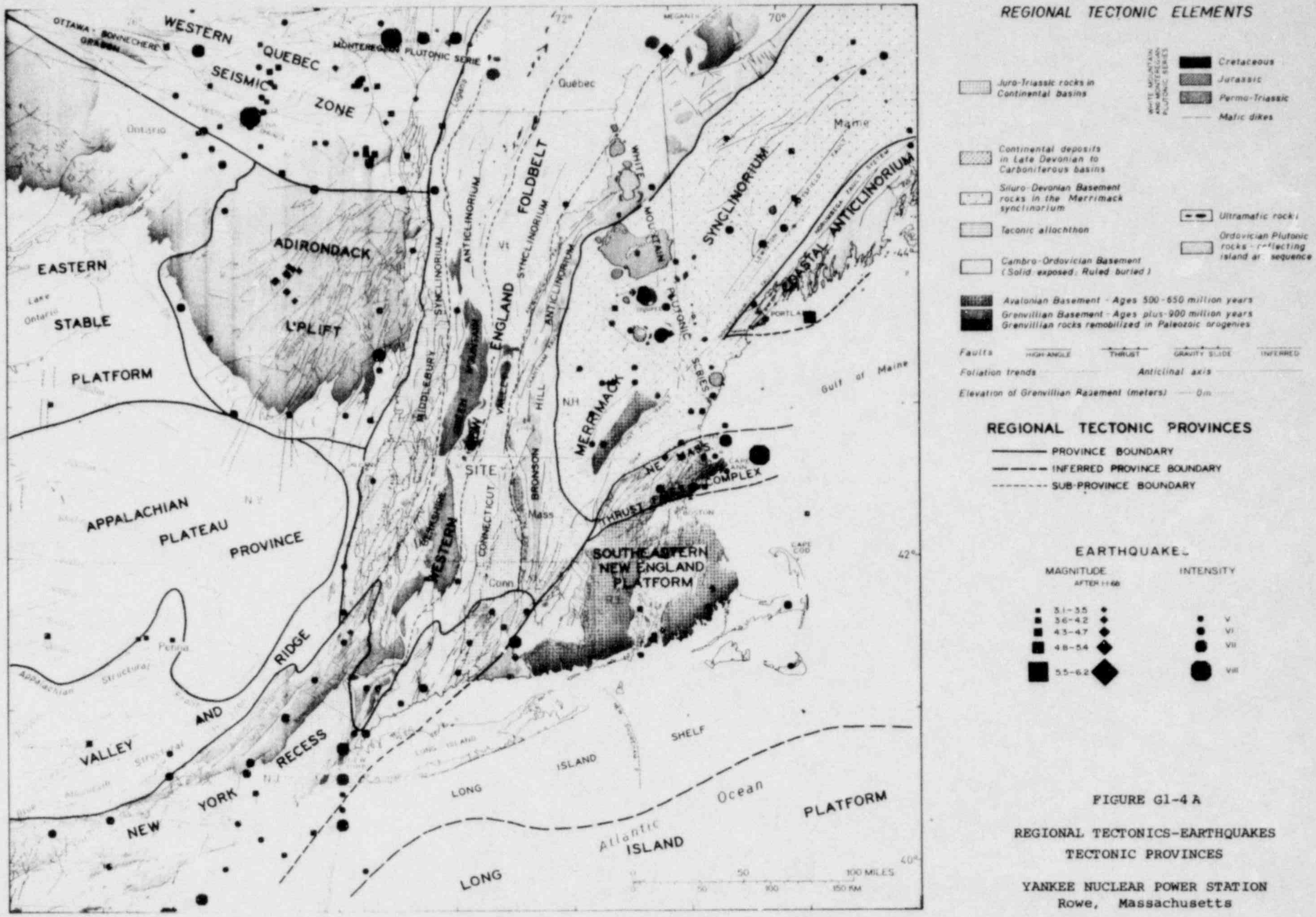
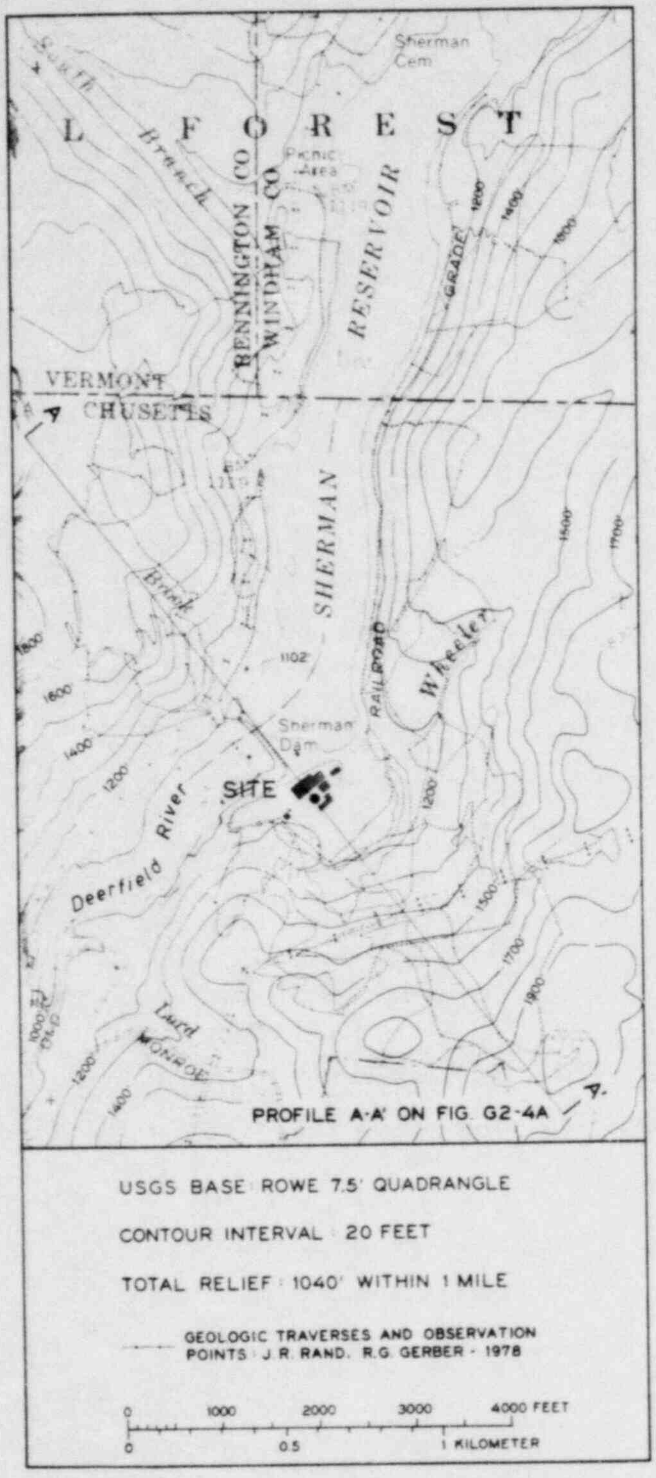


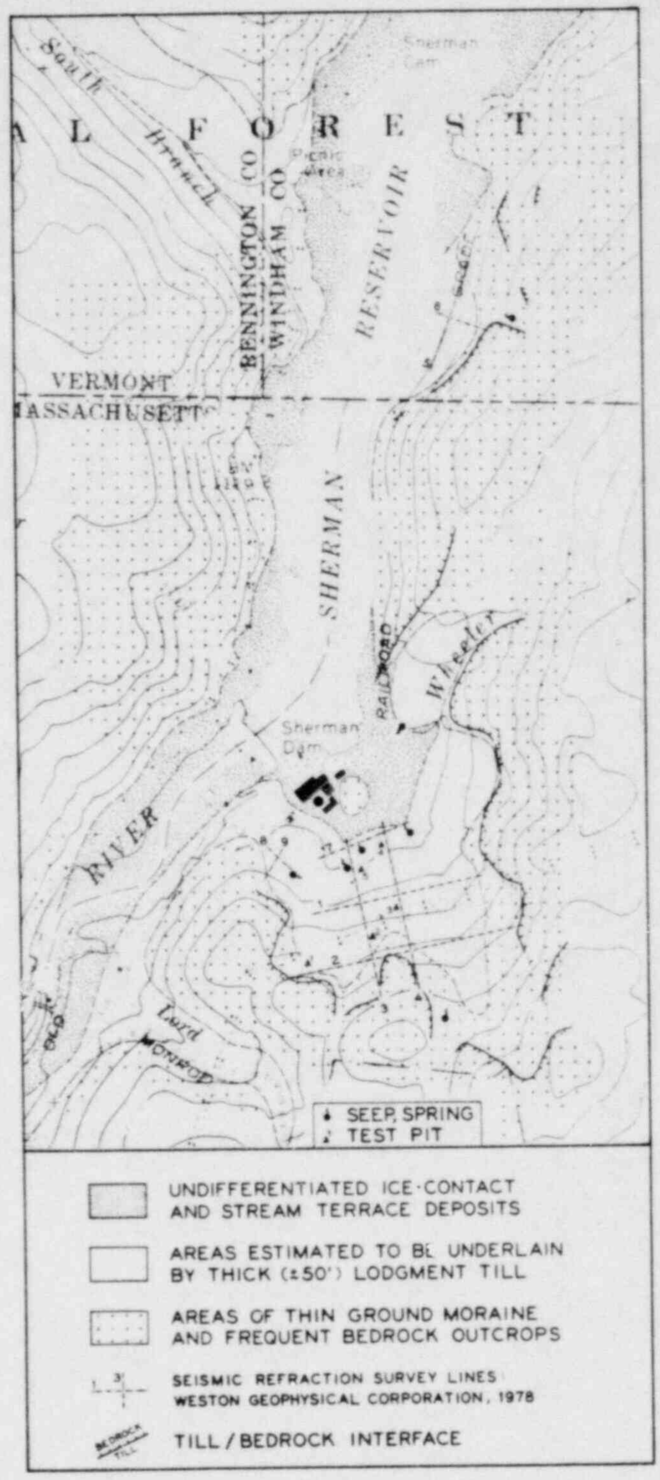
FIGURE G1-4 A

REGIONAL TECTONICS-EARTHQUAKES
TECTONIC PROVINCES

YANKEE NUCLEAR POWER STATION
Rowe, Massachusetts



A. TOPOGRAPHIC MAP - SITE LOCALE



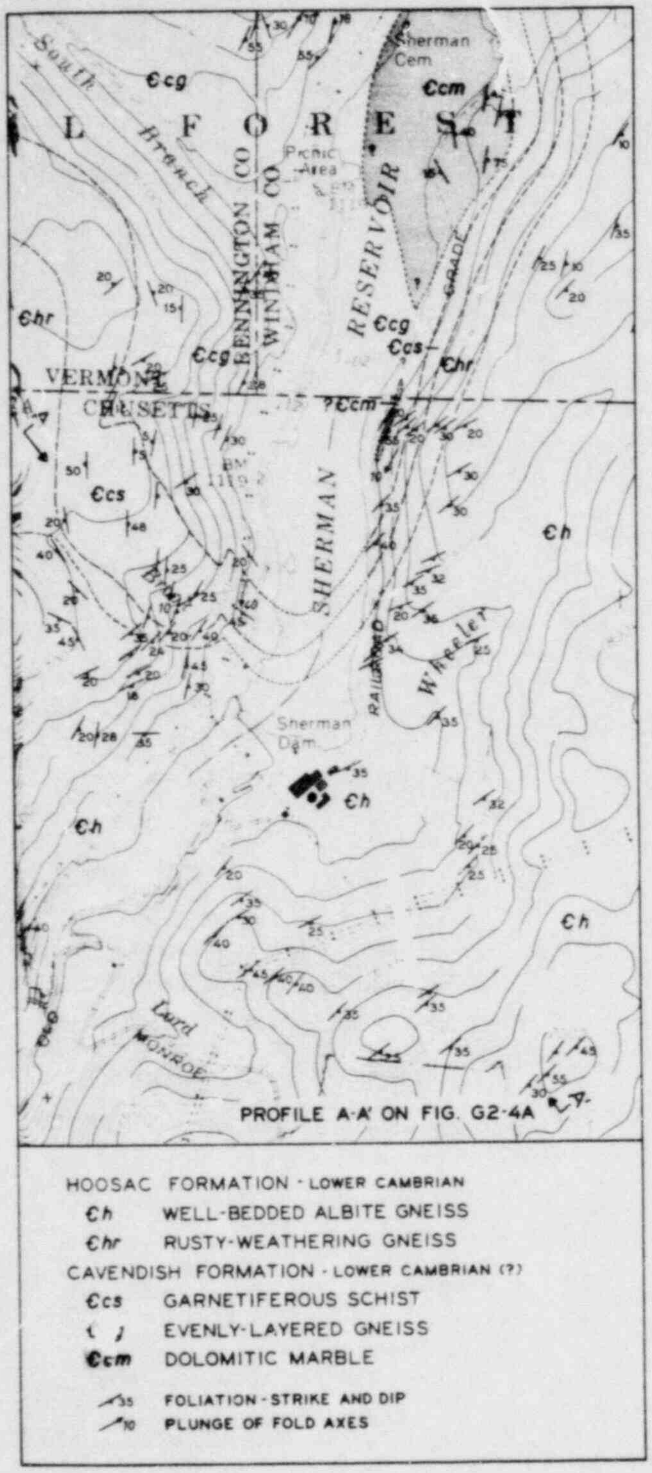
B. SURFICIAL GEOLOGY - SITE LOCALE

FIGURE G2-1

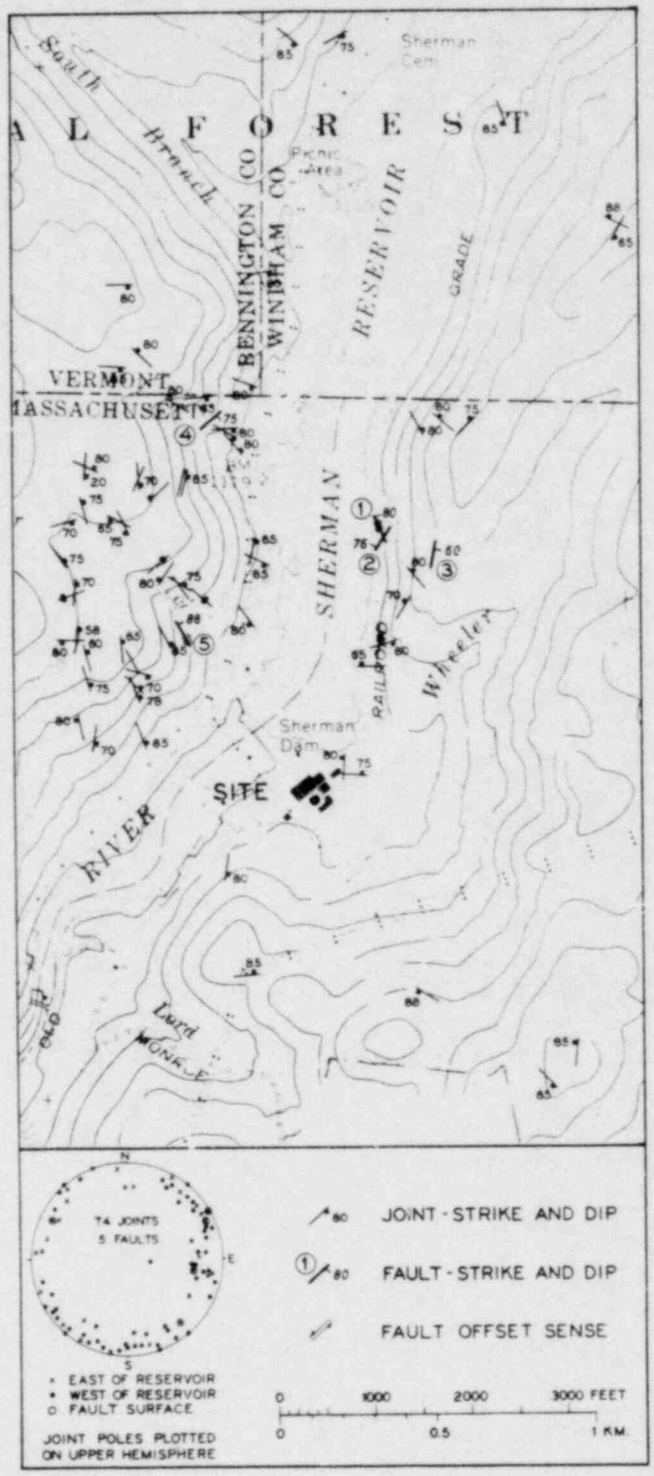
SITE LOCALE

TOPOGRAPHY
and
SURFICIAL GEOLOGY

YANKEE NUCLEAR POWER STATION
Rowe, Massachusetts



A. BEDROCK GEOLOGY - SITE LOCALE



B. BEDROCK FRACTURES - SITE LOCALE

FIGURE G2-2

SITE LOCALE

BEDROCK STRATIGRAPHY
and
STRUCTURE

YANKEE NUCLEAR POWER STATION
Rowe, Massachusetts

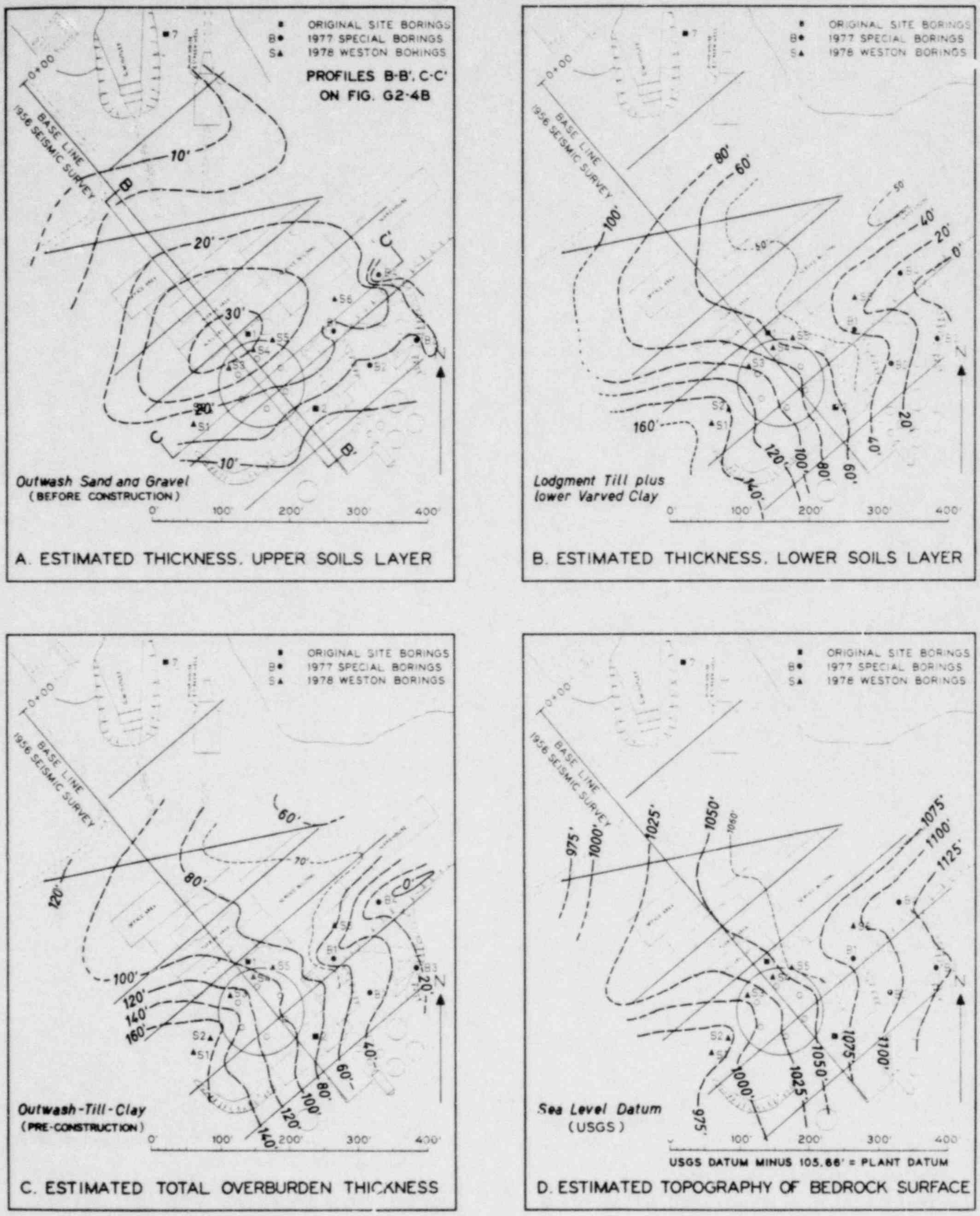
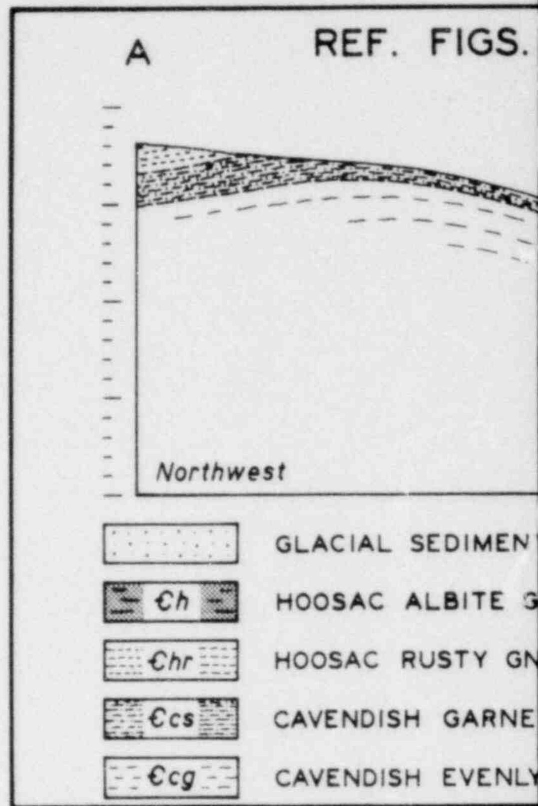
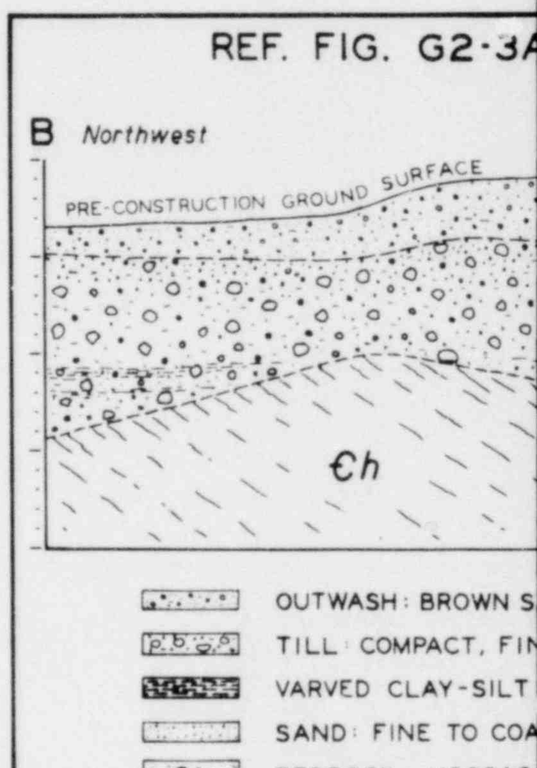


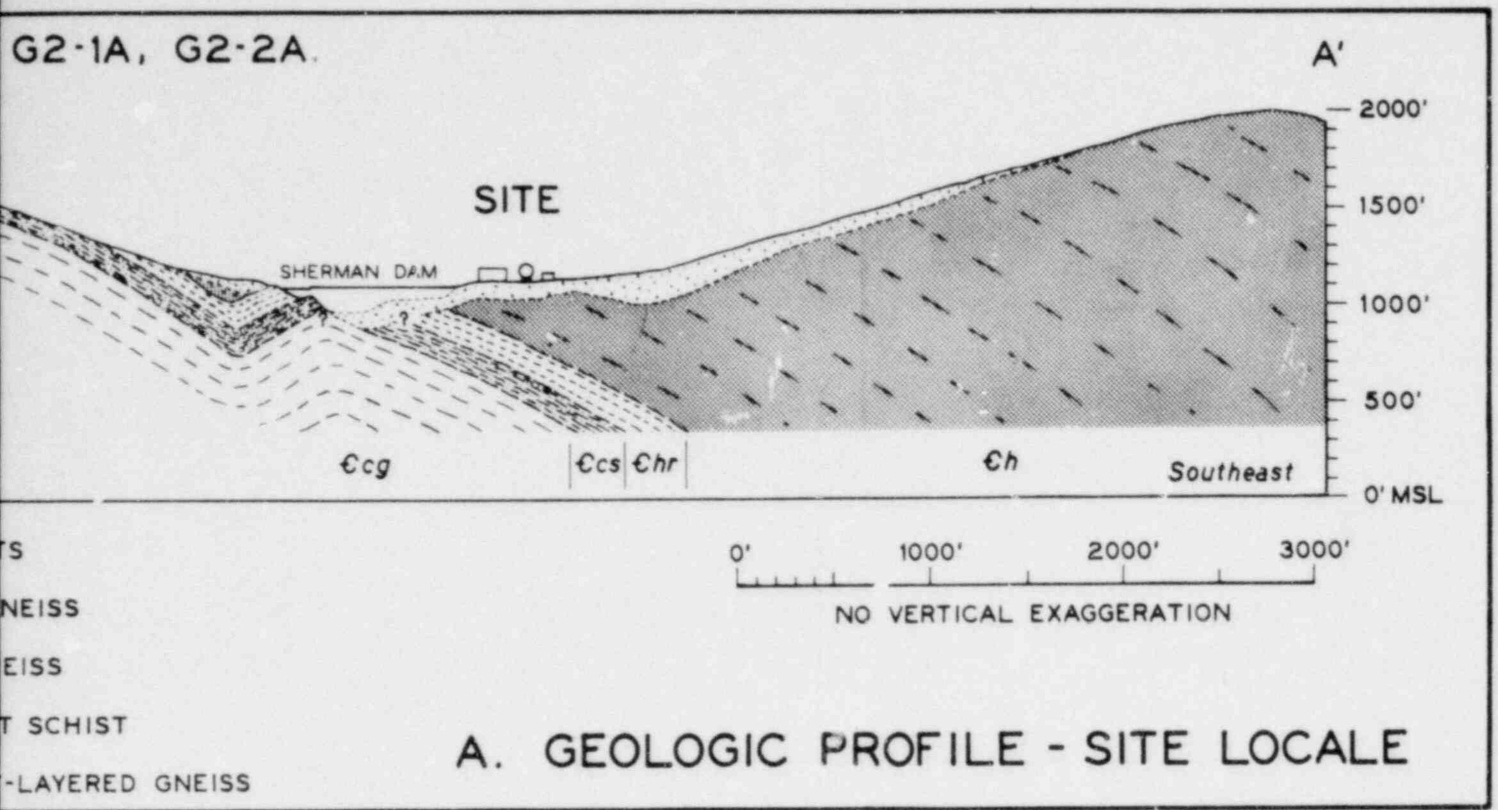
FIGURE G2-3

YANKEE NUCLEAR POWER STATION
Rowe, Massachusetts

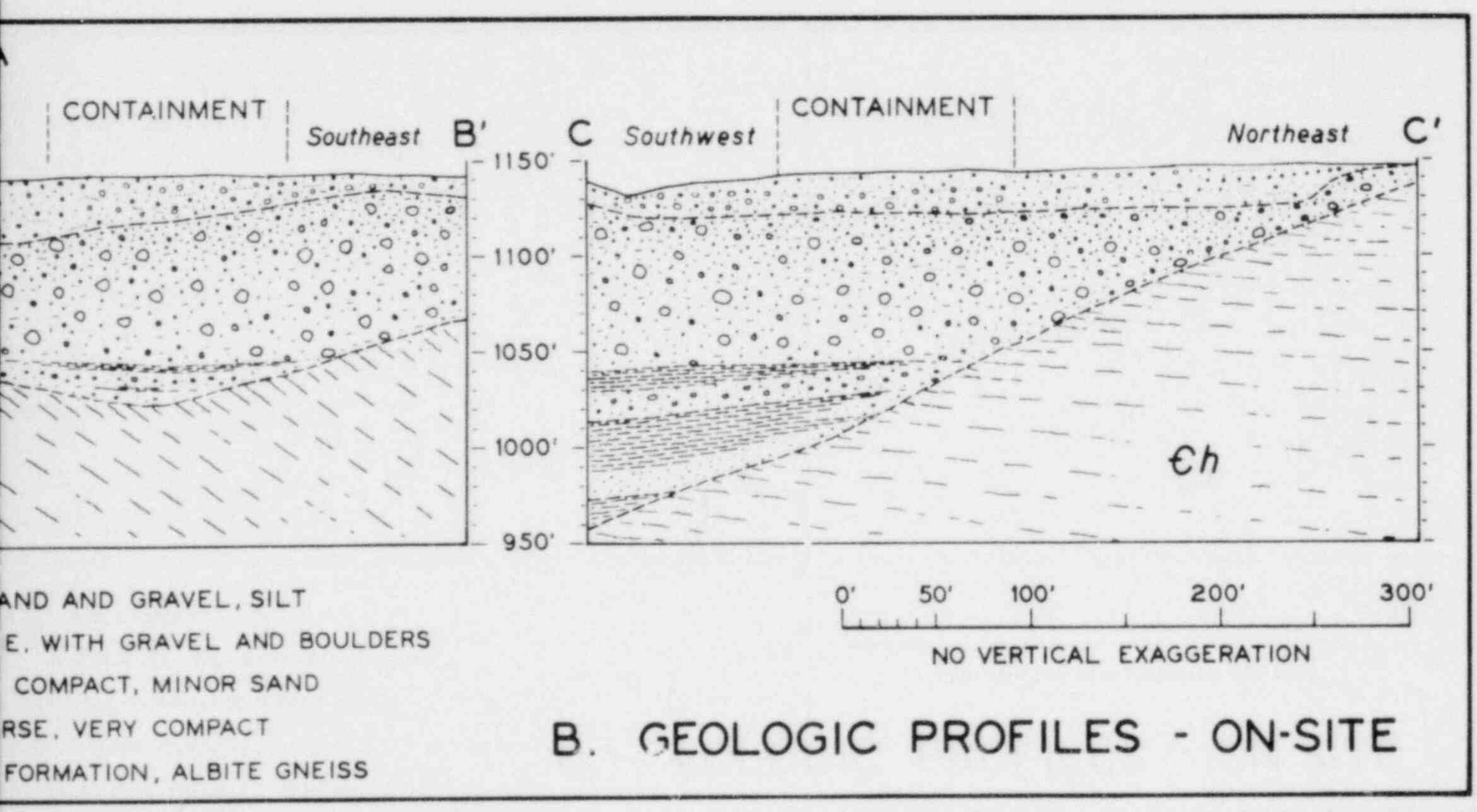
SITE SOILS LAYERS
and
BEDROCK TOPOGRAPHY


A
REF. FIGS.
Northwest
GLACIAL SEDIMEN
Ch
HOOSAC ALBITE G
Chr
HOOSAC RUSTY GN
Ccs
CAVENDISH GARNE
Ccg
CAVENDISH EVENLY


REF. FIG. G2-3A
B
Northwest
PRE-CONSTRUCTION GROUND SURFACE
Ch
OUTWASH: BROWN S
TILL: COMPACT, FIN
VARVED CLAY-SILT
SAND: FINE TO COA
Ch
BEDROCK: HOOSAC



A. GEOLOGIC PROFILE - SITE LOCALE

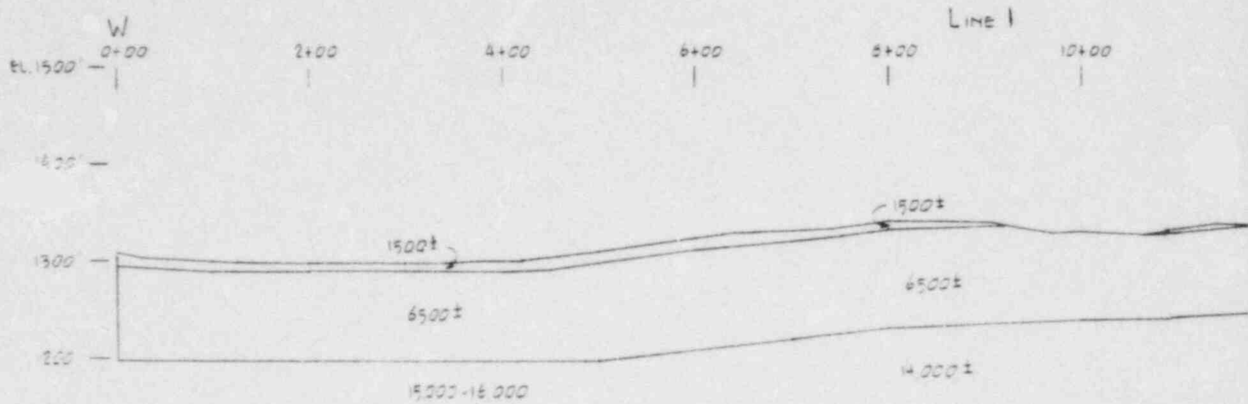


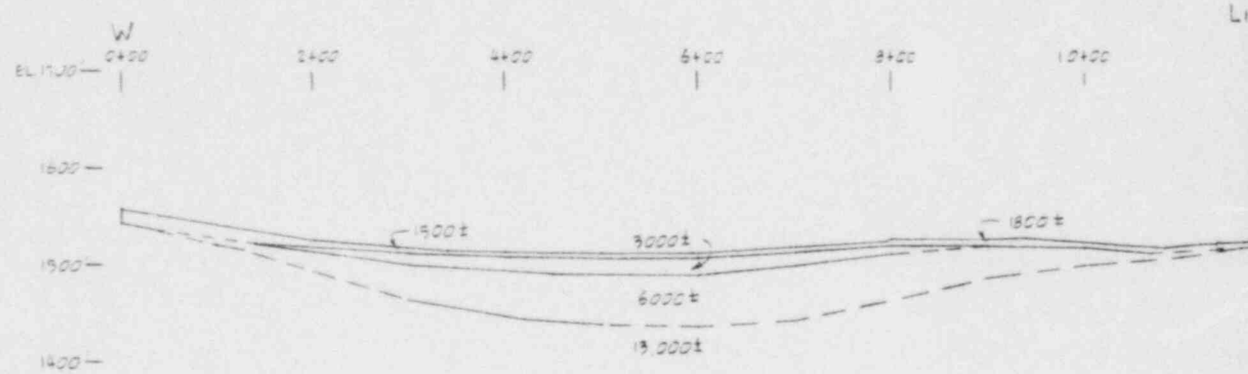
B. GEOLOGIC PROFILES - ON-SITE

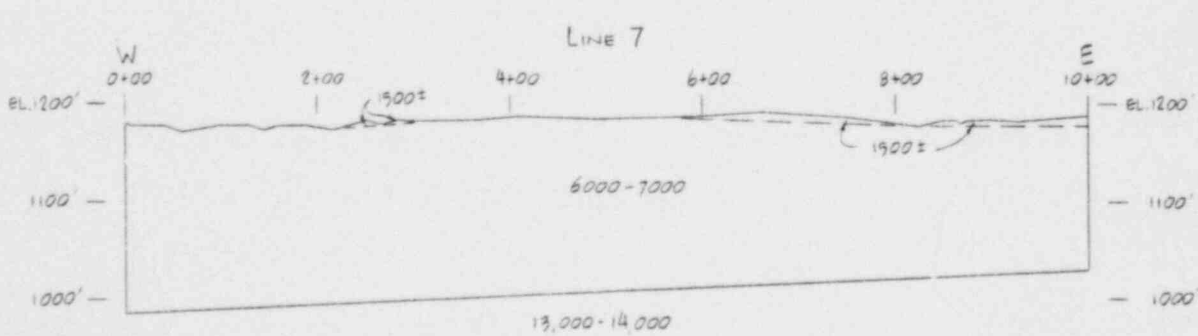
FIGURE G2-4
SITE LOCALE & ON-SITE

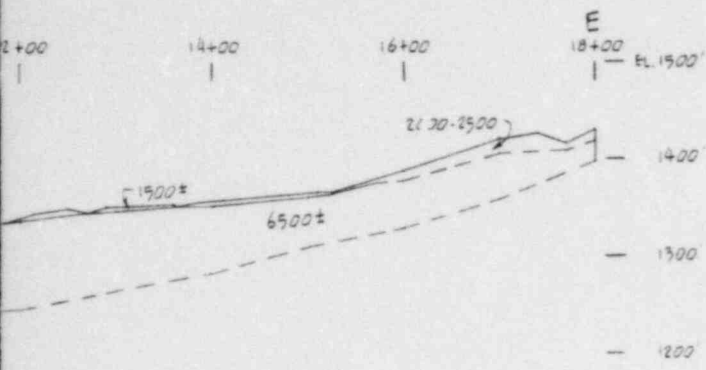
GEOLOGIC PROFILES

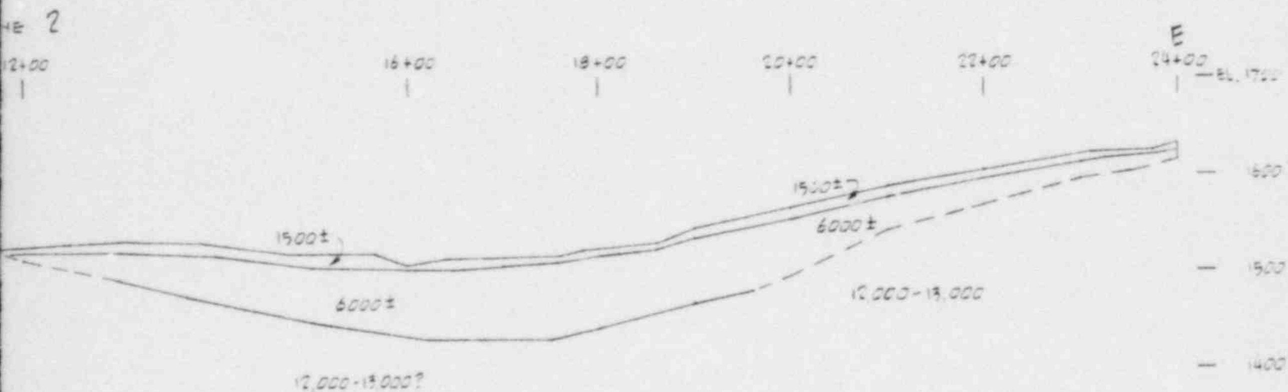
YANKEE NUCLEAR POWER STATION
Rowe, Massachusetts

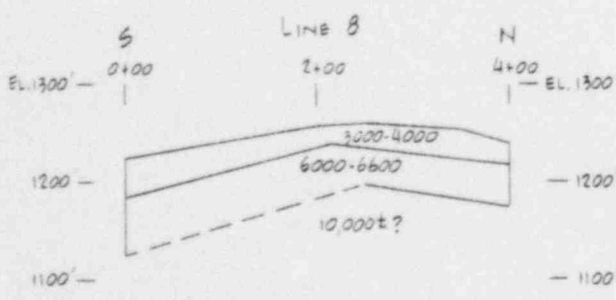

W
Line 1
0+00
2+00
4+00
6+00
8+00
10+00
EL.1500'
1400'
1300'
1200'
1500±
1500±
6500±
6500±
15,000-16,000
14,000±

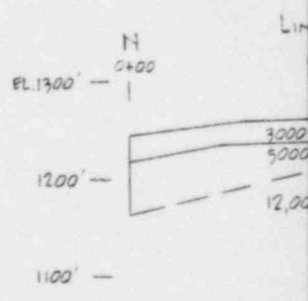

W
0+00
2+00
4+00
6+00
8+00
10+00
EL.1700
1600
1500
1400
1900±
3000±
1800±
6000±
13,000±


Line 7
W
E
0+00
2+00
4+00
6+00
8+00
10+00
EL.1200'
1100'
1000'
1300±
1900±
6000-7000
13,000-14,000


E
2+00
14+00
16+00
18+00
EL. 1500'
1400'
1300'
1200'
2100-2500
1500±
6500±


NE 2
E
12+00
16+00
18+00
20+00
22+00
24+00
EL. 1700'
1600'
1500'
1400'
1500±
6000±
1500±
6000±
12,000-13,000
12,000-13,000?


S
LINE 8
N
0+00
2+00
4+00
EL. 1300'
EL. 1300'
1200'
1200'
1100'
1100'
3000-4000
6000-6600
10,000±?


N
0+00
EL. 1300'
1200'
1100'

NOTES:
1. VELOCITIES SHOWN ARE IN FEET/SECOND.
2. CONFER TEXT FOR DISCUSSION OF VELOCITY VALUES.
3. GROUND SURFACE PROVIDED BY YANKEE ATOMIC.
4. LOCATION OF SEISMIC LINES SHOWN ON FIGURE G2-1.

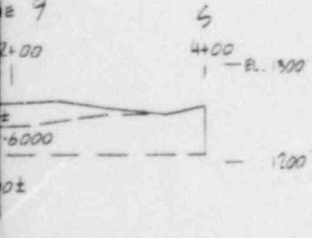
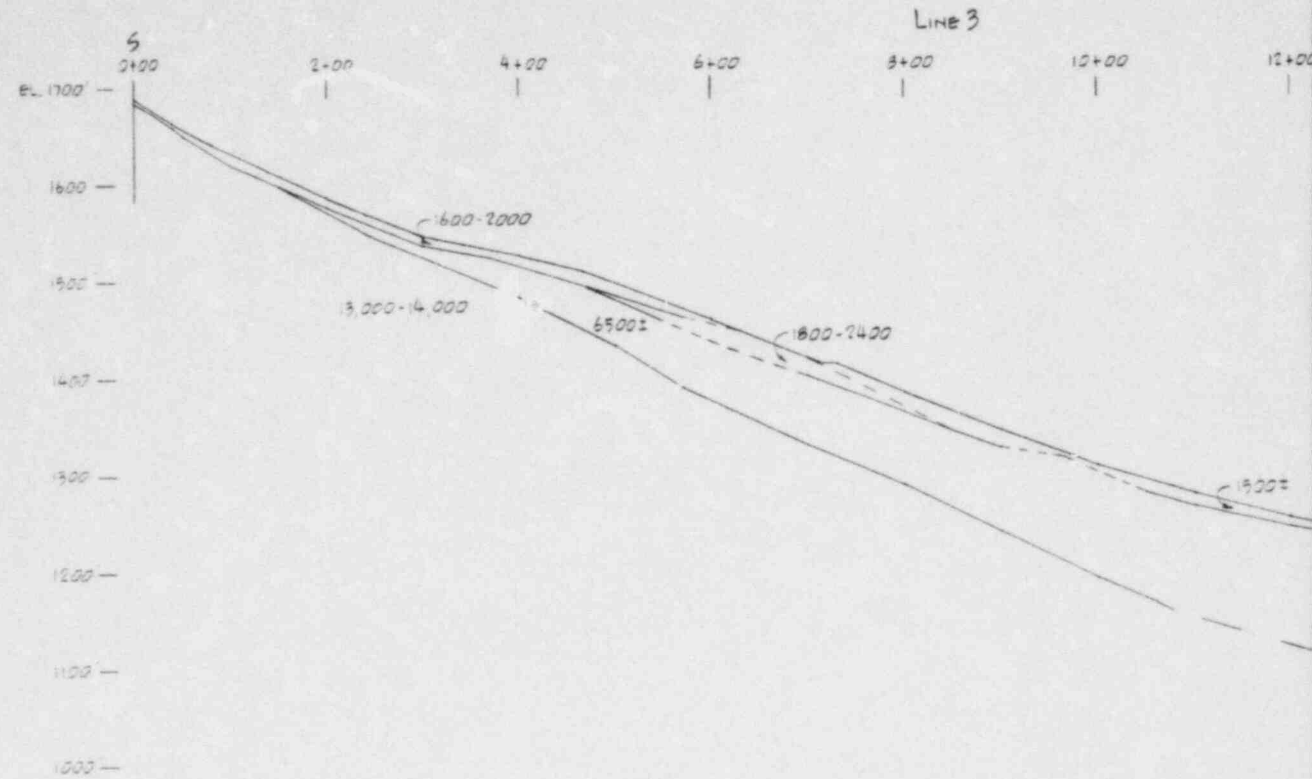
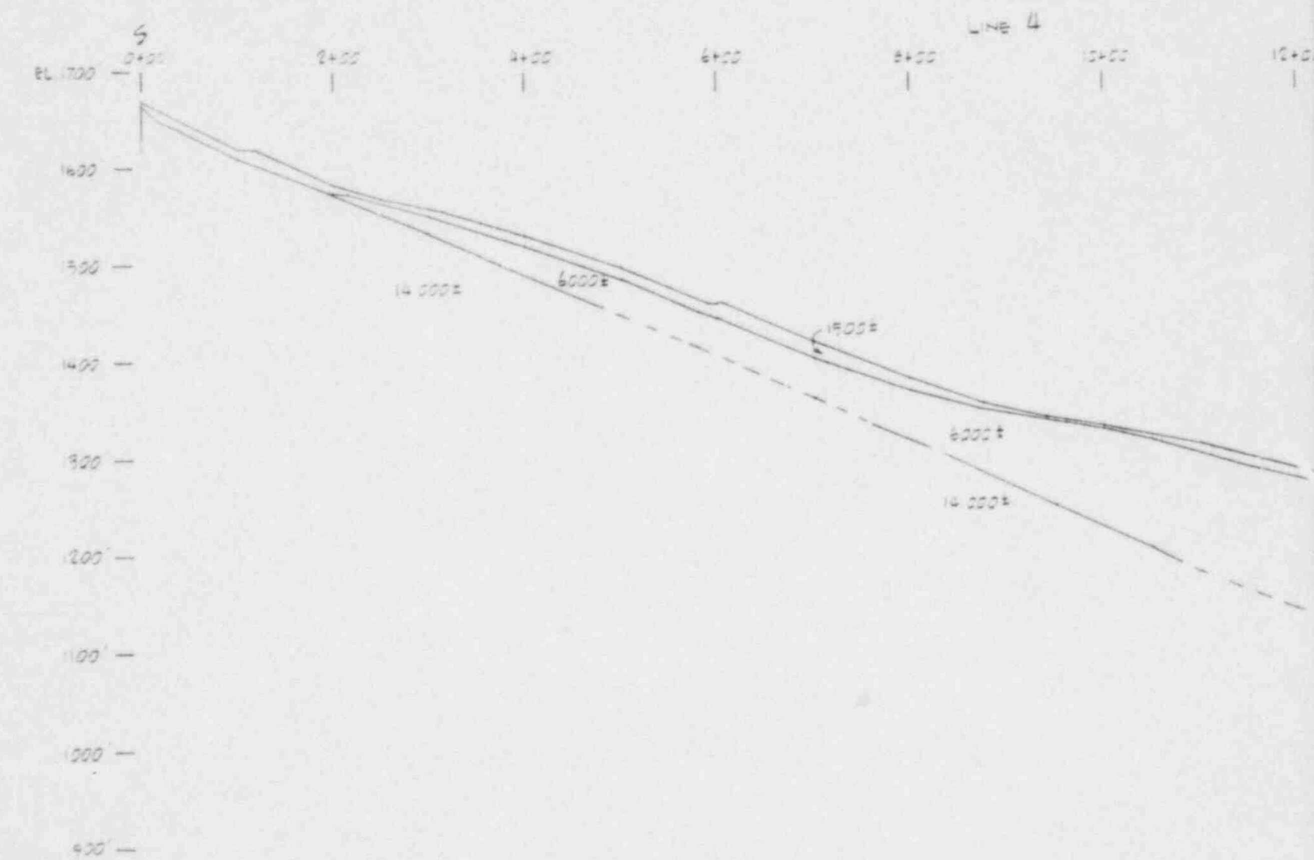


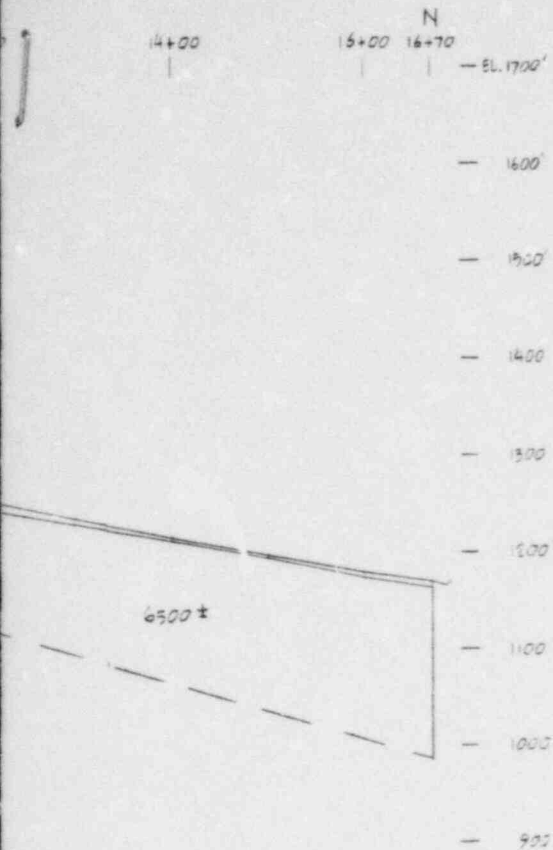
FIGURE G2-5

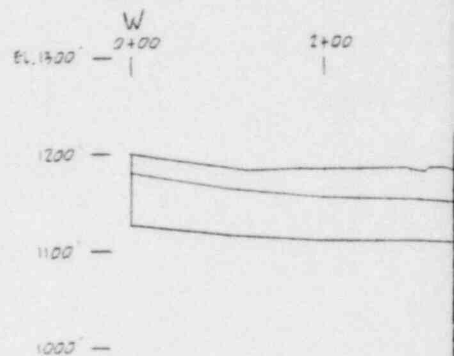
SEISMIC REFRACTION PROFILES
LINES 1, 2, 7, 8 & 9

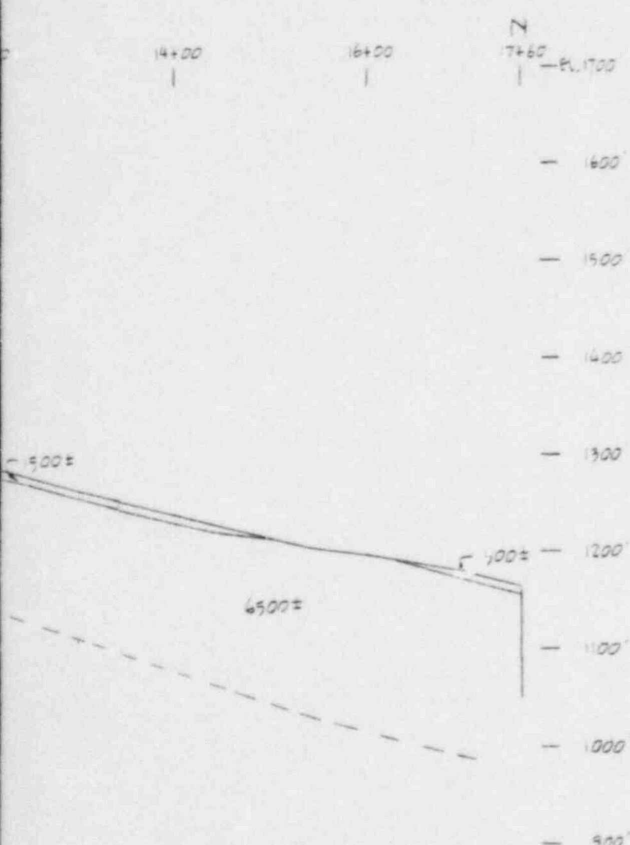
YANKEE NUCLEAR POWER STATION
Rowe, Massachusetts

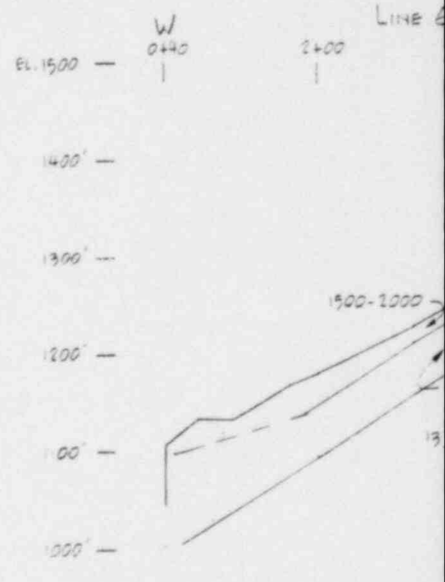

LINE 3
S
0+00
2+00
4+00
6+00
8+00
10+00
12+00
EL. 1700'
1600
1500
1400
1300
1200
1100
1000
1600-2000
13,000-14,000
6500±
1800-2400
1500±


LINE 4
S
0+00
2+00
4+00
6+00
8+00
10+00
12+00
EL. 1700
1600
1500
1400
1300
1200'
1100'
1000'
900'
14,000±
6000±
1500±
6000±
14,000±


N
14+00
15+00
16+70
EL. 1700'
1600'
1500'
1400'
1300'
1200'
6500±
1100'
1000'
900'


W
0+00
2+00
EL. 1300'
1200'
1100'
1000'


N
14+00
16+00
17+60
EL. 1700
1600'
1500
1400
1300
1200'
1100'
1000'
900'
6500±
100±


W
0+40
2+00
EL. 1500
1400'
1300'
1200'
1100'
1000'
1500-2000

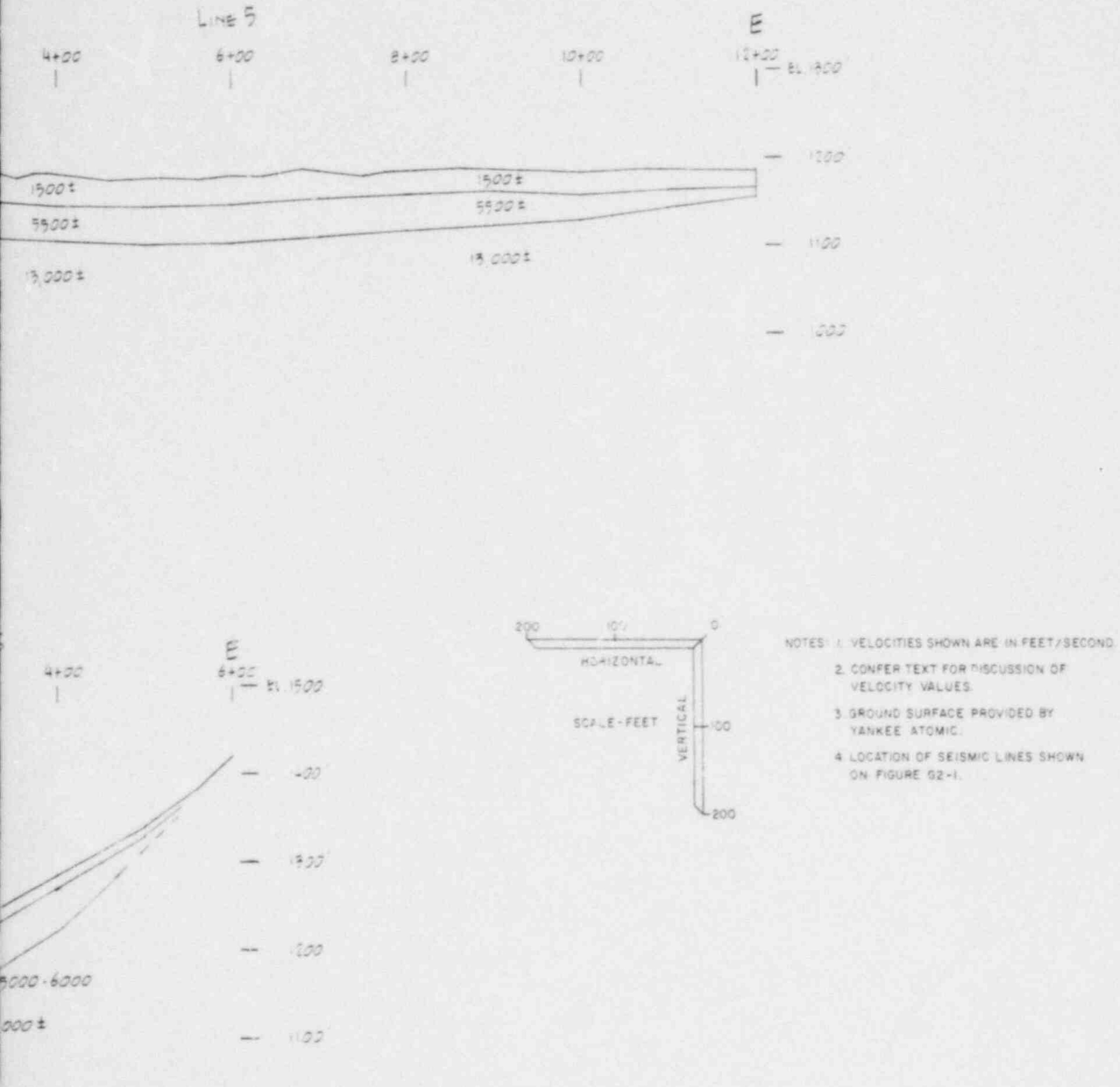


FIGURE G2-6

SEISMIC REFRACTION PROFILES
LINES 3, 4, 5 & 6

YANKEE NUCLEAR POWER STATION
Rowe, Massachusetts

APPENDIX A

BORING LOGS

PROJECT YANKEE ATOMIC ELECTRIC SITE ROWE BORING NO. S-1

DATE STARTED 9/27/78 COMPLETED 11/3/78 GROUND ELEV. 1020.7' TOTAL DEPTH 192.0'

LOCATION N 4905.8 E 5038.8 INCLINATION VERTICAL BEARING N/A LOGGED BY J. BRIDGE DATE 11/78

CASING I.D. 6", 5", 4", 3" CORE SIZE NX CONTRACTOR GUILD DRILLING CHECKED BY JCPE

REMARKS 3" PVC SEISMIC CASING INSTALLED AND GROUTED IN PLACE

ELEV. FEET	DEPTH FEET	SAMPLE NUMBER TYPE	SAMPLE BLOWS OR REC.	REC % — RQD % - - - (25 50 75 100)	CORE CONDITION BREAKS	CORE CONDITION JOINT DESCRIPTION	SPECIAL FEATURES OR ENG. TESTS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS WITH UNITS/STRATA CHANGES	FORMATION UNIT
1020		SS-1	7-17-8 REC 9"	0.0'-1.5'					SAND: WELL GRADED, MEDIUM COMPACT, COARSE TO FINE GRAINED, TRACE OF FINE GRAVEL, (SW), FILL.	
	5	SS-2	2-3-4 REC 0"	5.0'-6.5'					NO RECOVERY	
		SS-2A	2-1-2 REC 0"	6.5'-8.5'					NO RECOVERY	
1010	10	SS-2B	6-7-8 REC 4"	8.5'-10.5'			TYPICAL DRILLING FLUID LEVEL 8.7' 11/1/78		SAND: WELL GRADED, MEDIUM COMPACT, BROWN, COARSE TO FINE GRAINED, TRACE OF GRAVEL UP TO ½" (SW), FILL.	
	15	SS-3	25-40-48 REC 11"	14.3'-15.8'					SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, MICACEOUS, MEDIUM TO VERY FINE SAND, 10% TO 15% SILT, TRACE OF GRAVEL UP TO ½". (SW-SM), LODGMENT TILL.	
		NX-1	1.6'						SILTY SAND: SAME AS SS-3. (SW-SM)	
1000	20	NX-2	5.0'						SILTY SAND: SAME AS SS-3 (SW-SM) WITH COBBLES UP TO 6".	
	25	NX-3	3.6'						SILTY SAND: WELL GRADED, DENSE, OLIVE, MICACEOUS, V. FINE TO V. COARSE SAND, WITH 10% SILT AND CLAY, GRAVEL AND COBBLES UP TO 4". (SW-SM), LODGMENT TILL.	
990	30	NX-4	4.5'						SILTY SAND: SAME AS NX3. (SW-SM)	
	35	NX-5	5.0'						SILTY SAND: SAME AS NX3, EXCEPT 35.3'-36.5' MATRIX IS FINE TO V. FINE SAND WITH 15-20% SILT. (SW-SM), LODGMENT TILL.	
980	40	NX-6	4.0'						SILTY SAND: POORLY GRADED, DENSE, OLIVE, MICACEOUS, FINE TO V. FINE SAND, WITH 15-20% SILT AND CLAY, 5-10% GRAVEL AND COBBLES. (SP-SM), LODGMENT TILL.	
	45	NX-7	4.1'						SILTY SAND: SAME AS NX-6. (SP-SM)	
970	50	NX-C	1.5'						GRAVEL: RECOVERED, WASHED, COARSE TO MEDIUM SAND, SILTY COARSE TO V. FINE SAND, GRAVEL AND COBBLES. (SP) LODGMENT TILL.	
	55	NX-9	2.0'						SILTY SAND: POORLY GRADED, DENSE, OLIVE, MICACEOUS, SILTY SAND AND GRAVEL. (SM), LODGMENT TILL.	
960	60	NX-10	3.5'						SILTY SAND: SAME AS NX-9. (SM)	
		SS-4	23-45-69 REC 13"	61.5'-63.0'					SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, MICACEOUS, V. COARSE TO V. FINE SAND, 10-15% SILT AND CLAY, 5-10% GRAVEL. (SW-SM), LODGMENT TILL.	
	65	NX-11	5.0'						SILTY SAND: SAME AS SS-4. (SW-SM)	
		SS-5	26-71-68 REC 12"	68.0'-69.5'					SILTY SAND: SAME AS SS-4. (SW-SM)	
950	70	NX-12	5.0'						SILTY SAND: SAME AS SS-4. (SW-SM)	
	75	SS-6	33-100/6" REC 10"	74.5'-75.5'					SAND: WELL GRADED, V. COMPACT, OLIVE, MICACEOUS, V. COARSE TO V. FINE SAND, 5-10% SILT & CLAY, 3-5% GRAVEL UP TO ½". (SW-SM), LODGMENT TILL.	

PROJECT YANKEE ATOMIC ELECTRIC SITE ROWE BORING NO. S-1

ELEV. FEET	DEPTH FEET	SAMPLE NUMBER TYPE	SAMPLE BLOWS OR REC.	REC % / RQD %	CORE CONDITION BREAKS	JOINT DESCRIPTION	SPECIAL FEATURES OR ENG. TESTS	SOIL AND ROCK DESCRIPTIONS WITH LIMITS/STRATA CHANGES	FORMATION UNIT
940	80	NX-13	5.0'					SAND: SAME AS SS-6. (SW-SM) SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, MICACEOUS, V. COARSE TO V. FINE SAND, 20-30% SILT & CLAY, 1-2% GRAVEL UP TO 1", FINES ARE MOD PLASTIC AND GIVE HIGH DRY STRENGTH. (SM-SC), LODGMENT TILL.	
		SS-7	30-50-45 REC 16"	81.5'-83.0'				CLAY: DENSE, OLIVE, CHLORITIC, WITH SILT AND 3-5% FINE TO V. FINE GRAY SAND IN V. THIN LENSES, SCATTERED GRAVEL, DISTURBED VARVES, PLASTIC, HIGH DRY STRENGTH. (CL)	
	85	NX-14	4.9'					CLAY: DENSE, OLIVE, CHLORITIC, WITH SILT AND 3-5% FINE TO V. FINE GRAY SAND IN V. THIN LENSES, SCATTERED GRAVEL, DISTURBED VARVES, PLASTIC, HIGH DRY STRENGTH. (CL)	
930	90	SS-8	13-19-33 REC 18"	88.0'-89.5'				CLAY: SAME AS NX-14. (CL)	
		NX-15	2.5'					CLAY: SAME AS NX-14. (CL)	
	95	SS-9	23-48-49 REC 16"	94.5'-96.0'				SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, MICACEOUS, COARSE TO V. GINE SAND, 20-25% SILT AND CLAY, 5-8% GRAVEL UP TO ¾". (SM), LODGMENT TILL.	
920		NX-16	4.1'					SILTY SAND: SAME AS SS-9, EXCEPT GRAVEL UP TO 3". (SM)	
		SS-10	38-70-77 REC 16"	101.0'-102.5'				SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, V. COARSE TO V. FINE SAND, 10-20% SILT AND CLAY, 3-5% GRAVEL. (SW-SM), LODGMENT TILL.	
	105	NX-17	4.8'					SILTY SAND: SAME AS SS-10. (SW-SM)	
		SS-11	24-28-39 REC 18"	107.5'-109.0'				SILT: HARD, OLIVE, SANDY, 5-8% FINE GRAY SAND, 2-3% GRAVEL, DISTURBED VARVES. (ML)	
910	110	NX-18	0'					NO RECOVERY.	
	115	SS-12	40-70-56 REC 17"	114.0'-115.5'				CLAY: HARD, OLIVE, 3-5% FINE GRAY SAND. (CL)	
		NX-19	0'					NO RECOVERY.	
900	120	SS-13	11-18-25 REC 18"	120.5'-122.0'				CLAY: HARD, OLIVE, VARVED, SOME SILT, 2-3% FINE GRAY SAND, PLASTIC, HIGH DRY STRENGTH. (CL)	
	125	NX-20	4.3'					CLAY: SAME AS SS-13. (CL)	
		SS-14	15-19-35 REC 20"	126.3'-128.3'				CLAY: SAME AS SS-13, EXCEPT LESS THAN 1% GRAVEL. (CL)	
890	130	NX-21	1.0'					CLAY: DENSE, OLIVE, WITH 5-8% SILTY SAND AND GRAVEL. (CL)	
	135	SS-15	90-100/3" REC 9"	133.3'-134.0'				SAND: WELL GRADED, V. COMPACT, OLIVE, 4-5% SILT & CLAY. (SW)	
		NX-22	0'					NO RECOVERY.	
880	140	SS-16	47-100/4" REC 10"	139.0'-139.8'				SAND: SAME AS SS-15, EXCEPT LESS THAN 1% GRAVEL UP TO 1". (SW)	
	145	SS-17	56-70-100/5" REC 17"	144.0'-145.4'				SAND: SAME AS SS-16. (SW)	
								SAND: SAME AS SS-16. (SW)	
870	150	SS-18 SS-18A	25-25-26 REC 18"	149.0'-150.5'				CLAY: HARD, OLIVE, VARVED, TRACE SILT AND FINE GRAVEL. (CL)	
	155	SS-19	22-39-81 REC 18"	154.0'-155.5'				SILT: HARD, OLIVE, VARVED, CLAYEY, 5-10% V. FINE GRAY SAND. (ML)	
860	160	SS-20	24-38-75 REC 17"	159.0'-160.5'				SILT: SAME AS SS-19. (ML)	

PROJECT YANKEE ATOMIC ELECTRIC SITE ROWE BORING NO. S-1

ELEV. FEET	DEPTH FEET	SAMPLE NUMBER TYPE	SAMPLE BLOWS OR REC.	REC % —— RQD % - - - (25 50 75 100)	CORE CONDITION BREAKS	CORE CONDITION JOINT DESCRIPTION	SPECIAL FEATURES OR ENG. TESTS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS WITH UNITS/STRATA CHANGES	FORMATION UNIT
	165	SS-21	26-62-100 REC 15"	164.0'-165.5'					SILT: SAME AS SS-19. (ML)	
									TOP OF WEATHERED ROCK OR BOULDER PAVEMENT @ 168.0'	
850	170	SS-22	72-100/5" REC 11"	169.0'-169.9'					SAND: V. COMPACT, DARK GRAY, 8-10% SILT, TRACE CLAY, POSSIBLY SEVERELY WEATHERED GNEISS.	
		NX-23	1.4'						GNEISS: GRAY, MODERATELY SOFT, GNEISSIC LAYERING 50°, PARTINGS ALONG LAYERING AT AREAS OF ABUNDANT MICA.	
									TOP OF ROCK @ 173.5'	
	175	NX-24	[illegible].0'						GNEISS: GRAY, ALBITE, BIOTITE, MODERATELY HARD, SLIGHTLY TO SEVERELY WEATHERED, GNEISSIC LAYERING 45° WITH CLOSE TO MODERATELY CLOSE PARTING PARRALLEL TO IT.	
840	180	NX-25	3.6'						GNEISS: SAME AS NX-24, SEVERELY WEATHERED ZONE 179.2' TO 179.8'.	
	185	NX-26	4.4'			70° JOINT 85° JOINT			GNEISS: SAME AS NX-24, EXCEPT LAYERS OF QUARTZITE UP TO 1½" FROM 185.1' TO 187.5', 70° ROUGH IRON STAINED JOINTS @ 183.6' AND 184.6'.	
830	190	NX-27	4.6'						GNEISS: SAME AS NX-26, EXCEPT SLIGHTLY WEATHERED.	
									BOTTOM OF BORING @ 192.0'	
	195									

PROJECT YANKEE ATOMIC ELECTRIC SITE ROWE BORING NO. S-2

DATE STARTED 10/24/78 COMPLETED 10/31/78 GROUND ELEV. 1020.9' TOTAL DEPTH 159.0'

LOCATION N 4904.9 E 5070.4 INCLINATION VERTICAL BEARING N/A LOGGED BY J. BRIDGE DATE 11/78

CASING I.D. 16" AND 6" CORE SIZE N/A CONTRACTOR R.E. CHAPMAN CHECKED BY JCPa

REMARKS NO SAMPLES TAKEN, INSTALLED ALUMINUM SEISMIC CASING AND GROUTED IT IN PLACE. IDENTIFICATIONS FROM DRILL ACTION AND CUTTINGS.

ELEV. FEET	DEPTH FEET	SAMPLE		REC % — RQD % - - - (25 50 75 100)	CORE CONDITION		SPECIAL FEATURES OR ENG. TESTS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS WITH UNITS/STRATA CHANGES	FORMATION UNIT
		NUMBER TYPE	BLOWS OR REC.		BREAKS	JOINT DESCRIPTION				
									NO SAMPLES TAKEN 0-13' COARSE SAND AND GRAVEL WITH BOULDERS, FILL.	
1007.9	13								13' TO 154' COARSE TO FINE SAND, GRAVEL, SILT, CLAY, COBBLES AND BOULDERS, LODGMENT TILL. TOP OF ROCK @ 154'	
866.9	154								GREY GNEISS	
861.9	159								BOTTOM OF HOLE @ 159'	

PROJECT YANKEE ATOMIC ELECTRIC **SITE** ROWE **BORING NO.** S-3

DATE STARTED 10/23/78 **COMPLETED** 11/1/78 **GROUND ELEV.** 1021.7' **TOTAL DEPTH** 139.0'

LOCATION N 4933.9 E 5135.4 **INCLINATION** VERTICAL **BEARING** N/A **LOGGED BY** J. BRIDGE P. TURNER **DATE** 11/78

CASING I.D. 6" AND 3" **CORE SIZE** NX **CONTRACTOR** GUILD DRILLING **CHECKED BY** J C[illegible]

REMARKS INSTALLED 3" PVC SEISMIC CASING AND GROUTED IT IN PLACE

ELEV. FEET	DEPTH FEET	SAMPLE NUMBER TYPE	SAMPLE BLOWS OR REC.	REC % — RQD % - - - (25 50 75 100)	CORE CONDITION BREAKS	CORE CONDITION JOINT DESCRIPTION	SPECIAL FEATURES OR ENG. TESTS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS WITH UNITS/STRATA CHANGES	FORMATION UNIT
1020		SS-1	1-1-1 REC 5"	0.0'-1.5'					SAND: WELL GRADED, V. LOOSE, BROWN, COARSE TO FINE GRAINED, 2-3% GRAVEL UP TO 3/4", TRACE OF SILT, (SW), FILL.	
	5	SS-2	3-4-4 REC 8"	4.0'-5.5'					SAND: SAME AS SS-1. (SW)	
							TYPICAL DRILLING FLUID LEVEL 8.0' 10/25/78			
1010	10	SS-3	10-8-12 REC 12"	9.5'-11.0'					SAND: WELL GRADED, MED. COMPACT, BROWN, COARSE TO FINE GRAINED, 3-5% GRAVEL UP TO ½", TRACE OF SILT, (SW), FILL.	
	15	SS-4	100/5" REC 4"	14.0'-14.4'					SAND: WELL GRADED, V. COMPACT, OLIVE, COARSE TO FINE SAND, 5-10% SILT, 4-6% GRAVEL UP TO ¾", (SW-SM), LODGMENT TILL.	
		NX-1	1.9'						SILTY SAND: SAME AS SS-4, EXCEPT 10-15% SILT, 10-15% GRAVEL AND COBBLES UP TO 2", TRACE CLAY, (SW-SM).	
	20	SS-5	100/0" REC 0"	19.2'-19.2'					NO RECOVERY	
1000		NX-2	3.0'						SILTY SAND: SAME AS NX-1. (SW-SM)	
	25	SS-6	17-57-100/4" REC 9"	24.2'-25.5'					SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, COARSE TO FINE SAND, 10-15% SILT, 5-6% GRAVEL, UP TO 1½", TRACE OF CLAY, (SW-SM), LODGMENT TILL.	
		NX-3	2.7'						SILTY SAND: SAME AS SS-6, (SW-SM).	
	30	SS-7	100/0"	30.5'-30.5'					NO RECOVERY	
990		NX-4	2.6'						SILTY SAND: SAME AS SS-6.	
	35	SS-8	100/0"	34.0'-34.0'					NO RECOVERY	
		NX-5	3.5'						SILTY SAND: WELL GRADED, DENSE, OLIVE, COARSE TO FINE SAND, 10-15% SILT, 8-10% GRAVEL UP TO 6", TRACE OF CLAY, (SW-SM), LODGMENT TILL.	
	40	SS-9	8-32-44 REC 9"	39.0'-40.5'					SILTY SAND: POORLY GRADED, V. COMPACT, OLIVE, MEDIUM TO FINE SAND, 10-15% SILT, 3-5% GRAVEL, UP TO 1", 2-3% CLAY, INCORPORATED IN THE TILL, (SM), LODGMENT TILL.	
980		NX-6	2.9'						SILTY SAND: SAME AS NX-5.	
	45	SS-10	53-52-56 REC 8"	45.5'-47.0'					SILTY SAND: POORLY GRADED, V. COMPACT, OLIVE, MEDIUM TO FINE SAND, 15-20% SILT, 2-3% CLAY, 2-3% GRAVEL UP TO 1½", (SM), LODGMENT TILL.	
	50	NX-7	1.5'						SILTY SAND: SAME AS SS-10, EXCEPT COBBLES UP TO 5". (SM)	
970		SS-11	56-100-100/5" REC 8"	52.0'-53.2'					SILTY SAND: WELL GRADED, V. COMPACT, OLIVE COARSE TO FINE SAND, 1[illegible]% SILT, 2-3% CLAY, 5-10% GRAVEL UP TO 1¼", (SM), LODGMENT TILL.	
	55	NX-8	2.8'						[illegible]MENT TILL: SAME AS SS-11, EXCEPT COBBLES UP TO 6". (SM)	
960	60	SS-12	64-85-100/3" REC 8"	58.5'-59.8'					SILTY SAND: SAME AS SS-11, EXCEPT 15-20% SILT, 5-10% GRAVEL UP TO ¾". (SM)	
		NX-9	1.0'						SILTY SAND: SAME AS SS 11. (SM)	
	65	SS-13	42-49-100 REC 2"	64.3'-65.8'					SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, COARSE TO FINE SAND, 20-25% SILT AND CLAY, (SM), LODGMENT TILL.	
		NX-10	1.0'						SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, COARSE TO FINE SAND, 15-20% SILT, UP TO 5% CLAY, 10-15% GRAVEL TO 2" (SM).	
950	70	SS-14	22-33-52 REC 11"	70.8'-72.3'					SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, COARSE TO FINE SAND, 15-20% SILT, 3-5% CLAY, 5-10% GRAVEL, UP TO 1¼", FINES ARE SLIGHTLY PLASTIC (SM), LODGMENT TILL.	
	75	NX-11	1.0'							

PROJECT YANKEE ATOMIC ELECTRIC SITE ROWE BORING NO. S-3

ELEV. FEET	DEPTH FEET	SAMPLE NUMBER TYPE	SAMPLE BLOWS OR REC.	REC % — / RQD % - - - (25 50 75 100)	CORE CONDITION BREAKS	CORE CONDITION JOINT DESCRIPTION	SPECIAL FEATURES OR ENG. TESTS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS WITH UNITS/STRATA CHANGES	FORMATION UNIT
		SS-15	17-27-42 REC 15"	76.0'-77.5'					SILTY SAND: SAME AS SS-14, EXCEPT GRAVEL UP TO 1½".	
940	80	NX-12	4.5'						SILTY SAND: SAME AS SS-14.	
		SS-16	12-33-42 REC 18"	82.5'-84.0'					SILT: V. COMPACT, OLIVE, SLIGHTLY PLASTIC, SILT, 15-20% MEDIUM TO FINE SAND, 2-3% FINE GRAVEL, (ML), LODGMENT TILL.	
	85	NX-13	2.1'						SILT: SAME AS SS-16 EXCEPT 5-10% GRAVEL UP TO 2".	
	90	SS-17	40-63-73 REC 14"	89.0'-90.5'					SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, COARSE TO FINE SAND, 15-20% SILT, UP TO 5% CLAY, 3-5% GRAVEL UP TO 1". (SM), LODGMENT TILL.	
930	95	NX-14	2.7'						SILTY SAND: SAME AS SS-17.	
		SS-18	32-100/5" REC 8"	95.0'-96.4'					SILTY SAND: SAME AS SS-17.	
920	100	NX-15	2.2'						SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, COARSE TO FINE SAND, 15 TO 20% SILT, 3-5% CLAY, 5-8% GRAVEL UP TO 2", (SM), LODGMENT TILL.	
		SS-19	34-64-86 REC 7"	102.0'-103.5'					SILTY SAND: SAME AS SS-17.	
	105	NX16	2.4'						SILTY SAND: SAME AS NX-15.	
	110	SS-20	100/0" REC 0"	108.5'-108.5'						
910		NX-17	3.4'						NESTED BOULDERS	
	115	NX-18	1.5'						NESTED BOULDERS TOP OF ROCK @ 118.5'	
900	120	NX-19	1.9'						GNEISS: GRAY, MEDIUM GRAINED ALBITE BIOTITE, GARNET BEARING, GNEISSIC LAYERING DIPPING 30°, QUARTZITE, MODERATELY HARD, SLIGHTLY TO SEVERELY WEATHERED, CLOSE TO MODERATELY CLOSE PARTING PARALLEL TO LAYERING.	
	125	NX-20	4.4'						GNEISS: SAME AS NX-19 EXCEPT NO GARNET.	
890	130	NX-21	4.4'						GNEISS: SAME AS NX-20, EXCEPT 50° ROUGH JOINT AT 134.0'.	
	135	NX-22	4.7'			MOD. WEATHERED			GNEISS: SAME AS NX-20, EXCEPT 70° JOINT AT 137.4'.	
880	140								BOTTOM OF BORING @ 139.0'	

PROJECT YANKEE ATOMIC ELECTRIC SITE ROWE BORING NO. S-4

DATE STARTED 10/24/78 COMPLETED 10/26/78 GROUND ELEV. 1021.6' TOTAL DEPTH 117.4'

LOCATION N 4930.7 E 5178.4 INCLINATION VERTICAL BEARING N/A LOGGED BY J. BRIDGE DATE 11/78

CASING I.D. 6" AND 3" CORE SIZE NX CONTRACTOR GUILD DRILLING CHECKED BY JCP

REMARKS NO SAMPLES TAKEN FROM 0.0' TO 83.5'. INSTALLED 3" PVC SEISMIC CASING AND GROUTED IT IN PLACE. SOIL IDENTIFICATIONS FROM CUTTINGS.

ELEV. FEET	DEPTH FEET	SAMPLE NUMBER TYPE	SAMPLE BLOWS OR REC.	REC % / RQD % (25 50 75 100)	CORE CONDITION BREAKS	CORE CONDITION JOINT DESCRIPTION	SPECIAL FEATURES OR ENG. TESTS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS WITH UNITS/STRATA CHANGES	FORMATION UNIT
							TYPICAL DRILLING FLUID LEVEL 11.5' 10/25/78		FILL: BROWN, MEDIUM TO COARSE SAND AND GRAVEL.	
940	13 – 80								LODGMENT TILL: DENSE OLIVE COARSE TO FINE SAND AND GRAVEL, COBBLES, SILT AND CLAY.	
	85	NX-1	2.3'						NESTED BOULDERS	
930	90	NX-2	1.2'						NESTED BOULDERS	
	95	NX-3	1.4'						NESTED BOULDERS TOP OF ROCK @ 98.0'	
920	100	NX-4	3.0'						GNEISS: GRAY, MEDIUM-GRAINED, ALBITE BIOTITE, MODERATELY HARD; SEVERELY WEATHERED ALONG VERY CLOSE TO MODERATELY CLOSE PARTINGS PARALLEL TO THE 45° GNEISSIC LAYERING.	
	105	NX-5	1.4'	29%						
910	110	NX-6	3.4'						GNEISS: GRAY, MEDIUM GRAINED, ALBITE BIOTITE, MODERATELY HARD, SLIGHTLY TO SEVERELY WEATHERED ALONG V. CLOSE TO MODERATELY CLOSE PARTINGS PARALLEL TO THE 45° GNEISSIC LAYERING.	
	115	NX-7	4.8'			STAINED 60° ROUGH JOINT			GNEISS: SAME AS NX-6, EXCEPT QUARTZITE LAYERS UP TO 3" @ 114.0' AND 115.0'.	
900	120								BOTTOM OF BORING @ 117.4'	

WESTON GEOPHYSICAL FORM G-5-3

DEPTH: FROM 0.0' TO 117.4'

PROJECT YANKEE ATOMIC ELECTRIC **SITE** ROWE **BORING NO.** S-5

DATE STARTED 10/16/78 **COMPLETED** 10/23/78 **GROUND ELEV.** 1021.7' **TOTAL DEPTH** 97.1'

LOCATION N4923.5 E 5210.8 **INCLINATION** VERTICAL **BEARING** N/A **LOGGED BY** J. BRIDGE **DATE** 11/20

CASING I.D. 4" AND 3" **CORE SIZE** NX **CONTRACTOR** GUILD DRILLING **CHECKED BY** JCM

REMARKS INSTALLED 3" PVC SEISMIC CASING AND GROUTED IT IN PLACE

ELEV. FEET	DEPTH FEET	SAMPLE NUMBER TYPE	SAMPLE BLOWS OR REC.	REC % — / RQD % --- (25 50 75 100)	CORE CONDITION BREAKS	CORE CONDITION JOINT DESCRIPTION	SPECIAL FEATURES OR ENG. TESTS	SOIL AND ROCK DESCRIPTIONS WITH UNITS/STRATA CHANGES	FORMATION UNIT
1020		SS-1	1/12"-1 REC 5"	0.0'-1.5'				SAND: WELL GRADED, V. LOOSE, BROWN, COARSE TO FINE, 3-5% GRAVEL UP TO 1", (SW), FILL.	
	5	SS-2	4-2-2 REC 5"	5.0'-6.5'				SAND: SAME AS SS-1 EXCEPT GRAVEL UP TO 1/2" (SW).	
1010	10	SS-3	7-35-35 REC 12"	10.0'-11.5'			TYPICAL DRILLING FLUID LEVEL 8.0' 10/17/78	SAND: WELL GRADED, V. COMPACT, BROWN, COARSE TO FINE, 6-8% SILT, 3-5% GRAVEL UP TO 1-1/2", TRACE OF CLAY, (SW-SM), ALLUVIUM?	
	15	SS-4	30-74-73 REC 11"	15.0'-16.5'				SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, COARSE TO FINE SAND, 10-15% SILT, 6-8% GRAVEL UP TO 1", TRACE OF CLAY, (SW-SM), LODGMENT TILL.	
1000	20	SS-5	51-90-94 REC 16"	20.0'-21.5'				SAND: WELL GRADED, V. COMPACT, OLIVE, COARSE TO FINE SAND, 10-12% SILT, 2-3% GRAVEL UP TO 3/4", 3-5% CLAY, (SW-SM), LODGMENT TILL.	
	25	SS-6	43-84-85 REC 15"	25.0'-26.5'				SAND: WELL GRADED, V. COMPACT, OLIVE, STRATIFIED, COARSE TO FINE, 3-5% SILT, 2-3% GRAVEL UP TO 3/4", (SW).	
990	30	SS-7	41-99-100 REC 17"	30.0'-31.5'				SAND: SAME AS SS-6. (SW)	
	35	SS-8	40-87-87 REC 17"	35.0'-36.5'				SAND: WELL GRADED, V. COMPACT, OLIVE, COARSE TO FINE SAND, 10-15% SILT, 5-7% CLAY, GRAVEL UP TP 3/4", (SW-SM), LODGMENT TILL.	
980	40	SS-9	100/4" REC 8"	40.0'-40.3'				SAND: SAME AS SS-8. (SW-SM)	
		SS-10	81-100/7" REC 7"	45.5'-46.1'				SAND: SAME AS SS-8. (SW-SM)	
970	50	SS-11	34-25-36 REC 14"	50.0'-51.5'				SILTY SAND: WELL GRADED, V. COMPACT, OLIVE, COARSE TO FINE SAND, 15-20% SILT, 5-10% CLAY, GRAVEL UP TO 1/2", (SM), LODGMENT TILL.	
	55	SS-12	37-75-74 REC 13"	55.0'-56.5'				SILTY SAND: SAME AS SS-11 EXCEPT 8-10% GRAVEL UP TO 1-1/2" AND BLOCKS OF VARVED SILT AND CLAY. (SM)	
960	60	SS-13	100/5" REC 5"	60.0'-60.5'				SILTY SAND: SAME AS SS-12. (SM)	
	65	SS-14	100/0"	65.0'-65.0'				NO PENETRATION	
		NX-1	2.2'					NESTED BOULDERS	
950	70	NX-2	1.8'					NESTED BOULDERS	
	75								

PROJECT YANKEE ATOMIC ELECTRIC SITE ROWE BORING NO. S-5

ELEV. FEET	DEPTH FEET	SAMPLE NUMBER TYPE	SAMPLE BLOWS OR REC.	REC % —— / RQD % - - - (25 50 75 100)	CORE CONDITION BREAKS	CORE CONDITION JOINT DESCRIPTION	SPECIAL FEATURES OR ENG. TESTS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS WITH UNITS/STRATA CHANGES	FORMATION UNIT
									TOP OF ROCK @ 75.0'	
		NX-3	2.2'						GNEISS: GRAY, MEDIUM GRAINED, ALBITE BIOTITE, WITH GARNET AND MUSCOVITE, MODERATELY HARD, SLIGHTLY TO SEVERELY WEATHERED ALONG V. CLOSE TO MODERATELY CLOSE PARTINGS PARALLEL TO 40° GNEISSIC LAYERS.	
940	80	NX-4	2.6'						GNEISS: SAME AS NX-3.	
	85	NX-5	3.8'						GNEISS: SAME AS NX-3.	
930	90	NX-6	1.5'						GNEISS: GRAY, MEDIUM GRAINED, ALBITE BIOTITE WITH ACCESSORY GARNET, MODERATELY HARD, FRESH TO SEVERELY WEATHERED ALONG CLOSE TO MODERATELY CLOSE PARTINGS PARALLEL TO GNEISSIC LAYERING, 70° IRON STAINED SEVERELY WEATHERED JOINT @ 92.3'.	
	95	NX-7	4.8'						GNEISS: SAME AS NX-6.	
									BOTTOM OF BORING @ 97.1'	
920	100									

PROJECT YANKEE ATOMIC ELECTRIC SITE ROWE BORING NO. S-6

DATE STARTED 10/10/78 COMPLETED 10/13/78 GROUND ELEV. 1021.5' TOTAL DEPTH 48.0'

LOCATION N 4911.7 E 5319.1 INCLINATION VERTICAL BEARING N/A LOGGED BY J. BRIDGE DATE 11/78

CASING I.D. 6" AND 3" CORE SIZE NX CONTRACTOR GUILD DRILLING CHECKED BY JC[signature]

REMARKS NO SAMPLES TAKEN FROM 0.0' TO 29.0'. INSTALLED 3" PVC SEISMIC CASING AND GROUTED IN PLACE.

ELEV. FEET	DEPTH FEET	SAMPLE NUMBER TYPE	SAMPLE BLOWS OR REC.	REC % —— RQD % - - - (25 50 75 100)	CORE CONDITION BREAKS	CORE CONDITION JOINT DESCRIPTION	SPECIAL FEATURES OR ENG. TESTS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS WITH UNITS/STRATA CHANGES	FORMATION UNIT
1020 – 993.5	0.0 – 28.0						TYPICAL DRILLING FLUID LEVEL 3.6' 10/13/78		0.0'-28.0' NESTED BOULDERS AND BROWN SAND AND GRAVEL. TOP OF ROCK @ 28.0'	
990	29.0 – 33.8	NX-1	3.6'						GNEISS: GRAY, MEDIUM-GRAY, MEDIUM-GRAINED, ALBITE BIOTITE, MODERATELY HARD, FRESH TO SLIGHTLY WEATHERED, CLOSE TO MODERATELY CLOSE PARTINGS PARALLEL TO 45° GNEISSIC LAYERING. JOINT, IRON STAINED, 50° @ 34.0'.	
	35	NX-2	4.6'						GNEISS: SAME AS NX-1 EXCEPT 70° JOINT @ 37.4'.	
980	40	NX-3	4.8'						GNEISS: SAME AS NX-1 EXCEPT SEVERELY WEATHERED JOINT @ 40.5'.	
	45	NX-4	4.5'						GNEISS: SAME AS NX-1 EXCEPT 55° JOINT @ 46.0'. BOTTOM OF BORING @ 48.0'	
970	50