SEABROOK STATION

ENVIRONMENTAL REPORT

VOLUME II

PUBLIC SERVICE COMPANY OF
NEW HAMPSHIRE

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SEABROOK STATION

Environmental Report
Construction Permit Stage

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE

SEABROOK, NEW HAMPSHIRE

FOR INFORMATION ONLY

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5. ENVIRONMENTAL EFFECTS OF PLANT OPERATION

5.1

5.1 Effects of Operation of Heat Dissipation System

5.1.1 Physical Influence upon Receiving Body of Water

During normal operation the heat dissipation system discharges about 8 x 10^9 BTU/hour per unit from a deep water discharge located offshore of Hampton Beach, New Hampshire. This heat is rejected to the Gulf of Maine by a once-through ocean water cooling system with a flow of 412,000 GPM per unit at a 37.8°F temperature rise.

As shown in Figure 5.1-1 the proposed location of the discharge zone is about 5,000 feet east of Hampton Beach. The discharge is near bottom in a depth of about 40 feet mean low water. The characteristics of the mixing zone and the effect that the heated effluent will have with respect to space and time upon the receiving body of water are being studied. Hydro-thermal model studies have been performed for a single port per unit discharge concept the results of which are presented in Appendix J, "Buoyant Jet Discharge Report" by Alden Research Laboratories, 1969. More model studies are being performed to evaluate multi-port designs.

Multi-port hydro-thermal model studies are now in progress at Alden Research Laboratories and scheduled to continue through 1973. When the results of these become available, the proposed discharge concept (single vs. multi-port) will be chosen. The basis for selection of a discharge concept is that its environmental impact be acceptable and that it meets all engineering requirements.

In addition to the hydro-thermal model studies, a hydrographic survey program has been undertaken. The purpose of this survey is to identify the hydrographic characteristics of the ocean waters in the vicinity of the offshore inlet and discharge zones. This program began in December 1968 and is scheduled to continue into 1974. Hydrographic data are being obtained on the water circulation pattern, temperature distribution, dissolved oxygen concentration, water level fluctuations, conductivity, salinity and density stratification in the near-offshore waters of the Hampton-Seabrook region. These data are collected through the use of dye release studies, drogue tracking, current meters, temperature monitoring instruments, tide gages and conductivity monitors.

Results of the 1968 and 1969 hydrographic survey are presented in Appendix K, "Thermal Discharge Application Report" by Ebasco Services Inc., October 1969. Those studies included: continuous releases of Rhodamine-B dye at various offshore locations in the vicinity of the proposed offshore inlet and discharge, a dye concentration monitoring program in the ocean extending in all directions from the release points, measurement of ocean current directions and velocities at each of the dye release points, measurement of wind speed and direction during the duration of the dye releases and the recording of temperature and salinities for each release point.

The scope of the present hydrographic program includes surveys using current meters, drogues, water level recorders, temperature monitors and wind measuring instruments. This program is being performed by Normandeau Associates Inc. of Manchester, N. H. and will continue into 1974. As data become available from these surveys they are used in the hydro-thermal model studies and in the design of the discharge and offshore inlet structures.

The single-port per unit discharge concept which was tested in a limited-scope hydro-thermal model study is designed for near-bottom horizontal discharge from an open-ended pipe of about 9.5 feet inside diameter submerged at a water depth of about 35 feet. The results of the model tests are presented in detail in Appendix J.

For the single-port per unit discharge there are two separate thermal plumes spaced sufficiently apart to avoid near-field interference with one another. In each plume the maximum surface temperature rise is 13°F above ambient which occurs inside a zone of approximately 300 ft^2 about 150 feet from the point of discharge. In an effort to reduce the maximum surface temperature rise of 13°F produced by the single-port discharge, hydro-thermal model studies of multi-port discharge concepts are being conducted at Alden Research Laboratories. When studies are complete these schemes will be evaluated from the viewpoint of their probable effect on the marine ecology. Upon this basis a scheme with an acceptable environmental impact will be selected.

In order to proceed with hydro-thermal model testing of multi-port discharge concepts it is necessary to establish discharge design criteria. The criteria which have been selected are as follows:

1. At the boundary of a zone, the thermal discharge from the Seabrook Station shall not raise the monthly mean of daily maximum water temperatures more than 4°F above ambient.

2. The thermal discharge shall not create a thermal block for marine life at the entrance to Hampton Harbor.

3. Bottom scour effects resulting from the discharge shall be avoided.

See subsection 5.1.3 for a more detailed description of the heat-affected zone.

As indicated in subsection 5.1.3, these criteria are considered adequate to protect marine life in the receiving waters and will result in a negligible environmental impact. Consequently, these criteria are set forth as design criteria and are proposed for the thermal effluent standard of the Seabrook Station.

The thermal discharge from the Seabrook Station does not affect the water quality in any other states. The nearest waters of another state are those of Massachusetts about 2 miles to the south. Due to the low velocities of ocean currents in this region any waters heated by the thermal discharge are sufficiently diluted and cooled upon reaching the interstate boundary that no influence will be detected.

5.1.2 Thermal Standards

The discharge from the Seabrook Station will be designed to comply with thermal standards promulgated by the Environmental Protection Agency or by appropriate State agencies pursuant to Public Law 92-500, "Federal Water Pollution Control Act - Amendment 1972". During the interim until such standards are specified, the discharge will be designed to comply with those prescribed by appropriate regulatory agencies.

The New Hampshire Water Supply and Pollution Control Commission has classified the waters of the New Hampshire Coastal Basin as Class B tidal waters (Figure 5.1-2). Chapter 149 of the Commission's Statutes states that the thermal effluent standard for a particular discharge into Class B waters is determined upon the recommendation of the New Hampshire Department of Fish and Game, New England Interstate Water Pollution Control Commission or the National Technical Advisory Committee Report on Water Quality Criteria dated April 1, 1968, "whichever provides the most effective control".

5.1.3 General Ecological Effects of Operation of the Heat Dissipation System

Temperature is considered an important factor influencing the distribution of marine organisms. Since most marine species are poikilotherms, their body temperatures vary according to the temperature and temperature changes of the water. The biochemical and physiological processes of poikilotherms are sensitive to temperature, and consequently vary according to temperature changes of the environment. Each species of aquatic poikilotherm has evolved certain homeostatic mechanisms which make it capable of functioning throughout the range of temperatures to which it is normally subjected. Within this temperature range growth rates, and certain aspects of reproduction and behavior are influenced by thermal fluctuations (Reference 17). Therefore, to assess the environmental impact of a thermal discharge it is necessary to determine if the temperature of the environment is altered beyond the limits to which the ecosystem is adaptable.

5.1.3.1 Zoogeographical Background

While high and low lethal temperature of organisms set the ultimate limits on their existence, the distribution and abundance of their populations is determined by the interaction of temperature with other environmental conditions (Reference 17). The combined effect of these factors has been recognized by zoologists in delineating biogeographical regions.

The Hampton-Seabrook estuary is located in the American boreal province, which extends from Cape Cod to Labrador. Since this location is not close to the extreme southern limit of the boreal province, its marine inhabitants have a broader capability for physiological adaption than those residing close to the limits of the region where ambient temperatures for the province are most extreme. Using data from Gosner (Reference 7) to compile a list of the geographic ranges of the 64 invertebrate species from the Hampton-Seabrook area that have been identified, it appears that 70 percent are actually eurythermal (i.e. capable of withstanding a broad range of temperatures) extending from Labrador to Long Island--half of them (50 percent) to Cape Hatteras. Only 20 percent of the species are truly boreal (see Tables 5.1-1 and 2). Another 10 percent of the species are members of the Virginia sub-region of the American temperature province, which extends from Cape Cod to Cape Hatteras. These species are at, or near, their northern limit and could be expected to increase their populations under elevated temperature conditions, whereas those boreal species near the southern limit of their distribution would be expected to decrease their numbers under elevated temperature conditions.

The predominance of eurythermal species in the Hampton-Seabrook area has important implications in considering the impact of thermal discharge from the Seabrook Station. It indicates that most species in this area can adapt to a wide range of temperature fluctuations.

5.1.3.2 Possible Effect of Temperature Alteration on the Hampton-Seabrook Area Biota

The discharge of thermal effluent by electric power generating plants has given new impetus to scientific studies on the tolerance of temperature extremes by aquatic organisms. Ideally these studies should be useful in predicting the effects of thermal discharges and in managing those discharges to produce the least ecological impact. However, study of even the latest reports indicates that their predictive utility is limited by the number of different methods employed as well as by great variation in the quality and completeness of field observations (Reference 5). It is necessary to read each original paper to learn the limits of the methodology used, and in many cases this limits the meaning that can be placed on comparison in table form. Though the applicant has tried to gather all the information available in the literature pertaining to thermal tolerance of the important species of the Hampton-Seabrook estuary (see subsection 2.7-2 and Tables 5.1-1 and 5.1-2) it is apparent that: 1) temperature tolerance information is limited even for some of the more common species; and 2) the methods used are subject to the limitations described above, and thus have limited predictive value. Some general conclusions can be made, however.

Under the present design for thermal effluent discharge, maximum temperature occurs only in the immediate vicinity of the discharge point, located about 5,000 feet off the Hampton shore north of the harbor inlet. The thermal effluent is to be discharged from a submerged multi-port diffuser or submerged buoyant jet outfall both of which accomplish rapid dilution of the heated discharge water. This process occurs in the "near-field" region of the diffuser where the momentum of the jets entrains cooler ambient waters resulting in a rapid temperature reduction of the effluent.

At the periphery of a defined zone surrounding the points of discharge the thermal effluent will not raise the monthly mean of the daily maximum water temperature more than 4°F above ambient. Inside this zone the temperature of the receiving waters will for the most part not exceed 6°F above ambient. The only exception to this where higher temperatures are encountered is in the rising buoyant jets issuing from the discharge ports. The momentum of these jets creates rapid mixing of the thermal effluent with receiving waters resulting in rapid dilution and temperature reduction of the discharge.

To avoid any direct thermal influence on the benthic community, the discharge nozzles are directed at a small angle above horizontal. This feature causes the plumes to rise without imposing a thermal effect on the seabed and also prevents bottom scouring.

It is demonstrated elsewhere that heated surface water will attract fish during the colder months, as they have been observed congregating around the thermal plumes of other power stations (Reference 6). Pearce, Silverman, and LeGoff (Reference 15) found that winter flounders would leave water of 18.5°C (65°F) to feed in water of 31°C (88°F) with no adverse effects, and other species show similar behavior.

The Seabrook Station discharge zone is not expected to have as much potential for attracting fish nor subjecting marine life to temperature shock as is the case for conventional surface discharge from power stations. This is due to the rapid dilution of the effluent from the Seabrook Stations' offshore submerged discharge. By virtue of the rapid temperature reduction accomplished by the entrainment of receiving waters into the rising buoyant jets, the temperature rise is minimized throughout the "near-field" region of the discharge. This is not the case for a conventional surface discharge in which relatively little entrainment of receiving waters with the effluent is possible.

During certain infrequent occurrences some heated water may reach the Hampton-Seabrook Harbor Inlet Channel, however, it is at a very slight increase above ambient temperature. Present estimates indicate that any of the thermal effluent reaching the Harbor entrance is heated to less than 1 1/2 - 2°F above ambient. This heated water can enter the estuary only during an incoming tide and is almost totally removed on the succeeding ebb tide due to the high flushing rate of the Hampton estuary. It is estimated that about 88 percent of the estuary volume leaves and returns on each ebb and flood tide (subsection 2.5.1.1.2). Consequent mixing of the effluent with the larger quantity of Harbor inflow results in a further temperature reduction of the heat affected water actually entering the Harbor. Based on this analysis the maximum thermal influence upon the estuary is predicted to be less than 1 1/2°F occurring only during the infrequent circumstance of prevailing onshore currents and flood tide. Hydro-thermal model studies at Alden Research Laboratories, Holden, Massachusetts are now in progress to verify this prediction. Appendix K discusses the dye release studies which have been conducted to determine that the thermal effluent reaches the harbor only during certain infrequent occurrences.

5.1.3.3 Effects on Passage Through Cooling Water System

Entrainment, the passage of small organisms (zooplankton, phytoplankton, fish larvae, etc.) through the cooling water system of the power plant is taken into consideration in evaluating the effects of the plant on the marine environment. As ocean water moves through the cooling system, the entrained organisms are subjected to mechanical, thermal and pressure influences.

The potential for mechanically caused damage to entrained organisms is caused by the operation of the circulating water pumps, the water velocity in the tunnels (7.2 fps) with resultant abrasive damage and the entrainment time of about 65 minutes for passage through the system. Most all surveys of entrainment effects show varying degrees of physical stress caused by abrasion (see Table 5.1-3).

The potential damage to planktonic communities from circulating water system mechanical stresses has been minimized by the decision to design a system with as little water consumption as possible. The rationale here is that with the prospect of an unquantifiable but estimated high percentage of the entrained plankters affected, it is ecologically most desirable to pass as little water through the plant as possible even though it results in a higher condenser temperature rise. Another advantage of this scheme is that with minimized water consumption the potential for fish entrapment is reduced.

Studies at other locations have shown a wide range of effects to plankton, depending on each plant's characteristics (see Table 5.1-3). The effect on the entrained species varies according to the magnitude of the increase in temperature, duration of entrainment, rate of pressure change and size of organisms. Although some mortality may be expected, the exact amount and its importance at any particular power station is almost impossible to predict without actual field studies at the intake and discharge areas. Mortality or damage to zooplankton and phytoplankton and reduction of photosynthesis by phytoplankters appears to depend on the degree of mechanical abrasion, rate of pressure change, temperature rise, length of entrainment, water quality, and ambient water temperature.

Entrained organisms experience abrupt changes in pressure in the intake tunnel and abrupt pressure changes concurrent with increased water temperature in the discharge.

Phytoplankton appear to be tolerant of the pressures encountered during entrainment. Observed damage to phytoplankton in circulating water systems has been attributed to excessive temperature and chlorine toxicity (Reference 21).

Vidaver (Reference 22) determined that the production of oxygen by several species of marine algae decreased with increased pressures over a range of exposure from 1,000 to 15,000 psi. Increases in temperature concurrent with the increases in pressure caused a further decrease in oxygen production by some species; while other species did not show such relationships.

The effect of entrainment on phytoplankton appears to vary according to the ambient temperature and thereby changes from season to season. Morgan and Stross (Reference 13) (1969) working with phytoplankton entrained at the Chalk Point Plant in the Patuxent River (Chesapeake Bay) found that photosynthesis increased when ambient temperature is 16°C (61°F) or below and decreased when it is 23°C (73°F) or above. In a subsequent study of the Chalk Point Plant, Flemer, Hamilton, Keef and Mehurshy (Reference 20) could find no net change in photosynthetic production of the river just downstream of the discharge canal. While the temperature increase predicted at Seabrook is considerably higher than that which occurs at the Chalk Point Plant, the ambient temperature of the New Hampshire Coastal waters is considerably lower over most of the year, so that some increase in photosynthesis during the colder months is possible. However, during most of the year nearly total mortality of phytoplankton due to passage through the cooling system is predicted due to temperature influences.

Effects of entrainment on zooplankton may be both mechanical and thermal. Many invertebrates respond to small changes in pressure of less than one atmosphere by changing their vertical distribution. Other responses to changes in hydrostatic pressure include increased heart beat rates, and increased ciliary activity. Pressure tolerances may increase or decrease with respect to an increase in temperature (Reference 21).

Ebbecke (References 23 and 24) found sea anemone (larvae) to be the most tolerant to pressure, followed in order of decreasing tolerance by starfish, sea urchins, jellyfish, ctenophores, Branchiostoma, gastropods, polychaetes, shrimps and teleost fish.

Since the delta T is 37.8°F and the period of elevated temperature about 35 minutes almost total mortality of entrained zooplankton and fish larvae over most of the year is predicted.

The significance of total mortality of entrained plankton must be related to the amount of plankton present in the cooling water source. It is hypothesized that the amount of plankton entrained represents only a small portion of plankton present in the area (see Section 2.5). Some of the planktonic stages of the benthic invertebrates (e.g. lobsters) have a strong surface orientation during their early life stages (Reference 3) and are thereby also protected from entrainment into the inlet which draws water from just below mid-depth (Section 3.4).

The larvae of most of the bi-valves and crustaceans in the area, including Mya arenaria, Mytilus edulis, Macoma balthica, Artica islandica, Ensis directus, Balanus balanoides, Crangon septemspinosus, Cancer spp., etc., could all be subjected to entrainment during their short planktonic stages. It is estimated, however, that mortality due to entrainment of some of the large numbers of larvae produced by these species is very minor compared to mortality from other natural causes, e.g., predation, bacterial and fungal attack (Section 2.7) as well as loss from the area due to tidal flushing and ocean currents (Section 2.5). It must also be noted that most marine species display prodigious reproductive potentials thereby compensating for massive pre-adult mortalities. In fact, adult population densities may be independent of pre-adult mortalities within a certain stage. The limiting factor regulating populations which have a meroplanktonic stage are usually not those imposed upon the larvae. MacGinitie and MacGinitie (Reference 12) believe that available space is the single most important factor limiting the size of littoral populations.

Plankton entrained and subsequently killed is still available as a food source in the area. Although there is expected to be a change in the community composition utilizing the dead plankton as a food source, there will be no net loss of energy to the immediate area. On the contrary, because of accumulation of dead plankters there is expected to be an increase in energy available.

5.1.3.4 Effects of Entrapment

Operations of the circulating water system requires the passage of about 412,000 gpm/unit. This quantity of water is drawn from the area approximately 3,000 feet offshore from the Hampton Beach State Park in water about 30 feet deep. The design of the offshore inlet structure is such that the inlet port is about 8 feet above the bottom (see Section 3.4 for a more detailed description of intake configuration). Inlet current is composed essentially of a horizontal flow with a velocity of no greater than 1.5 feet per second (fps) at the opening. This velocity reduces abruptly with distance from the opening to less than 0.5 fps at about a 5-foot distance and less than 0.25 fps at a 10-foot distance.

The potential for entrapment of finfish at power plants with intake structures is well recognized. Indeed this has caused much concern due largely to the publicity given the more dramatic occurrences of this phenomenon.

Actual damage to entrapped fish usually occurs after they enter the intake structure, whereupon they encounter rapid hydrostatic pressure changes, mechanical abrasion and impingement on the fine mesh traveling screens. Death may then result from a combination of abrasion, exhaustion and suffocation, caused by rapid changes in hydrostatic pressure, abrasion with the tunnel surface, screen movement, or trauma associated with screen water washing jets.

Rapid changes in hydrostatic pressure in the intake portion of the circulating water system for the Seabrook Station arise from the respective vertical descent and ascent of ocean water in the inlet and pumphouse riser shafts. Assuming entrapped organisms are drawn from mid-depth (15 feet) and are taken down to a mean depth of about 200 feet, an approximated differential hydrostatic pressure increase of 6 atmospheres would be encountered within about 30 seconds. This pressure is maintained for 30 minutes, whereupon the organisms are subjected to a pressure decrease of 6 atmospheres due to the ascent through the riser shaft at the site into the pumphouse forebay. Whether the marine organisms could tolerate the hydrostatic pressure changes just described would depend on the sensitivity of respective marine organism to the magnitude of the pressure stress and to the period of exposure.

Responses attributed to hydrostatic pressure changes differ according to several anatomical features found in various species of fish:

1. Presence or absence of a swimbladder
2. Whether the fish is a physoclist or a physostome

For some species of fish the swimbladder is totally absent. Species such as the Atlantic mackerel Scomber scombus and winter flounder Pseudopleuronectes americanus fall within this group. Since the Atlantic mackerel has no swimbladder it must constantly remain in motion, otherwise it would sink. Members of the mackerel family compensate for the pull of gravity by applying a slight but constant upward thrust while swimming.

The winter flounder, Pseudopleuronectes americanus on the other hand, remains exclusively on the bottom, thus it is advantageous that no swimbladder be present to increase its buoyancy.

Many species of fish must be able to maintain a steady position somewhere between the bottom and the surface for hours. To accomplish this, some fish have evolved a swimbladder in the abdominal cavity just below the backbone and above the stomach. The swimbladder is basically a hollow air-tight sac, that is used to control flotation. By secreting into or releasing oxygen out of the swimbladder, the fish can achieve neutral buoyancy (Reference 25).

Although a swimbladder is advantageous in some respects, it can be a marked disadvantage in others. Vertical movements of teleost fish are restricted by the presence of a swimbladder which increases or decreases in volume when the fish moves up or down in the water. If the fish moves above the level at which it is hydrostatically equalized with its environment, the decrease in hydrostatic pressure (1 atm for about every 10 m of water) leads to an expansion of the swimbladder. As a result the fish becomes more buoyant than the water and tends to rise to the surface. Conversely, if it swims into deeper water, the swimbladder decreases in volume, with the result that the fish displaces less water and tends to sink. A large vertical movement above or below this plane of equilibrium might result in the fish being carried up to the surface or down to the bottom. Too great a pressure reduction might lead to the rupture of the swimbladder wall (Reference 26).

As is noted, fish respond differently to their aquatic environment, depending upon the presence or absence of a swimbladder. Responses of fish with swimbladders may also be different depending on whether the fish are physoclists or physostomes.

Physoclists (those species without an airduct in the swimbladder) having a closed air bladder system, inflate or deflate the swimbladder by means of secretion or absorption of oxygen respectively (References 25 and 27). Bishai (References 28 and 29) generally found that physoclists were more sensitive to pressure changes below 73.5 psi than physostomes. The physoclists displayed their sensitivity by taking longer to adapt to pressure changes.

Jones (Reference 26) found that a physoclist encounters two restrictions with the presence of a swimbladder as it relates to vertical movements involving a reduction of pressure: first, a restriction on the extent of a rapid movement, and secondly, a restriction on the speed with which the fish can migrate from one level to another. So the fish may be considered as having a definite bathymetrical range within which it can pass rapidly from one level to another. But if it were to move outside its range, the speed with which it would be transported would depend on the rate at which it could adjust the volume of its swimbladder when subjected to changes in hydrostatic pressure.

Physostomatous fishes (those fish who's swimbladder communicates via an air duct with the alimentary canal), on the other hand, would be able to move freely above its plane of equalibrium, since it could vent the excess gas by means of the pneumatic duct (Reference 25). Its descents would be restricted the same way as a physoclist however (Reference 26).

The hydrostatic pressure differentials incurred by the intake circulating water system of the Seabrook Station would have its greatest effect upon those species of fish which have swimbladders, since any resultant variation in the ambient hydrostatic pressure would have an effect on this one organ. Responses of fish to the Seabrook water circulating system may also be different depending on whether the fish are physoclists or physostomes.

The offshore inlet of the Seabrook Station draws water below mid-depth, in 30 feet of water. If fish should become entrapped they will be drawn down the inlet riser shaft in approximately 30 seconds. Traveling to a mean depth of about 200 feet, the fish encounters a resultant increase of 6 atmospheres pressure. At this depth the swimbladder of the teleost fish compresses according to the subsequent rapid increase in hydrostatic pressure. In order to compensate for its resultant loss of buoyancy, the fish (whether physoclist or physostome) must secrete enough oxygen into the swimbladder to keep itself buoyant at that depth. If the fish does not, or cannot, secrete any oxygen against this increased pressure, and if it does not compensate by means of appropriate fin response, the fish will sink (References 25 and 26).

From the bottom of the inlet riser shaft the fish is conveyed through the intake circulating water tunnel for approximately 2 1/2 miles. Mechanical abrasion with the surface of the tunnel walls is inevitable if the fish does not equalize its buoyancy to the new depth.

Leaving the tunnel, the fish travels upward in the on-site riser shaft to the pumphouse forebay. The fish will move upward, barring any resistance to the ascent, in about 40 to 50 seconds, undergoing a decrease in pressure of 6 atmospheres.

The passage of the fish from the inlet riser shaft to the plant takes about 30 minutes. During this time interval the entrapped fish may or may not compensate to the change in pressure and its increased density commensurate with the 200 foot mean depth. If the particular fish species does not compensate, and is drawn up to the forebay, the resultant increase in swimbladder volume would be equal to that when it was first drawn into the circulating water system (Reference 27).

However, if the fish should equalize its buoyancy to compensate for the increased hydrostatic pressure while in transit through the intake tunnel, the subsequent decrease in depth encountered while ascending the riser shaft at the site would cause expansion of the swimbladder. This effect could be compensated for somewhat by phycostomatous fish; however, for physoclists compensation would probably require a greater amount of time (Reference 27). Should the rate of gas expansion exceed the physical limitations of the swimbladder, a rapid reduction in ambient pressure might lead to rupture of the swimbladder wall (Reference 26).

Regardless of the degree of physical damage due to the rapid pressure decrease, there would probably be a temporary disruption of the fishes ability to orient against the current. It is quite possible, therefore, that they would be swept against the traveling screens and impinged before any means of fish recovery could be employed.

Evidence of entrapment survival does exist, however, and certain means for reducing mortalities have proven effective. These means include more frequent screen washings, basket screens which assure removal of impinged fish and the so-called fish pump which lifts the entrapped fish from the forebay before they are impinged on the screen.

Obviously, means of mitigating fish damage should not be directed solely to the traveling screen area, rather they should also attempt to prevent entrance of fish to that point. Much effort has been directed within the electric industry toward the design of intake structures that discourage the congregation of fish at the point of intake and their subsequent entrapment. Intake structure placement should bear cognizance of resident and migrant fish populations, their spatial distribution and susceptability to entrapment. Once the fish of an area are known, design features may then be incorporated into the intake structure which minimizes entrapment potential. Certain design considerations such as elevation of the intake port and configuration of the structure are somewhat flexible thereby allowing latitude in planning to accomodate special circumstances.

Intake approach velocity is recognized as an extremely critical factor and there is general agreement that for a specific facility an increase in velocity results in greater numbers of entrapped fish. However, it must be stressed that such specific natural location characteristics as shoreline configuration and natural currents tend to confound attempts to predict expected fish entrapment rates based only on known intake approach velocities. Variable entrapment results between power plants with equal intake approach velocities emphasizes this point. Most power plants under design will operate at approach velocities no greater than 1 fps although regulatory standards do not presently govern this.

The configuration of the intake structure may influence the fish attraction potential. It is generally agreed that structures should be designed to minimize potential sanctuary areas in which small fish might tend to congregate. Semi-enclosed shadowy areas such as those afforded by channels, overhanging structures and cul-de-sacs are to be avoided as much as possible. With this in mind the Seabrook Station's offshore inlet structure is simple and unembellished (subsection 3.4.2.2).

Although various methods for repelling fish from intake areas have been tested (e.g. electric shock, sound, air bubbles) their success has been limited and inconsistent. Often the method proven effective at one location fails to minimize entrapment elsewhere.

The so-called intake velocity cap is of demonstrated value for reducing fish entrapment in west coast offshore power plants. Its basic effectiveness is based on the creation of intake flows which are essentially horizontal. As discussed in subsection 3.4.2.2, the features of the Velocity Cap are being further investigated before the final design of the Seabrook Station Offshore Inlets is determined.

With respect to the Seabrook Station intake entrapment potential, the following facts are evident:

1. Intensive fish sampling within the proposed intake area assures the Applicant that there are no major concentrations of resident fish which would be subject to entrapment. The fish species present are (in order of relative abundance as shown in gill netting studies) spiny dogfish (Squalus acanthias), cunner (Tautogolabrus adspersus), and longhorned sculpin (Myoxocephalus octodecemspinosus). Present in lesser numbers are: winter flounder (Pseudopleuronectes americanus), squirrel hake (Urophysis chuss), pollock (Pollachius virens), blueback herring (Pomolobus aestivalis), mackerel (Scomber scombrus), little skate (Raja erinacea), and cod (Gadus morrhua).

2. Single representatives of the following fish species have been collected in the area:

shorthorned sculpin	(Myoxocephalus scorpius)
tomcod	(Microgadus tomcod)
menhaden	(Brevoortia tyrannus)
sea raven	(Hemitripterus americanus)
smelt	(Osmerus mordax)
goosefish	(Lophius americanus)
silver hake	(Merluccius bilinearis)
sand flounder	(Lophopsetta maculata)

Although these fish are found here they are by no means restricted only to this area but rather they are commonly found throughout the Gulf of Maine (Reference 19).

3. The position of the inlet opening, just below mid-depth in the water column, precludes the entrapment of demersal fishes (i.e. flounder, sculpin, skate, hake and cod) as well as those that are surface oriented (i.e. juvenile herring, mackerel and juvenile hake).

4. The reduced inlet approach velocity (no greater than 1.5 fps) of a strongly horizontal nature due to the velocity cap may be overcome by healthy average sized pelagic fish which are known to frequent the proposed area at or near the intake depth (e.g. spiny dogfish, pollock, and adult herring). It should be pointed out that there is a rapid reduction in current velocity with distance from the actual inlet orifice. For example, assuming the design velocity at the orifice to be 1.4 fps a fish five feet away would be subjected to about 0.5 fps, and at ten feet only 0.25 fps. This shows that the area of inlet current influence is quite small.

The cunner poses a potential entrapment problem due to its habit of browsing subsurface objects such as rock ledges which support sessile invertebrate communities. Such behavior near the inlet structure could result in some entering the ports and being drawn further along to the traveling screens where they could be impinged. Of possible relevance to the Seabrook Station are the monitoring studies conducted on cunner entrapment at the Applicant's Schiller Station Unit No. 4 (located about fifteen miles to the north on the Piscataqua River).

Although gross differences between the two locations (i.e., Seabrook and Piscataqua River) exist, the findings at the Schiller Station provide some information which may be applicable to the Seabrook inlet. The main differing features which are most striking and significant are as follows:

1. The Schiller Station intake is on a swiftly flowing tidal river unlike the offshore inlet location of the proposed Seabrook Station.

2. The inlet port at Schiller Station Unit No. 4 is essentially on the bottom of a sloping river channel in about eighteen (18) feet of

water and about thirty-three (33) feet from the shore. This is considerably different from the Seabrook Station offshore inlet which is described in Section 3.4.

3. The calculated approach velocity for Schiller Station Unit No. 4 is 2.13 fps; considerably faster than that at the Seabrook Station offshore inlet.

4. Piscataqua River has an estuarine component to its fish community (e.g. Fundulus sp., sticklebacks, alewife) and generally lacks certain fish species found offshore (e.g., spiny dogfish, squirrel hake, little skate, goosefish).

With the above considerations in mind the Schiller Station entrapment data still offers certain information relevant to the proposed Seabrook Station inlet. The species most frequently caught at Schiller Station Unit No. 4 are demersal species (e.g. grubby and winter flounder) which seems logical because the inlet port is near-bottom. Another significant point is the relatively low number of pelagic fish which have been caught. Although mackerel, pollock, striped bass, silverside alewife and smelt are known to pass this station few have been entrapped. Indeed, the silverside which is the most abundant fish in the area has never been taken on this screen. Cunner which have been discussed previously are the third most entrapped fish presumably because of their preference for areas colonized by sessile invertebrate forms. Despite the high current velocity through the traveling screen (i.e. about 2.5 fps) and a four hour interval between screen washes, about 38 percent of the fish caught survive the experience. The total numbers of fish taken on the Schiller Station Unit No. 4 traveling screen are low (calculated at 0.33 fish/operating hour) and of those taken many (38 percent) survive. These figures are generally accepted by regulatory agency fishery biologists as insignificant to the maintenance of local fish populations.

To avoid attraction of cunner to the Seabrook Station Inlet area, the Offshore Inlet structures are provided with marine fouling protection to eliminate settlement of sessile forms. This greatly minimizes the entrapment potential.

In summary the resident fish most likely to be entrapped at the Seabrook Station Offshore Inlet are the pelagic schooling fish that occasionally pass through the area such as pollock and smelt. The low inlet approach velocity, horizontal inflow, absence of fouling forms on the inlet structures and simple nonattractive features assures minimal pelagic fish entrapment.

The potential entrapment of larger invertebrates has also received consideration. Valuable benthic crustaceans such as lobster and crab do not approach the inlet openings because of its elevated position. It is possible that pelagic invertebrates such as shrimp and squid could enter the inlet but present knowledge denies their presence in this area.

If after operation of the circulating water system, it becomes apparent that organisms in numbers greater than those considered unimportant for the maintenance of regional populations are being taken on the traveling screens, remedial measures are possible. Such remedial steps as louver diversion, fish pumps and basket screens have been considered and the intake structure forebay design is such that these future installations are possible. Such a decision must, of course, await fish entrapment monitoring results on the operating facility.

5.1.3.5 Effects of Shutdown

The possibility of plant shutdown poses a potential problem to life within the area of thermal influence. With plant shutdown the discharge water will decrease in temperature possibly resulting in a reverse thermal stress (cold shock) to aquatic biota. Maximum cold shock ranges from the operating temperature (delta T of about 37.8°F) to ambient temperatures in a matter of hours. This thermal change is experienced only at the discharge point with commensurate reductions at increasing distance.

Presence of marine life for any prolonged period of time within the rising thermal plume is unlikely due to its relatively strong current velocity of 12-15 fps at the discharge port. A fish swimming into the rising plume would be transported upward into the surface flow-away zone where temperatures are greatly reduced. Because of the dynamic nature of the plume it is inconceivable that large numbers of pelagic organisms, planktonic or nektonic will remain within the influence of the rising plume for more than one minute before reaching the surface flow-away zone in which the temperature rise is greatly reduced due to mixing with receiving waters.

The animals most likely to be influenced by a slight temperature change throughout the flow-away zone are fish and in particular those species of fish which typically migrate southward during late fall or early winter. It is possible that limited numbers of such fish as stripped bass and mackerel might delay this movement to warmer latitudes because of the warm discharge area. Should fish which normally winter in more southerly waters remain into the colder periods within the area of thermal influence then the sudden removal of this heat source would subject them to cold shock for the most part no greater than 4 - 5°F and generally even less.

Several design features serve to minimize sudden cold shock occurrence. The most important of these is the submerged jet discharge scheme which produces a thermal plume of high temperature only where there is a relatively swift current with a strong vertical component. Once the current velocity of the discharge is at a rate within which fish are capable of maintaining themselves for long periods of time the plume has mixed with sufficient receiving water to be at a maximum of 5°F above ambient and generally even less. This is the maximum temperature rise to which nektonic species could become acclimated and consequently it is the maximum cold shock to which they could be subjected. In addition since the discharge is designed to avoid thermal influence on the seabed, there is no potential for cold shock to the benthic community.

Also the presence of two reactors will provide a continuing heat source should one unit be shutdown. During shutdown procedures there is the ability to reduce the number of running circulating water pumps thereby extending the time of heat decay in the discharge area.

The frequency of scheduled shutdowns is once per year per unit after the first three years of operation. Prior to this time no shutdowns are planned. Unscheduled shutdowns are unquantifiable.

The intake and discharge of water in the area will not cause a significant change in circulation patterns over the entire area although very limited local perturbations in current are unavoidable. The construction and testing of a hydro-thermal model is now in progress and will provide more information on this subject. Entrainment of the ocean water does not change the dissolved oxygen concentration since the water taken in is at or near the saturated condition (see Section 2.5). Heating of the water will result in a higher saturation of oxygen in the effluent, but this concentration reaches equilibrium with the receiving waters when the discharge is cooled to ambient by dilution. The discharged water also has a slightly greater amount of nutrients resulting from the heat effected algae cells. This and other effects of intake and discharge of the local water will be monitored as described in subsections 6.1.1.1 and 6.1.1.2.

The inlet structure will be located about 3,000 feet offshore. In this location it is approximately 20 feet below the water surface. Studies have indicated that a location below 12 feet in depth is to be preferred; below that level problems with settlement of fouling organisms is less severe. This location of the inlet structure well above the bottom also prevents scouring of the bottom in the area of the intake. Prevention of bottom scouring in the discharge area is accomplished by directing the discharge nozzles slightly above horizontal.

5.1.3.6 Recirculation Potential

A submerged multi-port discharge concept is being investigated in the present model study; a submerged single port discharge scheme was investigated in a previous hydrothermal model study (Appendix J). These submerged jet discharge concepts induce rapid dilution of the heated effluent with the receiving water. In the near-field region of the discharge the effluent is diluted by at least a factor of 10 at less than 1000 feet from the point of discharge. This factor is constantly increasing with greater distance from the discharge zone into the far-field region. The rapid initial dilution and mixing of the effluent tends to reduce the potential for direct recirculation or re-entrainment of the discharge and minimizes the extent of the high ΔT zone of the near-field region.

There is no possibility for direct re-entrainment of undiluted effluent from the discharge into the inlet. Due to the initial rapid dilution of the discharge, any effluent reaching the inlet over 3,000 feet away is highly diluted. Also, the heated effluent rises to the surface during initial mixing with receiving waters to form a stratified surface layer. The location of the inlet structure over 3,000 feet from the discharge and the submergence of the inlet being below mid depth in about 30 feet of water absolutely precludes any potential for direct re-entrainment at the inlet of undiluted effluent. If it exists at all, the only possibility for re-entrainment is of highly diluted and well dispersed effluents; however, this could occur only during conditions of onshore currents.

The natural offshore drift of the receiving waters and the inherent momentum of the diluted effluent plume at the surface tends to carry the discharge plume away from the discharge and inlet structures. This prevents any localized concentration in the ocean along the coast or in Hampton Harbor.

The potential recirculation from the far-field discharge zone back into the near-field mixing region is being evaluated as discussed in subsection 3.4.3.

5.1.4 Assessment of Operational Impacts of the Circulating Water System on the Environment

The circulating water scheme of the Seabrook Station consists of an offshore inlet structure, intake riser shaft, intake conveyance tunnel, pumphouse riser shaft, pumphouse, condenser, a discharge riser shaft, discharge conveyance tunnel, discharge riser shaft and a discharge structure.

The operational environmental impact of this circulating water system is considered negligible in the following subject areas: (a) aesthetics, (b) noise, (c) relationships of wildlife adaptation to reconstructed vegetation types, and (d) increased human activity associated with operation of the circulating water system.

The only aspect of the Seabrook Station circulating water system that could have a possible influence on the aesthetics of the Hampton-Seabrook area would be the pumphouse located at the plant site; all other structures relating to the circulating water system would be located either underground or underwater, thereby negating their respective visual impacts. In order to harmoniously blend the above ground portion of the pumphouse with its surrounding terrestrial environment, it will be situated in such a manner that its visual effects will be muted by the surrounding trees indigenous to the area.

Operational impact to the environment arising from the noise incurred by the six circulating water pumps will be minimized by adequate noise abatement incorporated into the pumphouse at the time of construction. Thus, operational noise will be indistinguishable from that of the background noise level at the periphery of the exclusion radius. To insure that the operational noise level is maintained below an acceptable level, monitoring will be conducted at the plant site prior to and during operation.

Since underground bedrock tunnels have been selected as the means of circulating water conveyance, there will be no operational impact relating to wildlife adaptation to reconstructed vegetation types. During operation, the only impact upon the aquatic environment will be from the effects of offshore entrainment and discharge from the circulating water system, previously discussed in this section.

Increased human activity relating to the Seabrook Station circulating water system will arise from normal and yearly maintenance of the circulating water pumps, traveling screens, and other hydraulic equipment. Maintenance could include removal and disposal of debris caught on the traveling screens, and any marine fouling organisms collected within the circulating water system.

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TABLE 5.1-1. OPTIMAL AND LETHAL TEMPERATURE TOLERANCES FOR SPECIES OF THE OFFSHORE AREA.

SPECIES COMMON SCIENTIFIC	NORMAL HABITAT TEMPERATURE RANGE[1]	SPECIES COMMON SCIENTIFIC	NORMAL HABITAT TEMPERATURE RANGE[1]
Mahogany quohaug, *Arctica islandica*	B.V.	Razor clam, *Ensis directus*	B.V.
Tellin shell, *Tellina agilis*	B.V.	Clam worm, *Nereis virens*	B. 37°C
Bamboo worm, *Clymenella torquata*	B.V.	Atlantic chinkshell, *Lacuna vincta*	B. 40°C
Burrowing anemone, *Edwardsia sipunculoides*	B.	American lobster, *Homarus americanus*	B.V.
Horse mussel, *Modiolus modiolus*	B.V. 23°C upper limit in nature	Ribbed pod shell, *Siliqua costata*	B.V.
Common rock crab, *Cancer irroratus*	B.V.	Northern crab, *Cancer borealis*	B.V.
Sand dollar, *Echinarachnius parma*	B.V.	*Typhosella* sp.	No Information Avail.
Pollock, *Pollachius virens*	B.V.	Cunner, *Tautogolabrus adspersus*	B. (New Jersey)

[1] B = American boreal (Cape Cod to Coast of Labrador; Gosner, 1971).
V = Virginian (northern sub-region of American Atlantic temperature region -- Cape Cod to Cape Hatteras).

TABLE 5.1-2. OPTIMAL AND LETHAL TEMPERATURE TOLERANCES FOR SPECIES OF THE ESTUARINE AREA.

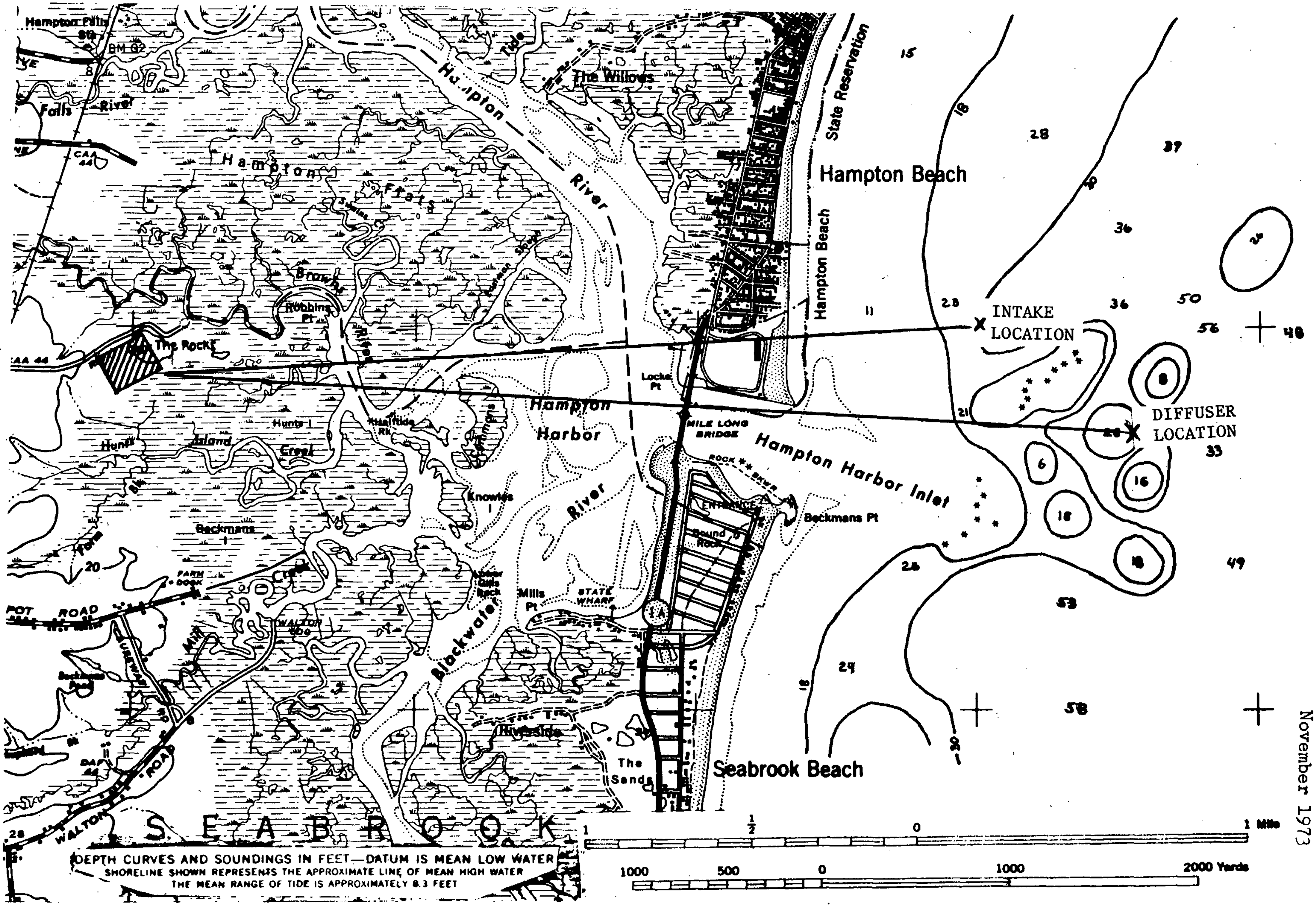
SPECIES COMMON SCIENTIFIC	NORMAL HABITAT TEMPERATURE RANGE[1]	SPECIES COMMON SCIENTIFIC	NORMAL HABITAT TEMPERATURE RANGE[1]
Bamboo worm, *Clymenella torquata*	B.V.	Clam worm, *Nereis virens*	B. 37°C
Shimmey worms, *Nephthys bucera* and *Nephthys cacca*	B	A polychaete, *Scoloplos fragilis*	B.V.
Common periwinkle, *Littorina littorea*	B. 39°C	Northern moon snail, *Lunatia heros*	B.V.
Gem clam, *Gemma gemma*	B.V.	Balthic macoma, *Macoma balthica*	B.V.
Soft-shelled clam, *Mya arenaria*	B.V.	Blue mussel, *Mytilus edulis*	Naturally restricted upper limit of 27°C
Acorn barnacle, *Balanus balanoides*	B.V.	Green crab, *Carcinas maenas*	40-45°C (Bay of Fundy to Long Island)
Sand shrimp, *Crangon septemspinosus*	B.V.	Sand eel, *Ammodytes americanus*	B.V.
Smooth flounder, *Liopsetta putnami*	Arctic to Boreal	Winter flounder, *Pseudopleuronectes americanus*	B.V. (and Georgia)
Atlantic silversides, *Menidia menidia*	B.V.	Striped bass, *Morone saxatilis*	B. to Florida
Rainbow smelt, *Osmerus mordax*	Boreal to N.J.	Alewife, *Alosa pseudoharengus*	B.V.
Mummichog, *Fundulus heteroclitus*	Boreal to Texas	Nine-spined stickleback, *Pungitius pungitius*	Arctic to N.J.

[1]B = American boreal (Cape Cod to Coast of Labrador; Gosner, 1971).
V = Virginian (northern sub-region of American Atlantic temperature region -- Cape Cod to Cape Hatteras).

TABLE 5.1-3. THE EFFECT OF ENTRAINMENT ON MARINE ORGANISMS: DATA FROM EAST COAST POWER PLANTS

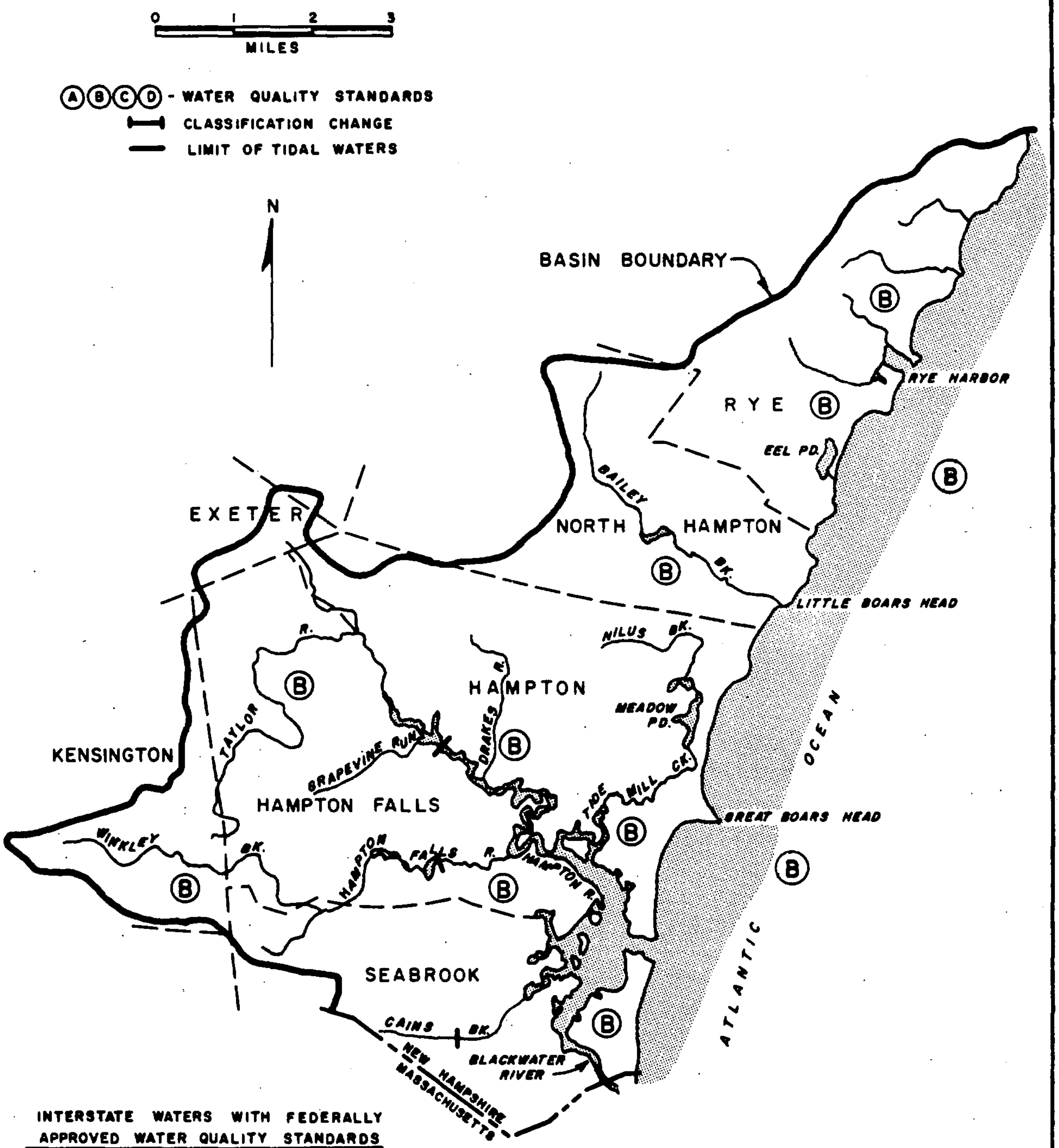
Note: This table is for general reference only and should not be used for specific comparisons between plant conditions.

NAME	LOCATION	COOLING WATER SOURCE	FLOW - CFS	ENTRAINMENT TIME	ΔT	BIOLOGICAL EFFECTS
Maine Yankee Nuclear Power Plant 855 MWe	Montsweag Bay, Wiscasset, Maine	Complex Estuarine Bay	950 cfs	62 sec. at elevated temp.	13.9°C	Simulation to temperature effects in lab caused 100% mortality of Chaetoceros lacinosus, no effects on Asterionella japonica, C. lorenzianus, C. socialis, Skeletonema costatum, Thalassiosira nordenskioldii, etc., (3rd Env. Rept., Vol. 1)
Seabrook Nuclear Power Station 2200 MWe (2 units)	Hampton - Seabrook Estuary, New Hampshire	Coastal Ocean	834 (per unit)	30 min. at elevated temp.	25°C	No data yet, but mortality of entrainment organisms expected to be relatively high.
Pilgrim Nuclear Station 655 MWe	Plymouth Harbor, Massachusetts Bay	Coastal Ocean	690 cfs	2 to 9 min. at elevated temp. (tidal dependent)	16°C	No adverse effects expected; effects to be minimized by by taking water from subsurface levels (Pilgrim Plant Report, 1971).
Brayton Point Fossil Plant 1125 MWe (3 units)	Taunton River, Mount Hope Bay off Narragansett Bay	Estuarine	1381 cfs	5.4 min. at elevated temp.	8.2°C avg.	No appreciable mortality of phytoplankton or zooplankton due to passage through the condensers at 7-10°C. Lab studies showed diatoms more sensitive to temperature increase than flagellates (New England Power Company, 1972).
Canal Stream Electric (Fossil) Plant 560 MWe	Cape Cod Canal	Ocean Canal	372 (peak)		19°C	Temperatures would exceed limits of eggs and larval forms of cod and mackerel during their spawning seasons, but damage considered negligible due to small percent of total number of eggs that would be affected (Fairbanks, Collins, Sides, 1971).
Connecticut Yankee Nuclear Power Plant 600 MWe	Haddam Neck, Connecticut on Connecticut River	Fresh water river	828 (peak)	50 - 100 min.	12.5°C	Of nine species of fish, none survived entrainment and passage into lower end of cooling canal where water temperatures were above 30°C for over 95% of the time that fish larvae and juveniles were present. (Marcy, 1971)
Millstone Point Nuclear Plant Unit No. 1 650 MWe	Waterford, Conn.	Coastal Long Island Sound	233 cfs	8 min. at elevated temp.	12°C	Relatively few phytoplankton killed by mechanical effects of entrainment, heat shock can kill phytoplankton in warmer months. Chlorination is responsible for greater mortality than heat in autumn and winter. Loss of phytoplankton not significant; loss of copepods and fish larvae could be important (Carpenter, 1971)
Northport Electric Plant (Fossil) (4 units)	Northport, N.Y. (Long Island)	Coastal Long Island Sound	1432 cfs		12.4°C	Production of entrained phytoplankton greatly reduced in summer, reduction in mobility of zooplankton and abnormalities in growth of Fundulus and some invertebrates were reported. (Coutant and Goodyear, 1972).
Indian Point Nuclear Power Plant (Units 1 & 2) 1158 MWe (total)	Peekskill, N.Y. on Hudson River	Lower Hudson Brackish Estuarine water	668 (Unit #1) 1812 (Unit #2)	40 min. at elevated temp.	8.3°C	Little adverse effect on plankton until temperature exceeds 90°F in summer (Lauer, 1972). Effect of entrainment on Striped Bass eggs and larvae will be minor, power-plant effect dwarfed by other natural and artificial perturbations of the system.
B.L. England Power Plant	Great Egg Harbor Bay, Atlantic City, N.J.	Estuarine			3 - 8°C	Mechanical death of large organisms, e.g. jellyfish. During August heat combined with chlorination detrimental to phyto- and zooplankton. Decrease in productivity during temperature peak with or without chlorination (Blake, 1970).
Chalk Point Power Plant	Patuxent River, Chesapeake Bay	Estuarine			3°C	Estuarine copepods were billed in passage through the plant, but this was considered to be due to chlorine rather than temperature which was below their lethal limits (Heinle, 1960). Phytoplankton photosynthesis increased when ambient 16°C or below, decreased when 20°C or above (Morgan and Stross, 1969).
Calvert Cliffs Nuclear Power Plant	Lusby, Md. on Chesapeake Bay	Estuarine		3.5 min. at elevated temp.	5.5°C	No mortality of plankton organisms at this Δt and for this time period (U.S.A.E.C. Rept., 1972)



November 1973

PSNH SEABROOK STATION	ROUTE OF CIRCULATING WATER TUNNELS	FIGURE 5.1-1



INTERSTATE WATERS WITH FEDERALLY APPROVED WATER QUALITY STANDARDS

All Tidal Waters

WATER QUALITY STANDARDS
ADOPTED BY
NEW HAMPSHIRE WATER SUPPLY AND POLLUTION CONTROL COMMISSION

PSNH SEABROOK STATION	COASTAL WATERS BASINS CLASSIFICATION	FIGURE 5.1-2

5.2

5.2 Radiological Impact on Biota Other Than Man

This Section considers the impact on biota other than man of the release of radioactive effluents from the Station. Included is a discussion of exposure pathways in subsection 5.2.1, distribution of radionuclides in the environment in subsection 5.2.2, and dose rate estimates to local flora and fauna in subsection 5.2.3.

5.2.1 Exposure Pathways

The various possible pathways for radiation exposure of local flora and fauna are illustrated in Figures 5.3-1 for gaseous effluents and Figure 5.3-2 for liquid effluents. These figures, although designed to illustrate pathways to man, also show most pathways by which flora and fauna can receive radiation exposure. In addition to the radiation exposure pathways discussed in subsection 5.3.1, and illustrated in the above figures, species of flora and fauna receive exposure as follows. Gaseous releases result in radiation exposure through submersion of terrestrial and intertidal area flora and fauna in the plume and direct radiation from the plume when it is not at ground level. In addition, activity which is deposited from the air to the soil, results in radiation exposure through direct radiation exposure.

Free swimming marine biological media receive radiation exposure from submersion in diluted cooling water and internal deposition of radionuclides. Bottom dwelling organisms receive direct radiation exposure by submersion in cooling water and internal deposition as well as direct radiation from radionuclides in sediment.

The capacity for a given species of plant or animal to concentrate specific radionuclides varies widely. The actual level to which an isotope is concentrated varies with season, geographical location, and a number of poorly understood factors. However it is clear that animals and plants cycle radionuclides through the environment by metabolism during life and by decomposition after death. After introduction of radionuclides into the marine environment, the activity is cycled between the water, sediment, and biota.

Radionuclides in water can initially be taken up by biota or deposited in sediments. Although sediments may initially remove large quantities of radionuclides from water exposing benthic species to a direct radiation exposure pathway, this sediment bound activity may later be leached from the sediment by the water or taken in by filter feeding organisms on sediment particulates and absorbed by the organism upon digestion.

The food chain in estuaries is based on both benthic plants and phytoplankton and it is thus necessary to consider both the benthic as well as the pelagic habitats. The primary producers of the benthic community are sediment based algae and rooted phanerogams. The marine fauna are made up of epifauna which live on the sediment surface and infauna living within the sediment. Also located in sediments are fungi and bacteria which are important in decay of organic matter to elemental forms.

In order for flora or fauna to be of importance in the cycling of radionuclides, the species must accumulate the radionuclide, be consumed by another organism, and be digestible. Even if an organism which accumulates activity is not eaten, its activity upon death enters the "biological cycle" through decay by sediment bound organisms. Biota can acquire activity through ingestion, adsorption, or absorption. Activity may be lost by decomposition and excretion. Sediment buildup occurs through the processes of absorption and exchange. Despite sediments being the major reservoir for radionuclides in an estuary, exchange of this activity between the water and sediments is greatly influenced by benthic organisms. Bacteria and microscopic algae coating the sediment in estuary regions hastens sedimentation of activity. Benthic infauna such as burrowing worms extend the sediment-water interface into the sediment. Burrowing thus increases the interface region and promotes the exchange of radionuclides with deeper sediments. Another major factor influencing sedimentation is the physico-chemical forms of the nuclide in the marine environment. For a number of isotopes there is little knowledge of the form or the change in form in varying environments over time. The factors which govern sedimentation of radionuclides will be discussed in greater detail in subsection 5.2.2.

The role of phytoplankton in the movement of radionuclides through the environment varies both in time and location. Phytoplankton are a food for filter-feeding animals while alive and in suspension. After death, they settle to the bottom and are consumed by detritus feeders or decay. Phytoplankton play a critical role in removal of radionuclides from seawater due to their large surface area per unit weight. This factor promotes adsorption while metabolic processes promote absorption of a number of nuclides.

The ability of phytoplankton to pass radionuclides up the food chain varies with cell size, the total number of cells in suspension, and the radionuclide concentration in the particular species of phytoplankton. Cell size and the number of cells per unit volume greatly affect the filtering efficiency of filter-feeding animals. As these two parameters vary widely so does the rate of radionuclide movement to species further up the food chain. Another factor influencing a filter feeding animal's accumulation of radionuclides from phytoplankton is that not all species of phytoplankton are digested by filter feeders with the same effluency. Thus, the activity cannot be assimilated by the filter feeder and passed up the food chain.

The food pathways in the marine environment are quite complex and food habits vary at different periods in an animals life cycle. As mentioned earlier, phytoplankton indirectly or directly form the basis for all animal life. In general larger marine animals and fish are unable to feed on phytoplankton, being dependent on filter feeding animals which can remove phytoplankton. These smaller animals include mollusks and certain fish such as menhaden which can feed on phytoplankton. These animals are in turn eaten by larger animals. It is thus quite difficult to predict the movement of each radionuclide through a particular environment with any degree of certainty.

Accordingly, the operational radiological environmental monitoring program described in subsection 6.2.1.2 includes an extensive marine monitoring program which includes collection of the following: fish, mollusks, crustaceans, plankton, algae, bottom sediments, and beach sands. Analysis will be by high resolution gamma Ge(Li) spectroscopy and Strontium-89 and 90 analysis if Cesium-137 is found in a gamma spectrum related to Station operation. In this manner ingrowth of plant related activity in any media will be quickly detected at levels far below those which would result in a significant exposure to any individual.

Because of the offshore discharges the annual average water concentration of activity inside Hampton Harbor will be greatly reduced over discharge concentrations resulting in minimal exposure from any pathway to any terrestrial species of flora or fauna. Potential pathways of exposure to terrestrial flora in the estuary intertidal zone from liquid releases are discussed in subsection 5.3.1. It is possible that terrestrial fauna such as muskrats would consume marine vegetation growing in the intertidal region inside the estuary. This would result in internal dose to these animals. In addition terrestrial flora and fauna would receive direct radiation exposure from sediment deposition of activity, and submersion in greatly diluted cooling water.

5.2.2 Radioactivity in Environment

Radionuclide Concentration in Surface Waters

Radioactive liquids are discharged from the Station into the Atlantic Ocean approximately 5000 feet east of Hampton Beach. Hydrothermal model studies made on a single port discharge design indicate a dilution of discharge concentrations of radionuclides (listed in Table 3.5-5) by a factor of 3.5. A multi-port discharge structure now proposed would result in the near-field entrainment of greater quantities of receiving water than the single port design. Accordingly the initial dilution achieved by this multi-port design would exceed that achievable with single port discharge. Hydrothermal model studies now in progress will determine the expected dilution factors with the multi-port design.

For the purposes of dose calculation to various classes of marine biological media in subsection 5.2.3 it is assumed that the fish, crustaceans, mollusks, and marine plants live in 100 percent effluent water with no credit for radioactive decay.

For the purposes of calculating dose from liquid effluents to terrestrial fauna (a muskrat consuming acquatic vegetation) inside Hampton Harbor, an annual average dilution factor of 500 has been assumed.

This factor of 500 annual average dilution is derived from dye dilution studies performed by Ebasco, Inc. in 1969 (Reference 5). It was found that recirculation of dye to Hampton Harbor from the dye release point located 4900 feet offshore of Hampton Beach State Park occurred on 3 of 15 flood tides monitored. The maximum dye concentrations recorded in the harbor varied from 0.1 to 0.5 ppb at flood slack which according to the formula:

$$1 \text{ ppb} \cong 2.6°F$$

could be considered equivalent to approximately a 0.25°F to 1.3°F temperature rise, reflecting any heat loss to the atmosphere. A 0.25°F temperature rise is equivalent to a dilution ratio of 160-1, while a 1.3°F temperature rise corresponds to a dilution of approximately 31-1. This yields an average dilution factor for these flood tides during which recirculation occurred of approximately 100-1. No residual concentration of dye was found in the harbor on any ebb slack period which indicates any diluted discharge water entering the harbor on a flood tide was completely flushed form the harbor on the following ebb tide. Thus, since recirculation occurred on only 3 of 15 flood tides or 1/5 of the time, the average dilution factor over the 15 tides monitored would be 100/5 = 500 - 1.

Terrestrial Vegetation

The estimated gaseous releases during operation are found in Section 3.5. Of the isotopes listed in Table 3.5-7, the only nuclides subject to deposition on vegetation are the various isotopes of iodine. A calculation of the areal concentration for each isotope follows.

The maximum offsite mean annual Chi/Q for the Station is 3.0×10^{-5} sec/m^3. The annual average iodine air concentrations at this point (.57 miles to ESE) is shown below.

Annual Average Iodine Air Concentration at Site Boundary

Isotope	Chi-Annual Average (pCi/m^3)
I-131	3.3-3 (*)
I-132	9.3-5
I-133	1.4-3
I-134	3.9-5
I-135	4.2-4

(*) 3.3-3 = 3.3×10^{-3}

A deposition velocity governing the transfer of iodine from air to vegetation of 1 cm/sec was chosen from amont the various measurements reported in the literature. After deposition from the air to vegetation it was assumed that the iodines are removed only by radiological decay.

Since radionuclides are washed off vegetation after deposition with a biological half-life averaging fourteen days, the assumption of removal by decay only makes for a conservative estimate of iodine deposition on vegetation. The decay constants, λ, are shown below for each isotope of iodine.

Isotope	Decay Constant, λ (in sec^{-1})
I-131	9.96E-7
I-132	8.26E-5
I-133	9.19E-6
I-134	2.23E-4
I-135	2.84E-5

The resultant concentration per square meter, ω, associated with the annual average iodine air concentrations at the site boundary is calculated from

$$\omega = \frac{(Chi)\ (Vd)}{\lambda}$$

where Chi = annual average iodine concentration in pCi/m^3

Vd = Deposition velocity (.01 m/sec)

λ = Decay constant (sec^{-1})

The calculated areal concentration for each isotope is as follows:

Isotope	Areal Concentration (pCi/m^2)
I-131	3.3+1
I-132	1.1-2
I-133	1.5+0
I-134	1.8-3
I-135	1.5-1

If we assume that there is 1.8 Kg of vegetation per square meter and that all activity goes onto vegetation the above areal deposition converts to the following vegetation concentration.

Isotope	Activity (pCi/kg)
I-131	1.8+1
I-132	6.1-3
I-133	8.3-1
I-134	1.0-3
I-135	8.3-2

The above vegetation activities will be used in subsection 5.2.3 in calculating dose to terrestrial biota.

Sediment Buildup

It is known that a portion of the radionuclides released in cooling water will build up in sediments about the discharge point. The rate of sedimentation is determined by a number of factors including among others the physical state of the isotope in seawater (particulate, colloidal, ionic), the radiological half-life, the nature of the sediments (particle size, ion exchange capacity), and the quantity of sediment in suspension available for radionuclide scavenging. Also of importance is the mode of release, the temperature difference between discharge and receiving water, and the discharge flow rate. Thermal stratification of the warmer discharge water will tend to keep the discharge water on the surface until its excess heat is lost to the atmosphere. Thermal stratification thus increases the potential area over which sedimentation may occur while lowering the radionuclide sediment concentration and dose from direct radiation. In an estuary region once radionuclides are deposited, they are subject to resuspension and movement by tidal currents. Sediments are also washed out from estuaries during periods of strong wave action to be deposited on the continental shelf.

A conservative calculation is presented below to assess the importance of direct radiation from sediment bound radionuclides. Assumptions used in this calculation include the following:

1. The physical state of fission products in seawater has been determined (Reference 1). This study by Greendale and Ballou determined the fraction of fission products in ionic, colloidal, and particulate form. Deposition fractions assumed for each isotope released from the Station going into sediments were calculated by increasing the sum of the colloidal and particulate fractions determined in the above study by 50 percent (up to a maximum of 100 percent). This increase takes account of non-physical deposition processes which may occur. Deposition fractions used in this calculation are shown in Table 5.2-1. For isotopes not reported in this study, 100 percent deposition was assumed.

2. Radionuclides are assumed to deposit uniformly in the top 20 centimeters of sediment. This is based upon studies showing that 50 percent of Cesium-137 depositing in an estuarine mud-flat is in the top 7 - 10 centimeters (Reference 2). A few samples taken in sand showed no concentration change with depth down to 15 centimeters, and only a 10 percent reduction between 15 and 25 centimeters.

3. Based on the annual quantities of radionuclides released from both Seabrook units shown in Table 3.5-5, the buildup of radionuclides was calculated. Using the deposition fraction shown in Table 5.2-1 the total activity deposited by isotope was calculated at yearly intervals from 1 to 40 years after station startup. This buildup was calculated using the following equation for each isotope.

$$A_i = \frac{DRi}{\lambda_i} \left(1 - e^{-\lambda_i t}\right) DF_i$$

where: A_i = Activity buildup to time t of isotope i, in Curies
DR_i = Release rate of isotope i in Ci/yr
λ_i = Decay constant for isotope i in year^{-1}
t = Time in years since station startup
DF_i = Deposition fraction for isotope i from Table 5.2-1

4. Deposition of Station released activity is assumed to take place over a circular area 1 mile in radius. The activity buildup calculated using the equation above assumed no resuspension of sediment bound activity with time or washout of activity to sea. Based on the above assumptions, the calculated sediment concentration to a depth of 20 centimeters by isotope at various times after Station startup is shown in Table 5.2-2 and the total curies of each isotope deposited is shown in Table 5.2-3. Totals from these two Tables are shown below.

Number of Years After Startup	Total Curies Deposited	Average Sediment Concentration ($\mu Ci/cm^3$)
1	6.2-2	3.8-8
5	2.4-1	1.5-7
10	4.4-1	2.7-7
20	7.6-1	4.7-7
30	1.0+0	6.2-7
40	1.2+0	7.5-7

By inspection of Table 5.2-3, it is seen that the bulk of deposited activity is due to Cesium-134 and Cesium-137. The proportion of deposited activity comprised of these two isotopes increases from 84.6 percent after 1 year's operation to 98.9 percent after 40 years' operation.

5.2.3 Dose Rate Estimates

Marine organisms will receive external radiation exposure from submersion in the cooling water and internal exposure from uptake of radionuclides from this water. Radiation exposure was calculated for free swimming fish, crustacea, mollusks, and marine plants assuming these species live and developed in 100 percent cooling water with no credit for radioactive decay.

Any external exposure does not vary with the size of the animal or plant. Immersion doses were calculated under the assumption that the organism was completely submerged and surrounded on all sides by an infinite volume of cooling water at the annual average nuclide concentration shown in Table 3.5-5. This is extremely conservative since many organisms spend a large portion of their time either at the surface or in sediment. The dose to an organism which spends all its time either on the surface or on the bottom would be approximately one-half the value shown in Table 5.2-4.

The following equation was used to calculate the immersion dose factors, (D.F) for each isotope.

$$(D.F)_i \text{ water immersion} = 1.865 \times 10^7 \left(\overline{E}_{\gamma i} + \overline{E}_{\beta i}/2\right)$$

where: $(D.F)_i$ = Dose factor (mrem/yr per μCi/ml of isotope i)

$\overline{E}_{\beta i}$ = Average beta energy per disintegration of isotope i (meV)

$\overline{E}_{\gamma i}$ = Average gamma energy per disintegration of isotope i (meV)

Dose factors were derived using the above equation for (Gamma plus Beta) and Gamma exposure. The dose factors used in the calculation are tabulated in Table 5.2-5.

Internal Dose - Marine Organisms

Uptake of radionuclides by finfish, crustacea, mollusks, and marine plants living in 100 percent cooling water was calculated using bioaccumulation factors from the literature. The bioaccumulation factor for an isotope in a given organism is defined as:

$$BF_i = \frac{Co}{Cw}$$

where: BF_i = bioaccumulation factor for isotope i in this organism
Co = concentration of isotope i in the organism
Cw = concentration of isotope i in the ambient water

The bioaccumulation factors used for fish, crustacea, and mollusks were those supplied by Freke (Reference 3). Bioaccumulation factors for marine plants used in this calculation were those tabulated by Chapman (Reference 4). It is assumed that the bioaccumulation factors for each organism represent equilibrium values. A summary of the bioaccumulation factors used in the calculation of internal dose is found in Table 5.2-7.

The internal dose to an organism living in the cooling water from the Station was calculated using the following equation:

$$D_i = (1.87 \times 10^7)\, A_i\, BF_i\, E_i$$

where: D_i = Dose rate due to isotope i (mrad/year)
1.87×10^7 = a constant to convert μCi/gm of organism to mrad/year
A_i = the concentration of isotope i in water
BF_i = the bioaccumulation factor for isotope i
E_i = the effective absorbed energy (MeV)

The maximum effective absorbed energy, E_i, used above were those for man. Thus, the calculated internal dose will be higher than is actually received by the organism. The calculated internal dose to fish, crustacea, mollusks, and marine plants is tabulated in Table 5.2-6.

Sediment - Dose to Marine Organisms

The deposition of radionuclides in marine sediment about the discharge point was discussed in Section 5.2.2. The concentration of each isotope in sediment at various times after station startup is shown in Table 5.2-2. Using these sediment concentrations it is possible to calculate the dose to a mollusk submerged in the sediment. The assumptions made are that the mollusk is surrounded on all sides by an infinite volume of sediment with the radionuclide concentration found in Table 5.2-2. This assumption leads to overestimates of dose due to sediment buildup of activity extending to a depth of only 20 centimeters. Thus, above and below a mollusk, there would be a maximum of 10 centimeters of sediment. Dose factors (mrad/year per μCi/ml) for submersion in radioactive sediment are listed in Table 5.2-5. The calculated Beta plus Gamma dose by isotope to a mollusk at 1, 5, 10, 20, 30 and 40 years after station startup is found in Table 5.2-8. It is seen that dose rate increases from 0.55 mrad/year after 1 year to 9.3 mrad/year after 40 years operation. For a benthic organism located at the water-sediment interface, the dose due to direct radiation from sediments would be approximately one-half those shown in Table 5.2-8.

Dose to Terrestrial Organisms

The dose to terrestrial animals around the Station will be quite close to those received by people in the same area. External dose due to direct radiation from the plume is independent of body size and identical for all species of flora and fauna. A discussion of the total body dose to man from gaseous effluents is found in Section 5.3.3. Other pathways of dose to biota are direct radiation from deposition of iodine on the ground surface. The areal concentration of iodine at the exclusion fence was calculated in Section 5.2.2. Dose factors (mrad/year per pCi/m^2) for exposure from activity deposited on the ground surface are found in Table 5.2-9. These dose factors were derived from the following equation:

$$(D.F)\ \text{ground} = (0.5) \sum_{i=1}^{n} (A_i)\ (R_i)\ (P_i)$$

where D.F. = the dose factor in units of mrem/year per pCi/m^2

A_i = Fractional abundance of photon (i) in the radionuclide under consideration

R_i = Exposure rate at 1 meter above an infinite smooth plant contaminated to one pCi/m^2 (in mrem/year)

P_i = Fraction of surface dose which penetrates to skin depth (7×10^{-3} cm)

0.5 = ground roughness factor

$$0.869 = \frac{\text{(rads in air)}}{\text{(R in air)}} \times \frac{\text{rem}}{\text{rad}}$$

The internal dose to a muskrat was calculated with the following assumptions:

1. The muskrat consumes 100 grams/day of vegetation growing in an intertidal area, at the plant exclusion boundary .57 miles to the ESE. The water in which the plant develops is assumed to have radionuclide concentrations 1/500 of the annual average liquid effluent discharge concentration. Concentration factors used for each isotope are those supplied by Chapman (Reference 4).

2. In addition to radionuclide uptake from water, the iodine deposition from air to vegetation calculated in 5.2.2 takes place and is added to the iodine uptake from seawater.

3. The internal dose to the muskrat is calculated using the following equation:

$$D_i = \frac{(1.87 \times 10^7)\ (X_i^{eq})\ E_i}{m}$$

where:

D_i = Dose rate due to isotope i (mrad/yesr)

1.87×10^7 = a constant to convert μCi/g of animal to mrad/year

X_i^{eq} = body burden of isotope i in μCi at equilibrium in the animal consuming 100 grams of vegetation per day

m = mass of the animal, assumed to be 1000g

E_i = the effective absorbed energy for isotope i in man

X_i^{eq}, the equilibrium body burden in μCi is calculated from the following equation

$$X_i^{eq} = 1.4\ T_i\ (W_i/500)\ (Ci)g\ F_i$$

where:

T_i = effective half-life of isotope i, - assumed to be equal to the radiological half-life (days)

$(\frac{Wi}{500})$ = concentration (μCi/ml) of isotope i in discharge water from Table 3.5-5 divided by a dilution factor of 500

C_i = bioaccumulation factor for isotope i in marine vegetation

g = mass in grams of vegetation consumed daily - assumed to be 100g

F_i = fraction of ingested quantity of radionuclide i absorbed by animal - assumed to be 1.0

For the five isotopes of iodine, to the product of $(W_i/500)Ci$ was added the calculated iodine deposition to vegetation calculated in 5.2.2

Based on the above assumptions, the calculated internal dose to a muskrat by isotope is shown in Table 5.2-11. The total dose is calculated to be 0.29 mrad/year.

References

1. Greendale, A. E., and Ballou, N. F., "Physical State of Fission Product Elements Following Their Vaporization in Distilled Water and Sea Water", U. S. Naval Radiological Defense Laboratory, San Francisco, Report USNRDL-43G (1954).

2. Preston, A., Jefferies, D. F., "Aquatic Aspects in Chronic and Acute Contamination Situations" in "Environmental Contamination by Radioactive Materials", International Atomic Energy Agency, Vienna, p. 191 (1969).

3. Freke, A. M., "A Model for the Approximate Calculation of Safe Rates of Discharge of Radioactive Wastes into Marine Environments", Health Physics, 13, 734 (1967).

4. Chapman, W. H., Fisher, H. L., and Pratt, M. W., "Concentration Factors of Chemical Elements in Edible Aquatic Organisms", University of California Radiation Laboratory Report UCRL-50504 (December 30, 1968).

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5. Ebasco Services Incorporated, "Thermal Discharge Application Report, Circulating Water System, Seabrook Nuclear Station Unit No. 1", (Oct. 1969).

TABLE 5.2-1

Deposition Fraction Used in Calculating Sediment Buildup of Radionuclides

Radionuclide	Deposition Fractions
I-131	.150
I-132	.150
I-133	.150
I-134	.150
I-135	.150
Sr-89	.195
Sr-90	.195
Sr-91	.195
Y-90	1.000
Y-91	1.000
Y-92	1.000
Zr-95	1.000
Nb-95	1.000
Mo-99	1.000
Cs-134	.450
Cs-136	.450
Cs-137	.450
Te-132	.825
Ba-140	1.000
La-140	1.000
Ce-144	1.000
Mn-54	1.000
Mn-56	1.000
Co-58	1.000
Co-60	1.000
Fe-59	1.000
Cr-51	1.000

TABLE 5.2-2

AVERAGE CONCENTRATION BY ISOTOPE (μCi/CC) IN SEDIMENT
AT VARIOUS TIMES AFTER STATION STARTUP

YEARS AFTER STARTUP

SOTOPE	1	5	10	20	30	40
I -131	2.69-09	2.69-09	2.69-09	2.69-09	2.69-09	2.69-09
I -132	1.11-11	1.11-11	1.11-11	1.11-11	1.11-11	1.11-11
I -133	4.45-10	4.45-10	4.45-10	4.45-10	4.45-10	4.45-10
I -134	2.79-12	2.79-12	2.79-12	2.79-12	2.79-12	2.79-12
I -135	7.91-11	7.91-11	7.91-11	7.91-11	7.91-11	7.91-11
SR -89	4.87-12	4.91-12	4.91-12	4.91-1	4.91-12	4.91-12
SR -90	9.71-13	4.62-12	8.71-12	1.55-11	2.08-11	2.50-11
SR -91	2.47-13	2.47-13	2.47-13	2.47-13	2.47-13	2.47-13
Y -90	6.45-11	6.45-11	6.45-11	6.45-11	6.45-11	6.45-11
Y -91	3.92-11	3.97-11	3.97-11	3.97-11	3.97-11	3.97-11
Y -92	1.49-14	1.49-14	1.49-14	1.49-14	1.49-14	1.49-14
ZR -95	4.97-12	4.89-12	4.89-12	4.89-12	4.89-12	4.89-12
NB -95	2.81-12	2.81-12	2.81-12	2.81-12	2.81-12	2.81-12
MO -99	1.01-09	1.01-09	1.01-09	1.01-09	1.01-09	1.01-09
CS-134	4.70-09	1.34-08	1.59-08	1.64-08	1.64-08	1.64-08
CS-136	1.48-10	1.48-10	1.48-10	1.48-10	1.48-10	1.48-10
CS-137	2.73-08	1.31-07	2.47-07	4.43-07	5.99-07	7.22-07
TE-132	7.81-11	7.81-11	7.81-11	7.81-11	7.81-11	7.81-11
BA-140	6.52-12	6.52-12	6.52-12	6.52-12	6.52-12	6.52-12
LA-140	2.56-13	2.56-13	2.56-13	2.56-13	2.56-13	2.56-13
CE-144	8.11-12	1.35-11	1.37-11	1.37-11	1.37-11	1.37-11
MN -54	7.47-11	1.29-10	1.31-10	1.31-10	1.31-10	1.31-10
MN -56	1.59-12	1.59-12	1.59-12	1.59-12	1.59-12	1.59-12
CO -58	9.96-10	1.03-09	1.03-09	1.03-09	1.03-09	1.03-09
CO -60	9.79-11	3.83-10	5.81-10	7.37-10	7.79-10	7.90-10
FE -59	2.28-11	2.29-11	2.29-11	2.29-11	2.29-11	2.29-11
CR -51	1.48-11	1.48-11	1.48-11	1.48-11	1.48-11	1.48-11
TOTALS	3.78-08	1.50-07	2.69-07	4.66-07	6.22-07	7.45-07

TABLE 5.2-3

MAXIMUM RADIOACTIVITY (CURIES) BY ISOTOPE DEPOSITED IN SEDIMENTS AT VARIOUS TIMES AFTER STATION STARTUP

	YEARS AFTER STARTUP					
SOTOPE	1	5	10	20	30	40
I -131	4.38-03	4.38-03	4.38-03	4.38-03	4.38-03	4.38-03
I -132	1.80-05	1.80-05	1.80-05	1.80-05	1.80-05	1.80-05
I -133	7.24-04	7.24-04	7.24-04	7.24-04	7.24-04	7.24-04
I -134	4.53-06	4.53-06	4.53-06	4.53-06	4.53-06	4.53-06
I -135	1.29-04	1.29-04	1.29-04	1.29-04	1.29-04	1.29-04
SR -89	7.93-06	7.99-06	7.99-06	7.99-06	7.99-06	7.99-06
SR -90	1.58-06	7.52-06	1.42-05	2.52-05	3.39-05	4.06-05
SR -91	4.02-07	4.02-07	4.02-07	4.02-07	4.02-07	4.02-07
Y -90	1.05-04	1.05-04	1.05-04	1.05-04	1.05-04	1.05-04
Y -91	6.38-05	6.46-05	6.46-05	6.46-05	6.46-05	6.46-05
Y -92	2.42-08	2.42-08	2.42-08	2.42-08	2.42-08	2.42-08
ZR -95	7.80-06	7.96-06	7.96-06	7.96-06	7.96-06	7.96-06
NB -95	4.57-06	4.57-06	4.57-06	4.57-06	4.57-06	4.57-06
MO -99	1.65-03	1.65-03	1.65-03	1.65-03	1.65-03	1.65-03
CS-134	7.64-03	2.18-02	2.58-02	2.67-02	2.68-02	2.68-02
CS-136	2.40-04	2.40-04	2.40-04	2.40-04	2.40-04	2.40-04
CS-137	4.45-02	2.12-01	4.02-01	7.21-01	9.74-01	1.17+00
TE-132	1.27-04	1.27-04	1.27-04	1.27-04	1.27-04	1.27-04
BA-140	1.06-05	1.06-05	1.06-05	1.06-05	1.06-05	1.06-05
LA-140	4.17-07	4.17-07	4.17-07	4.17-07	4.17-07	4.17-07
CE-144	1.32-05	2.20-05	2.23-05	2.23-05	2.23-05	2.23-05
MN -54	1.22-04	2.10-04	2.13-04	2.13-04	2.13-04	2.13-04
MN -56	2.59-06	2.59-06	2.59-06	2.59-06	2.59-06	2.59-06
CO -58	1.62-03	1.67-03	1.67-03	1.67-03	1.67-03	1.67-03
CO -60	1.59-04	6.23-04	9.46-04	1.20-03	1.27-03	1.29-03
FE -59	3.71-05	3.73-05	3.73-05	3.73-05	3.73-05	3.73-05
CR -51	2.41-05	2.41-05	2.41-05	2.41-05	2.41-05	2.41-05
TOTALS	6.16-02	2.44-01	4.38-01	7.58-01	1.01+00	1.21+00

TABLE 5.2-4

Immersion Dose Rate to Marine Biota
Undiluted Liquid Effluent
(mrad/year)

Isotope	Gamma	Beta and Gamma
I-131	3.7-3	5.1-3
I-132	8.2-3	1.0-2
I-133	7.9-3	1.2-2
I-134	3.4-3	4.2-3
I-135	1.5-2	1.8-2
Sr-89	0	6.1-7
Sr-90	0	7.2-10
Sr-91	6.9-6	1.2-5
Y-90	0	5.6-5
Y-91	7.0-9	1.1-6
Y-92	1.3-7	4.8-7
Zr-95	2.7-7	3.4-7
Nb-95	2.6-7	3.1-7
Mo-99	4.1-4	8.0-4
Cs-134	3.3-4	4.0-4
Cs-136	2.7-4	3.0-4
Cs-137	5.9-4	8.0-4
Te-132	2.8-5	3.4-5
Ba-140	5.6-7	9.4-7
La-140	1.5-6	2.0-6
Ce-144	3.4-9	7.0-9
Mn-54	1.6-6	1.906
Mn-56	1.3-4	1.6-4
Co-58	6.4-5	8.0-5
Co-60	4.4-6	5.2-6
Fe-59	2.7-6	3.2-6
Cr-51	6.9-8	8.4-8
TOTAL	4.0-2 mrad/year	5.2-2 mrad/year

TABLE 5.2-5

Dose Factors for Immersion in Water
and Sediment
(mrem/yr per $\mu Ci/cm^3$)

Isotope	Gamma Factor	Beta and Gamma Factor
I-131	6.00E+06	8.30E+06
I-132	3.90E+07	4.80E+07
I-133	8.40E+06	1.30E+07
I-134	2.40E+07	3.00E+07
I-135	2.90E+07	3.50E+07
Sr-89	0	4.70E+06
Sr-90	0	1.30E+05
Sr-91	7.80E+06	1.40E+07
Y-90	0	8.40E+06
Y-91	3.70E+04	5.60E+06
Y-92	4.50E+06	1.70E+07
Zr-95	1.30E+07	1.60E+07
Nb-95	1.20E+07	1.40E+07
Mo-99	4.10E+06	8.00E+06
Cs-134	2.50E+07	3.10E+07
Cs-136	4.10E+07	4.50E+07
Cs-137	8.80E+06	1.20E+07
Te-132	3.50E+06	4.20E+06
Ba-140	4.00E+06	6.70E+06
La-140	3.60E+07	4.60E+07
Ce-144	2.60E+05	5.40E+05
Mn-54	1.30E+07	1.60E+07
Mn-56	3.10E+07	4.00E+07
Co-58	1.60E+07	2.00E+07
Co-60	4.00E+07	4.70E+07
Fe-59	1.90E+07	2.30E+07
Cr-51	4.60E+05	5.60E+05

TABLE 5.2-6

Internal Dose Rate to Marine Biota (mrad/year)
100 Percent Cooling Water

Isotope	Finfish	Crustaceans	Mollusks	Plants
I-131	1.0-1*	5.1-1	5.1-1	2.0+1
I-132	1.3-1	6.7-1	6.7-1	2.7+1
I-133	3.0-1	1.5+0	1.5+0	5.9+1
I-134	1.7-1	8.4-1	8.4-1	3.3+1
I-135	2.3-1	1.2+0	1.2+0	4.7+1
Sr-89	1.4-6	1.4-6	1.4-6	1.8-5
Sr-90	2.2-8	2.2-8	2.2-8	2.8-7
Sr-91	2.2-5	2.2-5	2.2-5	2.8-4
Y-90	3.3-3	1.1-2	1.1-2	2.2-1
Y-91	6.3-5	2.1-4	2.1-4	2.0-2
Y-92	2.5-5	8.4-5	8.4-5	8.4-3
Zr-95	6.7-6	2.2-5	2.2-5	2.2-3
Nb-95	2.1-5	4.2-5	4.2-5	2.1-4
Mo-99	1.0-2	1.0-1	1.0-1	1.0-2
Cs-134	8.0-3	1.3-2	2.7-3	5.3-3
Cs-136	2.4-3	4.1-3	8.1-4	1.6-3
Cs-137	2.2-2	3.7-2	7.4-3	1.5-2
Te-132	2.9-3	2.9-3	2.9-2	2.9-1
Ba-140	1.8-5	1.8-5	1.8-5	3.0-3
La-140	1.5-4	1.5-3	1.5-3	1.5-2
Ce-144	9.5-6	3.2-5	3.2-5	3.2-3
Mn-54	3.4-3	1.1-2	5.8-2	1.1-2
Mn-56	4.4-1	1.5+0	7.2+0	1.5+0
Co-58	4.6-3	4.6-1	1.4-2	4.6-2
Co-60	3.1-4	3.1-2	9.3-4	3.1-3
Fe-59	2.1-3	8.5-3	4.2-2	1.1-1
Cr-51	7.0-6	7.0-5	7.0-5	1.4-4
TOTALS	1.4+0 mrad/yr	6.9+0 mrad/yr	1.2+1	1.9+2

*1.0-1 = 1.0×10^{-1}

TABLE 5.2-7

Bioaccumulation Factors for Radionuclides in Marine Biota

Isotope	Finfish	Crustaceans	Mollusks	Plants
I-131	2.0E+01	1.0E+02	1.0E+02	4.0E+03
I-132	2.0E+01	1.0E+02	1.0E+02	4.0E+03
I-133	2.0E+01	1.0E+02	1.0E+02	4.0E+03
I-134	2.0E+01	1.0E+02	1.0E+02	4.0E+03
I-135	2.0E+01	1.0E+02	1.0E+02	4.0E+03
Sr-89	1.0E+00	1.0E+00	1.0E+00	1.3E+01
Sr-90	1.0E+00	1.0E+00	1.0E+00	1.3E+01
Sr-91	1.0E+00	1.0E+00	1.0E+00	1.3E+01
Y-90	3.0E+01	1.0E+02	1.0E+02	1.0E+04
Y-91	3.0E+01	1.0E+02	1.0E+02	1.0E+04
Y-92	3.0E+01	1.0E+02	1.0E+02	1.0E+04
Zr-95	3.0E+01	1.0E+02	1.0E+02	1.0E+04
Nb-95	1.0E+02	2.0E+02	2.0E+02	1.0E+03
Mo-99	1.0E+01	1.0E+02	1.0E+02	1.0E+01
Cs-134	3.0E+01	5.0E+01	1.0E+01	2.0E+01
Cs-136	3.0E+01	5.0E+01	1.0E+01	2.0E+01
Cs-137	3.0E+01	5.0E+01	1.0E+01	2.0E+01
Te-132	1.0E+01	1.0E+01	1.0E+02	1.0E+03
Ba-140	3.0E+00	3.0E+00	3.0E+00	5.0E+02
La-140	1.0E+02	1.0E+03	1.0E+03	1.0E+04
Ce-144	3.0E+01	1.0E+02	1.0E+02	1.0E+04
Mn-54	3.0E+03	1.0E+04	5.0E+04	1.0E+04
Mn-56	3.0E+03	1.0E+04	5.0E+04	1.0E+04
Co-58	1.0E+02	1.0E+04	3.0E+02	1.0E+03
Co-60	1.0E+02	1.0E+04	3.0E+02	1.0E+03
Fe-59	1.0E+03	4.0E+03	2.0E+04	5.0E+04
Cr-51	1.0E+02	1.0E+03	1.0E+03	2.0E+03

TABLE 5.2-8

DIRECT GAMMA PLUS BETA RADIATION DOSE BY ISOTOPE TO ORGANISM IN SEDIMENT (MRAD/YEAR)

YEARS AFTER STARTUP

SOTOPE	1	5	10	20	30	40
I -131	2.23-02	2.23-02	2.23-02	2.23-02	2.23-02	2.23-02
I -132	5.31-04	5.31-04	5.31-04	5.31-04	5.31-04	5.31-04
I -133	5.79-03	5.79-03	5.79-03	5.79-03	5.79-03	5.79-03
I -134	8.36-05	8.36-05	8.36-05	8.36-05	8.36-05	8.36-05
I -135	2.77-03	2.77-03	2.77-03	2.77-03	2.77-03	2.77-03
SR -89	2.29-05	2.31-05	2.31-05	2.31-05	2.31-05	2.31-05
SR -90	1.26-07	6.01-07	1.13-06	2.02-06	2.71-06	3.24-06
SR -91	3.46-06	3.46-06	3.46-06	3.46-06	3.46-06	3.46-06
Y -90	5.42-04	5.42-04	5.42-04	5.42-04	5.42-04	5.42-04
Y -91	2.20-04	2.23-04	2.23-04	2.23-04	2.23-04	2.23-04
Y -92	2.53-07	2.53-07	2.53-07	2.53-07	2.53-07	2.53-07
ZR -95	7.67-05	7.83-05	7.83-05	7.83-05	7.83-05	7.83-05
NB -95	3.93-05	3.93-05	3.93-05	3.93-05	3.93-05	3.93-05
MO -99	8.09-03	8.09-03	8.09-03	8.09-03	8.09-03	8.09-03
CS-134	1.46-01	4.15-01	4.92-01	5.09-01	5.10-01	5.10-01
CS-136	6.65-03	6.65-03	6.65-03	6.65-03	6.65-03	6.65-03
CS-137	3.28-01	1.57+00	2.96+00	5.32+00	7.18+00	8.66+00
TE-132	3.28-04	3.28-04	3.28-04	3.28-04	3.28-04	3.28-04
BA-140	4.37-05	4.37-05	4.37-05	4.37-05	4.37-05	4.37-05
LA-140	1.18-05	1.18-05	1.18-05	1.18-05	1.18-05	1.18-05
CE-144	4.38-06	7.31-06	7.39-06	7.39-06	7.39-06	7.39-06
MN -54	1.19-03	2.06-03	2.09-03	2.09-03	2.09-03	2.09-03
MN -56	6.36-05	6.36-05	6.36-05	6.36-05	6.36-05	6.36-05
CO -58	1.99-02	2.05-02	2.05-02	2.05-02	2.05-02	2.05-02
CO -60	4.60-03	1.80-02	2.73-02	3.47-02	3.66-02	3.72-02
FE -59	5.25-04	5.27-04	5.27-04	5.27-04	5.27-04	5.27-04
CR -51	8.30-06	8.30-06	8.30-06	8.30-06	8.30-06	8.30-06
TOTALS	5.48-01	2.07+00	3.55+00	5.93+00	7.80+00	9.28+00

TABLE 5.2-9

Beta Plus Gamma Dose Factors for Direct Radiation Exposure from Contaminated Ground ($mrad/year$ per pCi/m^2)

Isotope	(β & γ) Dose Factor
I-131	2.98E-05
I-132	1.75E-04
I-133	3.94E-05
I-134	1.20E-04
I-135	1.23E-04

(Derivation of dose factors above described in Section 5.2.3)

TABLE 5.2-10

(Beta and Gamma) Doses - Direct Radiation from Activity Deposited on Soil or Vegetation (mrad/year)

Isotope		Dose
I-131		9.8-4
I-132		1.9-6
I-133		5.9-5
I-134		2.2-7
I-135		1.9-5
	TOTAL DOSE	1.1-3 mrad/year

(Above doses calculated using dose factors tabulated in Table 5.2-9 and areal concentrations calculated in Section 5.2.2)

TABLE 5.2-11

Internal Dose Rate at Equilibrium to a Muskrat Consuming Intertidal Vegetation (mrad/year)

Isotope	X_i^{eq} Equilibrium Body Burden (μCi)	Effective Absorbed Energy, E_i (MeV)	Internal Dose Rate (mrad/yr)
I-131	2.7-5	.44	2.2-1
I-132	2.3-8	1.7	7.3-4
I-133	1.0-6	.84	1.6-2
I-134	5.7-9	3.19	3.4-4
I-135	1.7-7	1.2	3.8-3
Sr- 89	2.4-11	.56	2.5-7
Sr- 90	2.0-10	.21	7.9-7
Sr-91	1.3-12	1.32	3.2-8
Y-90	4.9-8	.89	8.2-4
Y-91	3.1-8	.59	3.4-4
Y-92	1.2-11	1.6	3.6-7
Zr-95	3.8-9	.57	4.1-5
Nb-95	2.2-10	.51	2.1-6
Mo-99	7.8-10	.54	7.9-6
Cs-134	5.8-8	1.1	1.2-3
Cs-136	5.1-10	.65	6.2-6
Cs- 137	4.0-6	.59	4.5-2
Te-132	7.2-9	1.9	2.6-4
Ba-140	2.6-10	2.3	1.1-5
La-140	2.1-10	1.9	7.6-6
Ce- 144	1.1-8	1.3	2.7-4
Mn-54	1.0-7	.51	9.7-4
Mn-56	1.3-9	1.9	4.7-5
Co-58	8.0-8	.61	9.3-4
Co-60	5.9-8	1.5	1.7-3
Fe-59	8.8-8	.81	1.4-3
Cr-51	2.4-9	.025	1.1-6
	TOTAL Dose Rate mrad/yr		2.9-1

5.3

5.3 Radiological Impact on Man

5.3.1 Exposure Pathways

The various potential pathways for radiation exposure of man are shown in flow chart format in Figure 5.3-1 for gaseous effluents and Figure 5.3-2 for liquid effluents.

After release, gaseous effluents will be a potential source of external exposure either from direct radiation from the elevated plume or submersion in the plume after it reaches ground level. At ground level, the plume is a potential source for internal exposure due to inhalation of radiogases and particulates. The ground-level plume may also permit inhalation by terrestrial animals. A small fraction of this inhaled radioactive material may be incorporated in animal products such as milk and meat which upon ingestion by man, can result in internal radiation exposure.

Deposition of radionuclides on plants may also result in two pathways to man. The first pathway is direct deposition of airborne activity on the surface of a plant resulting in either superficial contamination or internal contamination for the fraction of the deposition which is subject to foliar absorption. Deposition of airborne nuclides upon soil is the second pathway which results in uptake of radionuclides by growing plants. These plants may eventually be consumed by animals and thus result in a transfer of nuclides to milk and meat products which in turn will be ingested by man. Alternatively, the plants containing radionuclides may be directly consumed by man.

Ground surface contamination through airborne deposition results in external radiation exposure to man from direct radiation. Unharvested portions of plants will normally be plowed into the soil. Similarly, after death of domestic and wild animals, activity will be returned to the soil. This activity will contribute in a minor way to the exposure from those pathways with soil as an intermediate. Animals such as domestic and wild fowl may also pick up deposited radionuclides directly from the soil as they forage about for food. A fraction of this activity will be incorporated in animal products with the potential for internal exposure to man.

Cooling water containing significantly diluted concentrations of radionuclides from the station will be discharged approximately 1 mile offshore. The pathways by which radiation exposure of man may result is shown in flow chart format in Figure 5.3-2 and discussed below.

Aquatic plants and marine biological media such as fish, mollusks, and crustaceans have been observed to concentrate radionuclides directly from the water in which they develop. Marine biological media may also concentrate activity from ingestion of aquatic plants or terrestrial plants. Terrestrial plants such as marsh grass (Spartina) may undergo surface contamination periodically on tidal cycles if dilute radionuclide concentrations are present. Also, the soil on which marsh grass develops may be subject to contamination on incoming tides and this activity will be taken up from the soil by the growing plant. Bacterial consumption of dead Spartina grass and the subsequent utilization of bacteria and detritus feeders results in a pathway for marine biological media uptake of radionuclides.

Sand and sediments may receive deposition of particulate radionuclides or particulate matter which is able to bind soluble radionuclides through ion exchange mechanisms. In addition, benthic filter feeders can hasten sedimentation of radionuclides through production of fecal particulates from ingested colloids and fine particulates. Marine media also contribute their body burden of activity to sediments upon death and decay. Radionuclides are cycled between aquatic plants and sediments with an uptake of activity from sediments by aquatic plants and a return to sediments of activity on plant death and decay. Terrestrial plants growing in intertidal areas which are subject to semidiurnal flooding by seawater also cycle radionuclides between the soil in which they grow and the superficial and internal radionuclides which the plant will contain. Gamebirds and terrestrial animals may take up radionuclides from ingestion of marine biological media, terrestrial plants, and soil. When birds and terrestrial animals die any radionuclides they contain are returned to the soil after decay.

Consumption of aquatic plants, marine biological media, terrestrial plants, gamebirds and terrestrial animals by man results in internal radiation exposure through uptake of a fraction of the radionuclides contained in these foods. External radiation dose to man will result from submersion of swimmers in water containing radionuclides and direct radiation exposure from this water to boaters, water skiers, sunbathers and fishermen. These individuals can also receive external radiation exposure when in proximity to nuclide containing sediments, soils, sands, or plants. A minor pathway of radiation exposure may be contamination of fishing and sporting gear with fine particles of inorganic or organic matter containing absorbed radioactivity.

Dose estimates for the major pathways of radiation exposure are discussed in subsections 5.3.2 and 5.3.3 and summarized in subsection 5.3.6.

5.3.2 Liquid Effluents - Radiological Impact on Man

Subsection 3.5.1 discusses the origin, treatment, and disposition of radioactive liquids that are produced through the operation of the Seabrook units. This discussion presents the estimated radioactivity content of those liquids that are collected and released from the site. Specifically, Table 3.5-5 presents the estimated radioactive liquid release from both Seabrook units in terms of both annual release quantity (Curies/year) and annual average concentration (μCi/ml) at the point of discharge to the Gulf of Maine. These radioactivity release levels, then, constitute the source of radiation exposure to the public through marine pathways.

As described in subsection 3.5.1 and pictured in Figure 3.5-1, the various sources of radioactive liquids that are discharged from the site reach the marine environment, the Gulf of Maine, via the circulating water system discharge conduit. Section 3.4 of this report depicts the discharge point as 5000 feet into the ocean east of Hampton Beach. This is significant from a radioactive liquid release standpoint since dispersion of the discharged plume containing the released radionuclides within the marine environment between the discharge point and the point of dose consideration will mitigate the radiological environmental impact.

As presented in subsection 5.3.1 and depicted in Figure 5.3-2, the general public radiation exposure pathways within or related to the marine environment for consideration at the Seabrook site include swimming, clam digging and similar activities within in-shore water areas potentially influenced by released radionuclides and ingestion of finfish, invertebrates, and marine plants harvested from areas potentially influenced by released radionuclides. Each of these radiation exposure pathways are evaluated below in terms of whole body and critical organ doses (for internal exposures) to individual members of the general public and in terms of whole body doses to the exposed population.

Radiation Exposure from Fish Consumption

Consumption of finfish or shell fish harvested from areas affected by released radionuclides will result in radiation exposure to members of the general public through internally deposited radionuclides. The radiological assessment of this exposure pathway is calculated by the specific activity approach - the concentration of each radionuclide in the marine habitat of the finfish or shellfish is converted to a specific activity within the fish, and with a fish consumption rate, the dose is calculated by comparison with permissible specific activities. The assumptions employed in this calculation are as follows:

a) The fish are exposed to radionuclide diluted from discharge concentrations (given in Table 3.5-5 of this report) by a factor of 3.5. This dilution factor is determined from the results of the singleport discharge hydrothermal model studies. These model tests indicate that the maximum surface temperature rise created by a near-bottom, single-port discharge in 35 feet of water is about 13°F above ambient. The zone of this 13°F temperature rise is small in area, and temperature decay is rapid with distance from it.

   In the near-field region adjacent to the point of discharge the momentum of the effluent is greater than ambient ocean currents and temperature reduction is primarily a function of dilution. Thus, the dilution factor for this region may be expressed as the ratio of the temperature rise at the point of discharge to the temperature rise at the point in question. Therefore, for the single-port discharge the lowest surface dilution is 45/13, or

3.5. Higher dilution factors will be encountered with distance from this +13°F zone.

Multi-port discharge concepts result in near-field entrainment of greater quantities of receiving waters than the single-port concept. Consequently, the multi-port discharge is capable of achieving a lower maximum surface temperature rise and greater dilution. Hydro-thermal model studies are now in progress to evaluate the characteristics of multi-port discharge concepts, all of which induce greater near-field dilution from the single-port concept. When these studies are complete, an accurate determination of near-field dilution will be made which will allow the use of a dilution factor representing the actual discharge concept to be employed for Seabrook.

b) The period of fish exposure is sufficient to establish an equilibrium condition between the radionuclide concentrations in water and in the fish flesh.

c) The reconcentration factors for each of the released radionuclides in marine finfish and invertebrates are as reported for the chemical elements in UCRL-50564, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms", Chapman, et. al., Dec. 30, 1968.

Table 5.3-1 gives the radionuclide specific activities within finfish and shell fish with the above discharge and reconcentration parameters.

The annual average consumption of 50 grams per day of finfish meat with the radionuclide specific activities listed in Table 5.3-1 would result in the following doses to an individual member of the public:

Total Whole Body Dose....................	0.002 mrem/year
Total Thyroid Dose.......................	0.10 mrem/year
Total G. I. Tract Dose...................	0.005 mrem/year
Total Dose to Other Organs...............	0.002 mrem/year

The annual average consumption of 50 grams per day of shell fish meat with the radionuclide specific activities listed in Table 5.3-1 would result in the following doses to an individual member of the public:

Total Whole Body Dose....................	0.002 mrem/year
Total Thyroid Dose.......................	0.50 mrem/year
Total G. I. Tract Dose...................	0.01 mrem/year
Total Dose to Other Organs...............	0.003 mrem/year

In the New Hampshire coastal waters, there is no commercial finfish industry. Finfish are caught by sport fishing efforts only, which includes fishing from land areas adjacent to the coast and fishing in the off-shore areas from private pleasure craft and sport fishing "party boats". Estimates of the number of sport fishermen and their catch for both the estuary and off-shore areas are on the order of 18,000 and 250,000 lbs., respectively. Only a small fraction of this catch would be from the Seabrook discharge plume area, where the minimum dilution factor of 3.5 applies. However, assuming entire catch came from the discharge area, the aggregate whole body population dose would be 0.013 man-Rems/year.

Regarding the lobstering efforts in the Hampton-Seabrook estuary and coastal waters, there are two types of lobstermen to consider. The first is the sport lobstermen - those licensed to work up to a limit of five lobster traps. The second is the commercial lobstermen. Data on these lobstermen for the year 1970 indicate that 19 held sport licenses and 62 held commercial licenses and their catch for the year from both estuary and off-shore areas was 1255 lbs. and 73,233 lbs., respectively. A breakdown of the data indicates that 89 percent of the catch was from off-shore areas (outside the Hampton Harbor Inlet). Only a small fraction of this catch would be from the Seabrook discharge plume area, where the minimum dilution factor of 3.5 applies. However, assuming the entire off-shore catch came from the discharge area, the aggregate whole body population dose would be 0.0012 man-Rems/year (with the assumption of 0.33 lb. lobster meat per lb. lobster).

Radiation Exposure from Marine Plant Consumption

Consumption of marine plants, such as seaweed, harvested from areas affected by released radionuclides will result in radiation exposure to members of the public through internally deposited radionuclides. The radiological assessment of this pathway employs the same method as outlined above for fish consumption only with different parameters. The dilution factor between the point of radionuclide release to the Atlantic and the seaweed habitat is assumed to be on the order of 500. The reconcentration factors at equilibrium are as listed for marine plants in Chapman, the above-mentioned reference.

With the Table 3.5-5 radionuclide discharge concentrations diluted by a factor of 500 and with radionuclide reconcentration in the plants, the annual average consumption of 5 grams per day of seaweed would result in the following doses to an individual member of the public:

Total Whole Body Dose	4.2-5 mrem/year
Total Thyroid Dose................	2.6-2 mrem/year
Total G. I. Tract Dose............	2.9-5 mrem/year
Total Dose to Other Organs........	1.6-6 mrem/year

If 1000 members of the general public consumed this seaweed at the 5 grams per day rate, the whole body population dose would be 4.2 x 10^{-5} man-Rem/year.

Radiation Exposure from Swimming

Immersion in coastal water affected by released radionuclides would result in external exposure to the swimmers. It is assumed that an individual swimming along the shoreline at Hampton or Seabrook beaches would be exposed to released radionuclides in concentrations diluted by factors at least on the order of 500. Swimming in these waters at the frequency of three hours per day for 60 days per year would result in whole body plus skin dose to an individual of approximately 2.9 x 10^{-6} mrem/year. For swimming population of 200,000 at the above rate, the whole bodypopulation exposure would be approximately 5.8 x 10^{-4} man-rem/year.

Radiation Exposure from Clam Digging

Harvesting clams on mud flat areas upon which radionuclides released from the Seabrook discharge conduit have deposited would result in skin and whole body radiation exposures to the clam diggers. It is assumed that all the radionuclides that reach the Hampton Harbor clam flats over the 40 year life of the station settle out of the tidal waters and become permanently incorporated into the flat sediment. The amount of each radionuclide reaching the flats is assumed to be the amount released from the Seabrook discharge conduit divided by an estimated dilution factor of 500.

Clam digging regulations in New Hampshire dictate that all clamming be on a non-commercial basis (recreational clam digging only) limited to Friday, Saturday and Sunday, and holiday digging only. An ambitious clammer, one digging for 2 hours each permitted day of the year (167 days per year), would receive a skin dose of approximately 1.3×10^{-5} mrem/year and a whole body dose of approximately 9.5×10^{-6} mrem/year.

The number of clamming licenses issued in New Hampshire for 1972 is approximately 15,000. It is assumed that all of these license holders dig in the Hampton-Seabrook area and that they average 2 hours per day for 75 days per year on the flats. The aggregate whole body dose to this clamming population is 6.4×10^{-5} man-rem/year

Summary of Marine Pathway Exposures

The radiological environmental impact of radioactive liquid releases, as assessed in the above discussions, is summarized in Table 5.3-2.

5.3.3 Gaseous Effluents

Subsection 3.5.2 discusses the sources and treatment of gaseous radioactive wastes from the Seabrook Station. The estimated annual release rates, by isotope, are shown in Table 3.5-7. All of this gaseous waste, except that due to leakage in the turbine hall, is discharged to the environment through the unit's primary vent stack. Gaseous waste from the turbine hall is released from wall and roof ventilators in that building. For purposes of calculating doses, it is assumed that all gaseous released from the site are from ground level.

External Exposure from gaseous releases

Radioactive gases released to the atmosphere will result in external radiation doses to individuals in the population. The radiation from these gases consists of gamma rays, which result in a dose to deep tissues or skin body dose, and beta particles which result only in a surface or skin dose and which is effectively reduced by normal clothing. In the discussion below, whole body dose refers to the gamma ray component of the dose and skin dose refers to the beta plus gamma doses at the outer surface of the skin and assumes no dose reduction due to clothing.

The whole body dose from the releases shown in Table 3.5-7, has been evaluated at 2 locations - the highest dose point on the site boundary and the highest residential dose location. The site boundary location is 3000 feet in the ESE sector with an annual average $\chi/Q = 3.0 \times 10^{-5}$ sec/m^3. The house location is approximately 7800 feet in the ESE sector with an annual average $\chi/Q = 6.5 \times 10^{-6}$ sec/m^3. The maximum skin dose is assumed to be received by an unshielded individual exposed 100 percent of the time at the site boundary.

Location	Whole Body Dose, mrem/year	Skin Dose mrem/year
Site Boundary	0.11	6.2
Residence	0.035	1.4

These doses take no credit for shielding or occupancy factors.

Thyroid Exposure from Iodines

Radioactive iodine isotopes released to the atmosphere will result in internal exposure to individuals in the population. Due to the affinity that iodine has for the thyroid gland, this organ becomes limiting in a dose calculation.

Three pathways of exposure to radioiodine were considered:

1. Inhalation of airborne iodine
2. Deposition of iodine on leafy vegetables and subsequent ingestion of these vegetables
3. Deposition of iodine on pasture grass and the subsequent cow-milk pathway

The critical individual in the population is assumed to be a child living at the highest residential dose point. This child is assumed to eat 3 kgm of unwashed leafy vegetables, from a vegetable farm with a 4 month growing season. It is further assumed that this child drinks 1 liter/day of milk from the nearest dairy farm for the six months per year pasture season.

The house is approximately 7800 feet from the station in the ESE sector, with an annual average $\chi/Q = 6.5 \times 10^{-6}$ sec/m^3. The dairy farm is 2.5 miles from the site, in the N sector, with an annual average $\chi/Q = 4.8 \times 10^{-7}$ sec/m^3. The vegetable farm is 4.2 miles in the NW sector with an annual average $\chi/Q = 1.6 \times 10^{-7}$ sec/m^3.

The thyroid dose from the releases shown in Table 3.5-7 for each of the 3 pathways is shown below:

Pathway	Thyroid Dose, mrem/year
Inhalation	0.011
Vegetables	0.004
Milk	0.10
Total	0.115

Dose Calculation Models

1. External beta dose

External beta doses are calculated assuming a semi-infinite cloud model as described by the following expression:

$$D_B = 0.23 \bar{E}_B \chi$$

where D_B = beta dose rate (rem/sec)

$\bar{E}_B$ = average beta energy per disintegration (Mev/dis)

χ = concentration of isotope in cloud (Ci/m^3 = dilution factor) (sec/m^3 times release rate) (Ci/sec)

This expression was taken from "Meteorology and Atomic Energy - 1968", Chapter 7.

2. External gamma dose

External gamma doses are calculated by the finite cloud technique described in "Meteorology and Atomic Energy - 1968", Chapter 7. The concentration of radioactive material within the sector of interest, is averaged in the horizontal direction across the sector. The cloud is thus considered to be comprised of a series of horizontal plane sources which vary in concentration vertically according to a Gaussian distribution about the cloud center plane.

This model has been adapted to a computer code "Plumdos" which calculates the gamma dose to a ground level receptor from up to 24 isotopes and for 7 gamma energy groups. The code considers meteorological input of 7 stability classes, 16 wind direction and 6 wind speed groups.

3. Thyroid dose

The thyroid doses are calculated based on the method described in the "Draft Environmental Statement Concerning Proposed Rule Making Action: Numerical Guides for Design Objectives and Limiting Conditions as Low as Practicable for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents", Appendix C, issued by the U.S.A.E.C. in January 1973. The dose conversion factors obtained from this report are listed below:

		mrem/year per pCi/m^3	
Isotope	Air	Leafy Vegetables	Milk
I-131	13	400	1840
I-133	5.4	28	130

These conversion factors are based on a child that inhales 2045 m^3/year of air, eats 6 kgm of leafy vegetables in a 4-month growing season and drinks 365 liter/year of milk. The milk factor is corrected for a 6-month pasture growing season.

The average concentration of iodine is calculated by multiplying the average release rate of Ci/sec times the dilution factor (χ/Q) in sec/m^3 for the location of interest. No correction is made for cloud depletion from deposition. The χ/Q values used are given in subsection 5.3.3.B and are based on the meteorology discussed in subsection 2.6.6.

5.3.4 Direct Radiation

This subsection deals with external radiological dosage attributable to direct radiation emanating from the facility and from radioactive material shipped to or from the station during its operation. Doses to individuals outside the facility due to radiation from the facility are described in 5.3.4.1; those resulting from the transportation of radioactive material are given in 5.3.4.2.

5.3.4.1 Radiation from Facility

Station radiation sources of significant activity are the reactor cores and their coolant, spent fuel elements, the waste tanks, filters, and demineralizers. The station design includes specific shielding of all this equipment to ensure low radiation levels even within the immediate areas of the facility.

The reactor cores have reinforced concrete primary shields that are at least 6-feet thick. Additional shielding of each core is provided by a 2.5-foot secondary shield structure that encloses the reactor coolant equipment (piping, pumps, steam generators, etc.) and by the primary and secondary containment structures that surround the reactor equipment. The primary containment wall of each unit is 4.5-feet thick; the domes are 3.5 feet. The secondary containment structure surrounds the primary containment and its walls are 15 inches thick. Spent fuel elements are stored under water in the fuel storage buildings. The minimum water depth in the spent fuel pools is 11.5 feet above the top of the fuel assemblies. The pool walls are 6-feet thick.

The station design calls for individual shielding cubicles for each of the remaining major sources of radiation. The cubicles have up to 2-foot walls and are located in the Primary Auxiliary Buildings, the Waste Processing Building and the Holdup Storage Building. The walls and floors of these buildings are 2-feet thick.

In addition to the heavy shielding provided as described, all these sources of radiation are totally or partially located below station grade. As a result, direct radiation doses outside the station from these sources are expected to be insignificant when compared to those attributable to normal background radiation.

With regard to radiation sources (of relatively lower activity) located above station grade, the most significant ones are the chemical and volume control systems (CVCS), the reactor make-up water tanks and the refueling water tanks.

The CVC system of each unit is located in a 4-foot concrete cubicle on the thrid floor of the Primary Auxiliary Building. Since radiation from this system must traverse at least 6 feet of concrete to escape from the PAB, the site boundary direct radiation dose from this source is negligible. In fact, using equilibrium tank activities, the calculated dose rate at the site boundary from both CVCS units is approximately 1×10^{-6} mrem/year.

Site boundary doses from the unshielded reactor make-up water tanks have been estimated to be small and to amount to approximately 2×10^{-4} mrem/year.

The refueling water tanks contain less activity than the reactor make-up water tanks and, in addition, they are partially shielded by a reinforced concrete wall that is two-feet thick. As a result, this source of radiation will also lead to negligibly small radiation levels at the site boundary or beyond.

To summarize then, radiation dosage to individuals outside the facility due to direct radiation from the facility are expected to be a few orders of magnitude less those attributable to normal background radiation.

5.3.4.2 Transportation of Radioactive Materials

Subsections 3.5.3 and Section 3.8 of this report outline the amounts and characteristics of radioactive materials expected to be transported to and from the Seabrook Station. Subsection 3.5.3 presents the anticipated volume and radioactivity content of each of the various solid radioactive waste products that are anticipated to be generated by the operation of the Seabrook units. Section 3.8 presents requirements for new (unirradiated) fuel element shipments to the site and spent (irradiated) fuel element shipments from the site.

Transportation of these radioactive materials has potential radiological impact on members of the general public who are exposed to radiation emanating from the shipments. This potential for exposure exists for both normal conditions of transport and situations arising through transportation accidents. These exposure potentials are evaluated in a report prepared by the Directorate of Regulatory Standards, U.S. Atomic Energy Commission, entitled "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants", dated December, 1972. This report presents a detail accounting of the subject of radioactive material transportation from nuclear power plants and specifically evaluates for a typical light water reactor radiation exposures to both transport workers and the general public as a result of such transportation.

It is concluded that the radiological impact evaluation of the transportation of radioactive materials from Seabrook Station is within the scope of the analyses presented in the above mentioned report, and therefore, no such analyses are required here.

5.3.5 Other Exposure Pathways

The radiological environmental impact analyses presented in subsections

5.3.1 through 5.3.4 above cover all the potential radiation exposure pathways that the Seabrook Station and its environment combine to impose on man. Thus, no other radiation exposure pathways need be considered here.

5.3.6 Summary of Annual Radiation Doses to Man

The radiological environmental impact of radioactive liquid and gaseous releases from the Seabrook site are presented above in subsections 5.3.2 and 5.3.3, respectively. The doses to the local and regional populace from these effluents are summarized in Table 5.3-3.

TABLE 5.3-1

FISH SPECIFIC ACTIVITIES

RADIONUCLIDE	FINFISH SPECIFIC ACTIVITY (μCi/gm)		SHELLFISH SPECIFIC ACTIVITY (μCi/gm)
I-131	1.8-9		8.8-9
I-132	6.1-10		3.0-9
I-133	2.6-9		1.3-8
I-134	4.0-10		2.0-9
I-135	1.4-9		7.0-9
Sr-89	1.9-14		2.3-13
Sr-90	7.8-16		9.8-15
Sr-91	1.2-13		1.6-12
Y-90	1.9-10		1.9-9
Y-91	5.4-12		5.4-11
Y-92	8.2-13		8.2-12
Zr-95	6.2-13		6.2-12
Nb-95	2.3-10		6.4-13
Mo-99	3.2-10		3.2-10
Cs-134	1.1-10		7.4-11
Cs-136	5.8-11		4.0-11
Cs-137	5.8-10		4.0-10
Te-132	2.2-9		2.2-9
Ba-140	4.1-13		8.2-12
La-140	1.2-12		1.2-11
Ce-144	3.7-13		3.7-13
Mn-54	1.1-11		1.8-10
Mn-56	4.0-10		6.5-9
Co-58	5.9-10		1.1-9
Fe-59	1.6-11		3.0-11
Cr-51	1.2-10		7.8-10
Cr-51	1.7-11		8.6-11
	1.2-8	TOTAL	4.8-8
H-3	3.4-7		3.4-7

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TABLE 5.3-2

Summary of Radiological Impact on Man from
Seabrook Radioactive Liquid Releases (both units)

EXTERNAL RADIATION EXPOSURE:

	Individual Whole Body plus Skin Dose	Population Whole Body Dose
Swimming	0.000003 mrem/year	0.00058 man-rem/year

	Individual Skin Dose	Individual Whole Body Dose	Population Whole Body Dose
Clam Digging	0.000013 mrem/year	0.00001 mrem/year	0.00006 man-rem/year

INTERNAL RADIATION EXPOSURE:

	Individual Doses (mrem/year)			Other	
	Whole Body	Thyroid	G.I. Tract	Organs	Population Whole Body Doses
Finfish Ingestion	0.002	0.1	0.005	0.002	0.013 man-rem/year
Shellfish Ingestion	0.002	0.50	0.01	0.003	0.012 man-rem/year
Marine Plant Ingestion	0.000042	0.026	0.00003	0.000002	.000042 man-rem/year

TABLE 5.3-3

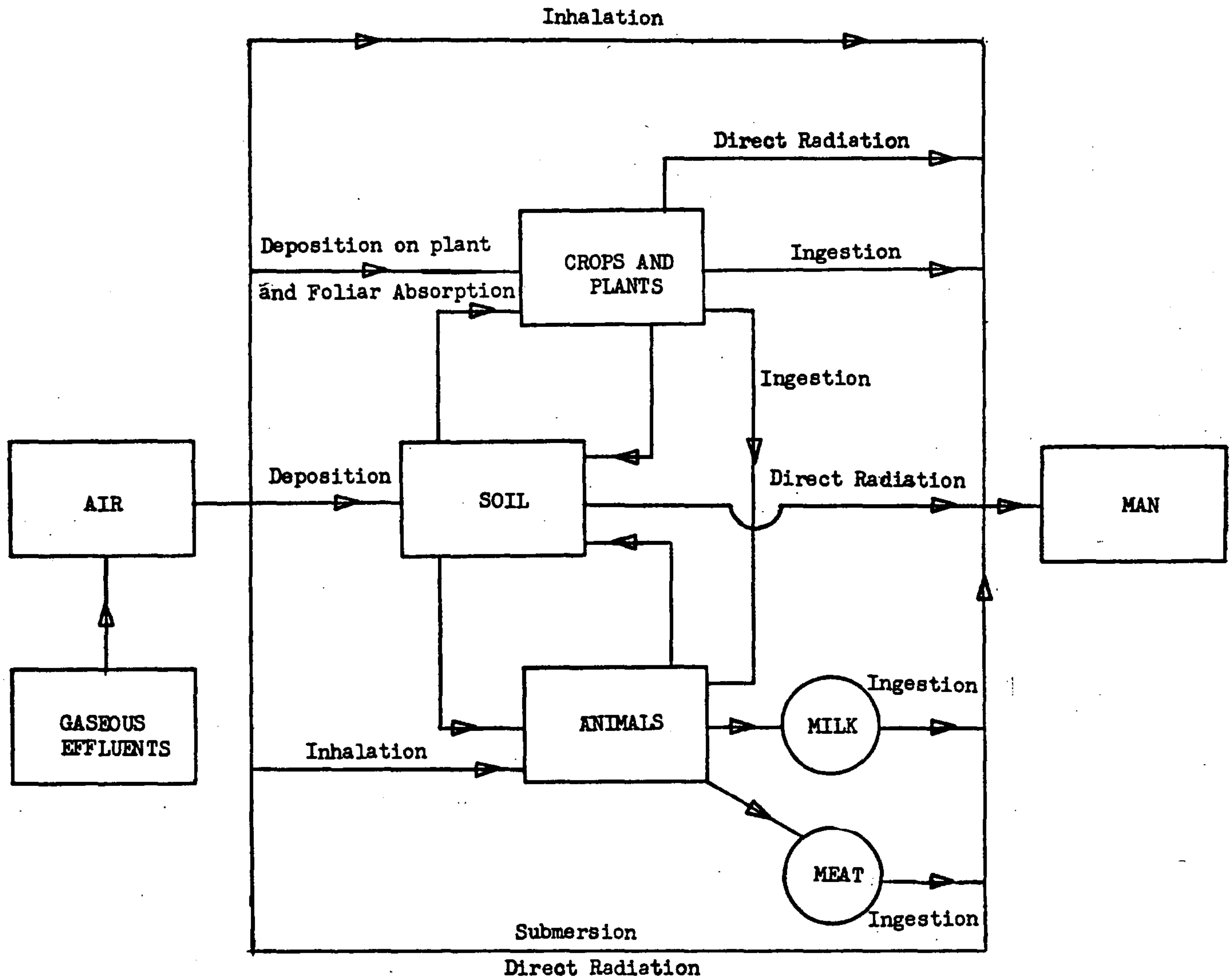
SUMMARY OF POPULATION DOSES

Radioactive Liquid Releases

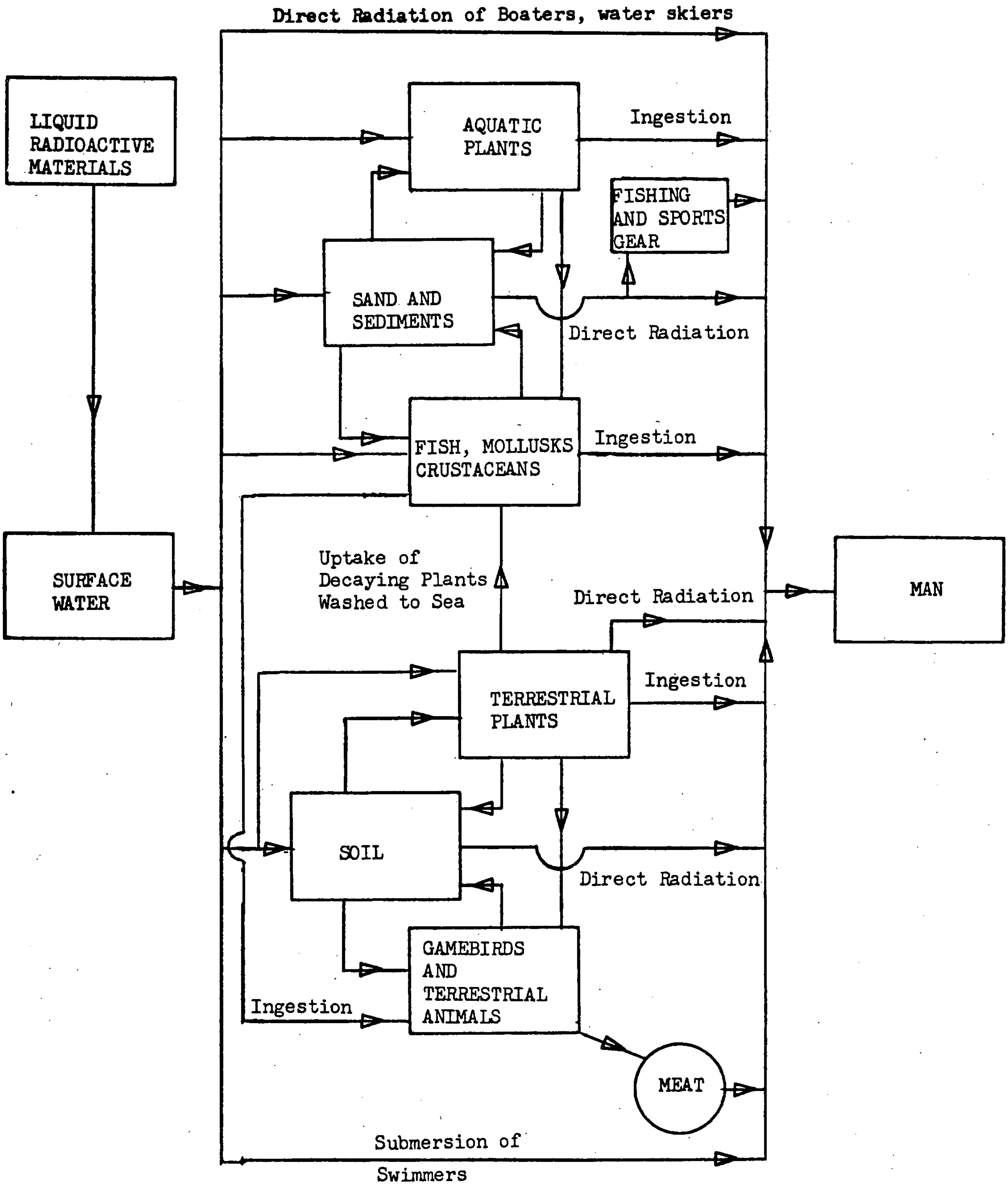
EXPOSURE PATHWAY	WHOLE BODY DOSE - man-rem/year
Swimming	0.00058
Clam Digging	0.000064
Finfish Ingestion	0.013
Shellfish Ingestion	0.012
Marine Plant Ingestion	0.000002

Radioactive Gaseous Releases
(whole body immersion doses)

RADIAL DISTANCE FROM SITE	WHOLE BODY DOSE - man-rem/year
1 mile	0.08
5 miles	0.44
10 miles	0.58
20 miles	0.75
30 miles	0.99
40 miles	1.2
50 miles	1.4



PSNH SEABROOK STATION	RADIATION EXPOSURE PATHWAYS TO MAN FROM GASEOUS RELEASES	FIGURE 5.3-1



PSNH SEABROOK STATION	RADIATION EXPOSURE PATHWAYS TO MAN FROM LIQUID RELEASES	FIGURE 5.3-2

5.4 Effects Of Chemical And Biocide Discharges

The chemical discharges resulting from routine operation of Seabrook Station are discussed in detail in Section 3.6. They are produced from the following sources:

1. Make-up water demineralizer
2. Blowdown from auxiliary boiler(s)
3. Oily wastes from equipment areas
4. Biocide application residuals
5. Circulating water system degradation.

In addition to the above described routine wastes, there are other waste sources prior to startup and of infrequent periodicity that are considered.

A complete list of all known nonradioactive chemical discharges and the proposed discharge quantities and concentration levels is as follows:

chemical	quantity (lbs/day)	discharge concentration ppm
Calcium	80	0.01
Magnesium	20	0.0025
Sodium	400	0.05
Chloride	30	0.003
Sulfate	1300	0.16
Bicarbonate	250	0.031
Silicate	30	0.003
Chlorine	37	<0.1 (intermittent)
Iron	24	0.002
Copper	144	0.02
Oil	none visible	
pH	6.7 to 8.0	

The response of aquatic biota to known concentrations of chemicals has received much attention yet understanding of the subject is far from complete.

A review of several available sources shows the information is not only incomplete, but in many instances appears contradictory, no doubt reflecting methodological differences and inconsistencies in establishment of test criteria. Below is a synoptic review of relevant considerations and some of the study results believed to be most applicable in an evaluation of Seabrook Station chemical discharge effects.

Calcium

Calcium ions are among the most commonly encountered substances in water. There they combine readily with anionic types forming various salts, notably, calcium carbonate, calcium chloride and calcium sulfate. In seawater calcium is in quantities approximating 400 mg/l (Reference 1). The effect of calcium in water has been found by several investigators to serve as a meliorater of toxic thresholds when operating in synergism with known toxic chemicals (Reference 2). Doudoroff and Katz (Reference 2) in their review of toxic chemicals to fish, cite study results showing toxic effects of calcium salts (calcium chloride and nitrate) at concentrations between 300 and 1000 mg/l as calcium. The same reference reports survival of fish in some waters with CaCl concentrations as much as 4000 mg/l. These are of course extreme cases and have little application in this discussion. The lowest reported sensitivities to calcium salts varies depending on the anionic elements involved. However, the material in McKee and Wolf's comprehensive review of water quality criteria shows no reported toxic effects for common calcium compounds to aquatic life at concentrations below about 500 mg/l (Reference 3).

Magnesium

Seawater is rich in magnesium, it being the third most abundant element, exceeded only by chlorine and sodium. Like calcium the magnesium cation is ephemeral in its existence quickly combining with common available anions (chloride, nitrate and sulfate ions) to form salts. Because of this characteristic the toxicity of magnesium salts appears more relevant than that of the ionic or elemental state. Magnesium chloride and nitrate can be toxic to fish in distilled water at concentrations between 100 and 400 mg/l as magnesium. However, magnesium chloride, nitrate and sulfate at concentrations between 1000 and 3000 mg/l as magnesium have been tolerated for 2-11 days (Reference 2). Generally the review of McKee and Wolf (Reference 3) contains assurances of no toxic effects from the common magnesium salts at concentration levels below 300 mg/l.

Sodium

This highly reactive metal does not occur free in nature due to its water solubility. It is the cation of many naturally occurring salts, foremost of which is sodium chloride. Seawater contains about 10,600 mg/l of sodium most of which is combined with chloride. Due to the presence of this quantity of sodium in seawater the tolerance limit of marine and estuarine organisms is obviously greater than these ambient concentrations.

Chloride

Chloride ions are found in practically all natural waters and are the most abundant ion in seawater (about 19,000 mg/l). Because of the abundance of chloride ions it is obvious that marine and estuarine forms have substantial tolerance to them.

Sulfate

Studies on the toxicity of the sulfate radical are few. In evaluating the toxicity of sulfates one must survey the three commonly formed water-soluble salts; sodium sulfate, potassium sulfate, and ammonium sulfate. Findings of the various toxicity studies dealing with sulfates cannot be readily compared with expressed sulfate levels since the effect may be wholly or partly due to the cation involved. In a summary on sulfates McKee and Wolf (Reference 3) recommend the following concentrations of sulfate as compatible with certain indicated water uses. These are:

domestic water supply	500 mg/l
irrigation of crops	200 mg/l
stock watering	500 mg/l

Bicarbonate

The concentration of bicarbonates in natural and polluted waters is a function not only of the bicarbonates present but also of the temperature, pH and concentration of other dissolved solids. It is generally understood that bicarbonates tend to reach an equilibrium with carbonates in natural waters. Information on the tolerance limits of marine life to bicarbonate concentrations cannot be found, probably because of the comparatively great ambient levels in seawater. For fresh water fish Hart _et al_ found that about 95 percent of the U. S. waters that supported a "good fish fauna" contained less than 180 mg/l of bicarbonate (Reference 4).

Silicate

Silica and silicates are generally not considered as highly reactive toxic substances. They are, in fact, an essential nutrient for the growth of marine diatoms. No adverse physiological effects have been noted for silica or silicate concentrations found in natural waters (Reference 5). According to Raux (in McGee and Wolf, Reference 3) silica in a concentration greater than 50 mg/l may cause difficulties arising from turbidity.

Chlorine

Free chlorine is a very toxic chemical which may be present in small amounts because of its introduction into the circulating water system for control of fouling organisms. Residual quantities are inevitably carried in the discharge effluent although the toxic character is not required for system cleansing beyond the condenser. The State of New Hampshire has an established standard of 0.3 mg/l. Recently the applicant in discussions with the Environmental Protection Agency Regional Office was advised that this concentration should be lowered to 0.1 mg/l. Therefore, consistent with this opinion, the applicant proposes 0.1 mg/l as a discharge concentration level.

Iron

Elemental iron is present in seawater at a concentration of .01 mg/l (Reference 1). The amount present in the discharge would result from circulating water system corrosion and erosion and are estimated as 0.002 ppm. A recent study at one of the applicant's fossil-fired generating stations demonstrated that discharge water samples show no consistent increase in iron over intake water in twelve monthly samples (Reference 6). In most studies of iron physiological effects both beneficial and adverse are expressed in terms of specific iron salts. When iron is added to water in the form of salts (chlorides, sulfates, etc.) there is an ionic dissociation. The resulting ferrous and ferric ions combine readily with hydroxyl ions (OH^-) to form precipitates, hence very little iron is found naturally in its ionic state. These events could produce lowered pH in unbuffered waters but salt water is strongly buffered and therefore unlikely to react in this manner. Two references provide information on iron concentration toxicity which seem germane to the Seabrook case. One shows survival of dogfish (Squalus sp.) over one week in 1-2 mg/l of iron (Reference 7). The other reports the death of dogfish in three hours when exposed to a 5 mg/l concentration of iron (Reference 8).

Copper

A trace amount of copper addition may be hypothesized due to the potential for condenser tube erosion. According to the applicants' experience elsewhere copper concentration increases, from transit through a typical circulating water system, are undetectable (Reference 6). Another means of estimating the copper concentration within the discharge water involves the use of predicted condenser tube wear rates. Based on this method a discharge concentration of 0.02 mg/l can be estimated. The toxicity of copper ions are well documented. Copper is well recognized for its toxic effects on marine forms which is well demonstrated by the wide acceptance of copper-based antifouling paints. Many adverse synergistic effects have been demonstrated with such other chemicals as magnesium salts and phosphates (Reference 9), chlorine (Reference 10), zinc and cadmium sulfates (References 11, 12 and 13), and mercury (Reference 14). On the other hand copper has shown evidence of decreasing the toxicity of cyanide (Reference 15). A fairly complete review of the many specific references covering responses of various life forms to known concentrations of copper is found in McKee and Wolf's Water Quality Criteria (Reference 3). On the basis of their review a maximum allowable copper concentration of 0.05 mg/l is recommended for seawater releases. Roosenburg (Reference 16) suggests the greening of oysters in the vicinity of power plant as being caused by copper accumulation but he unfortunately fails to offer data on the concentrations in the effluent water or within the area occupied by the affected oysters.

Oil

In the wake of the recently disasterous oil spills such as "Torrey Canyon" and the California offshore oil rigs the public has viewed with growing alarm the release of oil into public waters. Their concern is well supported by the literature. Chipman and Galtsoff (Reference 17) report that crude oil in concentrations as weak as 0.3 ppm is extremely toxic to freshwater fish. This same paper reports a toxic effect on the marine hydrozoan, Tubularia crocea, barnacles and to the embryos of the toadfish (Opsanus tau). The use of oil in controlling mosquito larvae is a well-known practice thus attesting to its toxicity. Another commonly used control method utilizing oil is in the destruction of noxious weed in irrigation ditches. This treatment was found to eliminate crayfish at concentrations of 300 ppm. North and Clendenning (Reference 19) in a study on the effects of discharged wastes on kelps, consider 10 ppm concentrations of fuel oil to be deteterious to Macrocystis pyrifera. Oysters may be susceptible to oil pollution at both the adult and larval stage. Both McConnell (Reference 20) and Gowanlock (Reference 21) attribute an extensive mortality of Louisiana oysters in 1932 and 1933 to oil-well wastes. Unfortunately, no concentration levels are available in this case. Destruction of oyster larvae is reported by Speer (Reference 22). Again there is no idea of concentration level however, the term "surface film" implies a concentration certainly greater than 1.0 ppm.

pH

Marine waters generally fall into the pH range of between 8.1 to 8.3 with estuarial dilution tending to lower pH values slightly (Reference 23).

Despite this rather narrow range the tolerance of aquatic organisms appears to be much greater. The review by McKee and Wolf (Reference 3) of known pH influences on plants and animals reveals that by limiting values to about 6.5 to 8.5 protection of aquatic life is possible.

Natural ambient water chemical conditions in the receiving waters have been ascertained and are reported in Section 2.5. For comparison the concentrations of discharged wastes occurring naturally are given below as well as the expected release concentration:

	Naturally Occurring Conc. (mg/1)	Proposed Release Conc. (mg/1)
Calcium	915	0.01
Magnesium	5085	0.0025
Sodium	8000*	0.05
Chloride	18084.6	0.003
Sulfate	2554.6	0.16
Bicarbonate	136.6	0.031
Silicate	2.1	0.003
Chlorine	not measured	<0.1
Iron	.06	0.002
Copper	.0009	0.02
Oil	none	none
pH	7.9-8.0	6.7-8.0

*An approximated value based on the known salinity of seawater.

The dilution of chemical discharges by the receiving waters will operate in a manner similar to the described for the thermal effect through entrainment of adjacent receiving waters (see Section 3.4). This indicates that a dilution of between 3.4:1 and 7.5:1 occurs as the effluent surfaces.

Station chemical wastes will be carefully contained such that ground water contamination does not occur.

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5.5 Effects of Sanitary and Other Waste Discharges

5.5.1 Sanitary Waste System

The effluent from the sanitary waste treatment system is essentially of drinking water quality. Its discharge into the ocean via the circulating water discharge pipe has no measurable or observable effect on the natural ambient environment. In quality and quantity it meets all known requirements for discharge as proposed.

5.5.2 Other Waste Systems

5.5.2.1 Auxiliary Boilers

The two auxiliary boilers for this facility are each designed for a nominal steam flow of 100,000 pound per hour and, as a maximum, would operate on the following basis:

1. One boiler operating year round.
2. Both boilers operating simultaneously one month per year.

During operation the expected flue gas emission rate of each boiler, is approximately 31,000 cubic feet per minute at 300°F.

Fuel oil (#2) is fired at a rate of 900 gallons per minute per boiler and has an expected composition as given below.

Fuel Oil Composition - %

Carbon and Hydrogen	99.595
Sulfur	0.300
Ash	0.005
Nitrogen	0.100
	100.000

Heating value - 143,000 BTU/gal.

For the pollutant compounds of SO_2, NO_x and particulates, a preliminary comparison between the emission rates for these boilers and federal and state standards is shown on the following table.

<u>Preliminary Comparison of Auxiliary Boiler Emission with Federal and Present New Hampshire Emission Rate Standards</u>

Basis: 1 Boiler

	Auxiliary Boiler	Federal Standards	New Hampshire Standards
SO_2	0.30 lb/10^6 BTU	0.8 lb/10^6 BTU	None
NO_x	0.30 lb/10^6 BTU (315 ppm)	0.3 lb/10^6 BTU	None
Particulates	0.012 lb/10^6 BTU	0.1 lb/10^6 BTU	.35 lb/10^6 BTU

As can be seen by the previous table the emission rates for the auxiliary boilers meet both the federal and present New Hampshire Standards.

Ambient air quality standards is met by discharging the flue gases at a point above the ground so that the maximum combined concentration (both boilers operating) under varying atmospheric conditions when added to the local background concentration do not exceed the federal and state secondary ambient standards.

5.5.2.2 Emergency Diesel Generators

The four Emergency Diesel Generators for this facility are designed for an electrical output of 4500 MW per diesel generator. They burn the same fuel as the Auxiliary Boiler and have an expected fuel consumption of 310 gal/hr. Exhaust gases are emitted at a rate of 20,000 cubic feet per minute at 850°F. Operation of the diesel generators is only on an emergency basis and testing is comprised of operating a generator once every month for two hours. The combined total usage for all four diesel generators will be approximately four days per year.

The change in ambient air concentrations of the SO_2, NO_x, Photochemical Oxidants, CO, Hydrocarbons, and Particulates pollutants due to operation of the generators is expected to be negligible because of the high exhaust temperature (850°F) and infrequent operation.

The State of New Hampshire Air Regulation 9 specifies that emissions from diesel engines be in compliance when the opacity of the exhaust gases does not exceed a 20 percent decrease in light transmission averaged over a 15 second period. The diesel generators are designed to meet this regulation.

5.6 Effects of Operation and Maintenance of the Transmission System

There will be no maintenance required on New Hampshire rights-of-way because construction roads will be temporary and culverts or bridges on all stream crossings will be removed upon completion of construction. Roadways will be allowed to reseed.

Of the 32 miles of transmission right-of-way in Massachusetts, 29 miles have existing access roads for operation and maintenance. Thus, new access roads will be required on only three miles of right-of-way. All culverts will be installed under the Massachusetts Inland Wetlands regulations and will be left in place after construction to maintain normal stream drainage. Roadways will be allowed to reseed.

Maintenance will be performed with standard and special vehicles using the roadway for access, thereby minimizing any effect on existing vegetation in the right-of-way.

Routine patrols will be done by helicopter. Minor maintenance associated with conductors and structures will be performed by the best method depending upon location in the right-of-way. Heavy equipment will not need to traverse rights-of-way for many years assuming poles are kept intact and properly treated at the ground line.

In New Hampshire rights-of-way will be maintained by a combination of selective cutting and spraying depending upon conditions. Any swamp or bog area will have selective cutting and no chemical treatment. Water shed areas will be treated in the same manner. Stream banks will be checked for height of growth. Any growth which will not interfere with the reliability of the line will be left to stabilize the banks of the streams.

Brush control of rights-of-way is done in compliance with the Pesticide Board of New Hampshire and will be done in the following manner:

1. In those areas where chemical treatment is allowed a stump spray will be applied soon after initial clearing is completed.

   This consists of a chemical mixture of two gallons of Bromacil to 98 gallons of water and applied to hardwood stumps at the rate of approximately 70 gallons of mixed material per acre.

2. The second treatment is a selective foliage application which is applied from four to six years after the stump spray. The selective application involves the retention of desirable ground cover by eliminating the tall growing plants.

   This chemical mixture consists of 1 gallon of Picloram and 2-4-D to 99 gallons of water and applied at the rate of approximately 70 gallons of mixed material per acre.

3. From this point on the chemical treatment is still a selective foliage application and is required on a cycle which varies from six to ten years between applications. The variation is due to the plant growth within the right-of-way.

   The mixture is the same as that used in the second application.

The right-of-way for the Massachusetts portion of Seabrook - Mass. Line will be maintained by selective cutting and herbicide treatments in the following manner:

1. A selective stump spray will be applied to the stumps of all hardwood tree species during the dormant season after land clearing is completed. A chemical treatment of three quarts of Dicamba and 99 gallons of fuel oil at the rate of 70 gallons per acre will be applied to the stumps in watershed areas. The Massachusetts Pesticide Board uses a broad interpretation of watershed; any land draining into a public water reservoir if owned by the water supply agency or not. In non-watershed areas, a chemical treatment of one gallon of Picloram and 2-4-5-T and 99 gallons fuel oil at the rate of 70 gallons per acre will be used.

2. The second treatment will be a selective basal application applied two years after the first treatment. The chemical formulations and rate of application will be the same as above.

3. The subsequent treatments will be selective basal application on a three to four-year cycle. The chemical formulations will be the same as above or other materials and rates of application that may be approved by the Massachusetts Pesticide Board. A shrub, conifer, fern, grass and wildflower plant community will develop.

The results of the treatments discussed above for all lines will provide beneficial nesting areas and food supply for wildlife. From experience on existing 345 kv lines there are no expected environmental impacts from any electrical effects associated with these lines.

5.7

5.7 Other Environmental Effects

The Applicant knows of no other potential effects which the plant may have beyond those discussed in the previous sections of this chapter.

5.8 Resources Committed

Many of the decisions involved in the construction and operation of a nuclear power plant may have potential environmental consequences, and the necessity of foreseeing and minimizing any negative consequences is recognized.

Terrestrial resources affected are the estimated 85 acres of mixed woodland and the wildlife habitat which it provides. This resource impact should be viewed in two distinct stages: the construction stage and the operating stage. The major difference between these two stages is the total area under impact during each.

Plant construction time is estimated to be about seventy-two (72) months total of which about fifty-four (54) months will involve heavy construction. Clearing for construction will involve the cutting and grading of approximately 85 acres of land. This alteration represents the maximum land commitment consisting of actual structure areas, switchyards, parking areas and construction lay-down areas. In addition, construction procedures may exert minor stresses beyond the immediate cleared area such as atmospheric pollution generated by exhaust from machinery and noise. These potential impacts are much harder to quantify and their influence depends greatly upon natural conditions as well as subjective judgment.

Specific botanical communities which will be disturbed in part by construction are the upland oak-hickory, old field pine, upland hardwood-evergreen and swamp hardwood communities. The plant types, location and spatial extent of these botanical communities are shown in the report of Hodgdon and Wicks entitled Botanical Survey of Seabrook Nuclear Project Site (Appendix A). Seabrook Station structures and associated components are shown in Figure 3.1-1. An estimate of the approximate area of each affected botanical community can be gained by comparison of the above reference figures.

The affected plant communities are not unique to the coastal region of New Hampshire. The only recognized features of particular botanical interest on the site are an isolated clump of comparatively uncommon (for Northern New England) herbaceous plants (Wild Coffee, Bush-Clover, Venus' Looking-Glass and Wild Licorice) and an area characterized by Hodgdon and Wicks (Appendix A) as a Hemlock Ravine. Neither of these two areas is expected to be altered by construction.

The resident large mammals and birds in the affected area will be displaced. It is possible that some lower forms of animal life such as reptiles, amphibia, insects and annelids will survive the construction process but because of their general lack of well developed motile powers many will perish. No rare or endangered animals are known to be present and therefore this tenuous resource is not involved. Those animals displaced from the construction site may find suitable habitat in adjacent areas. However, it is possible that these immigrants will percipitate intraspecific territorial competition or strain available food supplies resulting indirectly in some mortalities distant from the cleared area.

Following completion of the construction stage some areas will be replanted and in time will be restored to productivity. The selection of plant types will bear in mind such considerations as esthetic appeal, ability to provide suitable wildlife habitat, rapid growth characteristics, soil retention qualities and compatibility with the surrounding vegetation and salt environment. Naturally occurring noxious weeds will be supplanted with types more acceptable.

The final long-term terrestrial effect will be the loss of about forty acres of the approximately 250 acre portion of the plant site above high tide. Although some animal life within the affected area will be destroyed this resource is considered replenishable. Wildlife inventories of the site reveal no threatened rare or endangered species.

The construction of the power plant's circulating water system will involve deep bedrock tunnels thereby eliminating the effect on living forms except for the biota in the areas of the vertical riser shafts and diffuser system. Two of the riser shafts will be on the site high ground and have been considered above in the overall terrestrial commitment of resources. The other riser shafts to the inlet and the diffuser system will be offshore and will involve the commitment of about 1/2 acre of benthic environment during construction and afterwards. Intensive benthic sampling within the proposed area and in adjacent areas reveals that no rare or unique species will be affected.

Construction will have an immediate disruptive impact on the benthic organisms found along the intake and discharge structures. Although the resident and migratory finfish and the motile epifauna could avoid the construction impact, the less motile benthic organisms found here will be displaced or destroyed as a result of these operations. This should not result in any long-term adverse effect to the ecology of the area providing adequate construction methods are employed. These construction methods include safeguards to prevent excessive turbidity. Benthic organisms living within the impacted area are accustomed to frequent disruption and turbid conditions due to storms. It is estimated that the benthic area permanently occupied by intake structure and diffuser system amount to less than 1/2 acre.

The construction of storm drainage and a sewage plant outfall for use prior to plant operation will require minor construction from the high land to the edge of Browns River. This marshland construction will temporarily open one-half acre of marsh while concrete culverts are being placed. The trench will be refilled and vegetation restored so that no long-term effect of this phase of the work can be visualized.

Section 5.1 (Effects of Operation of Heat Dissipation System) considered the effect of thermal discharges on fish and marine invertebrates and concluded that they would probably be negligible except in the immediate vicinity of the discharge ports. From present knowledge, this should not cause any significant or long-term changes in the distribution or species composition of organisms in the Hampton-Seabrook estuary or offshore area. It is possible that numbers of detritus and deposit-feeding animals may increase in the immediate area of the discharge due to availability of dead plankters that are killed in the cooling water.

Effects of entrainment were also discussed in Section 5.1. Because of the relatively high delta T (Δt) and the long entrainment time, it is expected that entrainment will result in considerable mortality of entrained plankton. The significance of this problem can be directly related to the quantity and distribution of plankton in the waters that serve as a source of cooling water for the plant and the extent to which water exiting the discharge pipe is re-mixed with resident non-entrained waters. It is our hypothesis, based on a review of the literature and several months study, that:

1) the source of cooling water is large compared to the requirements of the plant (see Section 2.5);

2) that the plankton within these waters is ubiquitously distributed along the coastal waters of the Gulf of Maine;

3) that the numbers of plankton existing in the waters that will serve as a source of cooling water for the plant are large compared to the number that will be entrained in the plant;

4) that there is adequate advective currents in the discharge area to insure quick and complete mixing of the discharge waters; and

5) that this mixing of the waters will result in redistribution of the plankton so no "unit" of discharged water will remain void of living plankters for any long period of time.

This hypothesis, complemented by a general knowledge of the reproductive potential of holoplanktonic and meroplanktonic organisms leads us to conclude that the entrainment of planktonic organisms at the Seabrook Station would have no unreasonable ecological impact.

The probability of fish entrapment is primarily an engineering problem. Proper design of the intake structure will minimize the number of fish entering the intake tunnel. Experience with power plants in the area has shown entrapment of fish to be a minor problem. A brief description of these studies and their pertinence to the Seabrook Station is provided in Section 5.1. Based on the existing knowledge of local fish populations and intake design measures to mitigate entrapment it is unlikely that long-term effects would be felt.

Although discharges of radioactive wastes and neutralized demineralized regenerants will take place, the concentration released will be monitored (see subsections 6.1.1.1 and 6.1.1.3) to insure that they do not exceed regulatory agency standards. Compliance with these standards should ensure that there would be no unreasonable effect on local organisms.

In summary, in evaluating possible long-term effects, we have been unable to find significant evidence of either unfavorable or beneficial ecological effects due to plant construction or operation. Any changes brought about will probably be damped out by those perturbations natural to the environment.

Appendix 5.A

ADDITIONAL INFORMATION NEEDED FROM APPLICANTS FOLLOWING OPTION PROVIDED IN THE SEPTEMBER 4, 1975 AMENDMENT TO SECTION II.D. OF APPENDIX I

The following question and answer information is presented to comply with the request delineated in Enclosure 1 of a letter dated September 12, 1975 from the Nuclear Regulatory Commission which specifies what additional information is needed from applicants following the option provided in the September 4, 1975, amendment to Section II.D of Appendix I of 10 CFR Part 50, Code of Federal Regulations. For information and reference, the above mentioned letter is attached at the end of this appendix.

Question 1a.

For each building housing systems containing radioactive materials, provide a description of the provisions incorporated to reduce radioactive releases (iodine and particulates) from the ventilation exhaust system.

Answer 1a.

Buildings housing systems containing radioactive materials include:

1. Containment Enclosure Area
2. Fuel Storage Building
3. Containment Structure
4. Primary Auxiliary Building
5. Waste Processing Building
6. Turbine Building

Containment Enclosure Area

During normal plant operation 27,335 cfm of ventilation exhaust air from this area is filtered through a HEPA/charcoal filter train before being discharged into the unit plant vent. This filter train system is described in PSAR Section 9.4.2 and shown on PSAR Fig. 9.4-2. The HEPA/charcoal filter train consists of a roll filter, a medium efficiency filter, a HEPA filter, charcoal guard bed and an all welded adsorber section containing a four inch deep charcoal bed.

During emergency plant conditions the area will be isolated from adjacent areas and from the outside. It will be kept at a negative pressure of -0.25 in.W.G. by exhausting air from the area through a HEPA/charcoal filter train before being discharged into the unit plant vent. The filter train system is described in PSAR Subsection 6.2.3.5 and shown on PSAR Fig. 9.4-5. The HEPA/charcoal filter train consists of a moisture separator, HEPA filter, an all welded adsorber section containing a four inch deep charcoal bed and a second HEPA filter section.

Fuel Storage Building

During periods when irradiated fuel outside of a cask is being handled the fuel storage building is isolated from adjacent areas and the outside except that 15,000 to 30,000 cfm of ventilation air is drawn from the PAB ventilation supply air system. The building is kept at a negative pressure of -0.25 in.W.G. by modulating the supply air dampers and by operating one or two HEPA/charcoal filter trains. The filtered exhaust air is then discharged into the unit plant vent. The filter train system is described in a PSAR Section 9.4.6. The HEPA/charcoal filter train consists of a moisture separator, heater, HEPA filter, charcoal guard bed, an all welded adsorber section containing a four inch deep charcoal bed and a second HEPA filter section.

Following a fuel handling accident the ventilation, clean up and exhaust system operated identical to the way it does during fuel handling except that only one exhaust filter train is operated.

During periods other than described above the building normal ventilation system is operated. This system does not provide any exhaust air filtration. The exhaust air is, however, discharged to the unit plant vent.

Containment Structure

During normal plant operation the containment environment can be recirculated through a clean up HEPA/charcoal filter train at the rate of 4000 cfm. The filter train is described in PSAR Subsection 6.2.3.3 and shown on PSAR Fig. 9.4-5. The HEPA/charcoal filter train consist of a prefilter, a HEPA filter and a tray type adsorber section containing a two inch deep charcoal bed.

After reactor shutdown and prior to personnel entry into the containment, a containment purge system will be operated with a HEPA/charcoal filter train in the exhaust system prior to the exhaust air being discharged to the plant unit vent. This purge system will purge at the rate of 15,000 cfm. The purge system with the filter train unit is described in PSAR Subsection 6.2.3.2 and shown on PSAR Fig 9.4-2. The HEPA/charcoal filter train consists of a prefilter, a HEPA filter and an all welded adsorber section containing a four inch deep charcoal bed.

Primary Auxiliary Building

The PAB has a ventilation air flow pattern which draws air from areas with low radioactivity into areas of high radioactivity. These areas of higher radioactivity are exhausted through a HEPA/charcoal clean up filter train at the rate of 14,425 cfm prior to it being exhausted to the unit plant vent. This filter train also collects the 27,335 cfm from the Containment Enclosure Area described above and operated continuously at 41,760 cfm during all normal plant operation. The filter train is described in PSAR Section 9.4.2 and is shown in PSAR Fig. 9.4-2. The HEPA/charcoal filter train consists of a roll filter, a medium efficiency filter, a HEPA filter, a charcoal guard bed and an all welded adsorber section with a four inch deep charcoal bed.

Waste Processing Building

The Waste Processing Building has no provisions to reduce radioactive releases from the exhaust ventilation system, however, the exhaust air is discharged to the unit plant vent.

Turbine Building

The turbine building ventilation system is a non-ducted system. The ventilation air enters at the lower floor elevations and circulates up through the upper floor elevations via floor grating and openings. The ventilators air is then exhausted to the atmosphere through power roof ventilation located on the turbine building and heater bay. There are no provisions to reduce radioactive releases from the turbine exhaust ventilation system. The ventilation system is described in PSAR Section 9.4.4.

Question 1b.

For each building housing systems containing radioactive materials, provide the location, height of release, inside dimensions of release point exit, effluent temperature and exit velocity.

Answer 1b.

All of the exhaust air from the buildings housing systems containing radioactive materials discussed in the response to Question 1a above, except for the turbine building exhaust, are discharged through the plant unit vents. The plant unit vents are heavy gauge steel exhaust stacks up the side of the outer containment shell. They follow the contour of the containment dome and when they reach the top they have an elbow looking up. The elevation of the release point is about elevation 208 feet above MSL. The inside dimensions of the vent on Unit 1 is 6 feet by 9 feet and on Unit 2 it is 5 feet by 7 feet 6 inches. The release temperatures will be above 100°F on a design summer day and about 50°F on a design winter day.

Quantities of flow and exit velocities will be as tabulated below:

Building Areas	Flows in Cubic Feet Per Minute		
Unit 1	Normal	Fuel Hand. Max.	Fuel Hand. Min.
Containment Enclosure	27,335	27,335	0
Fuel Storage Building	33,000	30,000	15,000
Containment Structure	-	40,000	0
PAB (Radioactive Areas)	14,425	14,425	0
Waste Processing Building	110,840	110,840	110,840
PAB (Clean Area)	46,800	46,800	46,800
TOTAL	232,400	269,400	172,640

Supplement
October, 1975

Building Areas	Flows in Cubic Feet Per Minute		
Unit 2	Normal	Fuel Hand. Max.	Fuel Hand. Min.
Same as Unit 1 less WPB	121,560	158,560	61,800

Exit Velocities

Unit 1

Normal	4500 fpm
Fuel Handing, Max.	5300 fpm
Fuel Handing, Min.	3500 fpm

Unit 2

Normal	3300 fpm
Fuel Handling, Max.	4600 fpm
Fuel Handling, Min.	1800 fpm

There are ten turbine building exhaust ventilators located on the turbine building roof, and ten heater bay exhaust ventilators located on the heater bay roof.

Each turbine building ventilator has a maximum flow rate of 54,000 cfm, with a maximum exit velocity of exhaust of 2634 feet per minute. The turbine building ventilators are situated 129 feet 6 inches above ground level, and each has a 62 inch inside diameter.

Each heater bay ventilator has a maximum flow rate of 44,000 cfm with a maximum exit velocity of exhaust of 2750 feet per minute. The heater bay roof ventilators are situated 76 feet 2 inches above ground level, and each has a 56 inch inside diameter.

The release temperature will range from about 50°F to 175°F.

Question 1c.

For the containment building indicate the expected purge and venting frequencies and duration, and continuous purge rate (if used).

Answer 1c.

The reactor containment building is assumed to be purged four times a year. Two purges are considered to result from cold shutdowns for annual fuel loading and planned maintenance. The remaining two shutdowns are considered to occur while the reactor is in a hot standby condition to allow maintenance requiring access to the containment. There are no plans at the present time for continuous purge.

Question 2.

For a pressurized water reactor having recirculating U-tube steam generators and employing all volatile treatment (AVT) to main secondary coolant chemistry, provide the following information:

Question 2a.

Expected blowdown rate (lb.hr) and method of processing blowdown.

Answer 2a.

See Section 10.4.8, Steam Generator Blowdown System of the Seabrook Station PSAR (amendment 35).

Question 2b.

Number and type of condensate demineralizers (if applicable) and flow rate of condensate through polishing demineralizers (lb/hr.).

Answer 2b.

Not applicable. Seabrook will not utilize condensate demineralizers.

Question 2c.

Expected frequency of resin regeneration or replacement, volumes and and radioactivity of regenerant and rinse solutions, sluice water, or backwash water per batch of resin regenerated or replaced.

Answer 2c.

Not applicable to the Seabrook Station design.

Question 2d.

Method of collection, processing and disposal of liquid wastes, including decontamination factors assumed for process operations.

Answer 2d.

See Seabrook Station PSAR Section 11.2, Liquid Waste System, for method of collection, processing, and disposal of liquid wastes and decontamination factors assumed.

Question 2e.

P&ID's and process flow diagrams for the steam generator blowdown system and condensate polishing system.

Answer 2e.

See Seabrook Station PSAR Figure 10.4-9, (amendment 35).

Question 3

Provide a map showing the detailed topographical features (as modified by the plant) on a large scale within a 10-mile radius of the plant and a plot of the maximum topographic elevation versus distance from the center of the plant in each of the sixteen 22-1/2 degree cardinal compass point sectors (centered on true north), radiating from the center of the plant, to a distance of 10 miles.

Answer 3

Figure 5.A-1 is a map showing the detailed topographical features of the site area within 10 miles of the plant. Figures 5.A-2 (a through f) plot the maximum topographic elevation versus distance from the center of the plant in each of the sixteen principle compass directions.

Question 4

Provide representative annual and, if available, monthly summaries of wind speed and direction by atmospheric stability class, in joint frequency form from onsite data. If available, describe airflow trajectory regimes of importance in transporting effluents to a distance of 5 miles from the plant, including airflow reversals.

Answer 4

Monthly, seasonal, and annual joint frequency distributions of wind speed and wind direction by delta T stability class from onsite data have been provided for the period December 1972 through November 1973 in a report entitled "Seabrook Station Meteorological Data Supplement (February 1974)". This information was supplied in response to Question 2.25 of the Seabrook PSAR (amendment 7).

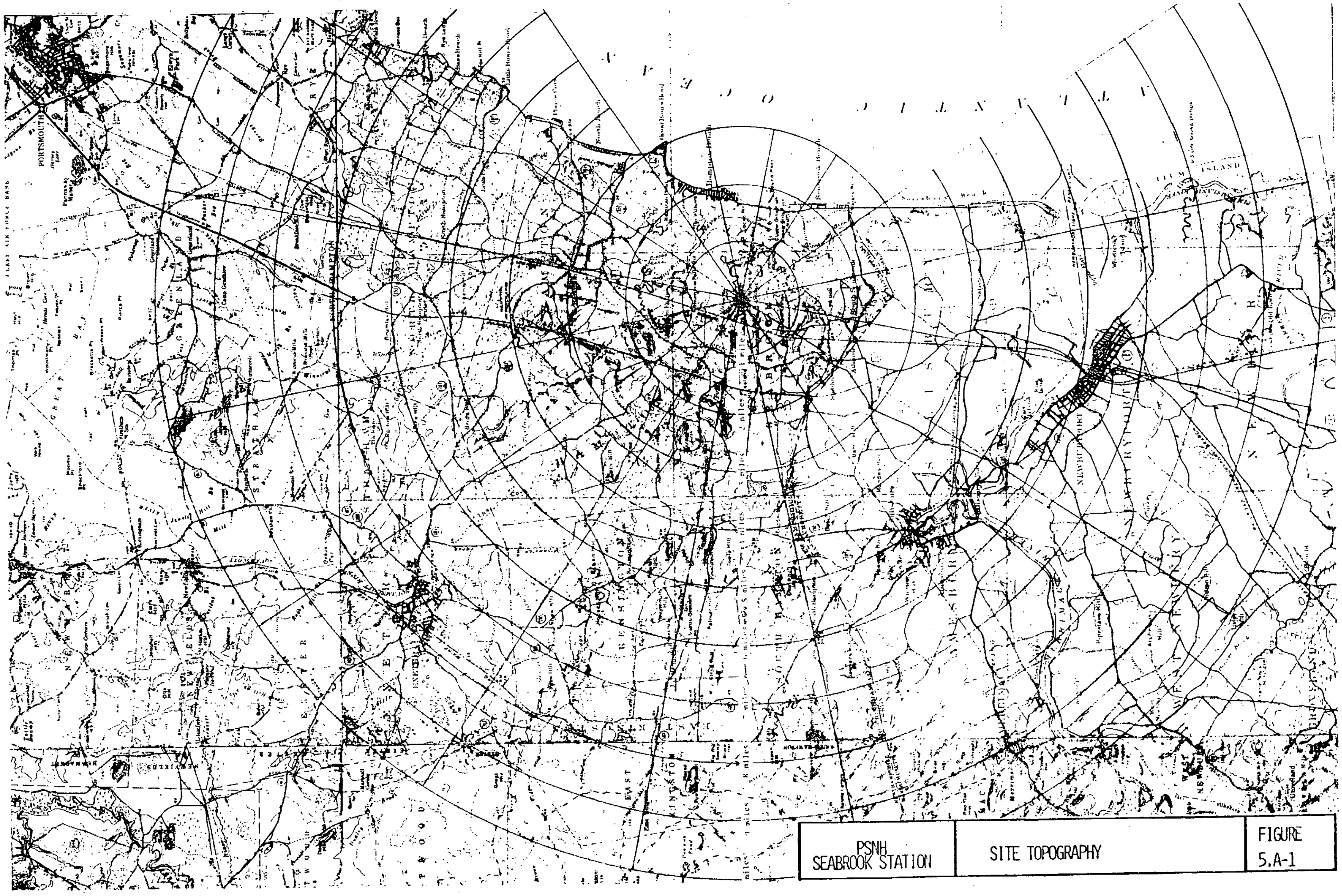
Question 5

Tabulate, for each compass point sector radiating from the center of the plant, the location of the nearest existing milk producing animals (cows and goats) within 5 miles of the site.

Answer 5

The following table indicated the location of the nearest cows and goats in each sector from the plant to a distance of 5 miles.

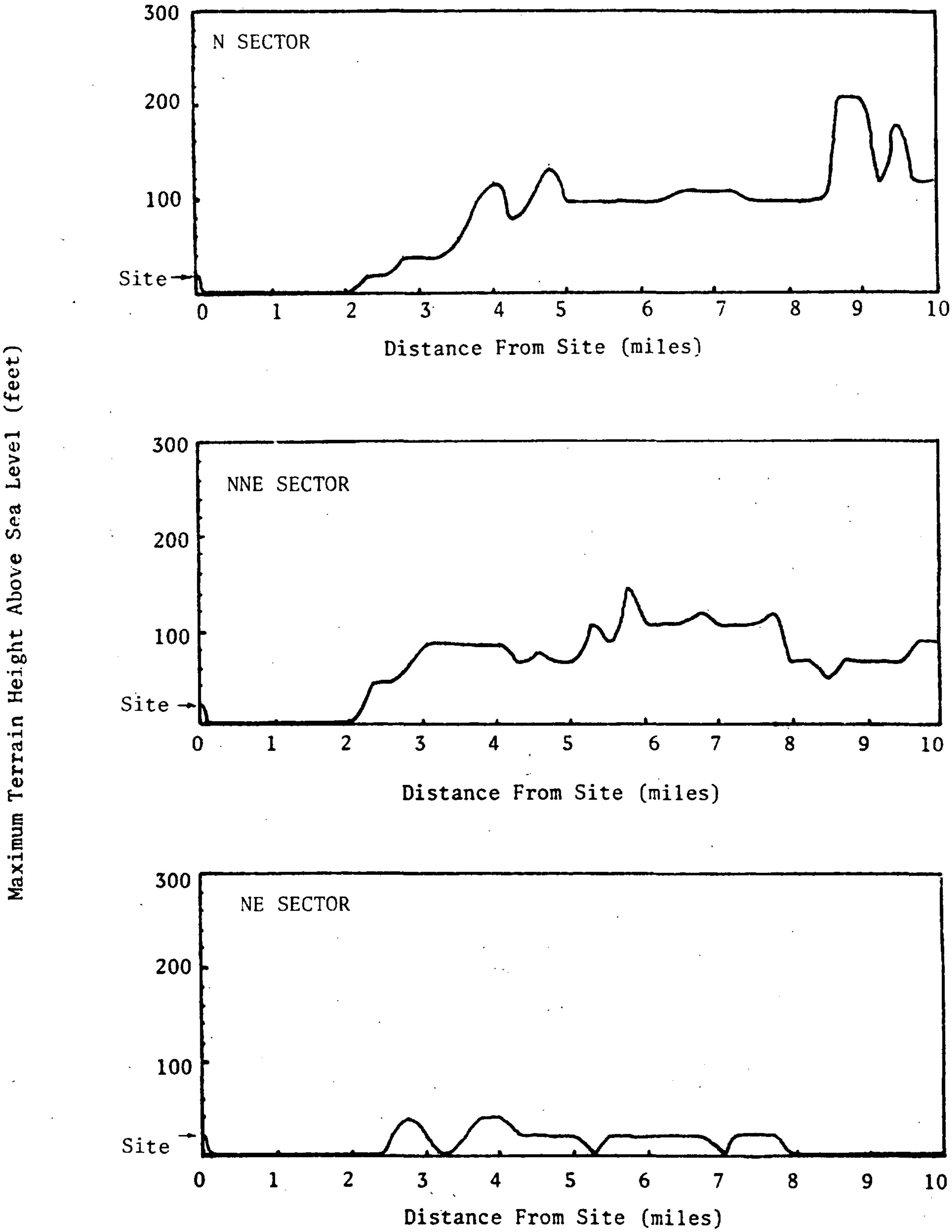
Sector	Nearest Cows (miles)	Nearest Goats (miles)
N	2.6	-
NNE	2.4	-
NE	-	3.6
ENE	-	-
E	-	-
ESE	-	-
SE	-	-
SSE	-	-
S	4.1	-
SSW	2.5	-
SW	2.5	-
WSW	2.6	-
W	-	-
WNW	3.9	-
NW	-	2.4
NNW	2.8	-



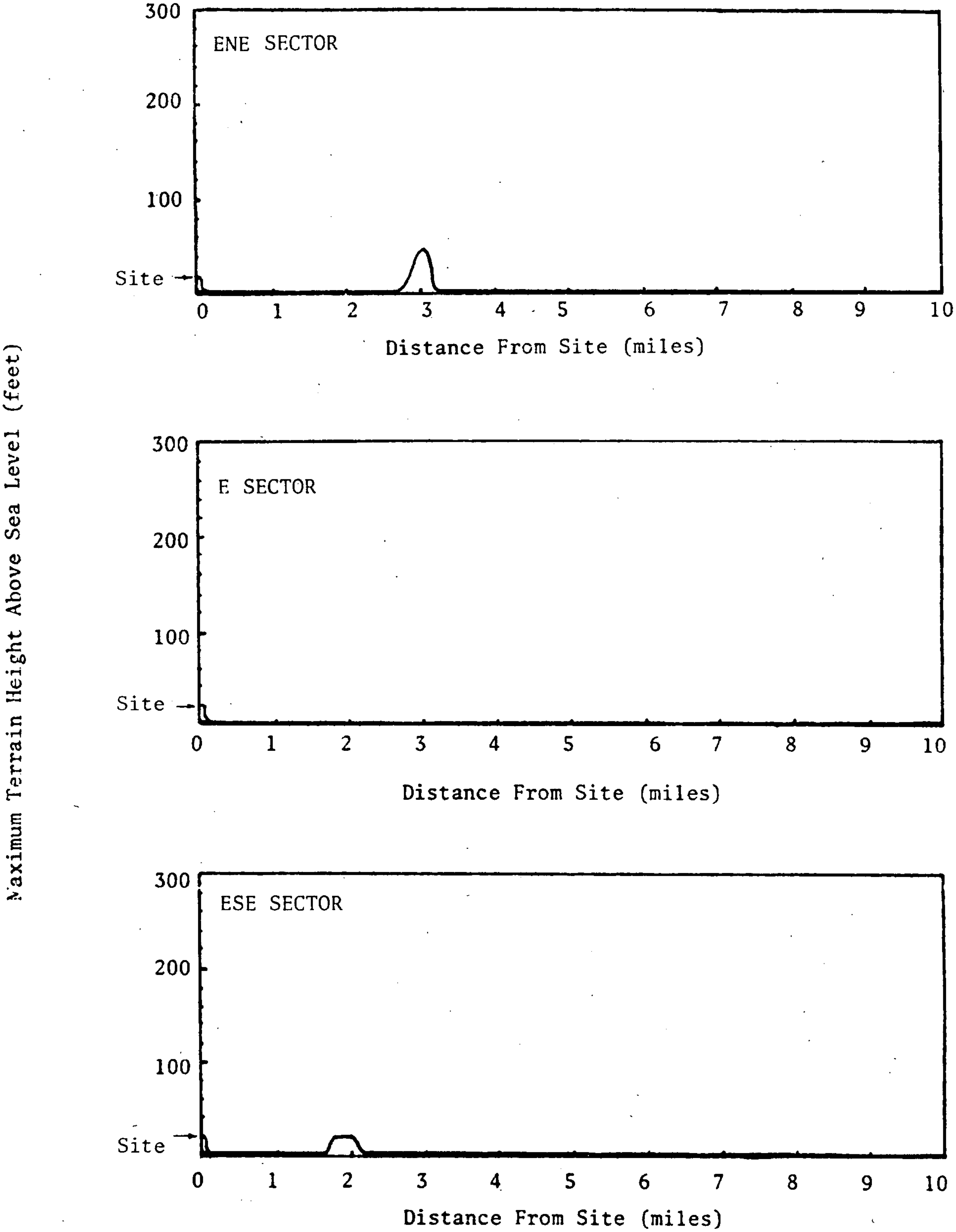
PSNH
SEABROOK STATION

SITE TOPOGRAPHY

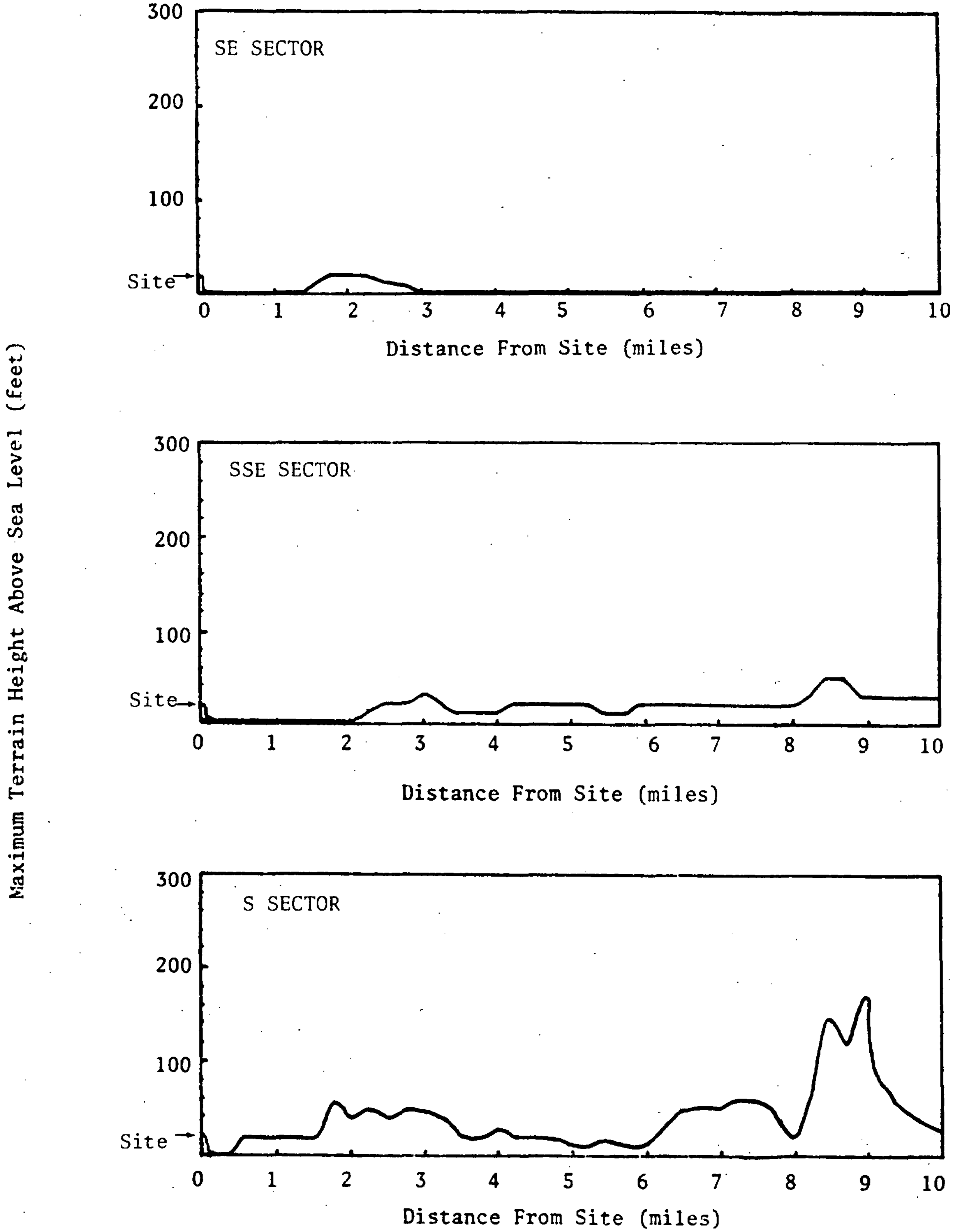
FIGURE 5.A-1



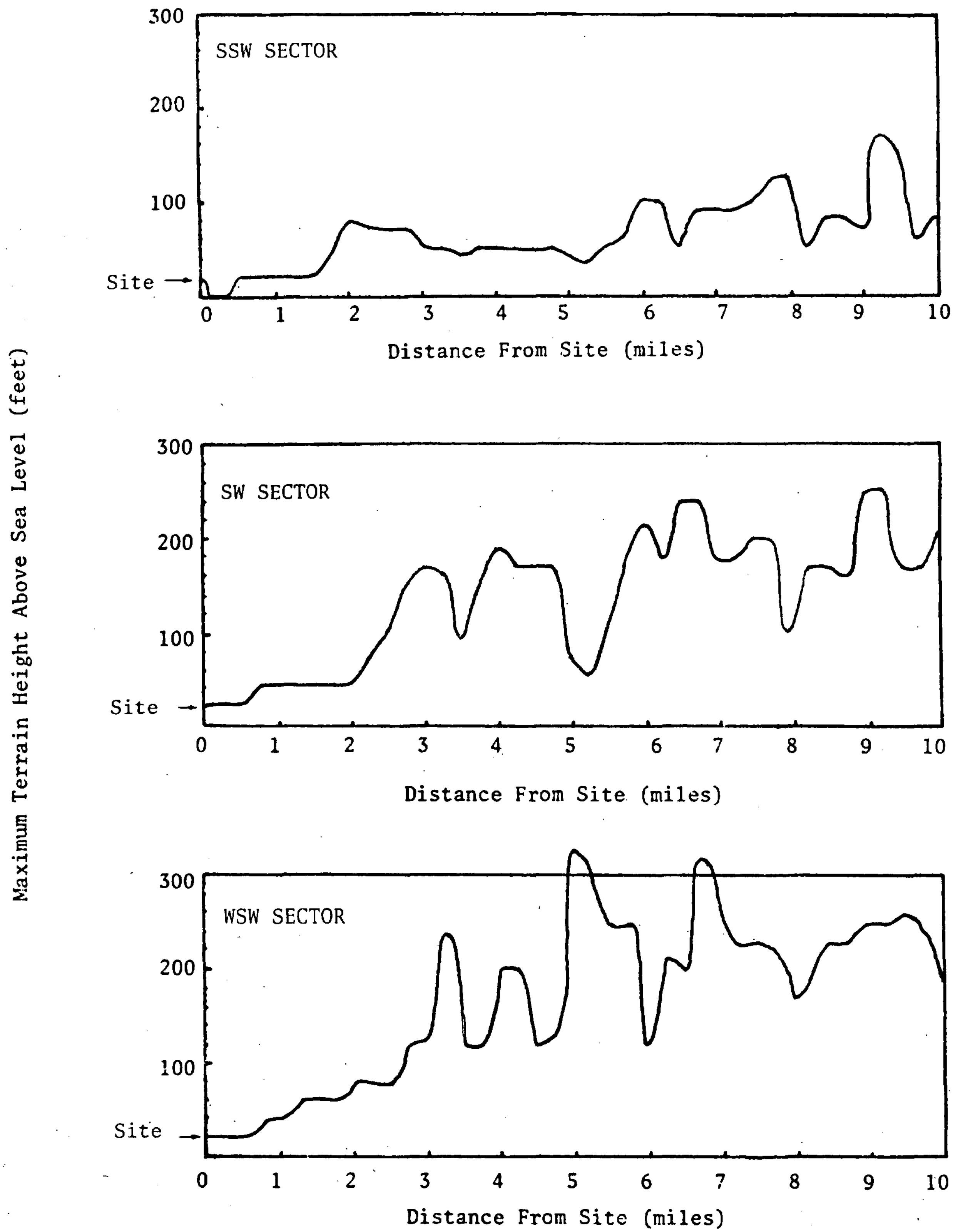
PSNH SEABROOK STATION	MAXIMUM TERRAIN ELEVATION AROUND THE SITE	FIGURE 5.A-2A



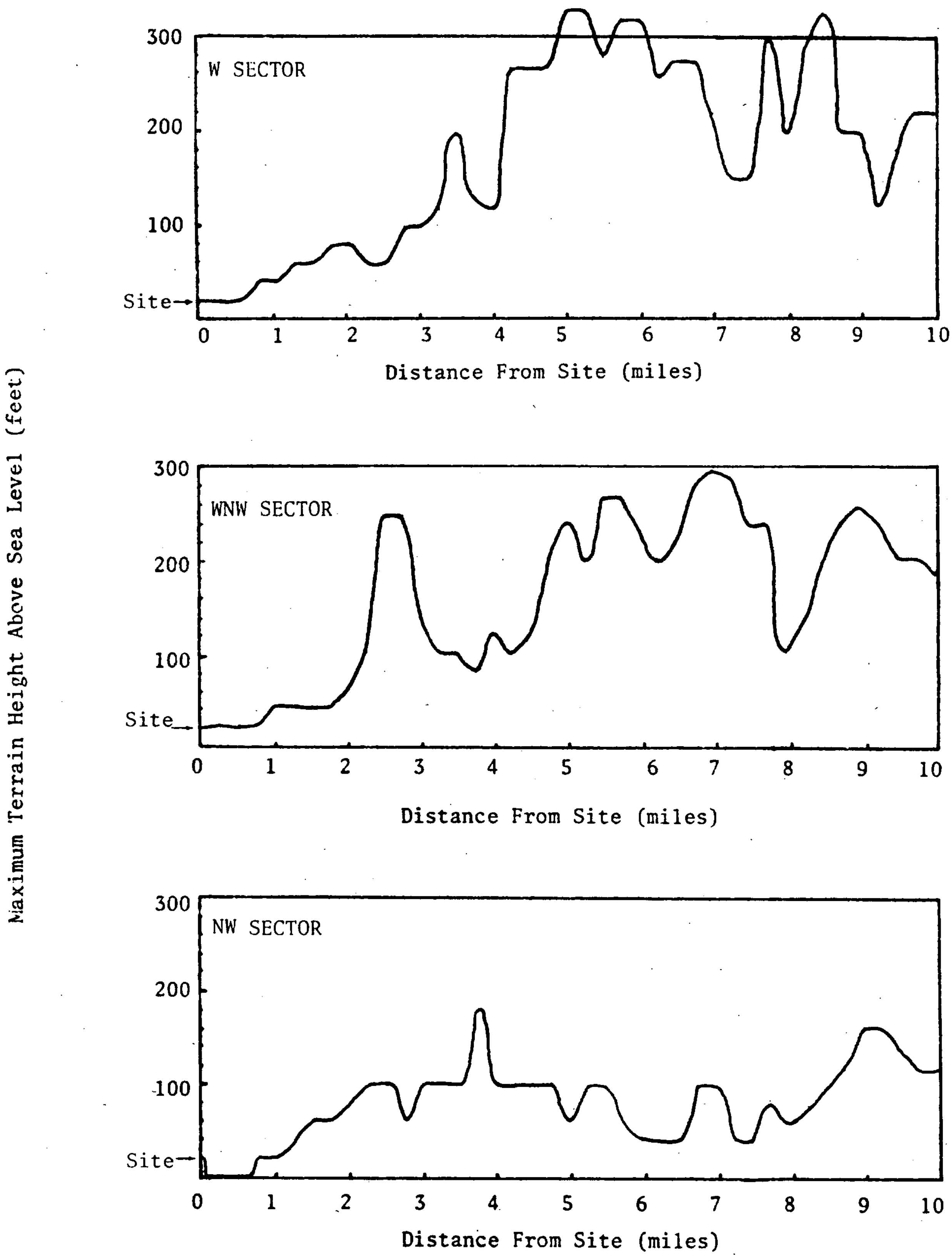
PSNH SEABROOK STATION	MAXIMUM TERRAIN ELEVATION AROUND THE SITE	FIGURE 5.A-2B



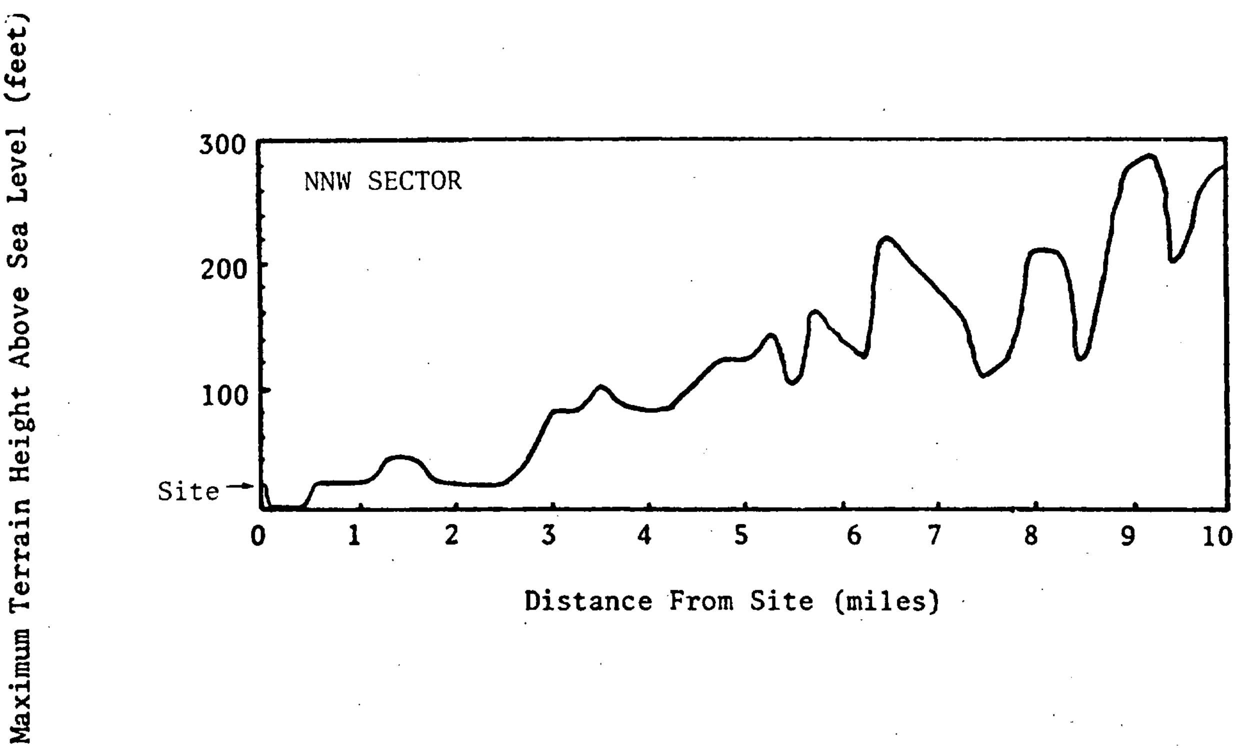
PSNH SEABROOK STATION	MAXIMUM TERRAIN ELEVATION AROUND THE SITE	FIGURE 5.A-2c



PSNH SEABROOK STATION	MAXIMUM TERRAIN ELEVATION AROUND THE SITE	FIGURE 5.A-2D



PSNH SEABROOK STATION	MAXIMUM TERRAIN ELEVATION AROUND THE SITE	FIGURE 5.A-2E



PSNH SEABROOK STATION	MAXIMUM TERRAIN ELEVATION AROUND THE SITE	FIGURE 5.A-2F

Such realistic staff models have been developed, and Enclosure 2 reflects the information we believe you should provide in order to use these models in the cost-benefit analysis of the radwaste system of your facilities. We recognize that because of difficulty in obtaining data it may not be practical in all cases to perform the most realistic dose calculation that is technically achievable. Therefore, if you choose to carry out the cost-benefit analysis and to provide site specific data in less detail than requested in Enclosure 2, it will be necessary to use a less complex calculational procedure comparable in conservatism to that used in the past, to demonstrate compliance with the Appendix I guidelines. Thus, the depth and scope of the information you wish to provide will dictate the calculational procedures to be used to demonstrate compliance with the Appendix I design objectives, but the information provided should, as a minimum, be sufficient to support the analyses used in your assessments. In any event, the calculational procedures utilized to demonstrate compliance with Appendix I and the data to be used in those models must be such that the actual exposure of an individual is unlikely to be substantially underestimated.

If the information requested in Enclosures 1 or 2 has been provided by you in material which you already have submitted or if the information has been provided for another docket file, references as to where the requested information can be found will be sufficient.

Delays in the review process will be minimized, if you submit a complete response to this letter by October 13, 1975. To further assure that the staff has sufficient information to perform its analyses, it may be necessary for members of our respective staffs to meet. Arrangements for such a meeting will be made subsequent to our review of your responses. To aid in our scheduling, please inform us within seven days after the receipt of this letter of the date you will be able to provide the requested information.

Your reply should consist of three signed originals and 197 additional copies as a sequentially numbered supplement to your environmental report (ER). If the information provided in the ER changes the description of systems or designs previously described in your PSAR an appropriate amendment of the PSAR should also be submitted.

The reporting requirements and the application requirements contained in Appendix I of 10 CFR Part 50 have been approved by the U.S. General Accounting Office under clearance number B-180225 (920071). This clearance expires June 30, 1978.

Sincerely,

Daniel R. Muller

Daniel R. Muller, Assistant Director
for Environmental Projects
Division of Reactor Licensing

Enclosures:
1) Additional Information needed to comply with 9/4/75 Amendment to Appendix I

2) Additional Information needed to comply with Section II.D. of Appendix I issued 5/5/75

cc: (see attached list)

cc:

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ADDITIONAL INFORMATION NEEDED FROM APPLICANTS FOLLOWING OPTION PROVIDED IN THE SEPTEMBER 4, 1975, AMENDMENT TO SECTION II.D. OF APPENDIX I

1. For each building housing systems containing radioactive materials:

   a. Provide a description of the provisions incorporated to reduce radioactive releases (iodine and particulates) from ventilation exhaust systems.

   b. Provide the location, height of release, inside dimensions of release point exit, effluent temperature and exit velocity.

   c. For the containment building indicate the expected purge and venting frequencies and duration, and the continuous purge rate (if used).

2. For a pressurized water reactor having recirculating U-tube steam generators and employing all volatile treatment (AVT) to main secondary coolant chemistry, provide the following information:

   a. Expected blowdown rate (lb/hr) and method of processing blowdown.

   b. Number and type of condensate demineralizers (if applicable) and flow rate of condensate through polishing demineralizers (lb/hr).

   c. Expected frequency of resin regeneration or replacement, volumes and radioactivity of regenerant and rinse solutions, sluice water, or backwash water per batch of resin regenerated or replaced.

   d. Method of collection, processing and disposal of liquid wastes, including decontamination factors assumed for process operations.

   e. P&ID's and process flow diagrams for the steam generator blowdown system and condensate polishing system.

3. Provide a map showing the detailed topographical features (as modified by the plant) on a large scale within a 10-mile radius of the plant and a plot of the maximum topographic elevation versus distance from the center of the plant in each of the sixteen 22-1/2 degree cardinal compass point sectors (centered on true north), radiating from the center of the plant, to a distance of 10 miles.

4. Provide representative annual and, if available, monthly summaries of wind speed and direction by atmospheric stability class, in joint frequency form from onsite data. If available, describe airflow trajectory regimes of importance in transporting effluents to a distance of 5 miles from the plant, including airflow reversals.

5. Tabulate, for each compass point sector radiating from the center of the plant, the location of the nearest existing milk producing animals (cows and goats) within 5 miles of the site.

NOTE: If you choose to provide site specific data in less detail than requested above, it will be necessary to use a less complex calculational procedure comparable in conservatism to that used in the past, to demonstrate compliance with the Appendix I guidelines. Thus, the depth and scope of the information you wish to provide will dictate the calculational procedures to be used to demonstrate compliance with the Appendix I design objectives, but the information provided should, as a minimum, be sufficient to support the analyses used in your assessments. In any event, the calculational procedures utilized to demonstrate compliance with Appendix I and the data to be used in those models must be such that the actual exposure of an individual is unlikely to be substantially underestimated.

ADDITIONAL INFORMATION NEEDED TO COMPLY WITH SECTION II.D OF APPENDIX I ISSUED MAY 5, 1975

General: Predictive models are necessary in estimating the concentrations of radionuclide effluents in pathways to man and their resultant doses. For the purpose of implementing the requirements of Appendix I, models are classified into two categories: those that estimate physical effects using simplifying, conservative assumptions, and those that are state-of-the-art attempts at realistically modeling physical effects. Prediction of the transport of radioactive effluents may require the use of one or both categories of models, each applicable under different situations and for different regions of the environment. A discussion of the rationale for model choice, the range of applicability of the models utilized, the methods used in model calibration and verification, and the input data selected for prediction should be provided as indicated below. The following request for information is generic in nature and may not be uniformly applicable to all sites and models utilized. The information provided should be sufficient to support the analysis to be used in your Appendix I assessments. Where the requested information has been previously provided in either the ER or SAR, provide a specific cross reference thereto. The projected plant operating life should be assumed to be 30 years.

A. Hydrology

1. Provide quantitative water-use diagrams for the plant showing maximum and monthly average flow rates to and from the various plant water systems (heat dissipation system, sanitary system, radwaste and chemical waste systems, process water system, etc.) in support of liquid radionuclide release rate and concentration estimates.

2. Provide the maximum and monthly average consumptive use of water by the plant. Include consideration of maximum and minimum power operation and temporary shut down.

3. Provide estimated monthly average release rates (flow volume and concentration) for liquid radionuclide effluents.

4. Provide a detailed description of the liquid discharge structure. Identify any institutional restrictions (State or local) on releases.

5. Identify the location, nature, and amounts of present and projected (over plant life) surface water uses (e.g., water supply, irrigation, reservoirs, fisheries, recreation) within 50 miles of the plant where detectable amounts of radioactivity from plant liquid effluents may be expected to affect such use. (See question 6 also.) The bases for estimating present and projected water use

must be provided and the users located on maps of legible scale. Provide a tabulation of the following specific information for water users.

a. Map identification key;

b. Radial and water route distance from the plant to the intake and discharge;

c. Withdrawal and return rates in cfs or gpm for present and projected monthly use;

d. Type of water use (e.g., municipal, industrial, irrigation);

e. Source and projection dates of water use estimates.

6. The ambient flow field of the water body affected by plant liquid radionuclide effluents must be described out to a radius of 50 miles. Expected seasonal and other temporal variations of important parameters (e.g., flows, currents, tides) should be described. At all points that could be affected by detectable amounts of radioactivity from plant liquid effluents where water is used, or where there are important changes in flow parameters, the following information should be provided for both present and projected conditions.

   a. For rivers, provide monthly average flows, velocities, and water levels. In the case of large lake and coastal sites, provide estimates of the persistence and frequency distribution of current magnitude and direction;

   b. Bathymetry and shoreline geometry;

   c. Bases and sources for data and estimates.

7. Describe the ambient flow conditions at, and downstream of the plant, for both present and projected upstream use. The area of consideration is <u>not</u> limited to 50 miles, but must reflect all important upstream processes that may affect the ambient flow. Provide information similar to that requested in 5 and 6 above for the points of significant effect.

8. Provide estimates of radionuclide concentrations and travel times at use locations identified in 5, above annually and for the time periods used to identify water use, flow fields and release rates. Describe the transport model(s) used, input data and parameters, sources of data and parameters, techniques and results of both laboratory and field calibration and verification studies, and the results of sensitivity analyses.

must be provided and the users located on maps of legible scale. Provide a tabulation of the following specific information for water users.

a. Map identification key;

b. Radial and water route distance from the plant to the intake and discharge;

c. Withdrawal and return rates in cfs or gpm for present and projected monthly use;

d. Type of water use (e.g., municipal, industrial, irrigation);

e. Source and projection dates of water use estimates.

6. The ambient flow field of the water body affected by plant liquid radionuclide effluents must be described out to a radius of 50 miles. Expected seasonal and other temporal variations of important parameters (e.g., flows, currents, tides) should be described. At all points that could be affected by detectable amounts of radioactivity from plant liquid effluents where water is used, or where there are important changes in flow parameters, the following information should be provided for both present and projected conditions.

   a. For rivers, provide monthly average flows, velocities, and water levels. In the case of large lake and coastal sites, provide estimates of the persistence and frequency distribution of current magnitude and direction;

   b. Bathymetry and shoreline geometry;

   c. Bases and sources for data and estimates.

7. Describe the ambient flow conditions at, and downstream of the plant, for both present and projected upstream use. The area of consideration is <u>not</u> limited to 50 miles, but must reflect all important upstream processes that may affect the ambient flow. Provide information similar to that requested in 5 and 6 above for the points of significant effect.

8. Provide estimates of radionuclide concentrations and travel times at use locations identified in 5, above annually and for the time periods used to identify water use, flow fields and release rates. Describe the transport model(s) used, input data and parameters, sources of data and parameters, techniques and results of both laboratory and field calibration and verification studies, and the results of sensitivity analyses.

1. Provide the following information from the onsite meteorological program:

   a. Monthly and annual wind speed and direction data, in joint frequency form, at all heights of measurement representative of wind characteristics for points of effluent release to, and transport within, the atmosphere.

   b. Monthly and annual joint frequencies of wind direction and speed by atmospheric stability class at heights and intervals relevant to atmospheric transport of effluents.

   c. Total precipitation by month, number of hours with precipitation, rainfall rate distributions and monthly precipitation wind roses.

   Note: The information, based on onsite meteorological measurements, should include at least one annual cycle of data collection from the onsite program. The information should be fully documented and substantiated as to the validity of its representation of expected long term conditions at and near the site.

2. Provide the following information, concerning regional meteorological conditions characterizing atmospheric transport processes within 50 miles of the plant, for as many relevant stations as practicable or necessary to define these transport processes within the region:

   a. Wind speed and direction data at all heights(s) at which wind characteristic data are applicable or have been measured;

   b. Atmospheric stability data as defined by vertical temperature gradient or other well-documented parameters that have been substantiated by diffusion test data;

   c. Monthly mixing height data; and

   d. Total precipitation by month, number of hours with precipitation, rainfall rate distributions and monthly precipitation wind roses.

   e. Describe airflow trajectory regimes of importance in transporting effluents to a distance of 50 miles from the plant, including airflow reversals.

   Note: The regional meteorological information provided should be based on at least a one-year period of record and should be concurrent for each station with the period of onsite data collection. Both onsite and regional meteorological data should be presented for each hour, and if possible also be available on magnetic tapes to expedite the staff review. Sources of meteorological information, in addition to the onsite program could include available National Weather Service (NWS) stations and other well-maintained and well-exposed (e.g. other nuclear plants, university, private meteorological programs) meteorological facilities.

3. Provide the following topographical information:

   a. A map showing the detailed topographic features (as modified by the plant) on a large scale within a 5-mile radius of the plant, and a smaller scale map showing topography within a 50-mile radius of the plant.

   b. A plot of the maximum topographic elevation versus distance from the center of the plant in each of the sixteen 22-1/2 degree cardinal compass point sectors (centered on true north, etc.), radiating from the center of the plant, to a distance of 50 miles.

4. Provide the following information concerning meteorological data:

   a. The identity of the sources of meteorological data used in the atmospheric transport models to assess the dispersion of gaseous effluents from the plant to a distance of 50 miles, and a description of the locations and elevations of all observations and the frequency and duration of the measurements made at each station.

   b. A description of the onsite pre-operational and operational meteorological programs including the instruments, performance specifications, calibration and maintenance procedures, data output and recording systems and locations, and data analysis procedures.

   c. A detailed description of any models(s) to derive estimates of basic meteorological parameters, such as atmospheric stability, and information concerning the validity and accuracy of the model(s).

5. Provide the following information concerning concentration evaluations:

   a. Estimates of relative concentrations (X/Q) and or deposition (D/Q) at points of potential maximum concentration outside the site boundary, at points estimated maximum individual exposure, and at points within a radial grid of sixteen 22-1/2 degree sectors (centered on true north, etc.) and extending to a distance of 50 miles from the plant. A set of data points should be located within each sector at increments of .25 mile to a distance of 1 mile, at increments of .5 mile from a distance of 1 to 5 miles, at increments of 2.5 miles from a distance of 5 to 10 miles, and at increments of 5 miles thereafter to a distance of 50 miles.

b. Estimates of X/Q for noble gas effluents and, if applicable, X/Q depleted by deposition and D/Q for iodine effluents at each of these grid points, as well as averages of these X/Q and/or D/Q values between all adjacent grid points along the radials.

c. A detailed description of the model(s) and the model assumption(s) used to determine the air concentrations and/or deposition, and information concerning the validity and accuracy of the model(s) and assumptions, and the identity of the meteorological data used.

C. <u>Radiological Dose Assessment</u>

1. If there is a priori knowledge that the current 50 mile population age distribution may be significantly different from the U.S. population distribution, then furnish the current age distribution of the 50 mile population (e.g., 0-12, 12-18, >18).

2. Provide in tabular form, the distances from the centerline of the first operational reactor for each of the sixteen sectors described in Section 2.1.3 of R.G. 4.2, Rev. 1, to the nearest vegetable garden (greater than 500 ft^2) out to a distance of 5 miles.

3. Tabulate, for each compass point sector radiating from the center of the plant, the location of the nearest existing milk producing animals (cows and goats) within 5 miles of the site.

4. Provide data on annual meat (kg/yr), milk (liters/yr) and truck farming production (kg/yr) and distribution within a 50 mile radius from the reactor. Provide the data by sectors in the same manner indicated in Sections 2.1.3.1 and 2.1.3.2 of R.G. 4.2, Rev. 1.

5. Furnish information on type, quantity and yield (kg/m^2) of crops grown.

6. Provide information on grazing season (give dates), feeding regimes for cattle (such as grazing practices, green chop feeding, corn & grass sileage feeding and hay feeding) pasture grass density (kg/m^2) and yield statistics (kg/m^2) for harvested forage crops for beef and dairy cattle feeding.

7. Determine and indicate in tabular format the present and projected commercial fish and shellfish catch (in lbs/yr) from contiguous waters within 50 miles of the plant discharge. Report the catch by total landings and by principal species, indicating the relative amounts used as human food. Indicate the location of principal fishing areas and ports of landing associated with these contiguous waters and relate these locations to harvest by species.

Indicate the relative amounts consumed locally. Determine and tabulate the present and projected recreational fish and shellfish harvest from these waters in the same format, also indicating principal fishing areas and their yield by species. As above, indicate the relative amounts consumed locally. Include any harvest and use of seaweed, other aquatic life, or any vegetation used as human food from these waters. Identify and describe any fish farms or similar aquatic activity within the 50-mile area utilizing water that may reasonably be affected by the power plant discharge. Indicate the species and production from each of these facilities and indicate the relative amounts consumed locally.

8. Identify any additional exposure pathways specific to the region around the site which could contribute 10% or more to either individual or population doses.

9. Annual Population Doses - Calculate, using the information provided in response to questions 1-8 above and any other necessary supporting data, the annual total-body man-rem and the annual man thyroid-rem to the population expected to reside in the 50 mile region at the midpoint of plant operation as well as the annual total body man-rem and the annual man thyroid-rem received by the U.S. population at the same time from all liquid and gaseous exposure pathways. Provide as an appendix to your response a description of the models and assumptions used in these calculations.

D. Effluent Treatment Systems

The following information should be consistent with the contents of the Safety Analysis Report (SAR) and Environmental Report (ER) for the proposed reactor. However, based on more recent operating data the staff has modified the calculational models previously used in the evaluation of radwaste treatment and effluent control systems. These modifications to models may result in an increase in the expected releases of radioactive materials in effluents particularly with respect to gaseous releases. In addition, the gaseous source terms now contain values for carbon-14, tritium, argon-41 and particulates not previously considered in our evaluation. Appropriate sections of the SAR and ER containing more detailed discussions of the required information should be referenced following each response. Each response, however, should be independent of the ER and SAR. This information constitutes the basic data required in performing a cost-benefit analysis for radwaste systems. All responses should be on a per-reactor basis.

1. Provide detailed cost estimate sheets, similar to attachments A and B, listing all parameters (and their bases) used in determining capital, operating, and maintenance costs associated with all augments considered in the cost-benefit analysis. All costs should be stated in terms of 1975 dollars.

2. Provide the cost of borrowed money used in the cost analysis and the method of arriving at this cost.

3. Describe the methods and parameters used in the cost-benefit analysis and provide bases for all parameters. Include the following information:

   a. Decontamination factors assigned to each augment and fraction of "on-line" time assumed, i.e., hours per year used.

   b. Parameters and method used to determine the Indirect Cost Factor and the Capital Recovery Factor.

4. Ventilation and Exhaust Systems

   For each building housing systems that contain radioactive materials, the BWR turbine gland seal exhaust and mechanical vacuum pump, the steam generator blowdown system vent exhaust (PWR), and the main condenser air removal system (PWR), provide the following:

   a. Ventilation system flow rates and provisions incorporated to reduce radioactivity releases through the ventilation or exhaust systems.

   b. Decontamination factors assumed and the bases (include charcoal absorbers, HEPA filters, mechanical devices).

   c. Release rates for radioiodine, noble gases, and radioactive particulates (Ci/yr), and the bases.

   d. Release points to the environment including location, height of release, inside dimension of release point exit, effluent temperature, and exit velocity.

   e. For the containment building, provide the building free volume (ft^3) and a thorough description of the internal recirculation system (if provided) including the recirculation rate, charcoal bed depth, operating time assumed, and mixing efficiency. Indicate the expected purge and venting frequencies and duration, and continuous purge rate (if used).

   f. If HEPA filters are used downstream of pressurized storage tanks provide the decontamination factor used in your evaluation.

5. Pressurized Water Reactor Blowdown System

For a pressurized water reactor having recirculating U-tube steam generators and employing all volatile treatment (AVT) to main secondary coolant chemistry, provide the following information:

a. Expected blowdown rate (lb/hr) and method of processing blowdown.

b. Number and type of condensate demineralizers (if applicable) and flow rate of condensate through polishing demineralizers (lb/hr).

c. Expected frequency of resin regeneration or replacement, volumes and radioactivity of regenerant and rinse solutions, sluice water, or backwash water per batch of resin regenerated or replaced.

d. Method of collection, processing and disposal of liquid wastes, including decontamination factors assumed for process operations.

e. P&ID's and process flow diagrams for the steam generator blowdown system and condensate polishing system.

ATTACHMENT A

TOTAL DIRECT COST ESTIMATE SHEET

Description of Augment ____

DIRECT COST (1975 $000)

ITEM	LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1. Process Equipment				
2. Building Assignment				
3. Associated Piping Systems				
4. Instrumentation & Controls				
5. Electrical Service				
6. Spare Parts				
SUBTOTAL				
7. Contingency				
8. TOTAL DIRECT COSTS				

ATTACHMENT B

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET

Description of Augment ______________________________

COST (1975 $000)

ITEM	LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1. Operating Labor, Supervisory and Overhead				
2. Maintenance Material and Labor				
3. Consumables, Chemicals and Supplies				
4. Utilities & Services Waste Disposal Water Steam Electricity Building Services Other				
5. TOTAL O & M ANNUAL COST				

6. ENVIRONMENTAL MONITORING PROGRAMS

6 EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 Applicant's Pre-Operational Environmental Programs

6.1.1 Surface Waters

6.1.1.1 Physical and Chemical Parameters

This subsection is divided into separate treatment of Hampton Harbor estuarine waters and offshore oceanic waters.

6.1.1.1.1 Hampton Harbor Estuarine Waters

Initial studies of the physical and chemical parameters of the Hampton Harbor estuary were started in 1968 with respect to the original Seabrook Station Nuclear Project. Studies of these parameters have been completed. No further extended effort is contemplated due to the fact that the plant cooling water system is different for the present Seabrook Station proposal. Since it is no longer proposed to take from or discharge cooling water to the estuary, and because the intake and discharge tunnels will be about 200 feet beneath mean sea level, no direct influence will be imposed upon the estuary.

Estuarine Temperature and Salinity Surveys - Normandeau Associates, Inc.

During 1969, Normandeau Associates, Inc. performed a survey designed to determine normal temperature and salinity variations for the Hampton Harbor estuary and to present the normal daily and seasonal fluctuations of these parameters (Reference 1). Temperature and salinity readings were taken at regular stations within the estuary from mid July to early November 1969. Although the survey did not continue year round, it did give a comprehensive picture of temperature and salinity variations for a period of approximately four months.

Rustrak temperature recorders, readings from certified, precision grade, mercury thermometers, and portable Yellow Springs Telethermometers were utilized in the temperature survey. Salinity measurements were made with a portable Beckman Salinometer. Rustrak recorders, installed at the Hampton Harbor Bridge and at the Hampton River Boat Club, provided a continuous record of temperature fluctuation at these two locations. Both surface and bottom temperatures were recorded at the Hampton Harbor Bridge while the instrument at the Boat Club, recorded water temperature at a depth slightly below extreme low water spring tide.

Temperature and salinity profiles were taken at in-harbor stations on July 18, 22, 23, 29, 31, 1969 and August 6, 8, 25, 27, 29, 1969 (Figure 2.5-7). Readings taken during August were limited to Stations H-1, C-8, B-11, and A-11. Profiles were derived by taking temperature and salinity readings from surface to bottom using a Yellow Springs Telethermometer and a Beckman Salinometer. Ordinarily, profiles were made on the flooding tide one week and the ebbing tide the following week. On August 29, however, temperature and salinity readings were taken at Stations H-1, C-8, B-11, and A-11 over a complete tidal cycle.

During 1970 surface and bottom temperature readings were taken routinely at each plankton station (Figure 2.5-8) by means of a Beckman Model 7 Salinometer, which was periodically calibrated against precision grade mercury thermometers.

Summer temperature data of surface and bottom waters during ebb and flood tides for selected stations were graphically plotted. These graphs were used to determine temperature/tide/time relationships within and outside of the estuary.

Hydrological Surveys - Ebasco Services, Inc.

During 1969, Ebasco Services, Inc. performed a study to determine the flushing characteristics of the estuary (Reference 2). The results are given in Section 2.5.

The field study program included a bathymetric survey of Hampton Harbor, a current meter monitoring program at Hampton Harbor Bridge, a tracer release monitoring program in the harbor, installation of recording tide gages at the Hampton Harbor Bridge and at the Hampton River Boat Club, and a current velocity measurement study in the Browns River. The procedures for the field studies were specified by Ebasco Services with the consultation of Dr. J. H. Carpenter, Research Scientist from the Johns Hopkins University. Interpretation and analysis of the data collected in the studies were carried out by Ebasco and Dr. Carpenter. Actual field work was conducted by Webster-Martin, Inc. of Burlington, Vermont, and McKenna Associates of Portsmouth, New Hampshire.

Two independent methods were utilized to determine the volume of the tidal prism in Hampton Harbor and its tributaries. The first method involved a volumetric determination, based on bathymetric survey data and tide gage recordings. The second method involved the correlation of tide gage readings, cross sectional area through the Hampton Harbor Inlet and current velocities measured by recording current meters placed in the harbor inlet.

Two recording tide gages were established in the estuary, one mounted on a central pier of the bridge which crosses the Hampton Harbor Inlet and the other mounted on a dock at the Hampton River Boat Club, about 2-1/2 miles upstream from the bridge. The gages were standard Julian P. Friez water stage recorders of the type used by the USGS. They were equipped with continuous recorder charts driven by a springwound mechanism. Both gages were installed over 18-inch diameter corrugated metal pipes which acted as stillwells and helped to dampen short period water surface oscillations.

The gage at the bridge was installed on December 22, 1968 and operated continuously until November 7, 1969. The gage at the Hampton River Boat Club was installed on January 22, 1969 and operated continuously until September 16, 1969. Level lines were run into each gage location and bench marks established so that gages could be referenced to mean sea level.

A survey of the harbor bottom and the harbor inlet was made by traversing on predetermined lines with a fathometer and relating water depth to water levels recorded by the tide gages. Depths were measured and recorded with a fathometer which has an accuracy tolerance of plus or minus 6 inches. Survey information is summarized on Figure 2.5-2 which is a plan of the bottom contours of the harbor area, referenced to mean sea level.

Recording directional current meters were used to help estimate the volume of tidal flow through the Hampton Harbor Inlet. Three different current velocity studies were performed: one in December 1968, one in January 1969, and one in July 1969. In the first two studies, meters were moored east of the bridge foundations in water of sufficient depth at low tide. A cross section of the channel configuration and the numerical designation of the locations where the current meters were installed is shown on Figure 2.5-6. Two current meters were used during each study. In locations 1 and 2, the two deepest sections, the meters were installed in a vertical string, with the upper meter location about 6 feet below the water surface at mean low water and the lower meter located about 6 feet above the bottom as shown on Figure 6.1-1. At locations 3, 4, 5 and 6 one meter was moored in each section at a point 6/10 of the water depth below the mean low water surface. During the December study one flood tide and two ebb tide periods were monitored in each of the six locations. In the January study three flood and three ebb tides were monitored in location 1, one flood and one ebb tide in locations 2 and 4, and two floods and one ebb in locations 5 and 6. Due to a malfunction of one of the meters, no data were collected in locations 4 and 6 and no deep readings were obtained in locations 1 and 2 during the January study. In July, two meters were installed in a vertical string in location 2 and remained in place for five tidal cycles. These meters recorded continuously, while the meters installed in December and January sampled and recorded velocities at 5-minute intervals.

The bathymetric survey of the harbor provided important data for determination of the volume of water in the tidal prism within the estuary. The areas bounded by each of the bottom contours shown on Figure 2.5-2 were planimetered and the results were used to compute the relationship of volume and water level in the following manner.

1) The water surface area in the estuary arms at mean low water was planimetered from large scale aerial photographs, giving a total area of 24 million square feet.

2) Assuming average width of 150 feet, side slopes of 1-1/2:1 and a depth of 8.6 feet from mean low water to mean high water, the additional surface area at mean high water would be about 4 million square feet.

3) With an average surface area in the intertidal zone of 26 million square feet and a tidal amplitude of 8.6 feet, the total volume in the intertidal zone is 224 million cubic feet.

4) If it is assumed that the estuary channels below mean low water have an average depth of 1.5 feet, the volume of water below mean low water in this portion of the estuary is approximately 36 million cubic feet.

5) Although the entire marsh area is not covered at mean high water, portions of it are and a considerable volume of water is stored in the network of channels which crisscross the area. It has been assumed that this water would be equivalent to 0.5 feet over the 150 million square feet of marsh area or about 75 million cubic feet.

Thus, from the geometry of the estuary, it is estimated that there are about 80 million cubic feet of water in the estuary at mean low water and 551 million cubic feet at mean high water. Therefore, on an average tidal cycle, approximately 471 million cubic feet of water enters and leaves the estuary. It will be assumed that the tidal prism for the Hampton estuary is 470 million cubic feet. A plot showing volume versus elevation for the entire estuary is given in Figure 2.5-4.

The current meter data obtained at the Hampton Inlet was used to check the tidal prism calculated as described above. In this analysis, 15-minute intervals of current meter output were correlated with the tide gage readings and cross sectional area in the section being considered at that tide stage. Using the cross sectional area and the recorded velocity, the volume of water flowing through the section during each 15-minute increment was determined. This procedure was repeated for each location until volumes had been calculated during each tidal cycle for which current meter data was available. The ebb and flood volumes flowing through each location were averaged, and the tidal prism for the entire section at ebb and flood was determined. These totals are listed in Table 6.1-1 along with the tidal amplitudes.

When the average of the flood and ebb flows are multiplied times the ratio of the recorded tidal amplitudes to the mean tidal amplitude (8.6 feet), the tidal prism is found to be 515 million cubic feet for December and 450 million cubic feet for January, both within 10 percent of the volume previously computed. This indicates that the 470 million cubic feet determined by the bathymetric survey is an accurate representation of the average tidal prism for Hampton Harbor and its associated estuarine areas.

To evaluate the average velocity through the Hampton Harbor Inlet an analysis was performed by taking into account the volumetric changes with time in the estuary as the tide rose and by correlating this flow rate with the available cross-sectional flow area under the Hampton Bridge. Figure 2.5-5 shows a plot of calculated average velocity versus time over a complete tidal cycle. The velocities shown on Figure 2.5-5 are calculated average velocities considering the entire cross-section through the inlet. From the current meter study conducted at the inlet the average velocity through the navigation channel was found to be approximately 1.2 feet per second.

In order to determine the rate of renewal of water within the estuary (or loss of water from the estuary) a continuous dye release was made at the bridge. A 40 percent solution of conservative Rhodamine-B dye was released at a depth of about 16 feet at the Hampton Harbor Bridge. The dye was pumped through a 3/8 inch diameter hose, at a rate of 2.5 pounds of dye solution per hour, with a chemical proportioning pump. Dye concentrations were measured with a Turner Model III fluorometer. In deeper portions of the harbor and at flood tide the equipment was mounted in a boat and concentrations were read and recorded while under way. Concentrations in the upper portion of the estuary at ebb tide were measured by collecting grab samples with an air boat and placing a vial of the sampled water in the fluorometer. Concentrations were measured on fixed traverses and at the bay stations shown on Figure 6.1-2. The renewal rate is defined as the rate at which new water is added to and old water is lost from the estuary. It is analagous to the flow in a unidirectional stream. In the case of an estuary dominated by tidal action and with very little freshwater-inflow this renewal rate cannot be computed directly but can only be estimated by determining the rate at which a conservative substance is lost from the system. This rate of loss can be computed if the rate of tracer addition to the estuary and the steady state concentration of dye in the estuary are known. These are determined in the following manner:

1) C = concentration of dye solution in pounds per pound of water
   W = density of water in pounds per cubic foot
   D = rate of addition of dye solution in pounds per hour
   R = rate of renewal of or loss of water from the estuary in cubic feet per hour

2) At steady state the concentration of dye is proportional to the ratio of the mass flow rates of the dye and water into the estuary. Therefore;

$$C = \frac{D \text{ lb dye/hr}}{(W \text{ lb water/ft}^3)(R \text{ ft}^3\text{/hr})}$$

$$R = \frac{D}{CW}$$

For the Hampton Harbor estuary the following analysis was carried out to determine the renewal rate.

In the first step the estuary was divided into areas of approximately equal dye concentration on an ebb slack tide under steady-state conditions. Each area was weighted by the volume of water contained therein at ebb slack and the equivalent mean concentration in the estuary was computed.

Average dye concentration in the estuary equals 90.82×10^{-3} divided by 82.86×10^{6} or 1.10 ppb by volume. Given this information the rate at which old water is lost from the estuary or new water is added, is computed using the equation $R = \frac{D}{C} \times \frac{1}{W}$, where $R = \frac{2.5}{1.10} \times 10^{9} \times \frac{1}{64} = 3.54 \times 10^{7}$ cubic feet per hour, or 9850 cubic feet per second.

Based on the tidal prism calculations for the Hampton Harbor estuary, approximately 470 million cubic feet of water enter and leave the estuary on each tidal cycle. This represents an average inflow or outflow over the tidal cycle of $\frac{470 \times 10^{6}}{3600 \times 12.5} = 10{,}425$ cubic feet per second. Thus about 9850/10,475 or 94 percent of the water entering the estuary on each flood tide is "new" water and likewise 94 percent of the water leaving the estuary on an ebb tide is lost and does not return, indicating a very high exchange rate from the harbor to the ocean.

Chemical Water Analysis - Sheppard T. Powell Associates, Inc.

Wet chemical and spectrographic analyses were made on water samples taken aperiodically from the estuary. The purpose of the analyses was to gain insight into the background levels of station waste components that may exist as ambient constituents in the water of the estuary. These tests are outlined in Section 2.5. Techniques are similar to those explained for offshore sampling in the following oceanic portion of this subsection.

6.1.1.1.2 Offshore Oceanic Waters

As with the estuarine studies, the first investigations of the offshore zone were initiated in 1969. Offshore studies have continued to the present and are scheduled to go on into the future. These studies are necessary because it is proposed that both the intake and discharge of cooling water for the plant will be in the offshore oceanic zone adjacent to Hampton Harbor.

Offshore Physical and Chemical Studies - Normandeau Associates, Inc.

Measurements of physical and chemical parameters of offshore oceanic waters in conjunction with the originally proposed Seabrook Station were made during the 1969, Phase I studies by Normandeau Associates, Inc. (Reference 1). Temperature was measured using certified precision grade mercury thermometers and portable Yellow Springs, Model 44, Telethermometers (accuracy about 0.1°C). Rustrak temperature recorders were installed at the Hampton Bridge and at the Hampton River Boat Club in order to provide a continuous record of temperature fluctuation (accuracy ± 2 percent of full scale). Salinity, temperature, and conductivity measurements were made with a portable Beckman (Model RS5-3) Induction Salinometer (accuracy about ± 0.1 unit). All instruments were routinely calibrated during the studies. Although numerous temperature and salinity profiles were measured in the estuary during July and August, the only measurements of these parameters in offshore waters were made in the vicinity of the proposed discharge conduits, aproximately 3/4 of a mile east-northeast of the entrance to Hampton Harbor, on August 10, August 26, and September 23, 1969. Data were recorded at five-foot intervals to a depth of 40 feet relative to the instantaneous water surface elevations. Surface water temperature at the Hampton Harbor Bridge was monitored from August 15 to 26, 1969, whereas bottom temperature was monitored from August 15 through November 7, 1969 except for September 26 through October 9 when a thermistor was damaged by heavy seas. Surface and bottom temperatures at the Hampton River Boat Club were monitored from July 14 to November 3, 1969. This program did not provide adequate data for describing the hydrography of offshore waters.

During the summer and fall of 1970 the Normandeau Associates, Inc. Phase II Study Program (Reference 3) included measurements of temperature, conductivity, and salinity, made in conjunction with plankton samples, at about nine offshore stations during both flood and ebb tides on an irregular basis from mid-July through mid-October, 1970. Readings were taken at surface and at bottom and on some occasions throughout the entire water column using a Beckman, Model RS5-3, Salinometer which was periodically calibrated against precision grade mercury thermometers and standard seawater samples.

During the summer and fall of 1971 the Normandeau Associates, Inc. Phase III Study Program (Reference 4) included measurements of temperature, conductivity, and salinity made in conjunction with plankton samples. Only one offshore station was sampled in detail on September 23rd and 24th, 1971, during a 24-hour plankton sampling. Measurements were made using both a Beckman, Model RS5-3, Salinometer, and a Martek TDC metering system which measured temperature and conductivity as a function of depth. Both units were routinely calibrated throughout the sampling season.

The 1972-73 hydrographic studies for the Seabrook Station are outlined in the Environmental Study Program of Normandeau Associates, Inc. (Reference 5). These studies are designed to determine the local water circulation patterns and hydrographic characteristics of the New Hampshire coastal waters on a year-round basis and to identify the source of the waters which the proposed Seabrook Station may utilize during its operation. This study program will continue until sufficient data have been collected to provide an adequate understanding of the natural water movements and hydrographic characteristics in the area of the proposed intake and discharge. There are basically seven areas of investigation as follows:

1. Monitoring From Moored Buoys

Current speed, current direction, and water temperature are being monitored for extended periods of time in the area of the proposed intake and discharge conduits (Figure 6.1-3) as well as at various locations several miles offshore during 1973. Currents are measured using Bendix Q-15 geomagnetic bi-directional ducted rotor current meters (accuracy ± 3 percent speed and ± 12° direction); velocity and direction are recorded continuously on strip-charts using <u>in situ</u> Bendix Model 270 recorders (accuracy ± 2 percent of full scale); water temperatures are monitored continuously using Rustrak strip-chart recorders (accuracy ± 2 percent of full scale) mounted in water-tight PVC containers; tidal heights are monitored for the duration of the study using a Marsh-McBirney water level gauge which is installed in Hampton Harbor (accuracy better than ± .15 feet); wind velocity and direction are being monitored for the duration of the study at the Hampton Beach State Park using a R.M. Young Company wind vane and anemometer with Rustrak recorder (accuracy ± 2 percent of full scale) mounted at a 30-foot height on a utility pole. All units are routinely checked to insure accurate calibration.

2. Offshore Surveys

Periodic hydrographic surveys are being conducted at permanent instrument stations located in the vicinity of the proposed intake and discharge zones and offshore to a distance of 12-15 miles. The following data are collected at each of these stations: Current speed and direction is recorded at five foot intervals from the surface to the bottom every 30 minutes during both flood and ebb phases of the tide using a Bendix Q-15 current meter and a Bendix Model S-232 deck readout. An Interocean Model 721 F electric cable winch with nine channel slip rings is used to raise and lower the current meter through the water column. Water temperatures, conductivity, and dissolved oxygen is recorded at five foot intervals from the surface to the bottom every 30 minutes during both flood and ebb phases of the tide using a Martek Mark II (accuracy $\pm$ 0.2°C, conductivity $\pm$ 2 percent of full scale, dissolved oxygen $\pm$ 1 percent full scale at temperature of calibration). Periodically surface water temperature is measured with a precision grade mercury thermometer and water samples are taken at surface and bottom for determination of dissolved oxygen using the Winkler method. Air temperature is measured periodically using a precision grade mercury thermometer. Wind speed, wind direction, wave height, and wave direction are observed visually every hour and recorded on data sheets. Surface drift bottles and sea-bed drifters are released periodically during mid-flood and mid-ebb to monitor patterns of net drift. Water samples are collected periodically at surface, mid-depth, and near-bottom for laboratory determination of nitrates, phosphates, and water density.

3. Drogue Tracking

A number of floating "W" type drogues rigged for near surface and 25-foot depths are released and tracked using readings of sextant angles made from a small boat during a tidal cycle period when anchor stations are being run. This data will help to delimit patterns of net drift in local areas such as near the proposed location for the intake and discharge conduits.

4. Drifter Releases

Glass drift bottles and plastic sea-bed drifters are released during an offshore cruise every three months at 19 stations along three eastwest transects out to about 25 miles offshore. At each station, ten of each type of drifter are released and a profile of temperature and conductivity is made. This program is being run in conjunction with Woods Hole Oceanographic Institution.

5. Sediment Transport

Sediment transport in the vicinity of the proposed offshore intake and discharge zones and along Hampton Beach is being monitored (Figure 6.1-4). Sediment transport is measured subtidally using marker stakes driven into the sea floor and marked with a buoy at the surface. Monthly measurements of elevation of stakes above the sediment interface are made by divers. At each station two markers are driven into the sand approximately 30 feet apart. These data are used to calculate average changes in sediment cover around the stakes. Sand transport onto the southern end of Hampton Beach is evaluated by monthly beach profiling and additional measurements of all parameters are made following severe storms.

6. Chemical Water Analysis - Sheppard T. Powell Associates, Inc.

Chemical water analyses were made for sea-water samples collected in the offshore area. The results of the analyses are described in Section 2.5. Sheppard T. Powell Associates, Inc. performed wet and spectrographic chemical analyses for specific water components. Their analytical techniques in general follow the Standard Methods for the Examination of Water and Wastewater, APHA, 1966 (Reference 6) or Methods for Chemical Analysis of Water and Wastes, EPA, 1971 (Reference 7) as appropriate.

As the comparative results of the aperiodic sampling has shown consistency, it is planned to retain such aperiodic sampling seasonally until the plant becomes operational. The list of constituents to be investigated is subject to revision as the station waste components become better identified during plant design.

7. Hydrographic Dye Diffusion Study - Ebasco Services, Inc.

Hydrographic data were measured by Webster-Martin, Inc. for Ebasco Services, Inc. in conjunction with dye releases in the ocean waters to monitor water movement in the vicinity of the proposed intake and discharge zones during December 1969 and April-May 1970. Appendix K is the final report of this program. A 40 percent solution of Rhodamine B dye was pumped from the shore through a 3/8 inch diameter hose to one offshore discharge point in December and five points from April to May. Water temperature and salinity measurements were made daily at the dye release point being used at that time. From the salinity and temperature data, water density was calculated to determine possible presence of density stratification. A recording anemometer was mounted on the roof of the Hampton Beach State Park Bathhouse to monitor wind velocity and direction during the dye release periods. Dye was released continuously and at a constant rate throughout both test periods. The release rate during the December 1969 study was 4.1 pounds of dye solution per hour, while during the April-May 1969 study the release rate was 2.4 pounds of dye solution per hour. Ten dye tracking stations were established near navigation buoys and shore reference points for the December 1969 releases, whereas a grid of 30 stations was established using moored reference buoys during the April-May study. Dye concentrations were measured with a boat-mounted Turner Model III Fluorometer and recorded with a Rustrak Recorder on a strip-chart on which time of sampling, tracking course, and fluorometer setting were noted. Water to be sampled was pumped through the fluorometer from an inlet located on the bottom of the boat about 2.5 feet below the water surface. All sampling was done while underway, except for vertical sample runs which were made periodically to determine the variation of dye concentration with depth. Sampling procedure was to measure the dye concentration from the release point outward to the limit of detectable dye concentrations. Sample runs were made on each daylight slack tide, whenever weather permitted. During the December release period ten sampling runs were made. From these data calculations of dye dispersal and dilution were made.

Throughout the April-May 1969 release period, tidal current direction and velocity were measured and recorded at the dye release points using two Geodyne Model 102-1 current meters -- one installed 8 feet above the bottom and the other near mid-depth. Each time the dye release point was moved the meters were also moved. The results of the dye tracking and current meter surveys for this study are useful in predicting the dynamics and dispersion of the thermal plume.

6.1.1.2 Ecological Parameters

Construction and operation of the proposed Seabrook Station would result in certain environmental alterations to the estuary, marsh, and offshore areas. The magnitude of these changes cannot be predicted at this time. It is possible, however, to evaluate these effects by categorizing them into those resulting from construction of the cooling water system in contrast to those effects resulting from the operation of this system.

It appears, at this time, that construction effects, although substantial in terms of habitat disruption, will be temporary. There is sufficient evidence to indicate that with proper construction techniques, recovery should occur.

Ecological effects resulting from the operation of the cooling water system are most difficult to predict. The probability that any of the operational effects would be ecologically significant cannot be fully determined at this time.

It is apparent, therefore, that pre-operational and post-operational ecological monitoring in conjunction with the construction and operation of this large generating facility is most important.

Construction Effects

The construction of the pipeline will involve dredging an approximately 50 foot wide trench along the route shown in Figure 3.4-1. Construction will result in:

1. Temporary disruption of the saltmarsh, intertidal, and bottom habitats along this route;
2. Release of some suspended sediments to the waters;
3. Other effects if measures used to restore the route to its natural condition are not properly controlled.

The Hampton-Seabrook area is historically a dynamic one -- within even the last 50 years there has been considerable meandering of tributary rivers, changing of the location of the inlet channel to the sea (it has moved several hundred feet northward), and shifting of sand causing filling of some areas and erosion of others. In addition, there is extensive sand transport along Hampton Beach.

The presence of the circulating water diffuser pipe in the offshore area is not expected to produce significant ecological alterations. Nevertheless, it is not known what the presence of pipe will do to natural water movement and sand transport. Since any change in natural water movement and sediment transport can potentially result in alterations to the natural habitats, there is sufficient concern to warrant careful ecological monitoring.

Possible Effects Of Operation

The operation of the condensing water system has many ramifications which may result in effects on the ecology of the area. These considerations can be divided into four general categories:

1. Entrapment

The potential for entrapment of fish appears to be related primarily to the engineering and design of the intake system. Approach velocities, escape mechanisms, and other features will be considered in the design of this system. It will be necessary, however, to document the amount of fish entrapped, if any, compared to the number of fish utilizing the area in order to estimate the effect on the ecology of the area.

2. Entrainment

The present design for the proposed condensing water system specifies an approximate 39°F increase in temperature of the cooling water. This will most likely kill all the plankton entrained in the intake water. There is some concern on the effects of this entrainment to the ecology of the area, but unless this can be related to the amount of plankton entrained to those which escape, the magnitude of this problem cannot be evaluated. Important species of the area that spend part of their lives as meroplankton include the soft-shelled clam, Mya arenaria, the lobster, Homarus americanus, and many species of finfish. Additionally, planktonic organisms form the basis for the food chain for many organisms in the area. Since the intake will be near the estuary entrance, there is also the possibility that many planktonic organisms will be entrained before they enter the estuary. The dead planktonic organisms discharged with the heated effluent may also alter the ecology of the immediate area around the discharge. The input of large quantities of dead plankton may affect benthic invertebrates or even change the composition of the community by encouraging deposit feeders.

3. Thermal Effects

The heated waters discharged into the ocean may cause changes in the pelagic and, indirectly the benthic environment, that could result in some ecological effects. It may also indirectly affect these habitats by altering small-scale circulation patterns in the area off of Hampton Beach. The general nature of the heated plume is buoyant and will rise to the surface through multiple diffusers. As it rises, the cooler resident waters will become entrained, thereby diluting the heated effluent and reducing the overall temperature while raising the temperature of the surface mass of water. The heated plume will reach the surface and be carried by currents and winds. There are several possible effects resulting from thermal discharges which should be considered. They include: the effect on the soft bottom benthic fauna; the effect of the heated plume on the biota on the Outer Sunken Rocks;

the formation of a thermal barrier to migratory fish; the possible attraction of migratory fish to the heated area; and, the possibility of a physical barrier to vertical migration by members of the planktonic community.

4. Discharge of Effluents, Other than Heat

The fourth possible ecological effect of the plant would be from effluents or discharges not directly associated with cooling water systems. In the operation of this proposed plant, several wastes will accumulate. Present plans call for disposing of these discharges directly into the circulating water tunnel to be diluted and discharged offshore. At present there are plans to dispose of liquid radiological wastes and neutralized demineralizer reagents. Additionally, it is possible that certain substances might leach from some of the plant's structures into the waterways.

It is important to monitor the biota for any effects from being exposed to these other effluents.

Pre-operational Monitoring Programs

Although monitoring of physical parameters is discussed in a previous section (6.1.1.1), it is obvious that some physical parameters will be measured in conjunction with biological sampling. The parameters that will routinely be measured when biological samples are taken include temperature, salinity, dissolved oxygen, and turbidity. Other physical parameters will be measured when appropriate in accordance with (see Garton and Harkins, Reference 11).

1. Benthos

As discussed above the construction and operation of the cooling water system will have several potential effects on the benthic environment. These include: 1) effects on benthic organisms caused by changes in water quality (e.g. turbidity); 2) effects of entrainment of larvae stages of benthic animals or entrainment of holoplankton used as food by benthic animals; and 3) indirect effects caused by possible alteration of circulation patterns or sediment transport.

The monitoring program for benthic organisms follows basically the guidelines set forth by the Environmental Protection Agency (Garton and Harkins, Reference 11). Duplicate samples will be taken from 42 stations (see Figure 6.1-5), in June and September, and from 19 stations (1 through 4, 7 through 10, 12, 14, 16, 26 through 33) in December and March. Samples (1/4 m^2) will be taken using a diver-operated Venturi dredge. Numbers and biomass for each species will be tabulated. Diversity and redundancy indices and dispersion values (Garton and Harkins, Reference 11) will be computed for each sample.

The reproductive cycle of the bivalve, Siliqua costata, will be monitored in the discharge area and at a control station. Siliqua was chosen because of its abundance in the sampling area, its importance in the food chain, and, being a bivalve, gonad samples are relatively easy to obtain.

2. Intertidal

a. General Intertidal Community

Operation of the cooling water system may affect some of the intertidal locations in the offshore area if reached by the thermal plumes. Several areas warrant special attention.

Five stations (see Figure 6.1-6) will be sampled seasonally. At each station a transect will be established and triplicate 1/4 m^2 samples taken at three elevations (mean low water, MLW; mid-tide; and mean high water, MHW). Species will be enumerated and biomass determined. Diversity and redundancy indices and dispersion values will be computed for each sample. Sediment samples will be taken with each sample and sediment composition (grain size) will be determined.

3. Soft-shelled Clam Populations

Construction and operation of the plant could possibly affect the clam population in a number of ways. These may include actual disruption of some of the clam flats during construction as a result of sedimentation or changes in water circulation. Other effects could possibly result from the operation of the power station. Entrainment of clam larvae or increased activity by clam predators are examples of possible changes.

Since clams are a dominant organism in the estuary and provide a most important sport shellfishery, their autecology warrants monitoring. Clam density, age-growth, and annual recruitment of clam spat will be monitored. Additionally, size and sediment composition of the major clam flats will be monitored.

The monitoring program will consist of an annual census of adult clam and clam spat density in the five major flats (see Figure 6.1-7); seasonal monitoring of age-growth of adult clams and clam spat recruitment on Flats 1 and 2; and, annual study of size and sediment composition of Flats 1, 2, and 3.

Sampling of clam and spat density and age-growth will follow the same methodology Normandeau Associates, Inc. used to monitor similar parameters in 1969, 1971, and 1972. Random transects and quadrats are established on the flats and two square foot samples excavated to a depth of three inches. This top layer of sand is bagged and later sieved for clam spat. The digging is continued to a depth of 15" and adult clams separated. The spat and adult clams are later measured and density and population structure determined. Growth is calculated from size-frequency distributions using binomial probability paper (Cassie, Reference 8).

The change in configuration of clam flats will be followed annually using a plane table or aerial photography. Sediment composition will be monitored on the transects established on the three clam flats.

4. Biota of Outer Sunken Rocks

Since Outer Sunken Rocks may be exposed to the heated effluent or be affected by the proximity to changes that may be caused by the intake structure, and discharge diffuser, it is important to monitor the biota that are found there.

Monitoring in this area is separated into several phases. Community composition will be determined on five transects on the northern end of the rocks (see Figure 6.1-8). On each transect, five 1/4 m^2 quadrats, ranging from mean high water (MHW) to the edge of the outcrop at a depth of about 25 feet will be sampled seasonally using a diver-operated Venturi dredge. Macroalgae and animals will be identified, enumerated, and their biomass determined. Percent cover of macroalgae will be estimated. The results of these stations will be compared to a control station (see Figure 6.1-8). Diversity and redundancy indices and dispersion values will be computed for each sample.

Since macroalgae, predominantly *Laminaria saccharina* and *Chondrus crispus*, constitute the dominant species of organisms on the rock, their growth rates and reproductive cycle will be monitored. Growth rates of selected plants along the transects will be determined by tagging individual plants and measuring them at monthly intervals. Their reproductive cycle will be determined by examining the plants within the 1/4 meter square quadrats. The percentage of plants at the reproductive peak (*i.e.*, as determined by reproductive structures, *e.g.*, nemathecia or "bullations"), will be estimated.

5. Epibiotic Settling Community (Panel Organisms)

Thermal release and other effluents from the discharge diffuser may also affect epibiotic communities, the so-called settling community. This community is composed of many small organisms that are not collected in other sampling methods. They also form the basis of the food chain for many "grazing" invertebrates and finfish. Because of the relatively short reproductive cycles and large numbers, these animals also provide a good index to changing conditions.

These organisms will be sampled by submersing panel arrays for varying times in a north-south transect in the discharge area and at two stations in the Browns River (see Figure 6.1-9). Each array will consist of a plexiglass (1/4" thick) slide rack holding twelve 3" x 3" removable plate glass panels vertically in the water column. Each month Panel No. 1 will be collected and replaced by a clean panel. The remaining panels are long-term; Panel No. 2 will be collected after two months submersion; Panel No. 3 after three months sumbersion, etc. The short-term panels provide information regarding time and length of reproductive period of sessile species which are able to colonize artificial substrates, while long-term panels furnish knowledge on temporal sequences and biotic succession within the panel community and supply data on many additional species which do not settle on short-term panels because proper niches are not available.

Organisms collected on these panels will be identified to lowest possible taxon and abundance expressed either as density or in relative terms such as rare, common, or numerous. Diversity and redundancy indices and dispersion values will be computed.

6. Meiofauna

Construction and operation of the plant and its presence near the Browns River may indirectly change the benthic community in the discharge area and in the Browns River. This change could probably be first manifested in the meiofauna since their development is more rapid, their reproductive cycle shorter, and their numbers greater than their larger relatives.

The diversity and density of meiofauna will be seasonally monitored along a north-south transect in the discharge area. Following the methods outlined in Hulings and Gray (Reference 13) meiofauna will be sampled from six to eight random 1/6 m^2 subsamples from each of five 1/4 m^2 grids placed along the transect and at two control locations in the offshore area. Two stations and a control in the Browns River will be sampled similarly (see Figure 6.1-10). Organisms will be identified and enumerated. Diversity and redundancy indices and dispersion values will be computed.

7. Lobsters and Crabs

There is some concern that some aspects of the construction and possibly operation of the Seabrook Station may alter the abundance or habits of the lobster, Homarus americanus, and crabs, Cancer spp. Since these shellfish are commercially important and have a widespread distribution in the area, it is important that they be monitored.

This monitoring study will consist of mark and recapture techniques. Although other attempts, using these techniques along the New Hampshire coast, have not proven very successful (personal communication, Mr. Ted Spurr, Biologist, N.H. Fish & Game Department), an attempt will be made employing a local successful lobsterman to fish the traps. If this is not successful, catch per unit effort will be estimated in subsequent studies. The mark and recapture study will take place both offshore and in the estuary (see Figure 6.1-11). The traps will be maintained from April to November, baited with a standard bait, and fished twice weekly. The lobsters and crabs trapped will be measured, sexed, tallied, marked, and released. Gravid conditions of both will be noted. Lobster lengths will be measured with vernier calipers from the right eye socket to the end of the carapace. They will be tagged according to a technique described by Scarratt and Elson (Reference 16), whereby a numbered plastic tag (Floytag -69) will be inserted under the carapace. Crab widths will be measured at the widest portion of the carapace and length taken from the right eye socket to the end of the carapace. The crabs will be identified to species -- Cancer borealis or Cancer irroratus -- and marked by clipping on the blunt teeth ringing the right side of the carapace.

Size-frequency distributions will be determined, and migratory behavior documented.

The trapping program will be supplemented by a monthly underwater census along transects in the study area. Those lobsters and crabs encountered underwater will be similarly marked and measured and released.

8. Finfish

Since the normal behavior of finfish found in the area may be altered by construction and operation of the plant, it is important to monitor their populations and distributions. Presence and abundance of finfish in the area of the intake and discharge will be carefully documented. Studies will be designed to evaluate possible thermal effects, entrapment, and entrainment of fish eggs and larvae.

The monitoring program for fish will consist of several sampling techniques, both offshore and in the estuary. In the offshore waters this program will consist of: 1) duplicate standardized night tows with an otter trawl and mid-water trawls in the discharge area (see Figure 6.1-12) on a monthly basis from April to October, and one sampling in the winter; 2) gill netting at night in the discharge and intake area at a frequency of three nights per month; and 3) duplicate metered tows for fish eggs and larvae each month.

Sampling in the estuary will consist of monthly seining in two locations (see Figure 6.1-12); duplicate metered tows for fish larvae in the Hampton River, Hampton Harbor, and Browns River on a monthly basis; and periodic surveys of potential spawning areas (e.g., Taylor River).

Adult fish will be identified and numbers, length, and biomass per species determined. Scale samples of selected specimens will be collected for age-growth studies. Larval fish will be identified and quantified. Statistical evaluation, as suggested by Garton and Harkins (Reference 11), will be used to detect changes in community composition.

These studies will be complemented by a creel census of local sport and commercial fishermen.

9. Plankton

a. General

As discussed above, operation of the condensing water system has many potentially detrimental effects to the planktonic community and to those animals who spend a portion of their lives as members of the plankton. The entrainment and subsequent killing of the plankton in the intake water provides perhaps the greatest threat to the planktonic community. The effects on the planktonic community of entrainment in the Hampton-Seabrook estuary and nearby coastal waters will be carefully monitored.

Monitoring of plankton will consist of duplicate monthly samples taken in six locations (see Figure 6.1-13). Samples will be taken from top and bottom using submersible plankton pumps. In addition, monthly volumetric samples will be made at the intake location. These samples will be taken from surface and bottom and throughout a complete tidal cycle that also provides day and night sampling.

In the samples from the seven monitoring stations, zooplankton and phytoplankton species will be identified and enumerated. Catch data will be statistically evaluated and confidence intervals established so that natural variability can be documented. Those monthly samples taken from the intake area for the second part of the study will provide information on average quantity of plankton exposed to entrainment.

b. Phytoplankton Productivity

The effects of entrainment on primary productivity will be determined by measurements of phytoplankton production. These measurements will employ the method of Ryther and Yentsch (Reference 15). Replicate subsurface samples will be taken bi-monthly from April to November and once in February at the discharge area and in two other offshore stations (see Figure 6.1-14).

Other Aspects of the Pre-operational Monitoring Program

1. Taxonomic Determinations

Species will be identified by trained personnel using the keys to identification of local species, e.g., Smith (Reference 10), Miner (Reference 7) and Gosner (Reference 5). Specimens that cannot be identified using the above keys or specimens whose identification is doubtful will be sent to experts at nearby institutions for identification or verification. These experts include Dr. Marie Abbott, Marine Biological Laboratory, Woods Hole Oceanographic Institute (marine invertebrates); Dr. Arthur C. Mathieson, Director, Jackson Estuarine Laboratory, University of New Hampshire (marine macroalgae); and Dr. Ellsworth H. Wheeler, Jr., University of New Hampshire (plankton). A reference collection of voucher specimens will be verified by local experts and will be available in the laboratory for verification of identification.

2. Natural Variations of Ecological Parameters

The pre-operational monitoring program will begin in the spring of 1973 and continue through the completion of the first unit of the proposed generating station in 1979. Observation of natural variation will be obtained from the annual reports dealing with each of the ecological parameters measured. In each case significance of an observed change in population or distribution of the local fauna and flora will be assessed using appropriate statistical analysis. Changes in biological phenomena will be compared to all physical parameters using multivariate statistical analysis. Natural variation of populations due to seasonal migration will be documented.

Several years of pre-operational studies and monitoring will provide reliable analyses of natural variations of animal and plant populations, as well as physical parameters.

In monitoring natural variation, several organisms because of their commercial or ecological importance or their ubiquitous distribution, have been selected as indicator organisms. These organisms include:

a. *Mya arenaria*, the soft-shelled clam

The soft-shelled clam is distributed throughout the estuary and is easily sampled. Since it is the most economically important shellfish in the estuary, there are already several year's data available on its density, distribution, and other aspects of its population. There is also a rather comprehensive literature available on its biology and physiology.

b. _Siliqua costata_, the ribbed-pod shell

Siliqua has a widespread distribution in the proposed intake-discharge area, is the most abundant bivalve in the offshore area and is easily collectable. _Siliqua costata_ is very important in the food web and serves as a major food item in the diet of many of the sea ducks and bottom fish that use the area. _Siliqua costata_ will also be used to assess any changes in reproductive cycles due to thermal addition or changes in water quality.

c. _Laminaria saccharina_, kelp

Laminaria saccharina will be used to assess any changes in reproductive cycle or growth rates of macroalgae living on Outer Sunken Rocks. _L. saccharina_ is very abundant and makes up a large portion of the biomass of macroalgae. Its large size makes it easy to measure and observe _in situ_. Since it is close to the southern limits of its distribution it should provide a sensitive index to effects of thermal addition.

d. _Chondrus crispus_, Irish moss

Chondrus crispus will be used to supplement information on reproductive cycle and growth rates of macroalgae. _C. crispus_ is abundant wherever hard substrate is available in the offshore area. It is the greatest component of the macroalgae biomass in the area.

e. Other

Organisms that warrant special attention because of their widespread distribution or commercial importance include _Homarus americanus_, the lobster; _Cancer_ spp., rock crabs; _Pseudopleuronectes americanus_, the winter flounder; _Morone saxatilis_, the striped bass; and _Crangon septemspinosus_, the sand shrimp. Their populations will be monitored in studies discussed above. The most ecologically important groups of animals, the benthos, and plankton, that serve as the basis of many of the food chains in the area will be monitored in studies especially designed for them. At present, no species, other than _Siliqua costata_, have been chosen as index species of these groups. It is possible that further study may necessitate other species be chosen as indicator organisms.

Biological Effects

Prediction of non-lethal physiological and behavioral responses have been implied in the discussion of the monitoring programs. Effects such as decreased or increased density, changes in reproductive cycle, growth rates, distribution or migratory patterns of the organisms that are significantly different from the normal variation observed in the pre-operational monitoring study will be correlated with changes in physical parameters caused by the plant's operation.

Known sources or parameters of lethality for organisms have been identified above. These include entrainment of the plankton in water that will be subjected to a rise of 39°F, entrapment of fishes in the intake structure, and disruption of habitat during construction of pipelines. Other potentially lethal effects could result from plant shutdown with consequent cold shock to fish attracted to plumes and from discharges of other plant-related effluents, *e.g.*, neutralized demineralized regenerants. Design of the pre-operational monitoring studies has provided for widespread location of sampling and control stations. This design should permit assessment of plant-related interactive effects when combined with physical and chemical data in an analysis of variance.

6.1.2 Groundwater

Most water supplies in the Seabrook area depend on local ground water sources that include major regional aquifers found in the glacial drift deposits that overlie the bedrock of the region. The major producing wells are located in the saturated sand and gravel layers in glacial ice contact deposits. These are the public wells for the Town of Seabrook and are located at a distance of over one mile to the southwest from the plant site. These wells range in depth from 22 to 54 feet. Almost all of the homes in the area are supplied by this municipal water supply. The few private wells that are within a mile of the plant site tap the shallow outwash deposits to the west and southwest and are less than 15 feet deep.

The potable and sanitary water for the plant will be obtained from the municipal water supply and will not affect the local ground water supply. No wells are planned for the site in the future. The groundwater movement in the region is generally limited to drainage areas where streams intersect the water table and where the streams lead to the tidewater. Because these drainage areas are small, the distances from recharge areas to the discharge point generally do not exceed one mile. The modification of the surface of the land at the plant site will not affect the recharge of the local wells because the recharge area for these wells is predominately the ice-contact deposits to the south and southwest of the plant approximately 1.5 miles away.

Bedrock at the plant site is at or near the surface and the ground water movement through the relatively impermeable till that overlays the bedrock is toward the tidal areas to the north, east and south of the site. The rainwater drainoff system at the plant will direct the runoff through a storm drain system that empties into Hampton Harbor. The sewage is passed through a treatment plant and then injected into the plant's circulating water system for dilution and removal to the ocean.

Since the plant will neither draw nor discharge water at the site, the local ground water conditions are not expected to change. Therefore, no program is necessary to monitor the groundwater except that which is required for radiological purposes.

6.1.3 Air

Recognizing the importance of determining actual atmospheric conditions experienced at the site, a meteorological data collection program was undertaken by PSNH and a weather tower was installed on the site in October 1971. A description of the program is given in the section that follows. The models used to analyze the data and obtain estimates of gaseous effluent dispersion are discussed in subsection 6.1.3.2.

It should be noted that construction plans for Seabrook do not include the use of cooling towers or open bodies of cooling water. As a result, no significant effect on the local meteorology due to the plant and its facilities is anticipated. Fogging and icing on the plant environs are not predicted.

6.1.3.1 Meteorology

The meteorological tower installed on the site is 150 feet high with a base at approximately 10 feet MSL. There are no trees or other vertical obstructions in the immediate vicinity of the tower. The nearest significant growth is 25-35 foot trees that begin about 500 feet to the west and southwest of the tower. There is no significant vegetation between the tower and Hampton Harbor. Grass is planted under the tower out to a radius of 50 feet to assure conservative temperature gradient data. The tower is instrumented as shown in Table 6.1-3. After one year of data accumulation, the original Aerovane wind system at 30 feet was replaced with a Bendix 3-cup anemometer and vane system. Another Bendix wind system was installed at the 130 foot level at the same time. The dewpoint sensor was installed on the tower March 17, 1972. Recorded dewpoint data has been verified by bi-weekly multiple sling psychrometer readings taken at the 30 foot level on the tower. Occasional minor adjustments to the recorded dewpoint data have been made to maintain the data within an accuracy of $\pm$ 0.5°C.

The temperature systems use Rosemount precision resistance bridges and record on an Esterline-Angus multi-channel recorder. One channel of the recorder is used to print a reference value of 0 volts from which all traces are calibrated.

The temperature sensors are installed in aspirated shields on the tower. The vertical temperature difference (ΔT) is measured between 30 and 130 ft.

The ΔT system is scaled for a range of from -10°F to +18°F, for a full span scale of 28°F. The Rosemount platinum resistance sensors and bridge system has an accuracy of 0.1 percent of span or $\pm$ 0.02 ohms, which ever is greater; the maximum possible system error therefore is $\pm$ 0.09°F. The recorder accuracy is $\pm$ 0.25 percent of scale, or $\pm$ 0.07°F. As a result, the maximum delta T system error could be $\pm$ 0.16°F, with a probable system error of $\pm$ 0.11°F.

All equipment was checked for normal operation before installation on the tower. At that time, the delta T system was calibrated to a 0.0°F value by means of a simultaneous ice bath of both sensors. All laboratory tests were made with each sensor permanently connected to the cable to be used with the sensor on the tower.

The tower will be maintained in accordance with Regulatory Guide 1.23 of the AEC. In addition to the bi-monthly meteorological strip chart review, every three months recorded temperatures will be checked against tower values obtained with ASTM precision thermometers. Wind systems will be checked for trouble-free operation every three months. Wind direction and speed transmitters are to be removed from the tower and given a complete laboratory check to assure they are working within the manufacturer's specifications at least every six months.

Processing of the on-site meteorological strip charts is as follows. For hourly data values, a mean value for the 30 minutes preceding the hour is determined directly from the strip charts. This value is transferred to a punched card by means of a Gerber semi-automatic analog-to-digital converter. The punched cards are checked by computer for consistent values from one hour to the next. After all checks are verified, a punched card is prepared that contains the date, time and the hourly values for all the parameters measured on the tower. These cards are used as a base from which data summaries are prepared. The seasonal and annual summaries prepared for Seabrook include a chronological listing of the hourly data values, wind speed and wind direction joint frequency distribution by stability, wind direction persistences, and moisture deficits by wind direction and stability. These are described in more detail in Section 2.6.

The meteorological tower will be maintained throughout the life of the plant. The equipment will be regularly calibrated and strip-chart records of wind speed, wind direction and temperature will be kept. Conversion of the charts to punched computer cards will be continued through 1973.

6.1.3.2 Models

The meteorological data collected at the site were also used to obtain diffusion estimates for assessing the consequences of accidental and routine releases of gaseous effluents from the station. The models on which these estimates were based are as follows:

A. Accident Diffusion Models

Diffusion estimates for assessing the consequences of postulated accidents were based on cumulative frequency distributions of hourly dilution factors (χ/Q) averaged over selected time intervals. The hourly χ/Q values, in turn, were evaluated by two different models depending on the time interval of concern. For time intervals up to 8 hours, hourly dilution factors were based on the ground level plume centerline model

$$\chi/Q_{\text{no wake}} = \frac{1}{\pi \mu \sigma_y \sigma_z} , \qquad (6.1\text{-}1)$$

where

χ = short term ground level concentration (Curies/m^3),

Q = release rate (Curies/sec),

μ = mean wind speed (m/sec),

σ_y = horizontal diffusion parameter (m), and

σ_z = vertical diffusion parameter (m).

To account for the additional dilution due to the wake effect of the reactor building at short distances from the plant, Eq. (6.1-1) is written as Reference 18:

$$\chi/Q_{wake} = \frac{1}{\pi\mu\sigma_y\sigma_z + cA\mu} \tag{6.1-2}$$

where

c = empirical building shape factor, and

A = reactor building minimum cross sectional area (m^2).

Values of c = 0.5 and A = 2090 m^2 were used for the Seabrook calculations. Equations (6.1-1) and (6.1-2) are used to define a building wake dispersion correction factor

$$D_b = 1 + \frac{cA}{\pi\sigma_y\sigma_z} \tag{6.1-3}$$

with the value of D_b limited to ≤ 3. The χ/Q with wake is then computed by

$$\chi/Q_{wake} = (\chi/Q_{no\ wake}) \ /D_b \tag{6.1-4}$$

Equation (6.1-4) is used only out to a distance of 3000 m. No credit is taken for building wake dilution beyond 3000 m.

Equation (6.1-1) or (6.1-2) is used out to a distance x_L, where

$$\sigma_z \Big|_{x_L} = 0.47\ L \tag{6.1-5}$$

and L is the depth of the limited mixing layer. A value of L = 900 m has been used for Seabrook (Reference 19). At a distance of $2x_L$, the limited mixing model

$$\chi/Q_{no\ wake} = \frac{1}{\pi\mu\sigma_y\ (0.8\ L)} \tag{6.1-6}$$

or

$$\chi/Q_{wake} = \frac{1}{\pi\mu\sigma_y\ (0.8\ L)\ D_b} \tag{6.1-7}$$

is used in place of Eq. (6.1-1) or (6.1-4), respectively. For distances between x_L and $2x_L$, a linear interpolation is made between the χ/Q obtained for distance x_L and the χ/Q obtained for $2x_L$.

For the time periods greater than 8 hours, the sector average model

$$\chi/Q = \frac{2.032}{\sigma_z \ \mu x} \tag{6.1-8}$$

is used, where x is the distance from the release point to the receptor, and the other terms are as previously defined. For distances greater than $2x_L$, the limited mixing sector average model

$$\chi/Q = \frac{2.55}{Lux} \tag{6.1-9}$$

is used. For distances between x_L and $2x_L$, a linear interpolation is made between the χ/Q at x_L and the χ/Q at $2x_L$.

A χ/Q was computed for each hour by the above models using the on-site meteorological data. The hourly dilution factors obtained and the corresponding direction in which the wind was blowing during each hour of the year were then stored in arrays for sequential processing. This involved the averaging of selected hourly χ/Q values over successive, overlapping time intervals of 1, 2, 8, 16, 72 or 624 hours. (The last four intervals correspond to the time periods 0 to 8 hours, 8 to 24 hours, 1 to 4 days and 4 to 30 days specified in Regulatory Guide 1.4.) (Reference 20).

For each selected interval size, the processing begun with the first hourly χ/Q value on record and was then repeated for the same interval size starting with each subsequent hour of χ/Q data. In the averaging process, the only χ/Q values within a given time interval that were considered in evaluating the mean dilution factor for the interval were those whose corresponding wind direction sectors were the same as that for the first hour in the interval.

As an illustrative example, consider a 4-hour interval and the following sequence of hourly wind directions: W W W W S W S S S W W W
The sequence of averaged dilution factors (assuming each hourly χ/Q is equal to unity) is then 4/4, 3/4, 3/4, 2/4, 3/4, 1/4, 3/4, 2/4, and 1/4.

An average dilution factor obtained in this manner corresponds to the average relative concentration a receptor would be exposed to if he is positioned for the entire time interval in the sector in which the wind blows during the first hour in the interval.

The average dilution factors computed as described were subsequently classified into 40 groups and corresponding cumulative frequency distributions of decreasing χ/Q values were prepared. The distributions were then analyzed to determine the values that were exceeded 50 percent of the time. The results obtained for the various time intervals are presented in subsection 2.6.6 for the exclusion radius (3000 feet) and the outer boundary of the low population zone (1.5 miles). Values for other distances out to 50 miles for population dose calculations are given in Table 2.6-4.

B. Routine Diffusion Models

Annual average χ/Q values were computed from the on-site data for each sector for distances out to 50 miles. For each hour, the ground level release sector average model and/or the limited mixing model was used depending on the stability category for the hour and the downwind distance. The models used to compute the hourly values are given by Eqs. (6.1-8) and (6.1-9). The mean annual value in sector i at distance k is computed from the hourly value as

$$\overline{(\chi/Q)}_{ik} = \frac{\sum_{j=1}^{n} (\chi/Q)_{ijk}}{N}, \qquad (6.1\text{-}10)$$

where n is the number of hourly χ/Q values in sector i and N is the total number of values for all sectors. The results of these computations are presented in subsection 2.6.6.

6.1.4 Land

6.1.4.1 Geology and Soils

Geological studies in support of safety analyses were conducted at the site in 1969 and in 1972. Seismicity investigations and seismic field work were performed by Weston Geophysical Research, Inc., and soil studies were conducted by Geotechnical Engineers, Inc. A detailed presentation of the studies appears in Section 2.5 of the Preliminary Safety Analysis Report for the Seabrook Station.

In brief, the surveys indicated that igneous bedrock crops out in the station area and at the entrance to Hampton Harbor, while metamorphic schist bedrock commonly forms bedrock valleys buried deeply beneath deposits of till, outwash and marine clay-silt. Between the site area and the coast line, a broad surface of tidal marsh overlies old sandy beach deposits, sandy outwash and marine clay-silt deposits; these unconsolidated fine-grained sediments locally exceed 100 feet in thickness. Total local relief on the bedrock surface rarely exceeds 200 feet above mean sea level in the general vicinity of the site.

The purpose of the reconnaissance seismic survey was to determine depths of bedrock and depths of major seismic overburden discontinuities and to provide bases for evaluating the ground acceleration and design response spectra associated with the safe shutdown earthquake defined in 10 CFR 100. The seismic field data were indicative of sound bedrock with high in-situ compressional wave velocity (18,000 ft/sec) and shear wave velocity (9,000 ft/sec).

In general, the survey shows that hard rock was shallow in the vicinity of the selected plant location, with dense till along the north side of the site and less dense till and possible other overburden materials west of the plant location. A design response spectrum was obtained for an earthquake of 10 to 15 second duration with a peak particle velocity of 6 to 8 in/sec and a recommended ground acceleration of 0.2g.

The Class I components of the station will be placed in or on hard, strong crystalline igneous rock. As a result, present soil properties are expected to remain unaltered following station construction and operation.

6.1.4.2 Land Use and Demographic Surveys

The actual land use in the site environs, described in Sections 2.1 and 2.2, was determined from material supplied by the Southeastern New Hampshire Regional Planning Commission, (Reference 21), and by the Central Merrimack Valley Regional Planning District Commission (Reference 22). These reports are quite recent, and are considered to represent an accurate description of land use in the site environs.

Demographic data for the region was obtained from several sources. For distances between five and fifty miles from the site, Bureau of the Census reports for the 1970 Census were used (References 23, 24, and 25), with a map showing town delineations in the area, to determine population distribution around the site. The actual distribution was determined at these distances by superimposing the grid described in Section 2.2 on the map mentioned above, and ratioing town populations by the fractional area within grid sections. This is considered an accurate method of determining population distribution at distances greater than five miles from the site.

For distances within five miles of the site, several different approaches were used to determine population distribution data. Because of the importance of population distribution data in the immediate area of the site, an order was placed with the Bureau of the Census for the preparation of detailed permanent population distribution data, in a format consistent with the grid described in Section 2.2, for the area within five miles of the site, based on the 1970 Census. An independent estimate of population distribution was made by the applicant, based on 1970 Census data and U. S. Geological Survey maps, used to locate population centers and individual dwelling units with respect to the grid described in Section 2.2. Within the Town of Seabrook, a comprehensive town plan (Reference 26), was used to estimate population distribution.

The total 1970 permanent population within five miles of the site as determined by the applicant was 1.2 percent larger than the estimate from the Bureau of the Census. The data obtained from the Bureau of the Census was used in this report, and in the Preliminary Safety Analysis Report, for the area within five miles of the site.

Population projections for New Hampshire to the year 2020 were taken from the reports in References (27) and (28). Population projections for Massachusetts to the year 1990 were taken from the reports in References (29) and (30). These data were extrapolated to the year 2020 by applying the 1900/1960 ratio to the 1990 data. Population projections for Maine to the year 2020 were taken from the report in Reference (31).

6.1.4.3 Ecological Parameters

The description of the existing ecological features of the site's terrestrial environment is based upon studies by consultants familiar with local biota within their recognized fields of expertise. These investigations cover the plant life, mammals and birds of the area and reports of study findings appear in Appendices A, B, and C.

Additional, frequent site visits by Public Service Company of New Hampshire personnel and their bioenvironmental consultants have served to reinforce and extend knowledge of terrestrial biota. From these sources the applicant has gained a qualitative appraisal of terrestrial life with some estimates of relative abundance. The site is not inhabited by any plant or animal considered to be endangered or near extinction.

The only continuing sequential sampling of terrestrial life presently planned is that done in conjunction with the applicant's proposed radiological monitoring program (see subsection 6.2.1).

6.1.5 Radiological Surveys

As described in Section 2.8, a field and laboratory analytical survey of the region around Seabrook was conducted in order to supply information on about background concentrations of radionuclides in important local and regional biota, as well as in soil, surface water, ground water, sediments, and milk. This survey also included in situ external environmental gamma field measurements at 21 points measured with a high sensitivity pressurized ionization chamber and field spectra taken with a sodium iodide detector and a multichannel analyzer. An objective of this initial radiological study was to gather information which could be used in formulating the pre-operational radiological environmental monitoring program. The results of this study are tabulated and discussed in Section 2.8, as well as a description of the equipment used and the sample locations for this background study.

At least 18 months prior to station startup, an ongoing pre-operational offsite environmental radiological monitoring program will be established to more accurately determine the following items:

1) critical population groups and pathways
2) procedures for routine sample collection and analysis
3) documentation of seasonal variations or trends, if any, of activity in those media which are to be sampled operationally
4) a baseline of data on the distribution of manmade and natural activity in sample media in the environment about the station

The program is designed to allow comparisons of operational measurements between locations considered "indicator locations" and locations designated "background locations" in light of any seasonal fluctuations or trends which were evident during the preoperation program. In monitoring airborne releases, indicator (Zone I) locations are those sampling sites situated within five miles of the station. It is considered that these close-in locations will reflect increases in environmental activity, if any, due to airborne releases. Background locations (Zone II) are those locations over five miles from the station, a distance considered outside the influence of routine airborne station releases. This simultaneous monitoring of Zone I and Zone II is designed to allow statistical comparisons of activity in various sample media in the two zones after station startup while eliminating the problem of changes in natural or fallout exposure rates throughout the entire area from causes not related to station operation. For example, following a nuclear weapons test, fallout would be collected by the air particulate and precipitation monitors throughout both Zone I and Zone II. Similarity of particulate gross beta, and gamma spectrum analysis of filters for all stations would indicate the activity was not due to station releases.

In monitoring surface water, fish, bottom sediments, beach sands, mollusks, crustaceans, plankton, and algae, comparisons will be made between samples collected from areas in the proximity of the station discharges and areas which, due to the action of tides and distance, are outside the influence of station releases.

It is anticipated, that the analyses of the various sample media, except thermoluminescent dosimeters will be contracted to an outside analytical laboratory in order to minimize dose pickup in transit. Environmental samples will be shipped to the contractor's laboratory by the fastest shipping method available in order to minimize decay of short lived isotopes possibly present in the sample. Analytical sensitivities discussed below are representative of the sensitivity of analysis presently being achieved by contractor laboratories using currently available instrumentation and techniques. An outline of the preoperational program is shown in Table 6.1-4. Sample points are shown in Table 6.1-5 through 6.1-13. The radiological environmental monitoring program as outlined below exceeds the monitoring requirements of the recommended minimum level environmental surveillance program around nuclear reactors recommended by the EPA, Office of Radiation Programs in their "Environmental Radioactivity Surveillance Guide" (ORP/SID 72-2). For most environmental media, samples are collected from more points, at more frequent intervals, with more specific analyses being performed than is specified by this guide.

The surveillance program will be reviewed at least biennially in order to determine that it is achieving its stated objectives and that no changes or additions to the monitoring program are necessitated by changes in effluent characteristics or experience at other reactors or research establishments.

The preoperational radiological environmental surveillance program will consist of the following:

6.1.5.1 Atmospheric Monitoring

Air monitoring sites will be established at a total of 10 locations. Seven of these will be located in Zone I, with three in Zone II. The Zone I sites will include three close-in monitoring locations situated so as to monitor maximum offsite ground level air concentrations based on annual meteorology as closely as possible under the restrictions of year round access to the site and availability of power. The other four Zone I air monitoring locations are to be distributed in the major wind rose directions throughout Zone I. The Zone II locations will be in Portsmouth, New Hampshire, Haverill, Massachusetts, and East Kingston, New Hampshire. They will serve as Zone II background locations for comparison against the Zone I indicator locations in evaluating the environmental impact of routine airborne effluents. At the same time, their operation will maintain constant surveillance of Haverhill and Portsmouth, the major population centers within 15 miles of the site, in case of a release of activity far in excess of normal levels during an improbable accident situation. East Kingston, New Hampshire provides a third Zone II air monitoring point to the WNW. Preoperational monitoring of these three background sites will provide data as to the normal magnitude of variations noted relative to the Zone I locations, and identify any marked seasonal fluctuations in airborne activity. This information is of use in assessing any increases noted in airborne activity after station startup in Zone I vs. Zone II monitoring locations.

Preoperational analyses at each air monitoring site will include gross long lived beta analysis (at least 24 hours after filter removal to allow for radon and thoron daughter decay) on a weekly basis. Monthly gamma spectrum analyses on Zone I and Zone II filter composites will be made to identify gamma emitters present. These monthly zone composites will also be analyzed for Sr-90 activity. Gamma analysis will be done by counting each zone's filter composite for at least eight hours using a lithium drifted germanium detector and a 4096 channel multichannel analyzer. In this manner, it is possible to resolve complex isotopic mixtures and to measure low level fallout activity at each site. Table 6.1-14 shows the minimum detectable activity by isotope which must be present on a filter. These minimum detectable activities are as supplied by third party analytical laboratories based on calibrations made using N.B.S. standards where possible. In addition, interlaboratory comparisons are carried out by these laboratories with samples supplied by the Analytical Quality Control Service of the Surveillance and Inspection Division of the EPA and other Federal regulatory agencies.

Glass fiber filters are analyzed for strontium by fusing a measured fraction of the filter with sodium carbonate and dissolving the melt. Silica is destroyed by treatment with hydrofluoric acid and the remaining salts are dissolved and diluted to a known volume with hydrochloric acid. Analysis then proceeds as for strontium in water as described in subsection 6.1.5.3.

Air samplers will operate continuously, drawing air at one cubic foot per minute (approximately 300 cubic meters per week) through a 47 mm fiber-glass filter (Gelman Type E or its equivalent). These filters are at least 99.7 percent efficient for particles larger than 0.3μ in diameter and 98 percent efficient for particles as small as 0.05μ according to the manufacturer. The volume of air sampled during each sampling interval will be recorded using an in-line integrating dry gasmeter. It will be equipped with a pressure gauge to allow volume correction based on the average gasmeter inlet line pressure.

The minimum detectable gross beta level using a low background beta counter is 0.005 pCi/m^3. For a monthly composite of four filters, a gamma spectrum has a minimum detectable level of 5.8×10^{-3} pCi/m^3 for Cs-134, Cs-137, and 4.2×10^{-3} pCi/m^3 for Mn-54, Co-58, Co-60, using the minimum detectable activities supplied in Table 6.1-14 and a sampling rate of 300 cubic meters per week per filter. The minimum detectable level for Sr-90 is 4.2×10^{-4} pCi/m^3 for a monthly composite of four filters.

6.1.5.2 Gamma Radiation Monitoring

Each air monitoring station will be equipped with thermoluminescent dosimeters (TLD to quantify background radiation on a monthly basis. In addition to air monitoring sites, 15 other sites will be chosen for placement of dosimeter packs. It is anticipated that each dosimeter pack at a monitoring location will include at least four individual dosimeters. This allows a more accurate measurement of the true monthly location mean and prevents erroneous readings being recorded due to chance fluctuations in a single dosimeter's readout. The variances calculated at each point through use of multiple dosimeters figures into the statistics used to compare one monitoring location to another on an operational basis. The smaller a location's monthly variance, the smaller the necessary difference between any two locations monthly means in order to achieve a given probability that the difference noted is not due to chance.

The proposed TLD monitoring locations are listed in Table 6.1-6. Zone I TLD locations include each air sampling site plus seven TLD sites placed at the exclusion radius. TLD's are thus located at the exclusion radius to the N, NE, E, ESE, SE, S, SW, W and NW. Five other Zone I TLD locations are situated as listed in Table 6.1-6. Zone II TLD locations include the three Zone II air monitoring locations plus sites in Exeter, New Hampshire, Amesbury, Massachusetts and Newbury, Massachusetts. The proposed TLD sites will thus cover most of the major population concentrations within 15 miles of the station.

At least six months before plant startup, the TLD background radiation network will be supplemented by the use of a high sensitivity pressurized ion chamber. This chamber is to be placed at TLD station TL 1.18 located 3000 feet from the station to the ESE. This location has the maximum mean annual chi/Q of any sector and thus should show the maximum incremental dose of any location from station gaseous effluents.

The pressurized ion chamber to be used is designed for continuous field operation and is capable of distinguishing gamma radiation field variations as low as 0.1μ rad/hr (0.9 mr/yr). Use of this chamber will supply information useful in validating the gaseous dispersion model used to calculate offsite doses through its ability to record very low level incremental exposures with little ambiguity as to source. Accurate calculations of the incremental exposure dose due to station operation can be made by integrating recorded dose rates above the mean background dose rate for the monitoring site.

Preoperational use of the ionization chamber will identify the magnitude of natural short term fluctuations in background due to processes such as "natural fallout" - the rapid washout of radon daughters from the atmosphere during rainstorms. Even this sort of short term variation should be distinguishable from plume contribution to background dose rate on an operational basis. The ionization chamber operates by recording the dose rate at 10 second intervals on magnetic tape. Once a week this tape is changed and the data is read out. The dose rate above the mean background rate for any time interval can be easily calculated and this information used to calculate incremental dose due to station operations.

According to studies performed by the AEC's Health and Safety Laboratory the energy response of this type spherical ionization chamber is reasonably linear over the range 100 kev - 7 meV (Reference 32).

The TLD's to be placed at the points described earlier will measure the monthly integrated dose due to gamma radiation. A packet of preselected, matched TLD chips from the same production batch (use of Harshaw TLD-100 LiF dosimeters is anticipated) will be placed at each location. Readout will be done locally in order to eliminate problems of dose pick-up in transporting dosimeters to a contractor's laboratory.

According to a recent study by the AEC's Health and Safety Laboratory using LiF dosimeters, it is feasible to measure a 10 percent change in a 10 mr dose (Reference 33). Thus, a one mr/month increase in normal background radiation due to station operations could be detected if the normal variations at each of the monitoring sites are well known or essentially constant. It is this periodic seasonal change in background radiation which the preoperational program will seek to clarify.

6.1.5.3 Precipitation Monitoring

During the preoperational program, samples of precipitation will be collected continuously at each air sampling site in both Zone I and Zone II. A funnel at least 9 inches in diameter will be used. This funnel is to be heated during the winter months to melt and collect precipitation falling as snow or sleet. Samples will be collected monthly and analyzed for gross beta, tritium, gamma emitters by high resolution gamma spectroscopy, and strontium-90 activity.

Gross beta analysis will be done by evaporating at least 1 liter, if available, of a composite sample to dryness and counting the residue in a low background beta counter. Analytical sensitivity for this procedure is 1 pCi/1. Tritium analysis will be done using a modified liquid scintillation procedure. Samples are first filtered and distilled to eliminate quenching materials which can cause erratic results. A sample of water is then mixed with a scintillation solution and counted in a liquid scintillation spectrometer for at least 500 minutes. Analytical sensitivity for tritium with this procedure is approximately 200 pCi/1.

Gamma spectrum analysis will be done on one liter of precipitation by placing the sample in a Marinelli beaker surrounding a Ge(Li) detector, in a standard calibrated geometry. This detector will be coupled to a 4096 channel multi-channel analyzer. The sample will be counted for a period of time sufficient to achieve the detection sensitivities shown in Table 6.1-15. Strontium-90 will be analyzed by evaporating to dryness one liter of water containing suitable carrier. The residue is dissolved in dilute acid and the strontium precipitated and separated. Yttrium is allowed to grow into the strontium precipitate for a period of 14 days. Yttrium-90 is then extracted in di-2-ethylhexyl phosphoric acid, and after back extraction into the aqueous phase, precipitated as yttrium oxalate. This precipitate is then counted in a low background proportional counter for 100 minutes and the strotium-90 activity calculated. Analytical sensitivity for Sr-90 by this procedure is 1.0 pCi/1. The percent recovery is determined using Sr-85 carrier of known activity counted by gamma spectroscopy. The yttrium-90 precipitate is recounted at a later time to determine if the decline in count rate corresponds to the half life of yttrium-90.

6.1.5.4 Foodcrop and Vegetation Monitoring

Representative samples of foodcrops and vegetation from six Zone I locations will be compared to three Zone II locations during the preoperational program. Samples will be collected at harvest (or at the end of the growing season) and at least once during the growing season in order to determine uptake of radionuclides either from the soil (after deposition from the air) or direct deposition on the plant. Sampling points for vegetation are shown in Table 6.1-7. Among the flora to be sampled are apples, vegetables, and marshgrass. Samples will be analyzed for gamma emitters by Ge(Li) spectroscopy with the analytical sensitivities shown in Table 6.1-15. Strontium-90 analysis will be done on each sample collected in order to determine the background levels for each sampling point. Strontium analysis will be done by first drying the samply for twenty-four hours, ashing in a muffle furnace and dissolving the residue in dilute acid. Analysis then proceeds as for strontium in water. Analytical sensitivity is 30 pCi/kg dry weight.

6.1.5.5 Milk Monitoring

Milk will be collected monthly from five locations during the preoperational program. Three Zone I dairies will be compared to two Zone II dairies located over fifteen miles from the station. Each sample will be analyzed for gamma emitters by high resolution Ge(Li) spectroscopy with analytical sensitivities as shown in Table 6.1-15. One liter of milk is placed in a Marinelli beaker over a Ge(Li) detector and counted for a period of time sufficient to achieve the detection sensitivities shown in Table 6.1-15. Strontium-90 is to be analyzed by stirring one liter of milk containing standard strontium, yttrium, and cesium carriers with a cation exchange resin. The strontium is stripped from the resin with strong acid and after 14 days ingrowth, the yttrium-90 is extracted with di-2-ethylhexyl phosphoric acid in toluene. This is back extracted into the aqueous phase and precipitated as the oxalate. This purified precipitate is then counted in a low background proportional counter and the strontium-90 activity calculated. A recount is made later to determine if the decline in activity corresponds to the half life of yttrium-90.

Iodine-131 analysis will be made using a radiochemical separation technique. One liter of milk is passed through an ion exchange column. The iodine is eluted from the column with sodium perchlorate and precipitated as silver iodide. After purification, the sample is mounted on a planchete and counted in a low background beta counter. Analytical sensitivity is 0.5 pCi/l.

6.1.5.6 Ground Water Monitoring

Preoperationally, well water is to be obtained from the wells listed in Table 6.1-9. These wells include three in the immediate area of the station and two distant wells which will be grab sampled and analyzed on a quarterly basis. The samples will be analyzed for gross beta, tritium, Sr-90, and gamma emitters by high resolution Ge(Li) spectroscopy. Analytical methods and sensitivities are as discussed under precipitation analysis above. The two distant wells will serve as a running background for the close-in wells during station operation.

6.1.5.7 Surface Water Monitoring

Surface water will be grab sampled monthly during the preoperational program from ten monitoring points both in Hampton Harbor and in the Atlantic. The sampling areas are as listed in Table 6.1-10. Points chosen include areas in the vicinity of the proposed discharge area and areas which are considered outside the influence of station releases. Samples will be analyzed for gamma activity and tritium by the techniques described in the precipitation section. Analytical sensitivity by isotope for gamma spectroanalysis is as shown in Table 6.1-15. Tritium analytical sensitivity is 200 pCi/l.

6.1.5.8 Soil Monitoring

During the preoperational program, in situ quantitative gamma spectrometric measurements of soil activity will be made at each air sampling station and accessible TLD stations on a quarterly basis. Spectra will be collected using high efficiency Ge(Li) solid state detectors. It is clear that *in situ* measurements of soil activity are more sensitive and provide more representative data on radionuclide activity in soil, and the exposure rate from these radionuclides, than does collection of soil samples and laboratory analysis. Field analysis of soil activity using an unshielded downward looking detector 1 meter above the ground, detects gamma rays from an area within about a 10 meter radius, thus averaging out any small local variations in the soil (Reference 34).

Soil samples will be collected at the time field spectra are taken to document the ambient Sr-90 level for each location.

Concurrent with use of the field gamma spectrum system, high pressure ionization chamber readings will be made to determine the total dose rate over the time period field spectra are collected. This total dose rate will be apportioned among the various contributing radionuclides detected in the gamma spectrum. Soil activity sampling locations are shown in Table 6.1-13.

6.1.5.9 Marine Media Monitoring

Preoperationally, samples of a variety of marine media will be collected semiannually. Seven locations have been chosen for sampling each of the following media: fish, mollusks, crustacea, plankton, and algae. Bottom sediments and beach sands will be sampled from ten locations. Sample locations for the above media are shown in Tables 6.1-11 and 6.1-12. The stations chosen will include points in the immediate vicinity of the discharge and areas outside the influence of routine station effluents.

In situ gamma spectrometry will be done at those beach sand locations accesible to the vehicle carrying the field gamma system. Otherwise, a one kilogram sample of sand will be collected and analyzed by the analytical contractor by high resolution Ge(Li) spectroscopy for any activity above the detection sensitivities shown in Table 6.1-15. Only edible portions of fish, mollusks, and crustaceans will be analyzed in all procedures. Strontium-90 analysis will also be carried out on each sample during the preoperational program in order to document ambient levels. Preparation of all media will include drying, ashing, dissolution in dilute acid, and analysis as for Sr-90 in precipitation.

6.1.5.10 Miscellaneous

The results of the surveillance program outlined above will be reviewed every 6 months to determine if it is necessary to add sample media, and change analytical and/or sampling procedures or sampling points in order to meet the objectives listed in the introduction to subsection 6.1.5.

Certain media such as small game were not included in the preoperational program because of the migratory nature of all common gamebirds in the area.

Since it is improbable that groundwater used by local farms would contain any plant related radionuclides and local poultry are fed processed feeds, there is no significant pathway by which locally produced meat or eggs could be as an exposure pathway to man. However if survey results indicate such a potential, the appropriate sample media will be added to the monitoring program to fully determine the extent and magnitude of the problems.

6.1.5.11 Quality Control Program

A quality control program will be established to check the validity of analyses performed by the contractor providing the radiological environmental analyses for Seabrook Station. The program will operate as follows. Various sample media with known activities are to be supplied to the environmental group at the site on a regular basis (at least quarterly) by the EPA Analytical Quality Control Service in Las Vegas, Nevada. These samples are designed to check various analyses including gamma spectroscopy for key nuclides, tritium, and strontium-90 analysis.

At the plant, the samples will be labelled and packaged so as to be completely indistinguishable from any other similar environmental sample.

A note will be made to the plant environmental sample file detailing the date shipped, the EPA Code number for this sample, and the manner in which it was labelled at the plant. When the contractor reports its results to the plant environmental group, the station group will fill out and submit the appropriate EPA Quality Control Service reporting forms. When the EPA reports actual sample activity back to the station, comparison will be made between contractor values and "known" EPA values. This program will validate reported values and allow rapid detection of problems in a particular analytical procedure should this problem arise.

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Table 6.1-1

Flow Through Hampton Inlet - Cubic Feet

Flood Tide	Ebb Tide	Average of Flood and Ebb	Average Tidal Amplitude
December, 1969 - 353×10^6	430×10^6	391×10^6 cf	6.55 feet
January, 1969 - 358×10^6	505×10^6	431.5×10^6 cf	8.25 feet

Table 6.1-2

Equivalent Dye Volume by Harbor Segments

Area Harbor	Dye Concentration ppb by Volume	Volume of Water in Each Area at Ebb Slack Cu Ft x 10^6	Volume of Dye Solution in Each Arc at Ebb Slack Cu Ft x 10^{-3}
Subarea 1	1.8	4.90	8.85
2	2.1	11.96	25.15
3	2.1	14.30	30.00
4	1.8	1.40	2.52
5	0	11.15	0
Browns River	1.2	1.25	1.50
Hampton River	1.2	19.00	22.80
Mill Creek	0	1.40	0
Blackwater River	0	17.50	0
Total		82.86	90.82

TABLE 6.1-3

SEABROOK METEOROLOGICAL EQUIPMENT SYSTEMS

30 Foot Level

Winds

11/1/71 - 11/21/72	Six-bladed Bendix Aerovane with Bendix Model 141-2 dual recorder.
11/21/72 - Present	Bendix P/N 2414914 3-cup anemometer and P/N 2416970 vane system with Bendix Model 141-2 dual strip chart recorder. Starting speed: less than 1 mph.

Ambient Air Temperature

11/1/71 - Present	REC platinum temperature sensor, 400A REC resistance bridge, and Esterline-Angus multipoint recorder.

Dewpoint

3/17/72 - Present	Foxboro Dewcel H103AZ, Dewcel Weatherhood, REC 400A resistance bridge, Esterline-Angus multipoint recorder.

130 Foot Level

Winds

11/28/72 - Present	Bendix P/N 2414914 3-cup anemometer and P/N 2416970 vane system with Bendix Model 141-2 dual strip chart recorder. Starting speed: less than 1 mph.

Delta T Temperature between 30 feet and 130 feet

11/1/71 - Present	REC platinum temperature sensor, 400D differential bridge, 421 BX-2X differential chassis, Esterline-Angus multipoint recorder.

TABLE 6.1-4

PRE-OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Media	Type Analysis Performed (Frequency)	Number of Sample Locations Zone I	Zone II
Air Particulates	Gross Beta (Weekly) Gamma Scan of Zone I and Zone II Composite (Monthly) Sr-90 Zone I and Zone II Composite (Monthly)	7	3
High Pressure Ionization Chamber	Gamma Dose Rate (Records Dose Rate every 10 sec.)	1	-
TLD Dosimeters	Integrated Gamma Dose (Monthly)	19	6
Food Crop and Vegetation	Gamma Spectrum (Twice during Growing Season) Sr-90 (Twice during Growing Season)	6	3
Milk	Gamma Spectrum (Monthly) Sr-90 (Monthly) I-131 (Radiochemical Separation - Low Beta Count) (Monthly)	3	2
Well Water	Gross Beta (Quarterly) Gamma Spectrum (Quarterly) Tritium (Quarterly) Sr-90 (Quarterly)	3	2
Surface Water	Gamma Spectrum (Monthly) Tritium (Monthly)	7	3
Precipitation	Gross Beta (Monthly) Tritium (Monthly) Gamma Spectrum (Monthly) Sr-90 (Monthly)	7	3
Soil	*In situ* quantitative Gamma Spectrum (Quarterly) Sr-90 (Quarterly)	13	6
Fish	Gamma Spectrum Analysis (semiannually) Sr-90 (semiannually)	5	2
Mollusks	Gamma Spectrum Analysis (semiannually) Sr-90 (semiannually)	5	2
Plankton	Gamma Spectrum Analysis (semiannually) Sr-90 (semiannually)	5	2

TABLE 6.1-4 (Continued)

PRE-OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Media	Type Analysis Performed (Frequency)	Number of Sample Locations Zone I	Zone II
Crustaceans	Gamma Spectrum Analysis (semiannually) Sr-90 (semiannually)	5	2
Algae	Gamma Spectrum Analysis (semiannually) Sr-90 (semiannually)	5	2
Bottom Sediments (Including Beach Sands)	Gamma Spectrum Analysis (semi-annually) #1 Sr-90 (semiannually)	7	3

#1 Accessible beach sand locations will be analyzed by *in situ* quantitative gamma spectroscopy as described in text.

TABLE 6.1-5

AIR MONITORING STATIONS

Zone I

	Location	Distance from Plant	Direction
A 1.1	Hampton State Park	1.8	E
A 1.2	Seabrook Beach	1.9	SE
A 1.3	Hampton River Boat Club	1.9	NNE
A 1.4	Farm Dock - Seabrook	0.7	S
A 1.5	Weare Corner - Seabrook	2.5	W
A 1.6	Dow's Lane - Seabrook	0.57	SW
A 1.7	Brimer's Lane	0.57	N

Zone II

	Location	Distance from Plant	Direction
A 2.1	Portsmouth, New Hampshire - PSCNH Branch Office - Route 1	9.5	NNE
A 2.2	Haverhill, Massachusetts - Winnekenni Park	12.5	SW
A 2.3	E. Kingston, New Hampshire - Electrical Substation	8.0	WNW

June 1973

TABLE 6.1-6

GAMMA RADIATION MONITORING STATIONS

Zone I

Station Designation	Distance from Plant	Direction from Plant
TL 1.1 - TL 1.7	At each of 7 Zone I air monitoring sites	
TL 1.8	0.57	NE
TL 1.9	0.57	E
TL 1.10	0.57	SE
TL 1.11	0.57	S
TL 1.12	0.57	W
TL 1.13	0.57	NW
TL 1.14 (South Seabrook Substation)	2.1	S
TL 1.15 (Seabrook Beach)	2.3	SE
TL 1.16 (Salisbury)	4.0	SSE
TL 1.17 (Seabrook)	0.9	W
TL 1.18 (Ion Chamber and TLD Site)	0.57	ESE
TL 1.19 (Hampton Beach Firehouse)	2.2	NE

Zone II

Station Designation	Location	Distance from Plant	Direction from Plant
TL 2.1	Portsmouth, New Hampshire - PSCNH Branch Office - Route 1	9.5	NNE
TL 2.2	Haverhill, Massachusetts - Winnekenni Park	12.5	SW
TL 2.3	E. Kingston, New Hampshire - Electrical Substation	8.0	W
TL 2.4	Exeter, New Hampshire	7.3	NW
TL 2.5	Amesbury, Massachusetts	5.1	SW
TL 2.6	Newbury, Massachusetts	8.4	SSE

TABLE 6.1-7

FOOD CROP AND VEGETATION MONITORING STATIONS

Zone I

Media	Location	Distance from Station	Direction
Apples	Applecrest Farm Orchards Rt. 88, Hampton Falls, New Hampshire	3.0	NW
Vegetables	Crooked Chimney Farm Rt. 88, Hampton Falls, New Hampshire	4.2	NW
Vegetables	Bartlett Farm Congress St. Salisbury, Massachusetts	3.0	SW
Marsh Grass	Hunts Island	0.57	ESE
Marsh Grass	Beckman's Island	0.57	S
Marsh Grass	Hampton Flats	0.57	NW

Zone II

Media	Location	Distance from Station	Direction
Vegetables	Ingaldsby Farm W. Boxford, Massachusetts	16.5	SW
Apples	R. H. Hetnar Orchard Prescott Road Epping, New Hampshire	16.8	NW
Marsh Grass	Vicinity of Wingaersheek Beach, Gloucester, Massachusetts	18.3	SSE

TABLE 6.1-8

MILK MONITORING SITES

Zone I

Location	Distance from Station	Direction
Harold Perkins Hampton, New Hampshire	2.4	NE
W. W. Marston Dairy Hampton Falls, New Hampshire	2.7	NW
R. Bartlett Dairy Congress St. Salisbury, Massachusetts	3.0	SW

Zone II

Location	Distance from Station	Direction
Rogers Spring Hill Farm Neck Road Bradford, Massachusetts	17.2	SW
McPhee Farm Prescott Road Epping, New Hampshire	16.4	NW

TABLE 6.1-9

GROUND WATER MONITORING SITES

Zone I

Location	Distance from Station	Direction
Bondi's Restaurant-Well Seabrook, New Hampshire	0.7	W
Brimer's Lane-Well Hampton Falls, New Hampshire	0.6	NNW
T. L. Boyd-Well Seabrook, New Hampshire	0.8	SSW

Zone II

Location	Distance from Station	Direction
Hampton Water Co. Well #9 Hampton, New Hampshire	3.3	NE
Kensington Elementary School Well Kensington, New Hampshire	5.0	NW

TABLE 6.1-10

SURFACE WATER MONITORING SITES

Zone I

Location	Distance from Discharge Area	Direction
Discharge Area	-	-
Intake Area	0.57	SW
Locke Point - Hampton Harbor Inlet	1.4	SW
Seabrook Beach - opposite Round Rock	2.3	SSW
Salisbury Beach	4.5	SSW
Hampton Beach	1.0	W
North Beach	2.0	NNW

Zone II

Wingaersheek Beach Gloucester, Massachusetts	18.0	SE
Odiornes Point Rye, New Hampshire	10.7	NE
Cow Beach Point York, Maine	19.6	NE

TABLE 6.1-11

MARINE MEDIA MONITORING SITES
FISH, PLANKTON, MOLLUSKS, CRUSTACEANS, ALGAE

Zone I

Location	Distance from Discharge Area	Direction
Discharge Area	-	-
Hampton Harbor Inlet - Locke Point	1.4	SW
Taylor River at Hampton Landing	2.7	NW
Browns River - Robbins Point	2.6	WSW
Blackwater River - near Route 286 Bridge	2.9	SSW

Zone II

Location	Distance from Discharge Area	Direction
Cow Beach Point York, Maine	19.6	NE
Ipswich Bay - Vicinity of Wingaersheek Beach, Gloucester, Massachusetts	18.3	SSE

TABLE 6.1-12

BOTTOM SEDIMENT AND BEACH SAND MONITORING LOCATIONS

Zone I

Location	Distance from Discharge Area	Direction
Discharge Area	-	-
Intake Area	0.57	SW
Hampton Harbor - opposite Commons Island	1.9	SW
Seabrook Beach - opposite Round Rock	2.3	SSW
Salisbury Beach	4.6	SSW
Hampton Beach	1.0	W
North Beach	2.3	NNW

Zone II

Location	Distance from Discharge Area	Direction
Wingaersheek Beach Gloucester, Massachusetts	18.0	SE
Odiornes Point Rye, New Hampshire	10.7	NE
Cow Beach Point York, Maine	19.6	NE

TABLE 6.1-13

SOIL MONITORING LOCATIONS

ZONE I

Location	Distance from Plant	Direction
Hampton State Park	1.8	E
Seabrook Beach	1.9	SE
Hampton River Boat Club	1.9	NNE
Farm Dock - Seabrook	.7	S
Weare Corner - Seabrook	2.5	W
Dow's Lane - Seabrook	.57	SW
Brimer's Lane - Hampton Falls	.57	N
TL 1.12 (Rocks Road)	0.57	W
TL 1.14 (South Seabrook Substation)	2.1	S
TL 1.15 (Seabrook Beach)	2.3	SE
TL 1.16 (Salisbury)	4.0	SSE
TL 1.17 (Seabrook)	0.9	W
TL 1.19 (Hampton Beach Firehouse)	2.2	NE

ZONE II

Location	Distance from Plant	Direction
Portsmouth, New Hampshire - PSCNH Branch Office - Route 1	9.5	NNE
Haverhill, Massachusetts Kenoza Park	12.5	SW
E. Kingston, New Hampshire Electrical Substation	8.0	WNW
Exeter, New Hampshire	7.3	NW
Amesbury, New Hampshire	5.1	SW
Newbury, New Hampshire	8.4	SSE

TABLE 6.1-14

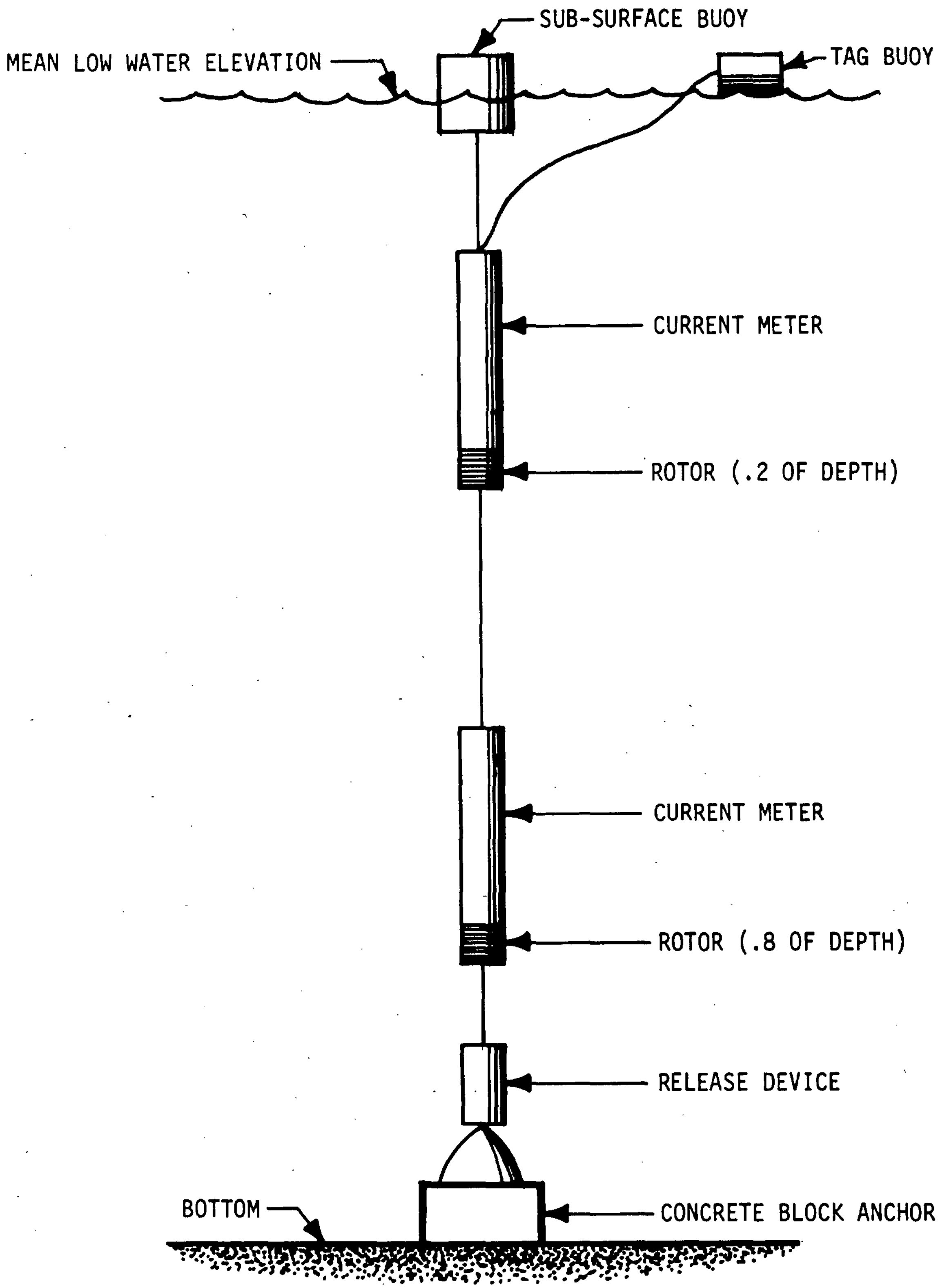
AIR PARTICULATE FILTER DETECTION SENSITIVITY BY HIGH RESOLUTION Ge(Li) GAMMA SPECTROSCOPY

Nuclide	pCi/Total Filter
Be-7	60
Cr-51	60
Mn-54	6
Co-58	6
Co-60	6
Se-75	52
Fe-59	11
Zr-95	11
Ru-103	7
Ru-106	60
I-131	8
Cs-134	7
Cs-137	7
Ba-140	25
La-140	6
Ge-141	12
Ce-144	52
K-40	52
Ra-226	12
Th-228	12

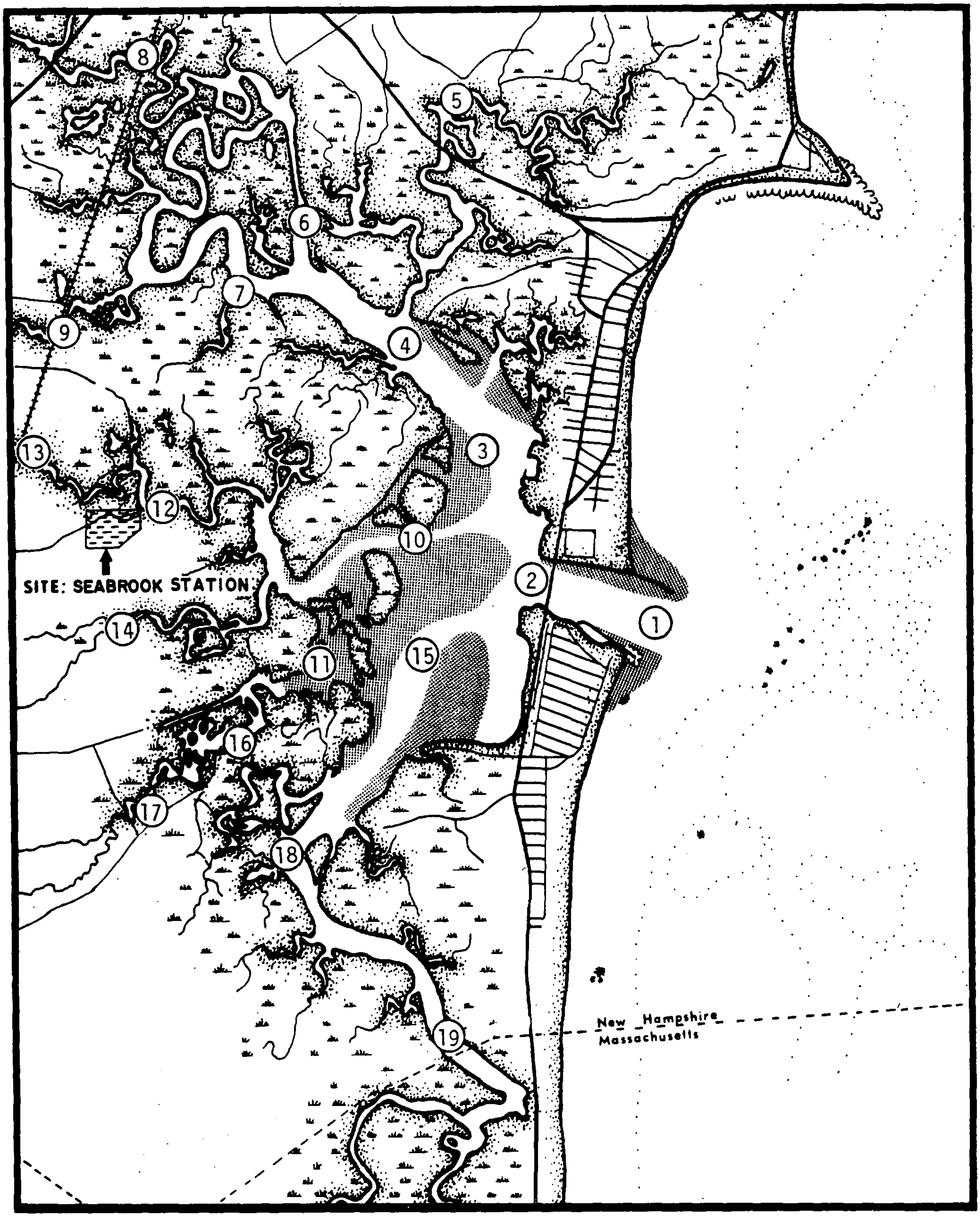
TABLE 6.1-15

ENVIRONMENTAL SAMPLE DETECTION SENSITIVITY BY HIGH RESOLUTION Ge(Li) GAMMA SPECTROSCOPY

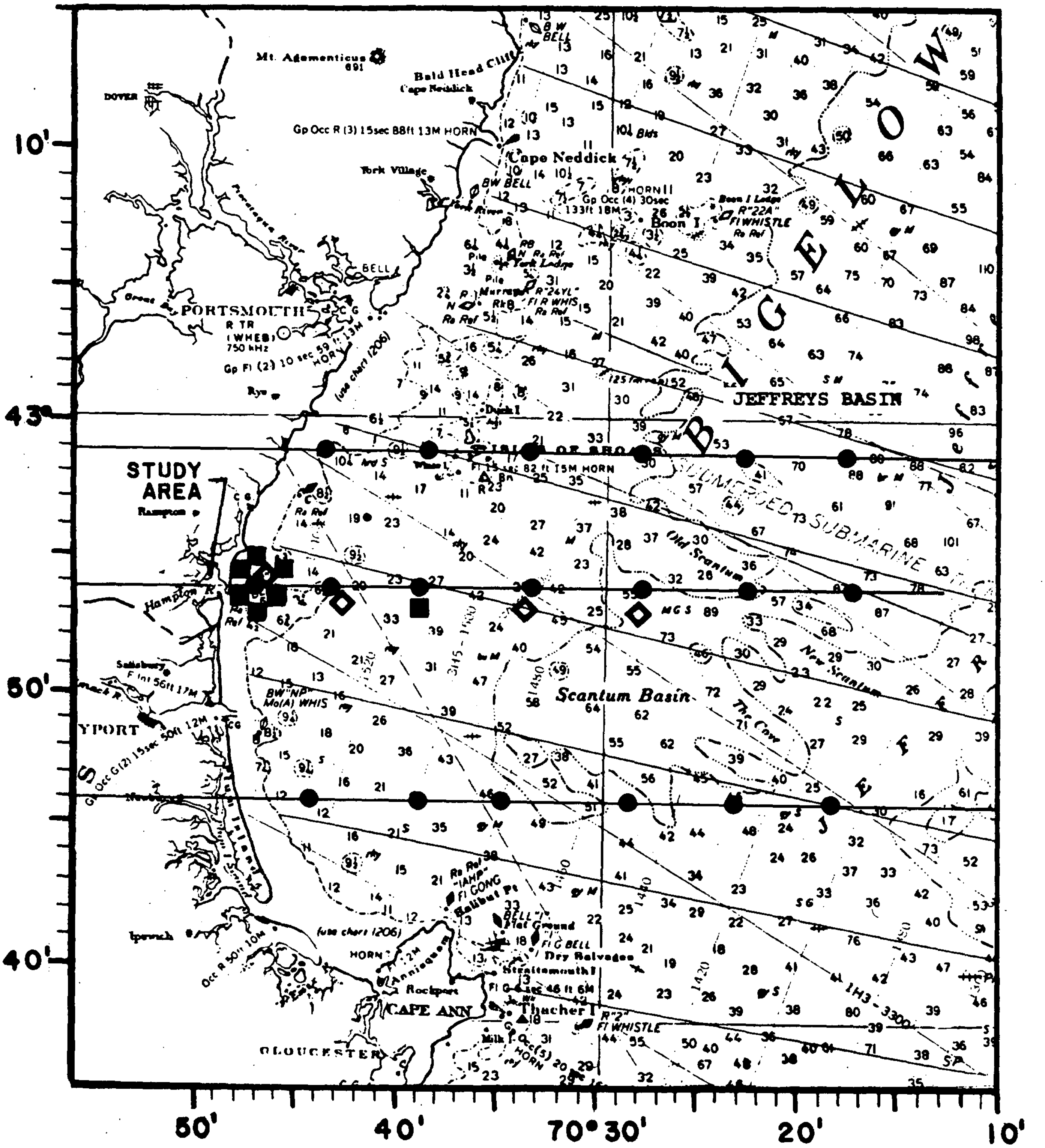
Isotope	Water or Milk (1 liter) pCi/l	Other Environmental Media (Soil, Vegetation, Fish, etc.-1 kg) pCi/kg
Be-7	60	100
Cr-51	60	100
Mn-54	6	10
Co-58	6	10
Co-60	6	10
Se-75	52	90
Fe-59	11	18
Zr-95	11	19
Ru-103	7	11
Ru-106	60	100
I-131	8	13
Cs-134	7	11
Cs-137	7	12
Ba-140	25	42
La-140	6	10
Ce-141	12	20
Ce-144	52	90
K-40	52	90
Ra-226	12	21
Th-228	12	21



PSNH SEABROOK STATION	TYPICAL TWO CURRENT METER INSTALLATION	FIGURE 6.1-1



PSNH SEABROOK STATION	INSHORE DYE RELEASE STATIONS	FIGURE 6.1-2

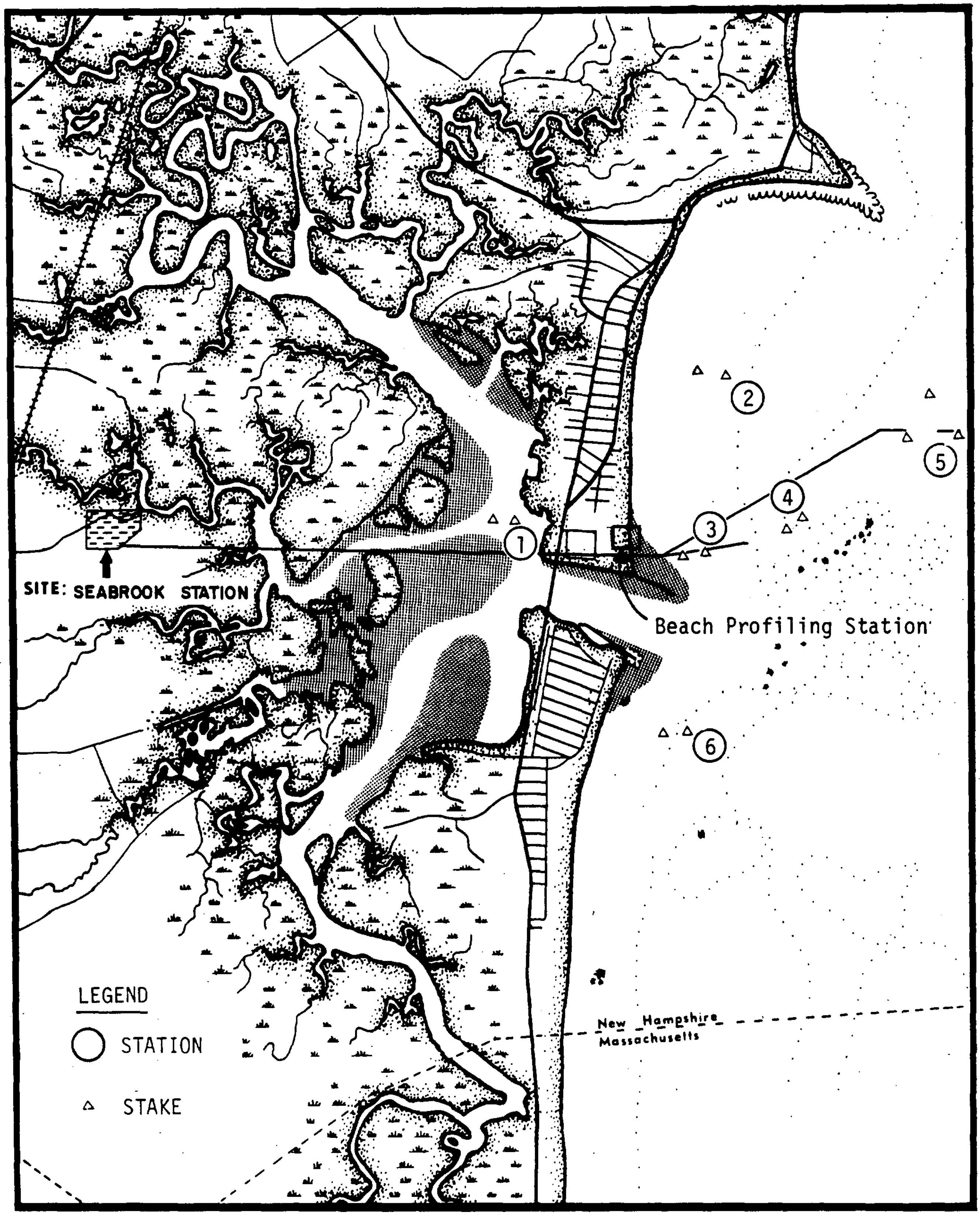


● PLANKTON STATIONS AND DRIFTER RELEASE STATIONS

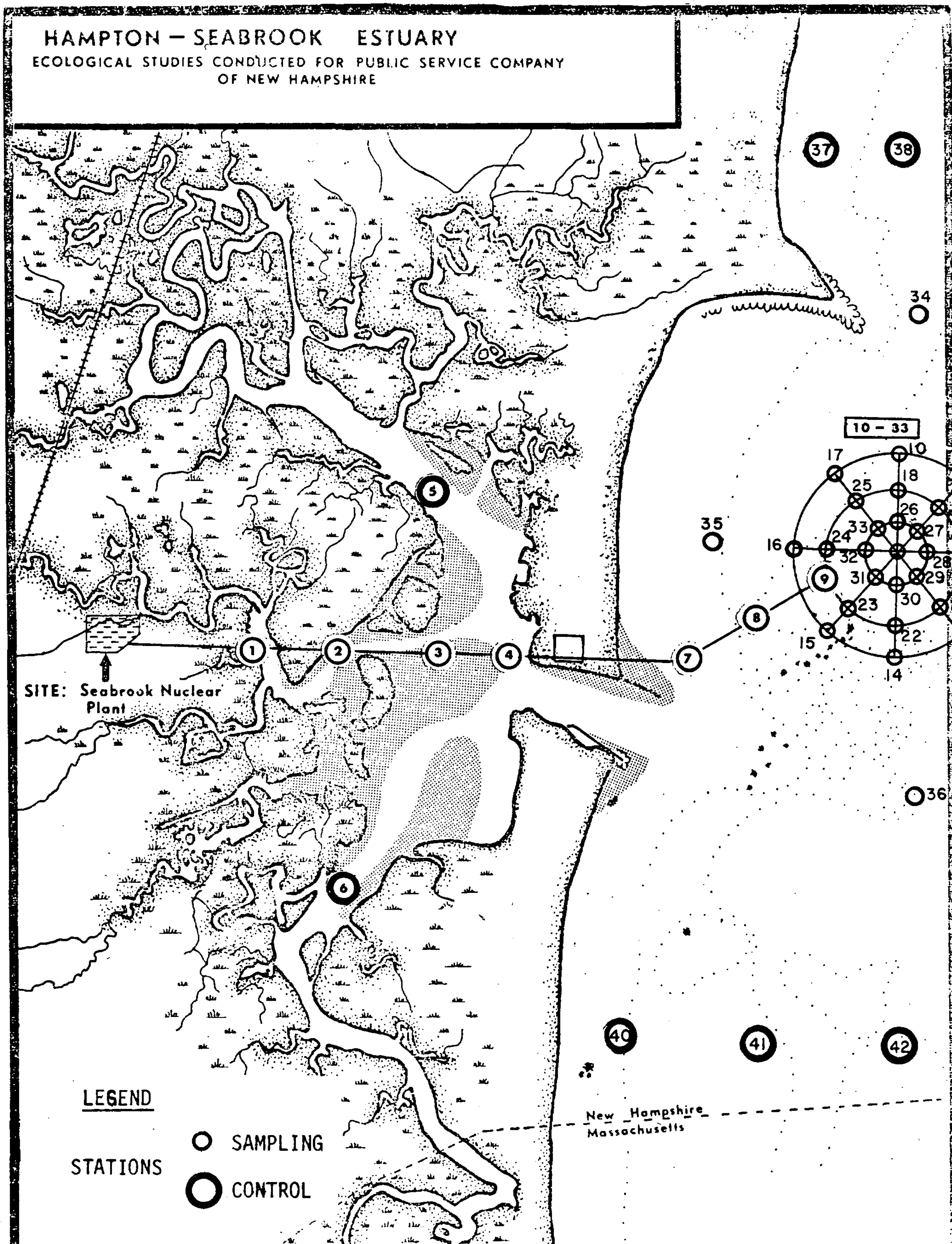
■ CURRENT MONITORING STATIONS

◇ HYDROGRAPHIC ANCHOR STATIONS

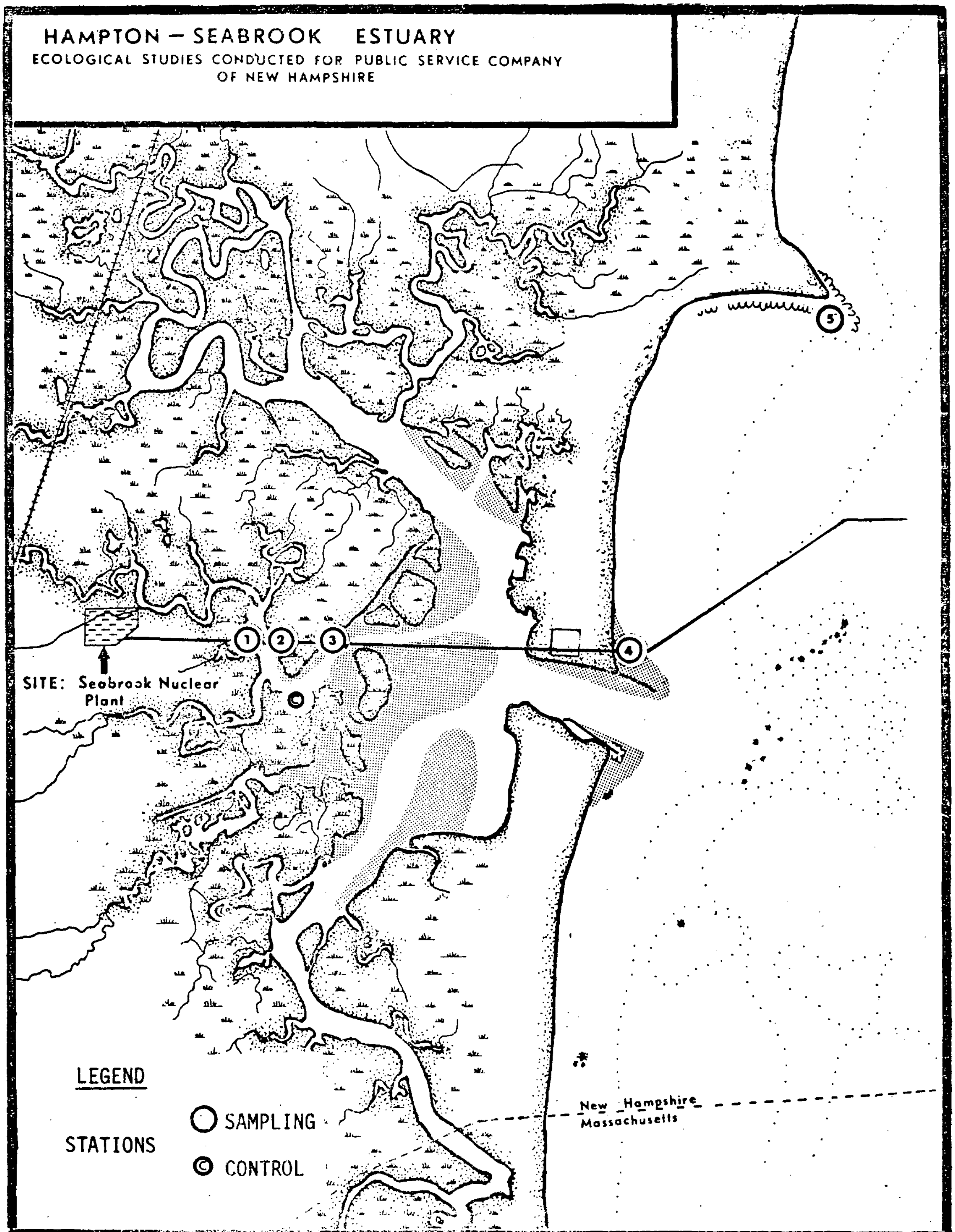
PSNH SEABROOK STATION	PLANKTON AND HYDROGRAPHIC MEASUREMENT STATIONS	FIGURE 6.1-3



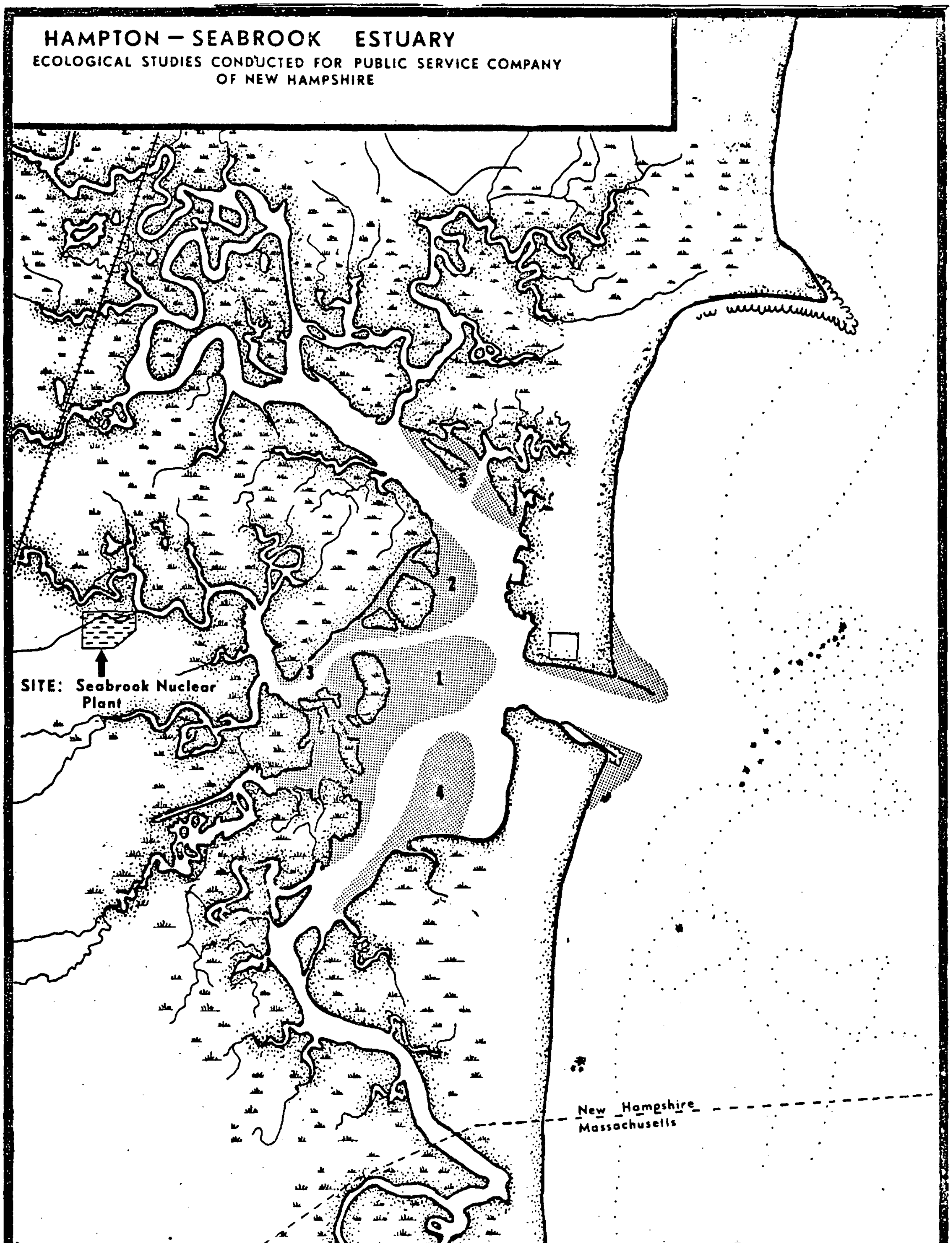
PSNH SEABROOK STATION	SEDIMENT TRANSPORT STATIONS	FIGURE 6.1-4



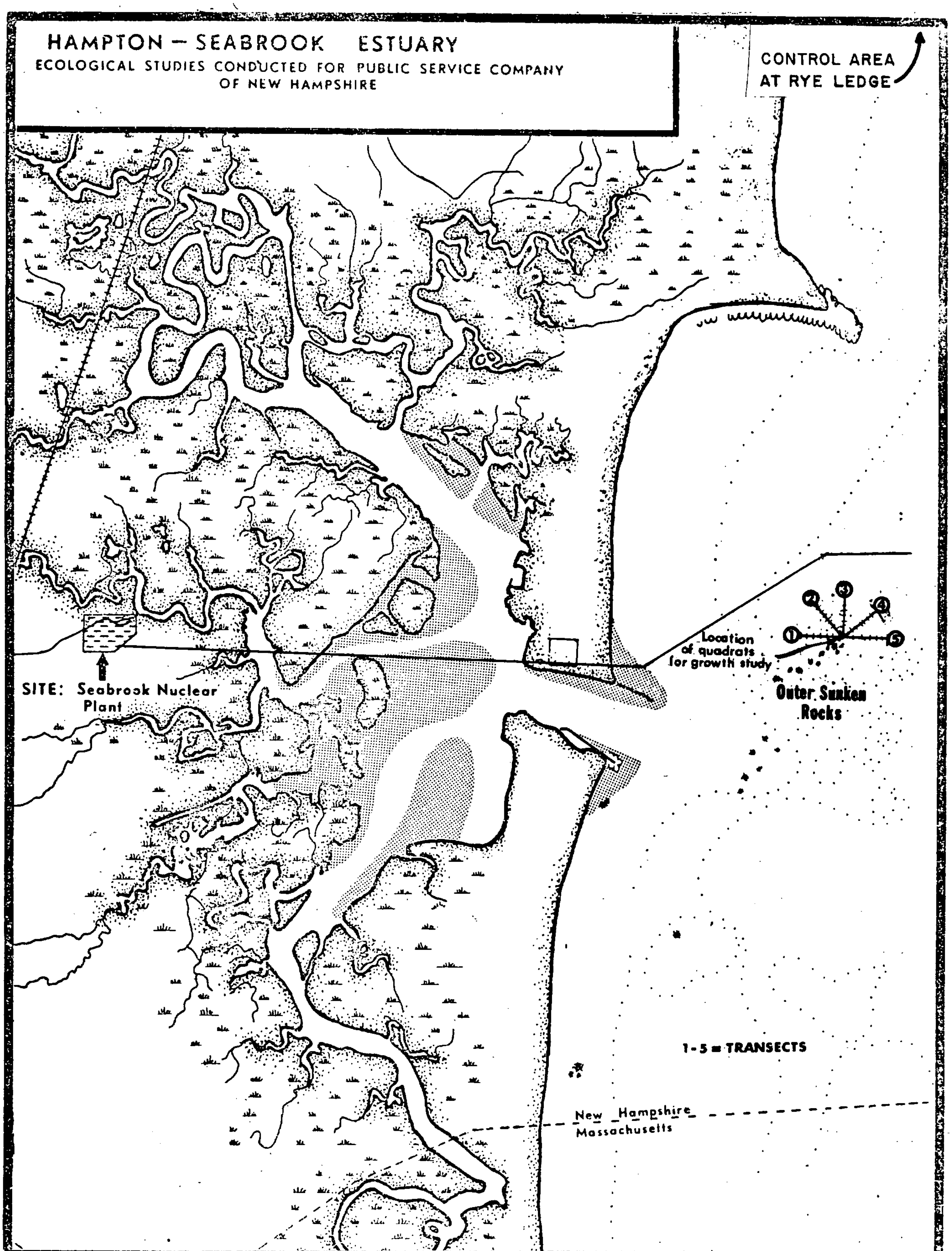
PSNH SEABROOK STATION	BENTHOS SAMPLING STATIONS	FIGURE 6.1-5



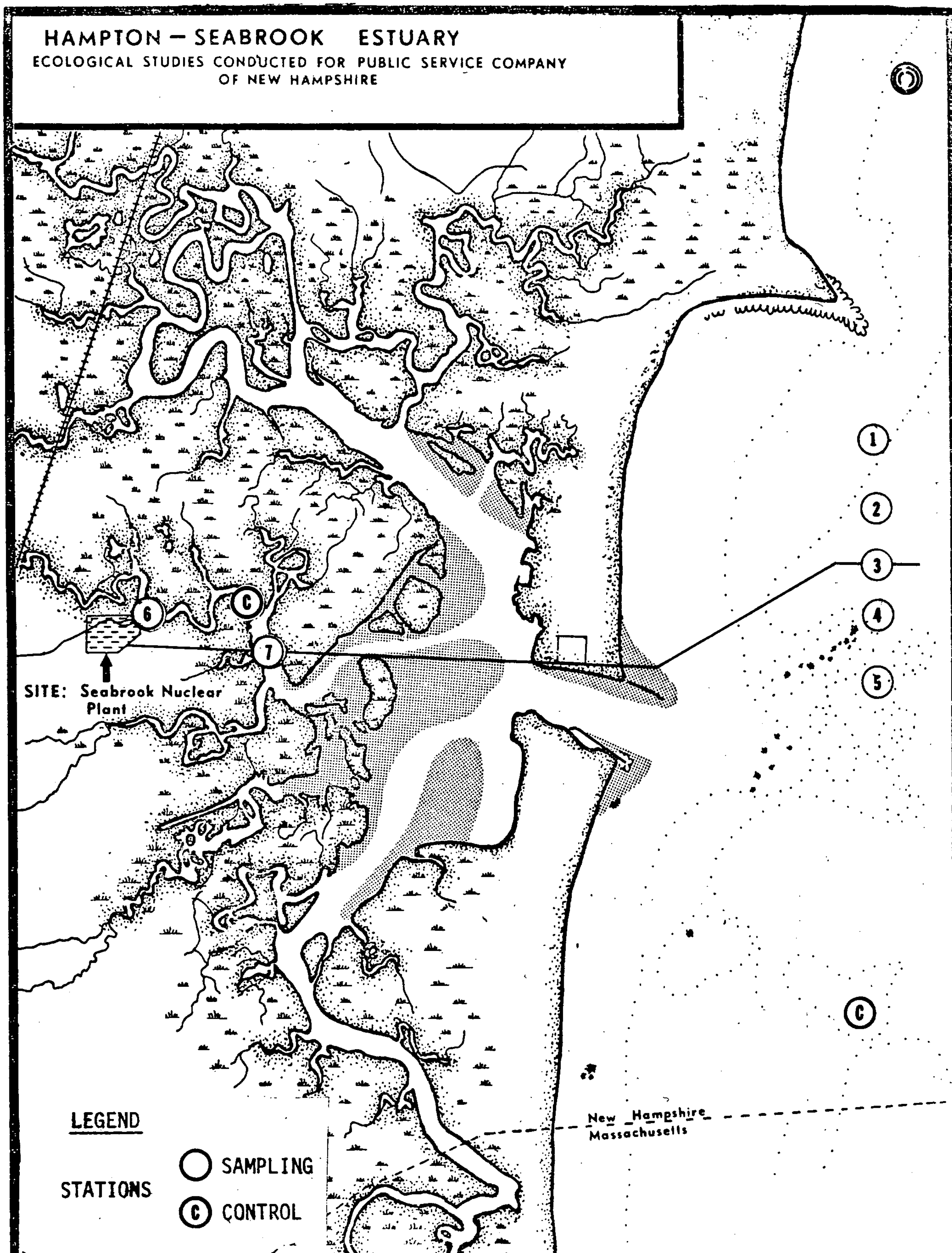
PSNH SEABROOK STATION	INTERTIDAL INVERTEBRATES SAMPLING STATIONS	FIGURE 6.1-6



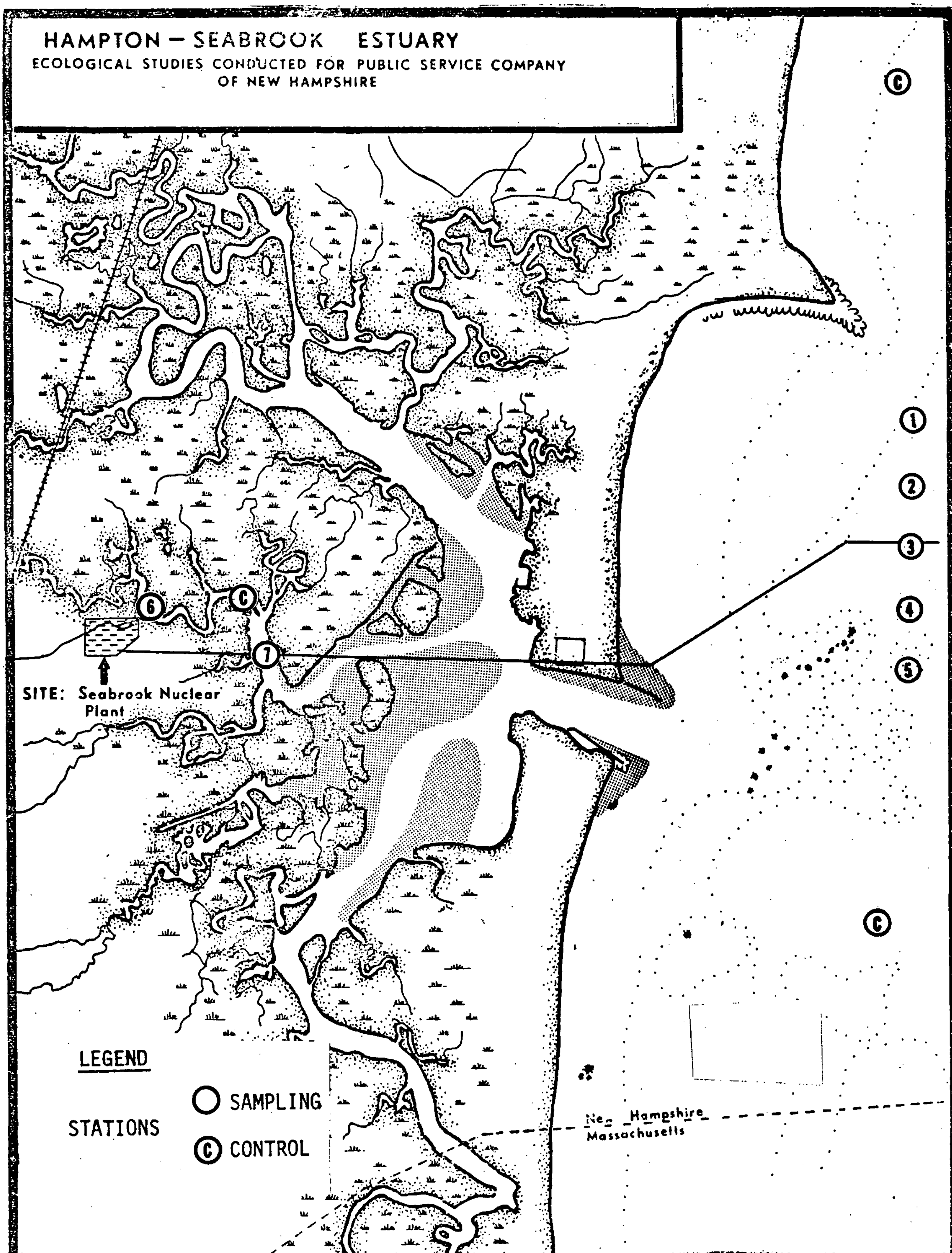
PSNH SEABROOK STATION	SOFT-SHELL CLAM SAMPLING AREAS	FIGURE 6.1-7



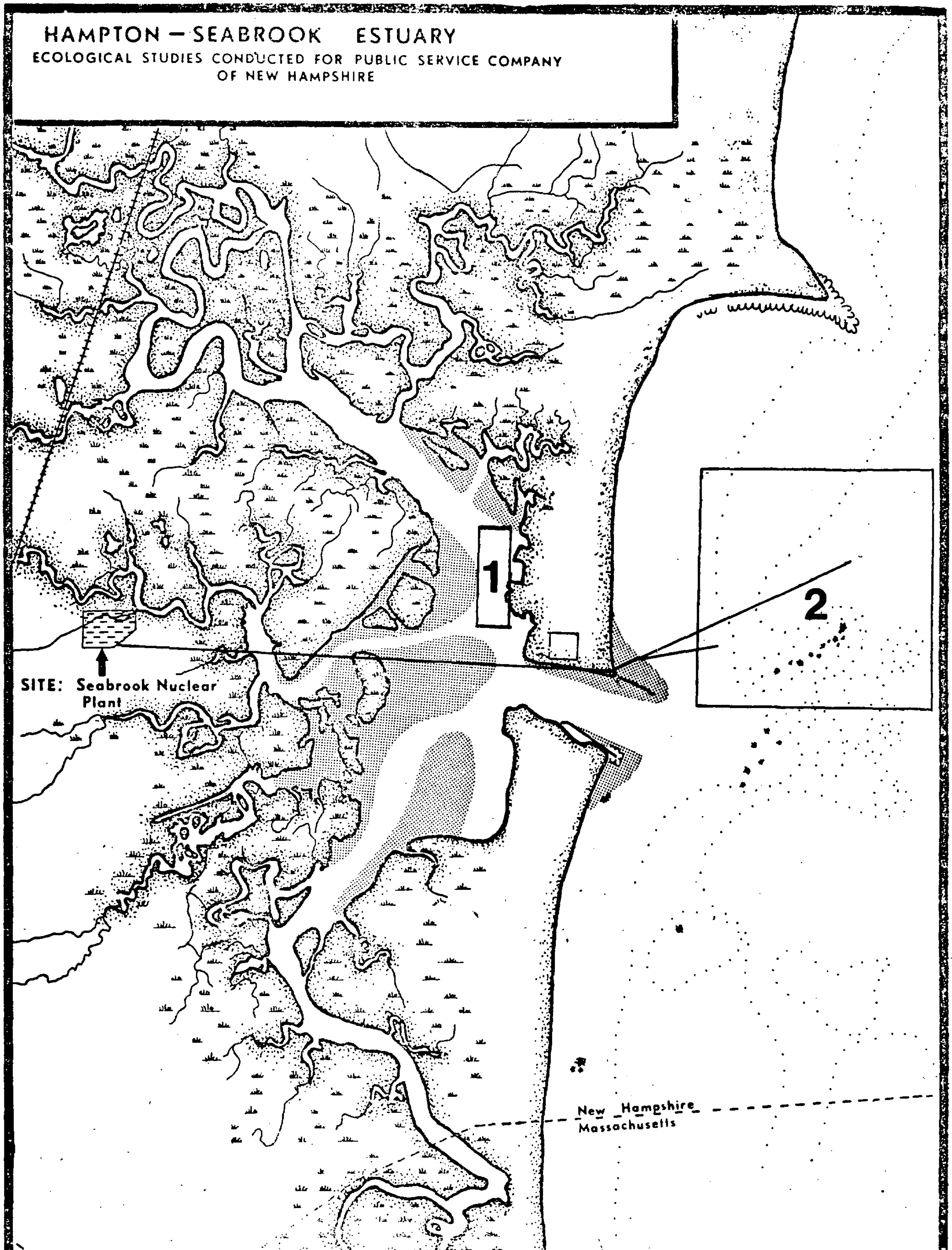
PSNH SEABROOK STATION	ROCKY SUBSTRATE SAMPLING STATIONS	FIGURE 6.1-8



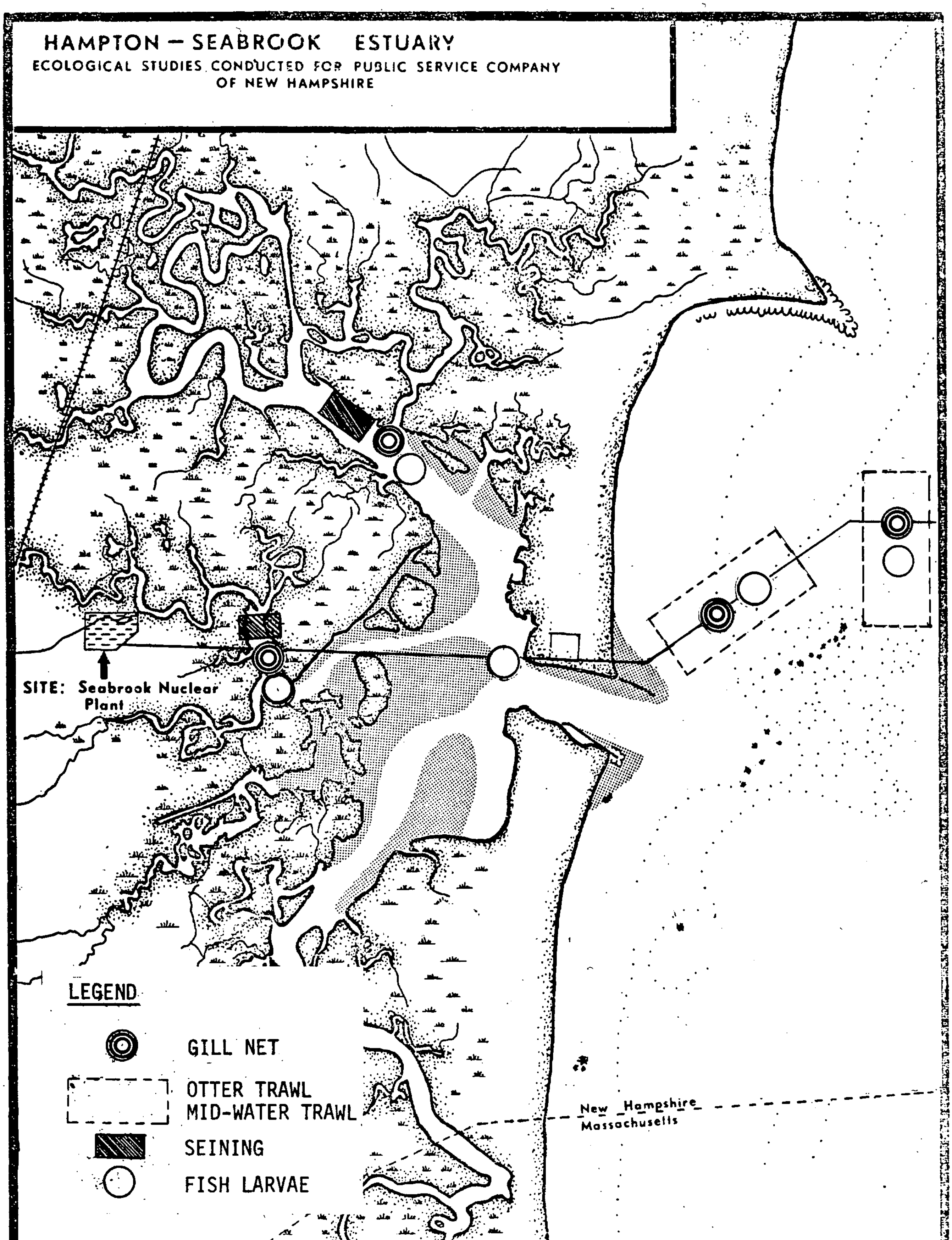
PSNH SEABROOK STATION	SETTLING COMMUNITY MONITORING STATIONS	FIGURE 6.1-9



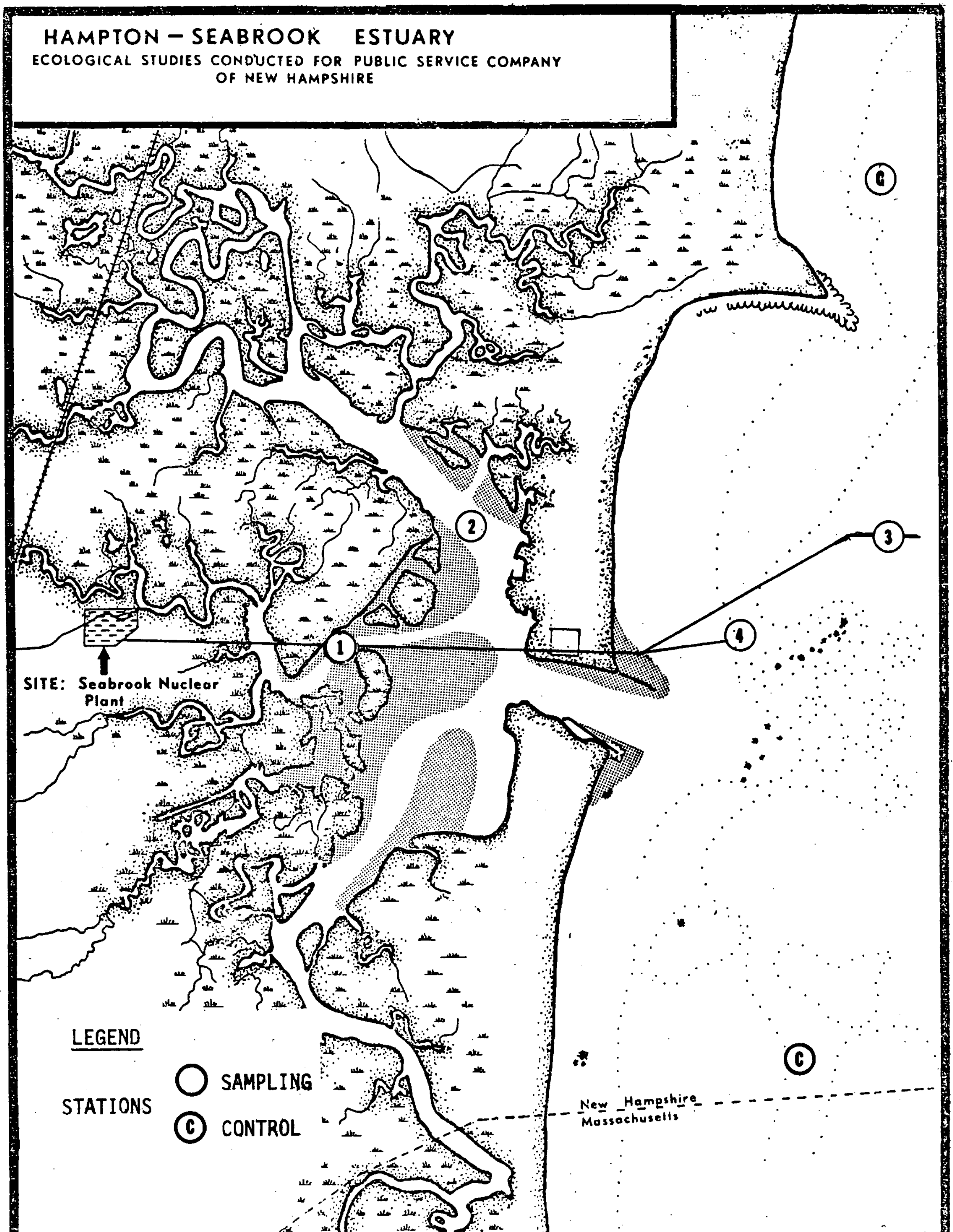
PSNH SEABROOK STATION	MEIFAUNA SAMPLING STATIONS	FIGURE 6.1-10



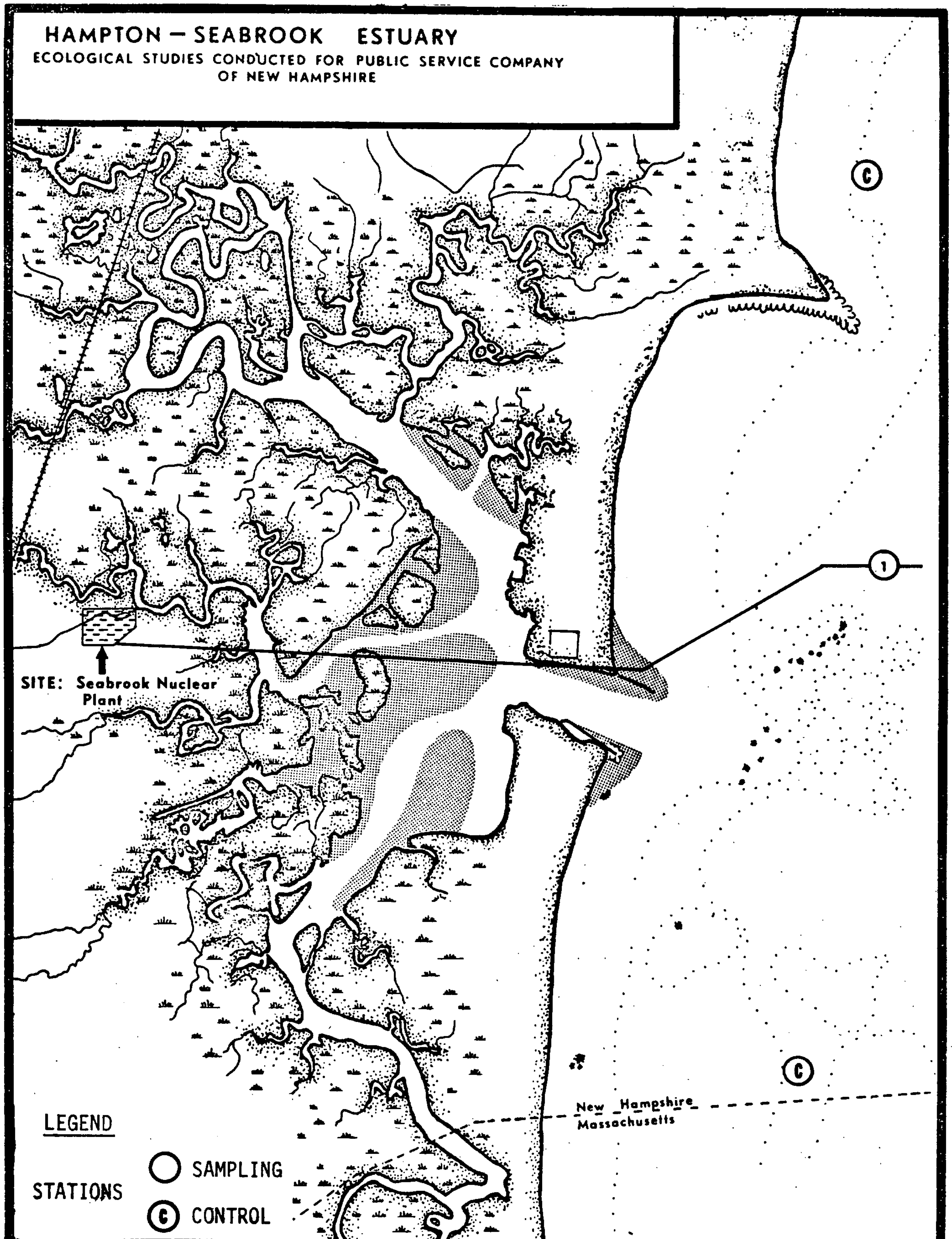
PSNH SEABROOK STATION	LOBSTER AND CRAB SAMPLING AREAS	FIGURE 6.1-11



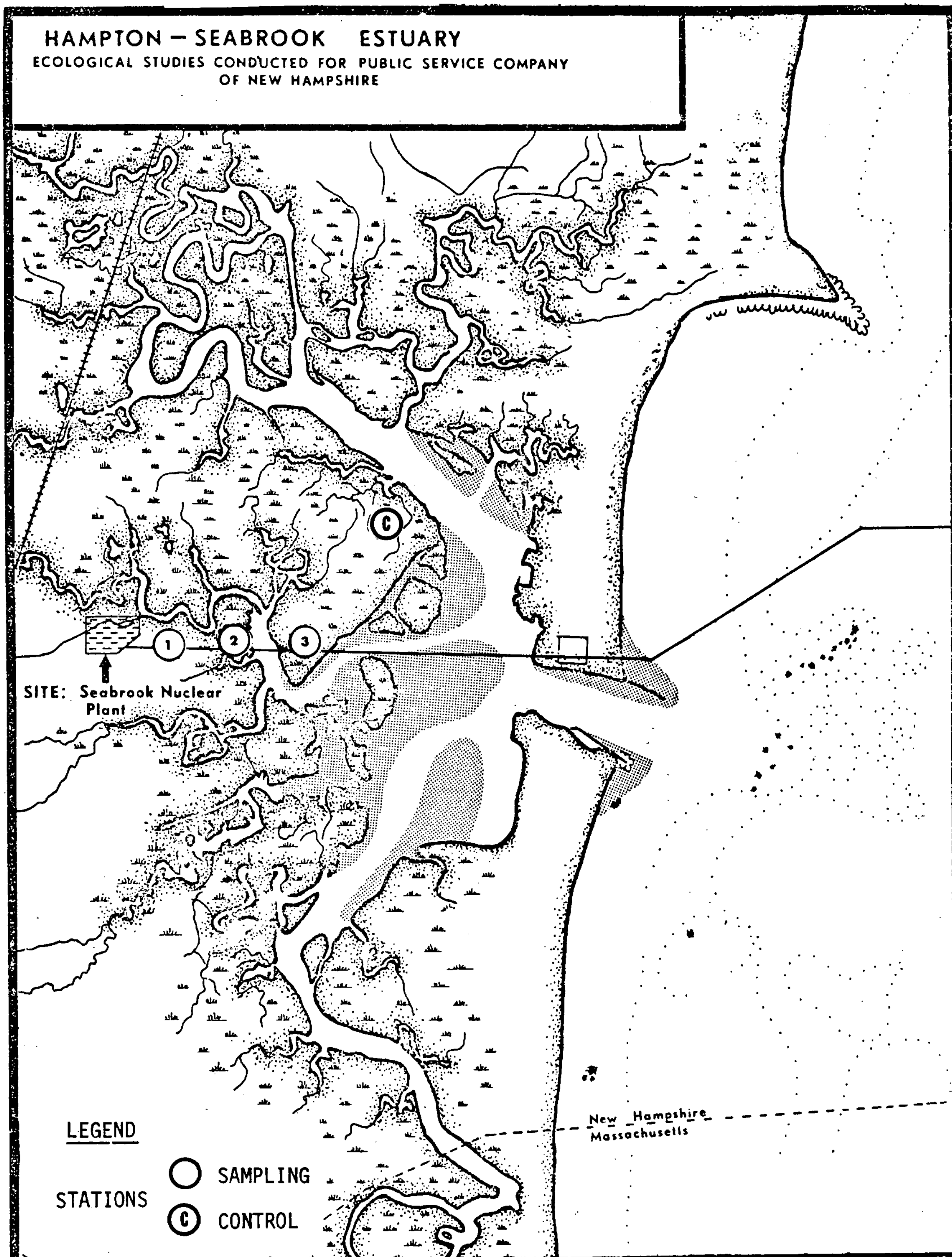
PSNH SEABROOK STATION	FINFISH SAMPLING STATIONS	FIGURE 6.1-12



PSNH SEABROOK STATION	PLANKTON STUDY STATIONS	FIGURE 6.1-13



PSNH SEABROOK STATION	PHYTOPLANKTON PRODUCTIVITY SAMPLING AREAS	FIGURE 6.1-14



PSNH SEABROOK STATION	MARSH GRASS PRODUCTIVITY STATIONS	FIGURE 6.1-15

6.2

6.2 Applicant's Proposed Operational Monitoring Programs

6.2.1 Radiological Monitoring

6.2.1.1 Station Radiation Monitoring System

6.2.1.1.1 General Description

In compliance with the requirements of 10 CFR Parts 20 and 50, and General Design Criteria #64, the effluent monitoring system is designed to provide radiation measurements, records, alarms and/or automatic line isolation at points of radioactivity discharge from the station. Design of these monitoring channels is such that they do not saturate if exposed to radiation levels of up to 100 times full scale indication; in addition, they may be checked on a daily basis, tested monthly, and recalibrated at refueling shutdowns. Each radiation monitor provides control room annunciation and indication and each provides instrument failure annunciation on loss of power or signal. Power for the monitors comes from vital buses to insure operation during emergency conditions.

6.2.1.1.2 Gaseous Effluent Monitoring

Radiogas monitors are located at three points within the Radioactive Gaseous Waste System. The first is located upstream of the ambient pressure carbon beds, the second is located between the ambient and high pressure carbon beds, and the third monitor is located downstream of the high pressure carbon beds. These monitors serve as indicators of carbon bed performance with control room annunciation to alert station operators of abnormal operation or conditions. Remote indication and annunciation are provided on the control panelfor the Radioactive Gaseous Waste System. A high radiation signal on the high pressure carbon bed outlet monitor terminates waste gas system discharges to the ventilation stack by automatic closure of the waste gas discharge valve.

Gaseous activity that might result from a primary to secondary system leak would be detected at the air ejector condenser vent. This monitor is a G-M detector with a minimum sensitivity of 1 x 10^{-6} μCi/cc for Xe-133. Control room annunciation and indication are furnished by this monitoring channel. The gas discharge of the air ejector condenser is normally unfiltered but may be manually redirected to the air ejector gas processing filters on receipt of a high radiation alarm.

Redundancy in the airborne radioactivity monitoring system is accomplished by the plant vent particulate and gas monitors. All air exiting the plant is continuously monitored for gaseous activity by an off-line G-M detector, and for particulate activity by a NaI scintillation detector scanning a moving filter paper which collects 99 percent of all particulate matter greater than 0.5 microns in size. There is control room indication and annunciation. The response range for gaseous activity is 1 x 10^{-6} to 5 x 10^{-2} uc/cc for Xe-133 and for particulate activity 1 x 10^{-10} to 1 x 10^{-6} uc/cc based upon I-131.

In a separate system, a stack sample is continuously drawn through a fixed particulate filter and a charcoal filter. The particulate filter is removed periodically and analyzed to determine the nuclide content of the stack effluent, and the charcoal filter is analyzed periodically in the station to determine the radioiodine content.

6.2.1.1.3 Liquid Effluent Monitoring

Liquid process radiation monitors located within the reactor coolant system, boron recovery, steam generator blowdown, component cooling, service water and liquid waste systems, continuously monitor all potential and actual liquid discharge pathways from the station. Radioactive liquids which are discharged from the station are continuously monitored during discharge. Prior to discharge, the contents of a test tank are isolated, recirculated, and sampled to determine whether a release may be made within the terms of the operating license. If the sample analysis indicates that the waste may be discharged, an operator must unlock and open the last stop valve in the discharge line (normally locked shut), open a second valve which automatically shuts on a high radiation signal, start a test tank pump, and close the recirculation valve. This procedure precludes the possibility of inadvertent discharge. The channel which continuously monitors the liquid waste system effluent is an in-line scintillation detector whose sensitivity range is 1×10^{-5} to 1×10^{-2} uCi/cc, based on Co-60.

To provide backup and a final check on station liquid effluents, a composite sample of the station circulating water system discharge shall be continuously collected for laboratory analysis as discussed in subsection 6.2.1.2.

6.2.1.2 Environmental Radiological Monitoring

The operation radiological environmental monitoring program is outlined in Table 6.2-1. Except for airborne iodine monitoring using charcoal cartridges, sample media for the operational program are identical to those of the preoperational program described in subsection 6.1.5. Sample sites are also identical for both phases of the program. The frequency of sample collection and the analyses performed do vary for some media as described below. The analytical sensitivity for a given analytical procedure is as described in subsection 6.1.5. Analytical procedures not discussed in 6.1.5 are discussed below. Factors influencing sample site selection are described in subsection 6.1.5.

It is anticipated that all radiological analyses except thermoluminescent dosimeter readout, which is to be done locally in order to minimize dose pickup in transit, will be done by a third party analytical laboratory. Analytical sensitivities quoted are representative of those supplied by these vendors.

The radiological environment monitoring program as outlined below exceeds the monitoring requirements of the recommended minimum level environmental surveillance program around nuclear reactors recommended by the EPA, Office of Radiation Programs in their "Environmental Radioactivity Surveillance Guide" (ORP/SID 72-2). For all environmental media, samples are collected from more points, generally at more frequent intervals, with more specific analyses being performed than is specified by this guide.

The surveillance program will be reviewed at least biennially in order to determine that it is achieving its stated objectives and that no changes or additions to the monitoring program are necessitated by changes in effluent characteristics or experience at other reactors or research establishments.

6.2.1.2.1 Air Particulate Monitoring

Air samplers will operate as described in subsection 6.1.5.1 at the same locations used in the pre-operational program. Long lived gross beta activity analysis (at least 24 hours after filter removal to allow for radon and thorium daughter decay) will be done weekly. Monthly gamma scans and Sr-90 analysis will be made on the monthly filter composite from each of the ten air monitoring locations. Analytical procedures and sensitivities are described in subsection 6.1.5.1. Sample locations are as listed in Table 6.1-5.

6.2.1.2.2 Airborne Iodine Monitoring

In series with, and downstream of the particulate filter at each air sampling location will be an impregnated charcoal filter cartridge designed to retain both inorganic and organic forms of gaseous airborne iodine. Charcoal filters will be changed and analyzed on a weekly basis. It is anticipated that filters will be gamma scanned using a Ge(Li) detector. The minimum detectable iodine-131 activity at the time of analysis is approximately 8 pCi. Assuming four cartridges are counted together after 7 days sampling and two days from sample removal until analysis, the minimum detectable air concentration would be 1.1×10^{-2} pCi/m^3 taking decay into account. If any activity above the 8 pCi minimum detectable activity is noted in the group scan, each cartridge in that group would be analyzed individually. For single cartridge analysis, the average minimum detectable air concentration associated with this minimum detectable activity would be 4.4×10^{-2} pCi/m^3.

6.2.1.2.3 Environmental Gamma Radiation

Thermoluminescent dosimeters will be placed at the 25 points described in subsection 6.1.5.2. Dosimeter readout will continue on a monthly basis. Analytical sensitivity and sample location selection criterion are discussed in subsection 6.1.5.2.

As described in subsection 6.1.5.2, a high pressure ionization chamber will be in constant use at the expected point of annual maximum ground level concentration of airborne effluents in the most prevalent downwind direction. This chamber will record the background dose rate at 10 second intervals on magnetic tape. Analysis of this data will document incremental exposures due to plant operation of less than 5 mrad/year. A more complete discussion of this instrument is found in subsection 6.1.5.2.

6.2.1.2.4 Precipitation

Precipitation sampling will continue during the operational program at each air monitoring location as discussed in subsection 6.1.5.3. Each monitoring location's monthly composite will be analyzed for gross beta, tritium, and gamma activity using the procedures specified in subsection 6.1.5.3. Analytical sensitivities are the same as in the above mentioned subsection.

Strontium-89 and strontium-90 analysis will be done on each sample. The analytical procedure for strontium-89 and strontium-90 is as follows. One liter of water containing suitable carriers is evaporated to dryness. The residue is then dissolved in dilute acid and strontium precipitated and filtered. Yttrium-90 ingrowth is allowed to proceed for 14 days. The yttrium-90 is then extracted in di-2-ethylhexyl phosphoric acid, and after back extraction into the aqueous phase, precipitated as yttrium oxalate. This precipitate is purified and counted in a low background beta counter for at least 100 minutes. Strontium-90 activity is then calculated based on the period of yttrium-90 ingrowth and the percent recovery of strontium determined using a strontium-85 carrier of known activity counted by gamma spectroscopy. Analytical sensitivity for strontium-90 by this procedure is 1.0 pCi/1.

Strontium-89 activity is measured by the "difference method". The purified strontium isotopes which were set aside during strontium-90 analysis are precipitated from ingrown yttrium with fuming nitric acid. After purification to remove barium-140, total strontium is precipitated as the oxalate and counted in a low background proportional counter. The strontium-89 activity is determined by subtracting the activity due to strontium-90 which was determined with the phosphate extraction procedure. Analytical sensitivity for Sr-89 by this procedure is 5.0 pCi/1.

6.2.1.2.5 Foodcrops and Vegetation Monitoring

Operational monitoring of foodcrops (apples, vegetables) and terrestrial vegetation (mixed grasses) will continue as during the preoperational program at six Zone I and three Zone II locations. Samples will be taken twice during the growing season at the sampling locations listed in Table 6.1-7. All samples will be analyzed by high resolution Ge(Li) spectroscopy with the analytical sensitivities as shown in Table 6.1-15.

Strontium-89 and 90 analysis will be performed on each sample. Strontium analysis in vegetation will employ the procedure described in subsection 6.1.5.4 with strontium-89 analysis done by the "difference method" described in subsection 6.2.1.2.4. Analytical sensitivity for strontium-89 and 90 in foodcrops is 150 and 30 pCi per kilogram of dry sample.

6.2.1.2.6 Milk Monitoring

Milk will be sampled from three Zone I and two Zone II dairies weekly during the time that animals producing milk for human consumption are on pasture. These samples will be analyzed weekly for I-131 by radiochemical separation and low background beta counting. During pasture season, a monthly composite of each monitoring location shall be analyzed for Sr-89 and Sr-90 and quantitative gamma spectrum. When animals are fed stored feeds, milk will be sampled and analyzed on a monthly basis for I-131, Sr-89 and 90, and quantitative gamma spectrum. Sensitivities and analytical procedures are as described in subsection 6.1.5.5. Analytical sensitivities for strontium-89, analyzed as described in subsection 6.2.1.2.4, and Sr-90 are 5.0 and 1.0 pCi/l respectively.

6.2.1.2.7 Soil Monitoring

During the operational program in situ quantitative gamma spectrometric measurements of soil activity will be made at each air sampling station and accessible TLD stations on a quarterly basis. Spectra will be collected using high efficiency Ge(Li) solid state detectors. It is clear that in situ measurements of soil activity are more sensitive and provide more representative data on radionuclide activity in soil, and the exposure rate from these radionuclides, than doses collection of soil samples and laboratory analysis. Field analysis of soil activity using an unshielded downward looking detector 1 meter above the ground, detects gamma rays from an area within about a 10 meter radius, thus averaging out any small local variations in the soil.

Soil samples will be collected at the time field spectra are taken to document the Sr-90 level for each location.

Concurrent with use of the field gamma spectrum system, high pressure ionization chamber readings will be made to determine the total dose rate over the time period field spectra are collected. This total dose rate will be apportioned among the various contributing radionuclides detected in the gamma spectrum. Soil activity sampling locations are shown in Table 6.1.5-13.

6.2.1.2.8 Ground Water Monitoring

Operationally, well water will be collected from the five wells monitored during the preoperational program. Three wells in the immediate area of the station and two distant wells will be grab sampled and analyzed on a quarterly basis. The samples will be analyzed for gross beta, tritium, and gamma emitters by high resolution Ge(Li) spectroscopy. Analytical methods and sensitivities are as discussed in subsection 6.1.5.3. Stontium-89 and 90 analysis will be made on each sample. Analytical sensitivity for strontium-89 and 90 using the procedure outlined in subsection 6.2.1.2.4 is 5.0 and 1.0 pCi/l respectively.

6.2.1.2.9 Surface Water Monitoring

Surface water will be grab sampled every other week from all surface water monitoring sites except the discharge and intake area conduit and composited for analysis on a monthly basis. Rather than attempt to grab sample the discharge and intake areas, it was decided to set up a continuous proportional sampler in the intake and discharge conduits. These continuous proportional samplers will be set up at the pump house to take continuous proportional samples from the intake and discharge tunnels. These composite samples will then be shipped to the analytical contractor on the same schedule as the balance of the surface water samples. Each composite sample will be analyzed monthly for gamma emitters by Ge(Li) spectroscopy and tritium. Analytical techniques, sensitivities, and sample location selection are discussed in subsection 6.1.5.7.

6.2.1.2.10 Marine Media Monitoring

Operationally, marine media samples will be collected quarterly from the monitoring areas described in subsection 6.1.5.9. As described earlier, seven locations have been chosen for sampling each of the following marine media: fish, mollusks, crustacea, plankton and algae. Bottom sediments and beach sands will be sampled and analyzed quarterly from ten locations. *In situ* gamma spectrometry will be done at those beach sand locations accessible to the vehicle carrying the field gamma system. Otherwise, a one kilogram sample of sand will be collected and analyzed by the analytical contractor by high resolution Ge(Li) spectroscopy as described in subsection 6.1.5.8. Sample locations are as shown in Table 6.1-11 and 6.1-12. Strontium-89 and 90 analysis will be made on each sample. The analytical sensitivites for strontium-89 and 90 are 25 and 5 pCi/kg respectively.

6.2.1.2.11 Quality Control Program

A quality control program will continue to operate during the operational program as described in subsection 6.1.5.11 for the preoperational program. This program is based upon standard samples supplied by the EPA's Analytical Quality Control Service in Las Vegas, Nevada. Analysis of each batch of TLD's at the station will include a number of dosimeters exposed to known low level doses with calibrated sources. This procedure will help maintain calibrated readout of the dosimeters from month to month. Accurate readings are also maintained through the use of an internal light source in the TLD reader which is checked frequently and reset, if necessary, to ensure drift-free readings. These measures will maintain a small standard deviation in TLD readings at a given dose and thus allow differences in location averages to be detected if they exist.

6.2.1.2.12 Environmental Radiological Monitoring Reporting

During the operational period of the station, radiological environmental surveillance reports will be prepared and submitted to appropriate agencies on a semiannual basis. The report will include, for each media sampled during the period, the number and geographical location of sampling points, the total number of samples analyzed, identification of organization or person collecting the sample, identification of organization which analyzed the sample, time and date of sample collection (or duration of collection for integrated samples), sample preparation (e.g. wet or dry analysis), type of analysis performed, value and units for each analysis and two sigma analytical errors and any known events which may have affected the analytical results.

In addition, those locations at which activity levels were found to exhibit statistically significant increases (at $p = .01$ level) above established or concurrent backgrounds will be identified. For these stations and media, an estimation of the individual or population dose above background will be made.

6.2.2 Chemical Effluent Monitoring

For the purposes of this subsection, chemical effluent monitoring is defined as that monitoring of non-radioactive chemicals that may be discharged with the condenser cooling water. The outlets of the discharge conduits, as described in Sections 3.4 and 5.1 are submerged in excess of 35 feet of water (MLW) and extend seaward from a point 5000 feet from the shoreline of Hampton Beach State Park. At the discharge points, chemical effluents due to plant operation are at environmentally acceptable levels or concentrations as prescribed by appropriate regulatory agencies. This is accomplished either through pre-treatment or dilution by the circulating water flow.

Sections 5.4 and 5.5 delineate chemical, biocide and sanitary wastes that are discharged into the circulating water system. The manner in which these wastes arise, i.e. sanitary systems, chemical waste systems, process water systems, biocide systems, etc. is described in Sections 3.3, 3.6 and 3.7.

Due to the distance of the outlet from shore, it is impractical to continuously monitor chemical effluents at this point. Further, most of the chemical effluents would be diluted to a concentration below the minimum detectable sensitivities of such monitoring equipment. It is therefore necessary to perform such monitoring at the point of injection into the circulating water conduit except for biocidal treatment, which is monitored at several points along the circulating water system.

Periodic Seawater Analyses

Periodic monitoring at the outlet is achieved by obtaining near-simultaneous seawater samples at this point and at the point of intake. These samples are analyzed by wet chemical and spectrographic techniques for specific constituents. The results are then compared and the differences related to chemical effluent discharges of a conservative nature which do not change chemical form in the interim of time before analysis. Such sampling is a continuation of the program described in subsection 6.1.1.1. The frequency of sampling is at least seasonally to offset annual trends in the chemical constituency of the ambient seawater. Such a sampling program will be continued until it is ascertained that no detrimental effects are being caused by the discharge.

Grab samples of seawater are obtained at the same time as periodic thermal profiling at these points as outlined in subsection 6.2.3. At the same time, measurements of salinity and dissolved oxygen are made with equipment of the sensitivity described in subsection 6.1.1.1. Salinity and temperature data are used to calculate the stability of the water column while D.O. measurements provide the degree of oxygen saturation. No significant increase in D.O. can occur in the circulating water system because the observed ambient D.O. levels are usually at or just above the saturation level of the thermal discharge. (See subsection 2.5.1.2.) This is to be verified by periodic surveillance.

Biocidal System Chemical Effluent Monitoring

Biocidal control to prevent fouling is used in the intake conduits from the intake structure to the plant and through the condenser. Active chlorine is injected into the circulating water flow at the intake structure. Both free and combined residual chlorine are monitored during injection, at the condenser and in the discharge conduit near the intake structure. As discussed in subsection 3.6.1 and 5.4.1 chlorination will be adjusted to yield a calculated free chlorine residual concentration of <0.1.

Combined Station and Sanitary Wastes Chemical Effluent Monitoring

Subsections 3.6.2, 3.7.1, 5.4.2 and 5.5.1 state that all treated liquid wastes from industrial processes and from the sanitary waste system are combined in the monitoring and sampling station and then pumped into the circulating water discharge pipe. The combined wastes are in compliance with applicable effluent limitations, standards of performance and water quality standards prior to dilution in the circulating water discharge system. At the monitoring and sampling station the combined liquid wastes from water treatment, demineralizer regeneration, steam generator blowdown, and the oil separator are monitored for pH, oil concentration, total suspended solids and specific elements as required. Sanitary waste effluent from the tertiary treatment tank is monitored for pH, total suspended solids, phosphates, B.O.D., D.O., coliform count and free chlorine.

Monitoring techniques conform to accepted methods as given by <u>Standard Methods for the Examination of Water and Wastewater</u>, APHA, 13th ed. 1971 or by <u>Methods for Chemical Analysis of Water and Wastes</u>, Water Quality Office, EPA, 1971 as appropriate.

Applicable Standards

The New Hampshire Water Supply and Pollution Control Commission standards for water quality are applicable at this time to the liquid wastes discharged from Seabrook Station.

6.2.3 Thermal Effluent Monitoring

The Applicant will assure that an approved thermal monitoring program will be developed prior to operation. The program will include the techniques and procedures that permit assessment of the thermal effluent's compliance to applicable rules and regulations.

Surveillance techniques will include in situ monitoring of temperature at specified locations in the region of the discharge and at the intake structure.

Additional temperature monitoring techniques can be used if required. Monitoring will continue until compliance with regulatory criteria is satisfied.

6.2.4 Meteorological Monitoring

The on-site meteorological data collection program described in subsection 6.1.3 above will be maintained throughout the life of the plant. The equipment will be regularly calibrated and strip chart records of wind speed, wind direction, temperature and dew point will be collected. Conversion of these records to punched computer cards will be carried out as necessary.

Construction plans for Seabrook do not include the use of cooling towers or open bodies of cooling water. As a result, fogging and icing due to plant operation are not expected.

6.2.5 Operational Ecological Monitoring

The operational ecological monitoring program will consist of a continuation of the pre-operational studies (subsection 6.1.1.2). Some aspects of these studies, particularly those dealing with monitoring of physical parameters will be modified. In particular, frequency of temperature, salinity, and dissolved oxygen monitoring in the discharge area will be increased to weekly measurements over a full tidal cycle so that plume behavior can be documented. Turbidity will be monitored weekly during construction. Monitoring of other physical parameters may be increased in frequency when it is deemed necessary.

Biological monitoring of motile epifauna and finfish will be increased in frequency in the area of the discharge and intake conduits after the plant is in operation. This increased monitoring will continue until the effect of the structures and the heated plume on feeding behavior and migration patterns is understood.

Additionally, other biological sampling will be coordinated with plant operating variables, e.g., more intensive sampling and observations will also be conducted during scheduled maintenance shutdowns to determine effects on finfish and motile epifauna. Provisional monitoring will also be planned if unpredicted effects are observed.

Physiological or behavioral effects on the biota not ascribed to the natural variation documented in the pre-operational monitoring will be determined to have been caused by the operation or construction of the plant unless correlated with other unusual natural phenomena. In instances where changes are plant-related, studies will first be conducted to determine whether any measures can be taken to alleviate these effects without suspending the plants' operation. Assessment of plant-related changes will include an evaluation of whether the change is temporary or permanent.

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TABLE 6.2-1

OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Media	Type Analysis Performed (Frequency)	Number of Sample Locations Zone I	Zone II
Air Particulates	Gross Beta (Weekly) Gamma Scan of Location Composite (Monthly) Sr-90 on Location Composite (Monthly)	7	3
Airborne Iodine	Charcoal Cartridge - I-131 by Gamma Spectrum (Weekly, see note 1)	7	3
High Pressure Ionization Chamber	Gamma Dose Rate (Dose Rate every 10 seconds)	1	-
TLD Dosimeters	Integrated Gamma Dose (Monthly)	19	6
Food Crop and Vegetation	Gamma Spectrum (Twice during Growing Season) Sr-89, 90 (Twice during growing season)	6	3
Milk	Gamma Spectrum (Monthly) Sr-89, 90 (monthly) I-131 (Radiochemical Separation - Low Beta Count - #2)	3	2
Ground Water	Gross Beta (Quarterly) Gamma Spectrum (Quarterly) Tritium (Quarterly) Sr-89, 90 (Quarterly)	3	2
Surface Water	Gamma Spectrum (Monthly) Tritium (Monthly)	7	3
Precipitation	Gross Beta (Monthly) Tritium (Monthly) Gamma Spectrum (Monthly) Sr-89, 90 (Monthly)	7	3
Fish	Gamma Spectrum (Quarterly) Sr-89, 90 (Quarterly)	5	2
Mollusks	Gamma Spectrum (Quarterly) Sr-89, 90 (Quarterly)	5	2

1 Analyzed as a composite. If any activity detected above minimum detectable level in a group, cartridges will be analyzed individually.

2 Milk will be collected and analyzed for I-131 weekly during pasture season. Gamma spectrum and Sr-89, 90 analyses will be done monthly during this time on composite sample from each location. Monthly sampling and analysis during balance of year.

TABLE 6.2-1 (Continued)

Media	Type Analysis Performed (Frequency)	Number off Sample Locations Zone I	Zone II
Plankton	Gamma Spectrum (Quarterly) Sr-89, 90 (Quarterly)	5	2
Crustaceans	Gamma Spectrum (Quarterly) Sr-89, 90 (Quarterly)	5	2
Algae	Gamma Spectrum (Quarterly) Sr-89, 90 (Quarterly)	5	2
Bottom Sediments (Including Beach Sands)	Gamma Spectrum (Quarterly #3) Sr-89, 90 (Quarterly)	7	3
Soil	_In situ_ quantitative Gamma Spectrum (Quarterly) Sr-90 (Quarterly)	13	6

3 Accessible beach sand locations will be analyzed by _in situ_ quantitative gamma spectroscopy as described in text.

6.3

6.3 Related Environmental Measurement and Monitoring Programs

Environmental monitoring programs within the Hampton-Seabrook region other than those being conducted or planned by the applicant are varied. In evaluating this subject a thorough canvas was made of those local, state, and federal agencies deemed likely to be involved in such efforts. In addition nearby educational institutions were contacted and queried as to possible scientific research projects within the area of the site. In establishing the applicability of related studies to those of the applicant, a determination was made of comparable parameters and location. Below are discussed those study programs which because of their subjects and sampling locations are considered related to the environmental programs of the applicant.

Dr. Raymond Gilmore of Nasson College, Springvale, Maine, is involved in a study of the marine polychaete *Ophelia denticulata*. His project centers on the validation of the species status of this relatively uncommon (for North American) annelid. The *Ophelia* population Dr. Gilmore is working with is located within the Hampton Harbor adjacent to the Common Island clam flat. His sampling program is sporadic. It is doubtful that his study findings will relate directly to those of the applicant's environmental monitoring program. However, the applicant has agreed to keep Dr. Gilmore advised of whatever specimens of *Ophelia* they collect and further to provide him with those not needed for catalog voucher samples.

Mr. Thomas C. Shevenell, a research associate in the Department of Earth Sciences at the University of New Hampshire, is involved in thesis research which includes some sequential collection of physical data adjacent to the proposed discharge area. Mr. Shevenell's thesis deals with dispersal and distribution of near-shore particulate matter. The sample data include monthly determinations of temperature, salinity (conductivity), light transmission and total suspended solids. In addition some data exist on local currents (bottom drifters), nutrients and chlorophyll values. Only Mr. Shevenell's most southerly stations extend into the applicant's study area. The applicant is in contact with Mr. Shevenell and some exchange of data has occurred.

Jackson Estuarine Laboratory of the University of New Hampshire was contacted relative to their research efforts within the Hampton-Seabrook area. The applicant is assured by the laboratory Director, Dr. Arthur Mathieson, that no one at this facility other than Mr. Shevenell, who utilizes the laboratory, is presently engaged in studies at Hampton-Seabrook.

The New Hampshire Public Health Department along with personnel at the Departments of Zoology and Biochemistry at the University of New Hampshire assisted by New Hampshire Fish and Game Department are presently engaged in a monitoring program involving toxic effects of red tide affected soft-shell clams on laboratory mice. This program was initiated in the fall of 1972 when a bloom of the dinoflagellate Gonyaulax tamarensis occurred. Clams are sampled weekly from flat number 1 (Common Island) and processed for bioassay. It is expected that this monitoring effort will continue at least until clam toxicity levels decrease to a point which indicates they have definitely purged themselves of the paralytic shellfish poisoning factor. The applicant is in touch with Dr. Burdette Barrett, Supervisor of Marine Fisheries, New Hampshire Fish and Game Department who is involved in this program. During the height of the red tide outbreak the applicant's staff and their bioenvironmental consultant, Normandeau Associates, Inc., assisted the Fish and Game Department in the collection of offshore samples.

The marine biologist of the New Hampshire Fish and Game Department, Mr. Edward Spurr, has been engaged in lobster research since 1970. This study's main objective is to provide the knowledge necessary for development of sound management programs to aid the New Hampshire lobster fishery. This involves the gathering of catch statistics to determine gear efficiency, lobster growth, maturity and fecundity, population size, rates of exploitation, and to assess environmental influences on the rate of lobster harvest. Although there is no actual overlap of lobster sampling area with that of the applicant's studies, the information gained by both New Hampshire Fish and Game Department and the applicant is similar. Both express lobster abundance in terms of catch per unit effort. Actual exchange of catch records does not exist, however, both parties are aware of the other's program and have discussed mutual interests.

The New Hampshire Water Supply and Pollution Control Commission is involved in a continuing program of water quality assessment for the coastal waters of the state. The principle water quality parameters of interest are those which relate to contamination from sanitary waste discharges (e.g. M. P. N. Coliforms, dissolved oxygen, BOD). Other routine physico-chemical parameters monitored are temperature, chlorides, color and pH. For the study period 1969-1970 over 3,500 surface water samples were taken in the coastal and Piscataqua River watershed area. Some of these samples were taken from stations located within the Hampton-Seabrook study area and, therefore, are directly related to conditions measured by the applicant's environmental studies.

An adjunct portion of the Water Supply and Pollution Control Commission monitoring program is some limited sampling for radionuclide levels and mercury concentration levels. Both of these parameters are measured in representative plants and animals and for radionuclides only in ocean water. The seawater and biological samples are being analyzed for radioactivity in order to establish background levels which may serve as a basis for future assessments. The state agency specifically points out that such information is required in view of the applicant's proposed nuclear generating facility. The mercury analysis followed increasing concern by the Federal Food and Drug Administration and was ordered by the Governor of New Hampshire.

The applicant is in touch with the Water Supply and Pollution Control Commission staff on the matter of radiation assessment and is in hopes of developing a cooperative program of radiological monitoring.

A meteorological monitoring station exists at the Hampton town garage about 2.4 miles northeast of the Seabrook site. This station is maintained by the Air Force Cambridge Research Laboratory and is a part of the mesonet system which is designed to gather information useful in documentation of ground fogging conditions. Wind speed and direction are monitored here and comparisons have been made between the mesonet station data and that of the Seabrook Station meteorological monitoring station.

A proposed maintenance dredging project of the Hampton-Seabrook harbor inlet by the Department of the Army New England Division, Corps of Engineers is planned. Preparatory to this dredging sediment samples were taken in the work area for chemical analysis. Chemical analysis is required for dredge spoils to assure compliance with Environmental Protection Agency (EPA) criteria regarding the concentration levels of such potentially harmful ingredients as volatile solids, chemical oxygen demand, kjeldahl nitrogen, oil and grease, mercury, lead, zinc, and copper. The results of this analysis show all chemical parameters tested to be below EPA maximum allowable values. Although this brief test procedure does not strictly qualify as an environmental monitoring program, the information gained may serve as a basis for future comparisons of similar sediment components. There are presently no further plans for pre-dredge environmental assessment but it is possible that some more comprehensive program of monitoring may be undertaken. The applicant is in touch with the New England Division, Corps of Engineers and, therefore, is aware of its Hampton-Seabrook plans. Information on local soft-shell clam reproductive cycle was requested and has been forwarded to the Corps of Engineers by the applicant to assist them in their dredging plans.

Although there is no actual overlap of sampling area, the applicant is aware of and in contact with personnel involved in the New England Offshore Mining Evaluation Study (NOMES). Project NOMES has been designed by the National Oceanic and Atmospheric Administration (NOAA) to evaluate the biological, chemical, and physical effects of dredging sand and gravel from marine deposits. The NOMES study area lies considerably south of Hampton-Seabrook offshore from Boston Harbor.

Another National Oceanic and Atmospheric Administration project is an ichthyoplankton investigation associated with MARMAP cruises. The immediate program objectives are: (1) receive, catalog, process, store and disseminate ichthyoplankton samples and data; (2) sort, identify, measure and enumerate fish eggs and larvae and determine zooplankton biomass; (3) conduct studies of the systematics of previously undescribed Northwest Altantic larval fishes; (4) develop new techniques to more effectively and efficiently sort, measure, and enumerate fish eggs and larvae; and (5) prepare and publish tabular, graphic, and descriptive summaries of the distribution, taxonomy and early life history stages of fish eggs and larvae. Sample stations extend throughout the coastal waters of the Gulf of Maine with several located offshore of the Hampton-Seabrook harbor in water currently under study by the applicant. Contacts have been made between MARMAP personnel and the applicant. The results of such discussions are modifications of the applicant's ichthyoplankton sampling such that results are directly comparable with MARMAP data. It has been suggested by Dr. Joseph J. Graham of NOAA, National Marine Fisheries Service Biological Laboratory, West Boothbay Harbor, Maine, that it would be mutually profitable to exchange plankton information. The applicant is prepared to cooperate fully in the exchange of such data.

A joint project funded by the Atomic Energy Commission, New England Electric System and the Middlesex - Essex Power Pool seeks to develop a computer model for prediction of nuclear power plant effects on near-shore coastal waters. The work is being done by EG&G of Bedford, Massachusetts. From the analysis of data on ocean currents, temperature, salinity, wind direction and velocity, etc. as well as a review of the extensive literature on ocean environments, the study hopes to construct a model which will predict both thermal and radiological effects. The area under study is generally off the Massachusetts coast. However, the northern most EG&G sample stations overlap the southerly stations of the applicant's environmental study program. The applicant has been approached by EG&G seeking our participation in this program but at this writing there is no formalized agreement for cooperation.

7. ENVIRONMENTAL EFFECTS OF ACCIDENTS

7.0 ENVIRONMENTAL EFFECTS OF ACCIDENTS

7.1 Plant Accidents

A series of postulated accidents has been evaluated. The accidents selected for review correspond to those outlined in the AEC's "Guide to the Preparation of Environmental Reports for Nuclear Power Plants" dated August, 1972. That document classifies accidents in eight major categories. Individual accidents have been defined within each of the broad categories. The applicant has adopted those assumptions outlined in the guide for the individual accidents except in cases where the assumptions are not appropriate to the specific design of the Seabrook Station or where other values are considered to be more suitable. In those cases where there are deviations from the recommended bases, such deviations are noted and justification is provided.

One change from the recommended assumptions is the selection of specific meteorological dispersion parameters. Rather than using 1/10 the values of Safety Guide 4, the on-site data has been used to establish dispersion parameters for distances out to 50 miles. Subsection 6.1.3.2 of this report discusses the methods used to calculate dispersion parameters and Table 2.6-4 lists the values used in the environmental impact evaluation.

Another difference from the suggested values is the fraction of fuel failures assumed to be present in the reactor. Based on the experience gained in the operation of Westinghouse Zircaloy clad fuel, a clad failure fraction of 0.2 percent is considered to be more suitable than the AEC's suggested value of 0.5 percent. This selection is based on operation of more than 160,000 Zircaloy clad rods in Westinghouse fuel assemblies installed in seven operating power reactors. Peak burn-ups have been up to approximately 38,000 MWD/MTU. The maximum level of leakage which has been observed was 0.7 percent in Beznau Unit 1, which was a single, isolated case. All other plants have experienced considerably lower leakages. Furthermore, fuel element design improvements have been introduced since the 0.7 percent leakage was observed in Beznau Unit 1.

Another minor departure from the standard assumptions is the steam generator blowdown rate. Because of more stringent requirements on steam generator water solids concentration for the Seabrook Station than had been required in the past (125 ppm vs. 600 ppm), the blowdown rate used is 50 gpm rather than 10 gpm included in the list of standard assumptions.

Environmental impact from plant accidents is quantified in terms of "man-rem" since human radiation exposure is the significant environmental effect. The term "man-rem" is conceptually straightforward. Its determination involves the calculation of radiation exposures at various distances from the Seabrook site resulting from the predicted releases of radioactivity and its dispersion in all directions. The calculated exposures, in rem, at a given distance are multiplied by the number of people residing at that distance in the applicable sector to derive the population dose. For purposes of these calculations, a distance of 50 miles from the Seabrook site has been selected as the radius to which such determinations are made. The mathematical description of the concept is contained in Supplement 7.1, appended to this section.

The radiation doses calculated for the various events assume that all individuals within the 50-mile radius of Seabrook remain out-of-doors during the entire period of the transport of the radioactivity. This neglects the shielding effects of structures in which the individuals might be located. As a result of this assumption, the population doses reported are overestimated.

Another factor which should be noted is that values reported for whole body doses include the skin dose from beta radiation as well as the whole body component from gamma radiation. Since beta particles would not penetrate the body to the depth of the blood forming organs, about 5 centimeters, they do not contribute to the "whole body" dose, but strictly speaking would result in a "skin dose". However, as stated above, the beta contribution is included in the whole body dose values, which results in an overstatement of the whole body exposures.

In assessing the significance of the consequences of the various classes of accidents, it is useful to compare the derived population doses with some meaningful benchmark. The population dose from natural background radiation is considered to represent a base from which comparisons can be made. Actual background measurements have been made in the vicinity of Seabrook and the values range from 54 to 98 mrem/year. Using a value of 75 mrem/year as an average and adding to this the 25 mrem/year from food and water intake, results in a total background dose to individuals living around Seabrook of approximately 100 mrem/year. This individual exposure results in a population dose to those in a 50-mile radius of Seabrook of 5.7×10^5 man-rem, based on a population projection for the year 2000.

ACCIDENT 1.0 - Trivial Incidents

Included in the evaluation of routine releases (Section 5.3).

ACCIDENT 2.0 - Small Releases Outside Containment

Included in the evaluation of routine releases (Section 5.3).

ACCIDENT 3.0 - Radwaste System Failure

The radioactive liquid and gaseous waste processing systems installed at Seabrook will consist of pumps, valves, processing equipment, collection and storage vessels, and process and control instrumentation. Some functions of the systems are performed automatically, with monitoring and control afforded by the instrumentation provided, while other functions require manual action on the part of an operator. Automatic functions are limited to those characterized by strictly mechanical actions necessary within a particular system such as level controlling a tank, maintaining an evaporator, operating properly, etc. Any action leading to transfer of a radioactive fluid from a system to the environment requires positive operator action along with his control and monitoring.

Prior to releasing radioactive liquids or gases to the environment, they are collected or delayed in tanks (carbon delay tanks for gases and waste test tanks for liquids) from which the operator obtains samples for radioactivity analysis in the laboratory. With the results of the radioactivity analysis, the operator can determine whether the release to the environment can be made in compliance with the terms of the operating license. With an affirmative determination, the operator opens the discharge valve and the radioactive fluid is released to the environment through a process radiation montior interlocked with the discharge valve such that a high radiation alarm will close the discharge valve and thereby terminate the release.

All of the operator actions required are performed in strict accordance with detailed written radwaste system operating procedures which include instructions, checklists, and release permit forms. The release is made only after the release permit has been completed and has been reviewed and authorized by the cognizant staff department.

This combination of automatic and operator control on the operation of the radwaste systems signifies that for functions involving collecting or processing a radioactive fluid within a system, operator action and, therefore, the possibility of operator error are minimized, and for actions leading to release to the environment, the feature of positive operator action and control is maximized. The operating procedural requirements signify that the positive, sequential operator action necessary to release a radioactive fluid to the environment is fully reviewed and documented. The release permits are permanently filed to offer a written record of radioactivity releases to the environment.

Radwaste system components are designed and fabricated in accordance with various safety and quality standards. Specific safety classification varies from Non-Nuclear Safety (ANS Safety Class) for components and equipment offering little or no potential for radioactivity release to the environment upon failure, to Safety Class 3 for those with a specified release potential. Pressure vessels, piping, pumps, valves, and storage tanks in those portions of the systems classified as Safety Class 3 are designed, fabricated, and installed in accordance with ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components - Class 3.

The above discussion points out that considerations for the accidental release of radioactivity from the Seabrook radwaste systems have been taken into account through minimization of the probability of operator error or component failure. Nonetheless, analyses are performed that consider radwaste system operator error and component failure for assessment of the off-site radiological impact of the released radioactivity. These analyses are presented below.

3.1 Release of 25 percent of the inventory of a primary drain tank.

General - Each of the two Seabrook units has a primary drain tank that accepts reactor coolant letdown and leakage, that is recyclable after processing by the boron recycle system. These tanks are located in the primary auxiliary building and have an 8600 gallon capacity. The liquid contained in these tanks is hydrogenated and, for purposes of this calculation, is assumed to be equivalent to reactor coolant.

The liquid from these tanks is processed by a degasifier, which removes essentially all of the noble gases,and is then stored in a boron recovery storage tank. The liquid is then processed by the boron recovery evaporator and stored in test tanks. The liquid is sampled in the test tanks and either returned to the reactor makeup system or discharged.

Because the majority of this liquid is recycled and that when released it is necessary to transfer between systems, it is concluded that operator error would not result in the inadvertent release of this liquid to the environment.

This event, then, is postulated to involve a tank puncture or piping rupture such that 25 percent of the 8600 gallon contents is accidentally spilled on the floor of the primary auxiliary building. This event would result in a radioactivity release to the atmosphere through gas evolution from the spilled liquid. There would be no liquid release to the environment since the building would contain the spilled liquid (which would be collected by the building sump system.)

Assumptions -

1. The normal primary drain tank inventories and the quantities released to the environment as a result of this incident are shown below. These are based on 0.2% failed fuel and a loss of 25% of the tank's contents. A partition factor of 10^{-4} was assumed for the halogens in the liquid released.

Isotope	Primary Drain Tank Inventory, Ci	Environmental Release, Ci
Kr-83m	2.8 + 0	7.0 - 1
Kr-85m	1.1 + 1	2.8 + 0
Kr-85	8.4 - 1	2.1 - 1
Kr-87	8.4 + 0	2.1 + 0
Kr-88	2.2 + 1	5.5 + 0
Xe-131m	4.4 - 1	1.1 - 1
Xe-133m	3.6 + 0	9.0 - 1
Xe-133	1.6 +2	4.0 + 1
Xe-135m	5.4 + 0	1.4 + 0
Xe-135	2.0 + 1	5.0 + 0
Xe-137	1.1 + 1	2.8 + 0
Xe-138	4.6 + 0	1.2 + 0
I-131	1.6 + 1	4.0 - 4
I-132	6.0 + 0	1.5 - 4
I-133	2.6 + 1	6.5 - 4
I-134	3.8 + 0	9.5 - 5
I-135	1.4 + 1	3.5 - 4

2. The two hour X/Q values are appropriate for the dose analysis of this release.

Results -

The two hour whole body and thyroid doses at the site boundary are 0.00052 Rem and 0.000025 Rem respectively. Population doses are as shown in Table 7.1-1.

3.2 Release of 100 percent of the normal radioactivity inventory of a primary drain tank.

General - This event is postulated to arise as a result of the rupture of a primary drain tank. As for the tank puncture event, this accident would result in a radioactivity release to the atmosphere through gas evolution from the spilled liquid. The liquid itself would be contained within the building and handled by the building sump system.

Assumptions -

1. The normal noble gas and halogen inventories within a full primary drain tank correspond to 0.2 percent fuel clad defects as listed above for accident 3.1.

2. All of the noble gas content and 10^{-4} of the halogen content of the spilled liquid is released to the environment.

3. The two hour χ/Q values are appropriate for the dose analysis of this release.

Results - The two hour whole body and thyroid doses at the site boundary are 0.0021 Rem and 0.0001 Rem, respectively. Population doses are as shown in Table 7.1-1.

3.3 Rupture of a waste gas decay tank.

General - The radioactive Gaseous Waste System (Section 3.5) is designed to remove fission product gases from the reactor coolant. The system includes 5 low pressure (0-2 psig) carbon delay tanks where the gases are allowed to decay before being returned to the coolant or released to the atmosphere. Each tank is designed to provide 17 hours of Kr delay and 12 days of Xe delay which results in a total system delay of 85 hours for Kr and 60 days for Xe.

The normal expected inventory in the carbon tanks is shown below. This inventory is based on gas stripping from 160 gpm (80 gpm from each unit) of reactor coolant for an indefinite period of time. The 160 gpm represents full capacity for the 2 letdown degassifiers.

The radioactive Gaseous Waste System is designed to Safety Class 3 criteria and to withstand a hydrogen detonation. In addition, the carbon tanks are designed to withstand the safe shutdown earthquake. In the event of a pipe or carbon tank failure, noble gases would be released from the carbon. The quantity of radioactivity released would depend on the failure location but would in all cases be a small fraction of the total system inventory.

Assumptions -

1. It is assumed that a failure occurs upstream of the first carbon tank. This results in a depressurization of the tanks and the release of a fraction of the noble gas inventory in the carbon. The isotopic release fractions are calculated as described by Underhill (Nuclear Safety 13(6) 1972). The activity released shown below is based on the inventory with 0.2 percent failed fuel and a maximum carbon tank pressure of 17 psia.

Isotope	Tanks Inventory Ci	Fraction Released	Curies Released
Kr-85m	7.2 + 1	0.0084	6.0 - 1
Kr-85	1.0 + 2	0.0025	2.5 - 1
Kr-87	1.7 + 1	0.027	4.6 - 1
Kr-88	9.6 + 1	0.013	1.2 + 0
Xe-131m	2.0 + 2	0.00022	4.4 - 2
Xe-133m	3.2 + 2	0.00072	2.3 - 1
Xe-133	3.4 + 4	0.00034	1.2 + 1
Xe-135m	2.2 + 0	0.14	3.1 - 1
Xe-135	2.8 + 2	0.0042	1.2 + 0
Xe-138	2.0 + 0	0.13	2.6 - 1

2. The two hour χ/Q values are appropriate for the dose analysis of this release.

Results - The two hours whole body dose at the site boundary is 0.0001 Rem. Population doses are as shown in Table 7.1-1.

ACCIDENT 4.0 - Fission Products to Primary System (BWR)

Not applicable to pressurized water reactors.

ACCIDENT 5.0 - Fission Products to Primary and Secondary Systems (Pressurized Water Reactor)

5.1 Fuel cladding defects and steam generator leak - Included in the evaluation of routine releases (Section 5.3)

5.2 Off-design transients that induce fuel failures above those expected and steam generator leak

General - As the title of this accident implies, events of this nature are not anticipated and cannot be described with any degree of accuracy. Rather, this evaluation might be viewed as encompassing a class of events whose occurrence is unforeseen and cannot be quantified to a substantial degree. The results of such events should be mitigated through the action of the reactor protection system.

Assumptions -

1. 0.02 percent of the core inventory of noble gases and 0.02 percent of the core inventory of iodines are released to the reactor coolant and mix uniformly.

2. The average inventory in the reactor coolant prior to the accident is based on 0.2 percent fuel clad defects.

3. A release path to the environment exists through a leak in the steam generator(s). The leak rate is 20 gallons per day and persists for eight hours at which time the reactor coolant system pressure is reduced and the leakage is terminated.

4. All the noble gases and 10 percent of the iodines in the water which leaks through the steam generators are carried with the steam to the main condenser. These noble gases and 0.1 percent of the iodines in the steam are released from the air ejector through a charcoal filter, which has a 99 percent iodine removal efficiency, to the environment.

5. The eight hour χ/Q values are appropriate for the analysis.

Results - 1. The activity released to the environment as a result of this accident is shown in the following table.

Isotope	Activity Released (curies)
I-131	1.83-6
I-132	2.76-6
I-133	4.09-6
I-134	4.78-6
I-135	3.70-6
Kr-85m	8.27-1
Kr-85	2.13-2
Kr-87	1.58+0
Kr-88	2.25+0
Xe-131m	3.00-2
Xe-133m	1.15-1
Xe-133	4.62+0
Xe-135m	1.13+0
Xe-135	1.18+0
Xe-138	3.69+0

2. The eight hour whole body dose at the site boundary is 1.4×10^{-4} rem and the eight hour thyroid dose is 3.5×10^{-8} rem. Population doses are shown in Table 7.1-1.

5.3 Steam Generator Tube Rupture

General - This accident is defined as the complete severance of a steam generator tube while the reactor is operating at full power. In view of the fact that steam generator tubes are constructed of Iconel 600, a ductile material, it is considered that a sudden, complete severance is unlikely. The more likely mode of failure would be randomly distributed leaking tubes. Leakage from defective tubes increases gradually with time and is then terminated by plugging the leaking tubes. Tubes are typically plugged when leakage increases to 500 to 1000 gallons per day. Leaks are detected by daily water inventories, steam generator sampling, blowdown radiation monitors, and air ejector discharge radiation monitors.

Since this accident does not cause fuel failure, the source term is the activity contained in the coolant prior to the accident.

Assumptions -

1. The quantity of reactor coolant which leaks through the broken tube before the steam generator is isolated is 125,000 pounds. This represents about 22 percent of the reactor coolant mass, a larger fraction than the standard AEC assumption of 15 percent.

2. Reactor coolant fission product concentrations correspond to operation with 0.2 percent failed fuel.

3. Noble gases and iodines which leak through the broken tube behave in the same manner as described previously for off-design transients (accident category 5.2).

4. The one hour χ/Q values are appropriate for the analysis.

Results - 1. The activity released to the environment as a result of this accident is shown in the following table.

Isotope	Activity Released (curies)
I-131	2.95-5
I-132	1.02-5
I-133	4.42-5
I-134	6.24-6
I-135	2.49-5
Kr-85m	2.50-1
Kr-85	1.59+0
Kr-87	1.36+1
Kr-88	4.31+1
Xe-131m	3.63+1
Xe-133m	1.93+1
Xe-133	9.76+2
Xe-135m	2.04+0
Xe-135	6.81+1
Xe-138	7.72+0

2. The whole body dose at the site boundary is 7.0×10^{-3} rem and the thyroid dose is 1.1×10^{-6} rem. Population doses are shown in Table 7.1-1.

ACCIDENT 6.0 Refueling Accidents

6.1 Fuel bundle drop

General - The possibility of damage to a fuel assembly as a consequence of mishandling is minimized by thorough training, detailed procedures, and equipment design. Inadvertent disengagement of a fuel assembly from the fuel handling machine is prevented by positive grappling design features. The maximum elevation to which the fuel assemblies can be raised is limited by the design of the fuel handling hoists and manipulators. A mechanical stop prevents the hoist from raising fuel above the point where adequate water for shielding is available. At no time during the transfer from the reactor core to the spent fuel storage rack is a fuel assembly removed from the water.

Interlocks are incorporated in fuel handling equipment to prevent movement into the walls. All motors are equipped with mechanical brakes or self-locking gears to prevent movement in case of a loss of power; however, all motor functions have manual backup capacity.

During withdrawal or insertion of a fuel assembly, the load on the hoist cable is monitored at the control console to ensure that movement is not being restricted. A piston-operated spreader device is provided which spreads adjacent fuel assemblies within the core to provide unrestricted removal and insertion. The spreader is part of the mass assembly and is operated prior to grappling of the fuel assembly.

Although the failure of one row of fuel rods upon dropping a fuel assembly has been assumed, it is expected that no fuel rods would fail. The failure of one row of fuel rods assumed the point of impact was at the most effective location for fuel rod damage; i.e., the center of percussion. Due to the length of the fuel assembly, it is highly probable that it would strike the pool wall or other high objects as it rotates, thus breaking its fall and reducing the effects of impact. Contrary to the unlikely occurrence of a line load and a direct angle of strike necessary to obtain one row of fuel rod failures, a glancing angle of strike and a non-line load, either of which will reduce or preclude fuel damage, is more probable.

Reliability of the fuel handling equipment, including the bridge and trolley, the lifting mechanism, the tilting machines and the transfer carriage, and all associated instrumentation and controls, are ensured through the adoption of pre-operational check-out tests and routines.

In over 73 reactor years of PWR operating experience in the United States, there has not been a single fuel handling accident in which either a new or spent fuel rod has sustained clad rupture.

Assumptions -

1. The accident occurs one week after shutdown from operation at full power.

2. The noble gases and iodines in the gaps of one row (15) of fuel rods are released to the water.

3. The decontamination factor for iodine is 760. This value is based on testing conducted by Westinghouse and reported in WCAP-7828, "Radiological Consequences of a Fuel Handling Accident", December 1971. No removal of noble gases occurs.

4. Local radiation monitors would detect the radioactivity released from the pool and isolate the containment ventilation exhaust system. This action prevents the release of radioactivity at that time.

5. The containment is isolated for 24 hours during which time the containment cleanup filter, rated at 4000 cfm, is operated. This filter has a 99 percent iodine removal efficiency and no effect on noble gases.

6. At the end of the 24 hours, the containment is purged for 16 hours. The purge path contains a charcoal filter for iodine removal (99 percent efficiency). The purging operation releases all remaining containment airborne activity to the environment.

7. The 8 to 24 hour χ/Q values are appropriate for the analysis.

Results - 1. The activity released to the environment as a result of this accident is shown in the following table.

Isotope	Activity Released (curies)
I-131	5.47-4
I-133	1.45-6
Kr-85	9.93+1
Xe-131m	5.54+0
Xe-133m	2.60+0
Xe-133	4.65+2
Xe-135	3.53-4

2. The sixteen hour whole body dose is 2.8×10^{-4} rem and the sixteen hour thyroid dose is 2.1×10^{-6} rem at the site boundary. Population doses are shown on Table 7.1-1.

6.2 Heavy object drop onto fuel in core

General - The heaviest object routinely lifted over the reactor vessel is the reactor vessel head. The head would not be likely to damage fuel even if dropped, since it cannot physically fit inside the vessel.

The upper core support assembly is also removed at each refueling. This structure fits inside the reactor vessel and if dropped could impose a load on the fuel. However, this would require that the slots in the core plate line up exactly with the pins in the core barrel. If this alignment did not occur, the core support assembly would be prevented from falling all the way into the reactor vessel.

Other heavy objects handled over the reactor vessel are the spent fuel assemblies. The discussion under accident 6.1 describes provisions made in design and handling operations to reduce the possibility of dropping a fuel bundle.

Prior to every refueling, all handling equipment is checked by non-destructive test methods to assure its integrity. In addition, load tests are conducted to verify safe handling capabilities.

Assumptions -

1. The accident occurs 100 hours after shutdown from operation at full power.
2. The noble gases and iodines in the gaps of the fuel rods in one average fuel assembly are released to the water.
3. Assumptions 3. through 6. of accident 6.1, Fuel bundle drop, apply to this situation.

Results - 1. The activity released to the environment as a result of this accident is shown in the following table.

Isotope	Activity Released (curies)
I-131	9.49-3
I-133	1.86-4
Kr-85m	1.35+3
Xe-131m	8.01+1
Xe-133m	8.21+1
Xe-133	9.13+3
Xe-135m	6.35-2
Xe-135	8.39-1

2. The sixteen hour whole body dose is 5.3×10^{-5} rem and the sixteen hour thyroid dose is 3.7×10^{-5} rem at the site boundary. Population doses are shown in Table 7.1-1.

ACCIDENT 7.0 Spent Fuel Handling Accidents

7.1 Fuel assembly drop in fuel storage pool

General - This accident is essentially the same as 6.1, Fuel bundle drop, except for the location in the fuel storage building as contrasted with the containment.

Assumptions -

1. The accident occurs one week after shutdown from operation at full power.

2. The noble gases and iodines in the gaps of one row (15) of fuel rods are released to the water.

3. The decontamination factor for iodine is 760. This value is based on testing conducted by Westinghouse and reported in WCAP-7828, "Radiological Consequences of a Fuel Handling Accident", December, 1971. No removal of noble gases occurs.

4. Local radiation monitors would detect the radioactivity released from the pool, provide an alarm, and shift the ventilation flow from the normal path to one containing charcoal filter assemblies.

5. The airborne activity is released to the environment over a two hour period.

6. Iodine removal efficiency of the charcoal filter assemblies is 99 percent. No removal of noble gases occurs.

Results - 1. The activity released to the environment as a result of this accident is shown in the following table.

Isotope	Activity Released (curies)
I-131	4.64-3
I-133	2.49-5
Kr-85	9.93+1
Xe-131m	5.56+0
Xe-133m	3.50+0
Xe-133	5.30+2
Xe-135m	1.35-5
Xe-135	2.19-3

2. The two hour whole body dose is 1.5×10^{-3} rem and the two hour thyroid dose is 8.8×10^{-5} rem at the site boundary. Population doses are shown on Table 7.1-1.

7.2 Heavy object drop onto fuel rack

General - The largest item handled in the fuel storage building is the spent fuel shipping cask. However, the crane and building arrangements for the Seabrook Station are such that it is impossible for the cask to be carried over the fuel storage racks.

The spent fuel pit bridge hoist which spans to storage pool serves as the fuel handling platform. This motor driven walkway is designed to preclude it from tipping over and to safely withstand the forces associated with earthquakes.

The fuel storage building itself is of reinforced concrete construction and is designed for earthquake loads and the forces and missiles which could result from a tornado. Consequently, heavy objects which could fall onto the storage racks from the building itself are not very likely.

Assumptions -

1. The accident occurs 30 days after shutdown from operation at full power.

2. The noble gases and iodines in the gaps of the fuel rods in one average fuel assembly are released to the water.

3. Assumptions 3. through 7. of accident 7.1, Fuel assembly drop in fuel storage pool, apply to this situation.

Results - 1. The activity released to the environment is shown in the following table.

Isotope	Activity Released (curies)
I-131	8.69-3
Kr-85	1.35+3
Xe-131m	3.24+1
Xe-133m	4.58-2
Xe-133	3.60+2

2. The two hour whole body dose is 4.7×10^{-3} rem and the two hour thyroid dose is 1.6×10^{-4} rem at the site boundary. Population doses are shown in Table 7.1-1.

7.3 Fuel cask drop

General - Spent fuel shipping casks are rugged pieces of equipment which must be designed to withstand a free fall of 30 feet onto an unyielding surface. Since the cask used to transfer spent fuel from the Seabrook Station will meet this requirement, only if the cask is lifted more than 30 feet is there a reasonable expectation of failure.

The only time a loaded cask is lifted more than 30 feet while on the site is when the cask is being removed from the underwater fuel cask loading area in the fuel storage building. After removal from the pool, the cask would be transferred to a rail car. However, this transfer to the rail car involves a vertical movement of only a few feet.

Assumptions -

1. The accident occurs in the spent fuel storage building 120 days after shutdown from operation at full power.

2. The noble gases in the gaps of ten fuel assemblies are released to the building atmosphere.

3. The airborne activity is released to the environment over a two hour period.

Results -

1. The activity released to the environment as a result of this accident is shown in the following table.

Isotope	Activity Released (curies)
I-131	3.73-5
Kr-85	1.32+4
Xe-131m	2.51+0
Xe-133	2.84-2

2. The two hour whole body dose is 3.8×10^{-2} rem and the two hour thyroid dose is 7.1×10^{-7} rem at the site boundary.

Population doses are shown in Table 7.1-1.

ACCIDENT 8.0 Accident Initiation Events Considered in Design Basis Evaluation in the Safety Analysis Report

8.1 Loss-of-coolant accidents

General - Evaluations of these events typically begin with the assumption that there is a sudden rupture in a reactor coolant system pipe. This event results in rapid discharge of reactor coolant from the broken pipe into the containment. Any fission products contained in the coolant or released to the coolant as a result of fuel clad failures would be transported to the containment atmosphere.

Engineered safety features are provided to isolate the containment, provide coolant water to the core, and reduce iodine concentration in the containment atmosphere. Because of the pressure increase resulting from the energy addition to the containment, leakage of fission products could occur.

Any fission products released from the primary containment would leak into the enclosure building where they would be passed through filters for iodine removal before release to the atmosphere. The noble gases are unaffected by the fission product removal systems.

8.1.1 Small Pipe Break

Assumptions -

1. For the small break no additional fuel failures occur and the source term is the radioactivity in the coolant corresponding to operation with 0.2 percent fuel defects.

2. All the noble gases and 50 percent of the iodines in the coolant are released to the containment atmosphere.

3. Half of the iodine released to the containment atmosphere is removed by natural effects including condensation, deposition, and settling.

4. The containment spray system does not operate.

5. The values for containment leakage, enclosure building ventilation system effectiveness and atmospheric dispersion are stated in Supplement 7.1.

Results - 1. The activity released to the environment as a result of this accident is shown in the following table.

Activity Released (curies)

Isotope	0 - 8 hrs.	8 - 24 hrs.	1 - 4 days	4 - 30 days
I-131	3.02-5	9.88-5	2.09-4	5.95-4
I-133	3.92-5	9.32-5	7.13-5	6.47-5
I-135	1.60-5	1.87-5	3.03-6	1.41-9
Kr-85m	5.00-3	3.56-3	2.26-4	1.87-9
Kr-85	6.62-4	2.26-3	5.53-3	4.52-2
Kr-88	5.97-3	2.00-3	3.10-5	3.6-13
Xe-131m	1.50-2	4.96-2	1.10-1	4.29-1
Xe-133m	7.58-3	2.26-2	3.44-2	2.18-2
Xe-133	3.92-1	1.26	2.49	4.75
Xe-135m	4.23-3	1.65-2	9.88-3	1.41-5
Xe-135	2.16-2	3.94-2	1.34-2	5.46-2

2. The thirty day whole body dose at the site boundary is 4.3×10^{-6} rem and the thyroid dose is 3.4×10^{-6} rem. Population doses are shown in Table 7.1-1.

8.1.2 Large Pipe Break

Assumptions -

1. As a result of the accident the noble gas and iodine activity in the fuel clad gaps is released to the reactor vessel.

2. All the noble gases and 50 percent of the iodines become airborne in the containment. Of this activity available for leakage, 5 percent of the iodine is in a form not removed by the containment spray system.

3. Iodine removal of the remaining 95 percent of the airborne iodine (elemental iodine) by the spray system occurs with a removal constant of 18 $hr.^{-1}$ based on characteristics of the spray system, containment volume, and iodine behavior with sodium hydroxide.

4. No further removal of elemental iodine occurs after the containment elemental concentration reaches 0.1 percent of its initial level. This represents typical behavior observed at experimental facilities. This level is reached approximately 25 minutes after spray system actuation. The values for containment leakage, enclosure building ventilation system effectiveness, and atmospheric dispersion are stated in Supplement 7.1.

Results - 1. The activity released to the environment as a result of this accident is shown in the following table.

	Activity (curies)			
Isotope	0 - 8 hrs.	8 - 24 hrs.	1 - 4 days	4 - 30 days
I-131	4.95-2	1.33-1	2.79-1	7.95-1
I-133	3.24-2	6.28-2	4.74-2	4.30-3
I-135	1.25-2	1.17-2	1.86-3	8.65-7
Kr-85m	5.32	3.78	.241	1.99-6
Kr-85	24.6	83.8	206.	1680
Kr-87	1.49	6.19-2	1.13-5	1.4-22
Kr-88	8.01	2.69	4.16-2	4.9-10
Xe-131m	1.47	4.95	11.6	56.7
Xe-133m	475	1410	2100	1320
Xe-133	307	1080	2650	7060
Xe-135m	4.31	11.7	6.39	8.86-3
Xe-135	20.6	48.7	20.6	1.02-1

2. The thirty day whole body dose at the site boundary is 9.0×10^{-3} rem and the thyroid dose is 4.5×10^{-3} rem. Population doses are shown in Table 7.1-1.

8.2 Rod Ejection Accident

General - This accident is defined as the mechanical failure of a control rod mechanism pressure housing resulting in the ejection of a rod cluster control assembly and drive shaft. The consequence of this mechanical failure is a rapid reactivity insertion together with an adverse core power distribution, possibly leading to localized fuel rod damage.

An analysis has been performed which concludes that an upper limit of fuel rods entering departure from nucleate boiling (DNB) is 10 percent. Thus, 10 percent represents an upper limit of cladding failures as a result of this accident. This analysis is reported in WCAP-7588, Revision 1, December 1971, "An Evaluation of the Rod Ejection Accident in Westinghouse Pressurized Water Reactors Using Spatial Kinetics Methods".

Certain features in Westinghouse reactors are intended to preclude the possibility of a rod ejection accident, or to limit the consequences if the accident were to occur. These include a sound, conservative mechanical design of the rod housings, together with a thorough quality control program during assembly. In addition, the nuclear design lessens the potential ejection worth of rod cluster control assemblies and minimized the number of assemblies inserted at high power levels.

Assumptions -

1. Initial coolant activity corresponds to 0.2 percent fuel defects.

2. The activity in the gaps of 10 percent of the fuel rods is released to the reactor coolant.

3. All the noble gas activity and ten percent of the iodine activity are released to the containment atmosphere. Half of the iodine released to the containment is removed by natural effects including plateout and settling.

4. Leakage from the primary containment mixes uniformly with 50 percent of the secondary containment volume. The secondary containment is exhausted through particulate and charcoal filters before release. None of the noble gases and 99 percent of the iodines are removed by the filters.

5. Since leakage from the containment could continue for an extended period of time, the χ/Q values for the various time periods up to 30 days are used.

Results - 1. The activity released to the environment as a result of this accident is shown below for various time periods.

Activity Released (curies)

Isotope	0 - 8 hours	8 - 24 hours	1 - 4 days	4 - 30 days
I-131	3.73-3	1.90-2	5.79-2	1.54-1
I-132	1.61-4	5.18-5	neg.	neg.
I-133	2.41-3	8.85-3	1.01-2	8.44-4
I-134	3.81-5	neg**	neg.	neg.
I-135	8.88-4	1.57-3	3.94-4	neg.
Kr-85m	2.45-1	2.59-1	2.59-2	neg.
Kr-85	1.09+0	6.23+0	2.19+1	1.68+2
Kr-87	6.12-2	3.75-3	1.09-6	neg.
Kr-88	3.61-1	1.78-1	4.35-3	neg.
Xe-131m	7.65-2	3.95-1	1.27+0	4.84+0
Xe-133m	2.30-1	1.06+0	2.34+0	1.37+0
Xe-133	1.39+1	6.97+1	1.99+2	3.53+2
Xe-135m	2.10-1	1.15+0	9.23-1	1.58-3
Xe-135	7.95-1	2.02+0	9.43-1	3.11-3
Xe-138	3.80-3	neg.	neg.	neg.

**negligible ($<10^{-6}$)

2. The thirty day whole body dose at the site boundary is 4.7×10^{-4} rem and the thirty day thyroid dose is 8.7×10^{-4} rem. Population doses are shown on Table 7.1-1.

8.3 Steam Line Break Outside Containment

General - The AEC's environmental report guide lists two steam line breaks for consideration. However, due to the nature of the assumptions, which are discussed below, the results would be identical for both events. Consequently, one steam line break accident is evaluated.

This accident is defined as the instantaneous rupture of a main steam line outside the containment. From an environmental effects viewpoint, this location is more limiting than inside since any radioactivity contained in the flashing mixture would be released to the environment without treatment. If the break occurred inside the containment, the combination of gradual leakage and treatment by the secondary containment filtration system would reduce the radioactivity release to a value far below that for the situation assumed here.

A slight deviation from the AEC assumptions is employed. Instead of applying a halogen reduction factor of 0.5 after the blowdown, a value of 0.1 is used. This value is based on experimental work performed at Battelle-Northwest Laboratories which indicated that approximately 9 percent of the iodine in a boric acid solution was released by evaporation when the liquid was boiled. This work is reported in BNP-100, "Iodine Removal from Containment Atmospheres by Boric Acid Spray", dated July 1970.

Assumptions -

1. Iodine activity in each steam generator is based on 0.2 percent fuel failures and 20 gallons per day primary to secondary leakage.

2. Ten percent of the iodine in the steam generator connected to the broken steam line is released to the environment. Because the blowdown occurs rapidly, the 0 - 1 hour χ/Q value is used.

3. Leakage continues at the rate of 5 gallons per minute through each of the four steam generators for a period of 8 hours. All

the noble gases from the four steam generators and 10 percent of the iodine from the affected steam generator are released during this 8 hour period. The 0 - 8 hour χ/Q values are used for this portion of the accident.

Results - 1. The activity released to the environment as a result of this accident is shown in the following table:

Activity Released (curies)

	From Steam Generator Blowdown	From Primary to Secondary Leakage
I-131	6.17-4	2.33-4
I-132	3.92-5	3.07-5
I-133	6.17-4	3.11-4
I-134	1.01-5	7.87-6
I-135	2.07-4	1.36-4
Kr-85m	Not Applicable	4.52-3
Kr-85		5.09-4
Kr-87		1.01-3
Kr-88		6.00-3
Xe-131m		1.15-2
Xe-133m		5.91-3
Xe-133		3.03-1
Xe-135m		1.51-2
Xe-135		1.88-2
Xe-138		1.29-4

2. The eight hour whole body dose at the site boundary is 7.1×10^{-7} rem and the eight hour thyroid dose is 2.4×10^{-5} rem. Population doses are shown on Table 7.1-1.

SUPPLEMENT 7.1

MODELS AND DATA FOR EVALUATING RADIOLOGICAL IMPACT OF ACCIDENTS

I. Introduction

The evaluation of the radiological impact of accidents involves assumptions and application of data. Many of these assumptions are stated in the AEC's "Guide for the Preparation of Environmental Reports" dated August, 1972. Other assumptions are specified in the discussions of the individual accidents. Although the accidents are in many ways dissimilar, many of the models and much of the data is commonly used in the evaluations. It is the purpose of this supplement to provide the general information used for accident evaluations. Because off-site doses can be caused only by radionuclides with a high degree of mobility, the isotopic data presented is limited to the noble gases and iodines.

II Data and Assumptions -

A. Radioactive source data

1. Power level

   3654 mwt is used based on the guaranteed core thermal output of 3411 mwt plus a 5 percent allowance for possible increased capability and a 2 percent uncertainty for calorimetric measurements.

2. Fission product inventory

   Total core inventories and gap activities are shown below for the isotopes of interest based on core operation at 3654 mwt for 650 days.

Isotope	Activities in Curies Core Inventory	Gap Activity
I-131	9.02+7	1.69+
I-132	1.37+8	2.90+5
I-133	2.02+8	1.27+6
I-134	2.37+8	3.09+5
I-135	1.83+8	6.59+5
Kr-85m	4.05+7	1.17+5
Kr-85	1.02+6	2.61+5
Kr-87	7.78+7	1.22+5
Kr-88	1.11+8	2.56+5
Xe-131m	6.87+5	1.56+4
Xe-133m	5.29+6	5.35+4
Xe-133	2.08+8	3.19+6
Xe-135m	5.60+7	3.98+4
Xe-135	5.69+7	2.40+5
Xe-138	1.83+8	1.36+5

3. Reactor coolant activity before the accident
Corresponds to operation with defects in 0.2 percent of the fuel rods. (See Table G-1 Appendix G).

4. Secondary coolant activity before the accident
Corresponds to the level which would be present with 0.2 percent fuel defects and 20 gpd primary to secondary leakage. (See Table G-2 of Appendix G).

B. Data and assumptions used to estimate activity released

1. Primary containment leak rate
0.05 percent contained volume per day for first 24 hours and 0.025 percent of contained volume per day thereafter.

2. Secondary containment air removal rate
2,000 cfm

3. Secondary containment mixing
Leakage from the primary containment is assumed to mix with 50 percent of the secondary containment system volume.

4. Adsorption and filtration efficiencies

   Charcoal filter efficiency is 99 percent for iodine.

5. Containment spray parameters

   $\chi_s = 18 \text{ hr.}^{-1}$

6. Containment volumes

   Primary containment - 2.8×10^6 ft^3

   Secondary containment - 1.0×10^6 ft^3

C. Dispersion Data

1. Boundary and LPZ distances

   Boundary - 3000 feet (914 meters)

   LPZ - 1.5 miles (2414 meters)

2. χ/Q values

   Based on 50 percent frequency values for one data and summarized in Table 2.6-4.

D. Dose Data

1. Method of dose calculation

   Whole body dose -

   The whole body dose is calculated assuming that the receptor is immersed in a semi-infinite plume of uniform concentration. Specific equations for the evaluations are the following:

$$D\beta = 0.23 \cdot \chi/Q \cdot \sum_i Q_i \cdot \bar{E}\beta_i$$

$$D\gamma = 0.25 \cdot \chi/Q \cdot \sum_i Q_i \cdot \bar{E}\gamma_i$$

where:

$D\beta$ is the whole body beta dose (rem)

$D\gamma$ is the whole body gamma dose (rem)

χ/Q is the atmospheric dispersion parameter (sec/m^3)

Q is the quantity of isotope i released during the interval of interest (curies)

$\bar{E}_i$ is the decay energy from isotope i (Mev/disintegration)

Thyroid inhalation dose is calculated by the following expression during each period of interest.

$$D_t = \chi/Q \cdot B \cdot \sum_i Q_i \cdot DCF_i$$

where:

D_t is the thyroid inhalation dose

χ/Q is the atmospheric dispersion parameter (sec/m^3)

B is the breathing rate (m^3/sec)

Q_i is the quantity of iodine isotope i released during the interval (curies)

DCF_i is the dose conversion factor for iodine isotope i (rem/curie inhaled)

Population Dose -

Population doses are determined as follows:

$$\text{Population dose} = \sum_{r=0}^{50 \text{ miles}} \sum_{\theta=1}^{16} [\text{Dose } (r)] \times [\text{Pop } (r, \theta)] \times [F\ (\theta)]$$

where:

Dose (r) is the dose at a given distance, r

Pop (r, θ) is the number of people living at distance r in sector θ (year 2000 population projection)

F (θ) is the fraction of time the wind blows toward sector θ

2. Dose conversion data

Physical Data for Isotopes

Isotope	Decay* Constant (hr^{-1})	Gamma* Energy (Mev/Dis)	Beta* Energy Mev/Dis	Dose Conversion Factor** (Rem/Curie)
I-131	3.59×10^{-3}	0.391	0.183	1.48×10^{6}
I-132	3.01×10^{-1}	2.130	0.485	5.35×10^{4}
I-133	3.30×10^{-2}	0.565	0.493	4.00×10^{5}
I-134	7.92×10^{-1}	2.614	0.580	2.50×10^{4}
I-135	1.03×10^{-1}	1.771	0.316	1.24×10^{5}
Kr-85m	1.58×10^{-1}	0.157	0.252	-
Kr-85	7.45×10^{-6}	0.004	0.221	-
Kr-87	5.33×10^{-1}	1.586	1.341	-
Kr-88	2.48×10^{-1}	1.915	0.372	-
Xe-131m	2.40×10^{-3}	0.001	0.055	-
Xe-133m	1.26×10^{-2}	0.026	0.207	-
Xe-133	5.44×10^{-3}	0.027	0.155	-
Xe-135m	2.67×10^{0}	0.416	0.104	-
Xe-135	7.63×10^{-2}	0.261	0.304	-
Xe-138	2.45×10^{0}	1.280	0.579	-

*J. F. Perkins, "Decay of U-235 Fission Products", Report No. RR-TR-63-11, July 25, 1963.

**J. J. DiNunno et. al., "Calculation at Distance Factors for Power and Test Reactor Sites" TID-14844, March 23, 1962.

Breathing Rate

20 m^3/day (from ICRP Publication 2 "Report of Committee II on Permissible Dose for Internal Radiation")

TABLE 7.1-1

SUMMARY OF POPULATION EXPOSURE FROM POSTULATED ACCIDENTS

FOR VARIOUS DISTANCES AROUND SEABROOK STATION

ACCIDENT	DESCRIPTION	THYROID DOSE (MAN-REM) 0-5 miles	0-10 miles	0-20 miles	0-30 miles	0-40 miles	0-50 miles	WHOLEBODY DOSE (MAN-REM) 0-5 miles	0-10 miles	0-20 miles	0-30 miles	0-40 miles	0-50 miles
3.1	Primary Drain Tank Puncture	0.0072	0.010	0.017	0.029	0.042	0.056	0.15	0.21	0.35	0.60	0.87	1.2
3.2	Primary Drain Tank Rupture	0.029	0.040	0.068	0.12	0.17	0.22	0.60	0.83	1.4	2.4	3.5	4.7
3.3	Gas Decay Tank Rupture	0	0	0	0	0	0	0.03	0.04	0.07	0.12	0.17	0.22
5.2	Off-Design Transient	1.0-5	1.4-5	2.4-5	4.0-5	5.9-5	7.9-5	0.042	0.057	0.094	0.16	0.23	0.31
5.3	Steam Generator Tube Rupture	3.4-4	4.6-4	7.6-4	1.3-3	1.9-3	2.5-3	2.1	2.8	4.6	7.8	12	16
6.1	Fuel Bundle Drop	4.9-4	6.4-4	8.8-4	1.2-3	1.4-3	1.6-3	0.065	0.085	0.12	0.15	0.18	0.21
6.2	Object Drop onto Fuel in Core	8.5-3	0.011	0.015	0.020	0.024	0.027	1.2	1.6	2.2	2.8	3.4	3.8
7.1	Fuel Assembly Drop in Storage Pool	0.026	0.035	0.058	0.098	0.15	0.20	0.45	0.62	1.0	1.7	2.5	3.4
7.2	Object Drop onto Fuel Rack	0.048	0.066	0.11	0.18	0.27	0.37	1.4	1.9	3.1	5.2	7.7	10
7.3	Fuel Cask Drop	2.1-4	2.8-4	4.7-4	7.9-4	1.2-3	1.6-3	11	15	25	42	62	84
3.1	LOCA, Small Pipe Break	8.3-4	1.1-3	1.6-3	2.2-3	2.8-3	3.4-3	1.1-3	1.4-3	2.1-3	2.9-3	3.7-3	4.5-3
8.1	LOCA, Large Pipe Break	1.1	1.5	2.1	3.0	3.8	4.5	2.2	3.0	4.3	6.1	7.8	9.5
8.2	Rod Ejection	0.21	0.27	0.40	0.55	0.70	0.83	0.11	0.15	0.22	0.31	0.39	0.48
8.3	Steam Line Break Outside Containment	7.2-3	9.9-3	0.016	0.027	0.041	0.055	2.1-4	2.9-4	4.7-4	8.0-4	1.2-3	1.6-3
	Background Radiation							5.3+3	1.6+4	6.5+4	1.6+5	3.6+5	5.7+5

Note: 1.2-3 = 1.2 x 10^{-3} = 0.0012

7.2 Transportation Accidents

As for the radiological assessment for normal conditions of radioactive material transportation from the Seabrook Station (section 5.3.4.2 of this report), reference is made to the Commission's report on the subject ("Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants") for an analysis of the radiological impact to transport workers and to the general public arising through transportation accidents involving radioactive materials shipments from a typical light water reactor. Since the analyses of the spectrum of transportation accidents presented therein are applicable to the Seabrook shipments, no separate analysis is required here.

7.3

7.3 Other Accidents

No other accidents were considered.

8. ECONOMIC AND SOCIAL EFFECTS OF CONSTRUCTION AND OPERATION

8 ECONOMIC AND SOCIAL EFFECTS OF PLANT CONSTRUCTION AND OPERATION

8.1 Value of Output

The price of electricity is the basis here used for determining its economic value to society since it reflects the value that users place on it. It must be emphasized, however, that this market price provides only the minimum value of the output, since many consumers would be prepared to pay more for electricity than they are actually being charged.

In calculating the value of the output at the Seabrook facilities we make the following assumptions:

1. The plant's output will be distributed among the various users as is the system's entire output. For 1982, these are projected by the Company as follows:

Residential	33.5 percent
Commercial (General)	8.7 percent
Industrial	26.5 percent
Other	25.7 percent
Losses (Reference 1)	5.6 percent

2. The average price per kilowatt-hour used in the valuation is based on actual 1972 prices. Given these prices, and the 1982 projected share for each class of users, we obtain an average price of 1.93 cents per kilowatt-hour. Note, that the use of 1972 rates yields a conservative estimate of the value of output, since in the present inflationary environment it seems clear that further rate increases are likely and can be expected to raise the average price by 1982. However, in the absence of a firm basis for projecting the magnitude of price increases the more conservative understatement of price was selected as the basis for determining the value of the electricity to be produced by the Seabrook plant.

3. The physical output of the plant is calculated on the following assumptions:

a. 2000 MW capacity

b. 7000 hours operation per year

c. 5.6 percent energy loss rate (1971 actual)

Total kilowatt-hour sales for the plant is thus: 13,216,000,000.

The value of the output in its first year of operation is therefore no less than: $255,068,800.

The aggregate value is based on the value of sales to all users: residential, commercial and industrial. It would be impractical to enumerate the specific uses of electricity and to evaluate how these contribute to a rising quality of life in the home and in the place of work. One illustration which may be worth noting in this context is the use of household appliances. Company projections show that between 1970 and 1980 the saturation ratio (number of appliances as a precent of total residential customers) of space heating will rise from 3.5 percent to 10.7 percent; water heating from 24.5 percent to 36.3 percent; ranges from 62.9 percent to 69.1 percent. Clearly, many families which presently do not make use of these and other appliances can be expected to acquire them as they seek to improve their living standards.

References

1. Public Service Company of New Hampshire, Uniform Statistical Report, 1971.

8.2 and 8.3 Income and Employment

These Sections, which are treated together, call for estimates of the effects of the plant's construction, and ultimate operation, on the region's income and employment.

The total effect on the region's economy is expected to be some multiple of the first round of income gain. This is because some portion of the income received by employees and material suppliers will be respent on local goods and services thereby resulting in a further gain in the region's income.

The regional multiplier can be calculated either from a regional input-output table or from a two-sector regional income model. In order to prepare an input-output table one would require detailed information on the sales of each industry to every other industry. Furthermore, it would be necessary to distinguish between shipments within the region and outside the region. For these reasons, the compilation of an input-output table, where it has been attempted, has proved to be an extremely complex, time-consuming, and expensive undertaking. The other approach to the estimation of regional multipliers is far simpler in concept and requires less data. It derives from a model which conceives of all industries as being either export or service-oriented. The functional relationship of income or employment between the two sectors forms the basis for calculating the likely increase in income.

The coefficient which describes the total increase in employment/income per unit increase in the activity of a basic industry is termed the multiplier. It can be calculated as follows:

Let $E_s = a_o + a_1 E_T$

and $E_T = E_s + E_x$

Where: E_s = Employment in service industries

E_x = Employment in export industries

E_T = Total employment

After substitution and rearrangement of terms we obtain:

$$E_s = \frac{a_o}{1-a_1} + \frac{a_1}{1-a_1} E_x$$

The multiplier is thus $\frac{a_1}{1-a_1}$

A similar formulation is used in Reference 1.

Although the export-service income model is conceptually simple and can be easily estimated, the predictive accuracy of the multiplier depends upon a number of crucial assumptions (Reference 2). Some of the difficulties encountered are illustrated in the present case.

The electric service territory of the Company is virtually conincident with the State of New Hampshire. Yet, we can expect some fraction of the construction labor force to reside in Massachusetts, whose border is about two miles away from Seabrook. No reliable multiplier can therefore be calculated for the Company's service territory without a careful estimate of the number of employees who will live outside this area, yet there is no reliable method for making this estimate.

The predictive accuracy of the multiplier is also dependent upon the proper assignment of each industry into the export or service sector. Yet, such determination cannot be based on general considerations. It must derive from careful analysis of the industry structure in the particular region. For example, the Finance, Insurance and Real Estate sector can be purely service-oriented in some regions, and have an export component in other regions.

Even if all industries could be properly classified into one or the other of the two mutually exclusive sectors, the resulting multiplier may still be unreliable. The multiplier reflects the relationship which prevails at the time the data are gathered. However, the impact which we seek to predict will depend upon the service-export relationship prevailing some time in the future.

The above discussion suggests that the multiplier estimates would be subject to a large margin of error. We therefore propose to discount all income expansion beyond the first round. That is, in order to offer conservative estimates of the benefits of the plant, we assume that the addition to income will be limited to the direct expenditures on employment and materials and the first round of expenditures on local services generated by the direct income gains; we will not take into account additional and successively smaller rounds of expenditures. The direct income gain will be further adjusted downwards to reflect leakages due to federal taxes and savings. In making these adjustments, we continue to be conservative since a significant share of federal taxes will in fact be respent in the area; similarly, some of the savings will find their way into new local investment.

Another source of local and regional income gain is the purchase of materials from local suppliers. The Company estimates that during the period of construction from 1975 through 1981 $6-7 million will be spent on local purchases in the Portsmouth area and a total of $25 million in the New England area. The ratio of value added to sales in manufacturing in New Hampshire was 0.538 (Reference 3). Based on this value we would estimate the income impact in the Portsmouth area at about $3,500,000 and in New England at about $13,500,000.

Income and employment are, of course, two sides of the same coin. Nonetheless, for some purposes it would be worthwhile to have estimates of the employment effects associated with a given income change. In order to project the increase in employment in the service sector associated with the regional income gain we would need to know the following:

1. The share of income expended on services;

2. The ratio of employment to sales in the service sector;

3. The leakage of income outside the region.

While we do not have reliable predictors for the above, we obtain rough estimates of the employment gain on the basis of the following assumptions:

1. 42.4 percent of personal consumption expenditures will go to the purchase of services (Reference 4);

2. For every million dollars of sales in the service sector, employment will rise by 69.6 (Reference 5);

3. All services will be provided regionally.

Based on these assumptions, service employment will be increased by the following amounts:

1975	148
1976	472
1977	590
1978	620
1979	620
1980	443
1981	118

Column (3) in Table 8.2-1 presents our income estimates of gains resulting from the construction payroll of the plant. Note that over the 1975-1981 period $102,000,000 in additional income will be generated directly by the construction of the plant.

Finally, note that our calculations do not include the income impact of the operating staff of the plant once construction is completed. The permanent operating staff of the plant is estimated to be 125 full time employees. It is difficult to project the level of wages and salaries so far ahead, but on the basis of present wage and salary levels in the Company's power plants the income of these employees would be over $2,000,000 annually exclusive of fringe benefits such as health insurance and retirement benefits.

References

1. North Atlantic Regional Water Resources Study, Appendix B, Economic Base, North Atlantic Regional Water Resources Study Coordinating Committee, May 1968, pp. B31-32.

2. A critical discussion of the assumptions underlying the empirical estimation of the regional income multiplier is found in Harvey S. Perloff et al., Regions, Resources and Economic Growth, University of Nebraska Press, Lincoln, 1960, pp. 93-96.

3. Annual Survey of Manufactures 1970, Part 1, p. 7.

4. Economic Report of the President, 1973, Table C-12.

5. Census of Business, 1967, Part 2, Table 2.

TABLE 8.2-1

INCOME EFFECTS OF THE CONSTRUCTION OF THE SEABROOK FACILITY

	Construction Employees	Payroll Expense	Regional Income Impact
		---------($000,000)---------	
	(1)	(2)	(3)
1975	550	$ 6	$ 5
1976	1,650	19	16
1977	2,200	24	20
1978	2,200	25	21
1979	2,300	26	21
1980	1,750	18	15
1981	600	5	4
Total		$ 123	$ 102

Source: Cols. (1) & (2): Data provided by the Company.
Col. (3): Col. (2) adjusted to reflect a 5.9 percent saving rate reported in Table 3 of the Economic Report of the President, 1973, and a 12.0 percent federal tax rate based on Table 1 in the Preliminary Statistics of Income 1970, Individual Income Tax Returns, U.S. Internal Revenue Service, for incomes ranging from $10,000 to $15,000.

8.3

8.3 Employment

Section 8.3 is combined with Section 8.2 in this report.

8.4

8.4 Taxes

The construction of Seabrook Station will affect the tax revenues received locally and within the state. At this time the state has neither a sales tax nor a state income tax. Municipalities raise the majority of their revenues through real estate taxation. With each passing year this becomes more and more difficult and the pressure becomes greater to institute other forms of taxation.

Capital Stock

There is a state tax levied which is based on the par value of new capital stock authorized. To judge the local effect of this form of taxation, it is assumed that all funds invested in Seabrook by Public Service Company of New Hampshire are provided by incremental permanent capital and include neither retained earnings nor depreciation funds. On this basis, the PSNH invested capital might be apportioned as follows:

Debt	$ 313,500,000
Preferred Stock	85,500,000
Common Equity	171,000,000
Total	570,000,000

The current taxation level on newly authorized stock is $100 per $100,000 of par value. On this basis the capital stock tax would be computed as follows:

		Par Value	Tax
Preferred	855,000 shares @ $100 par =	85,500,000	$ 85,500
Common	6,840,000 shares @ $5 par =	32,200,000	$ 32,200

The total capital stock tax which the State of New Hampshire would levy on the financing for Seabrook by Public Service Company of New Hampshire would be $117,700.

Real Estate

Real estate taxes on utility plant are levied by the municipality in which the property is located. There are bills before the current session of the state legislature to tax generating facilities by the state. The success or failure of these bills will have a substantial effect upon the taxes which must be earned and paid by the Seabrook facility. To illustrate this, an estimated tax is computed for the plant using each method for the year 1982.

On a municipal basis, assume the assessed valuation for the town exclusive of the plant grows from the 1972 amount of $33,148,000 to $53,998,000 in 1982. This would occur if the town had a 5 percent growth rate. Also assume the town had a budget increase from $1,042,000 in 1972 to $2,050,000 in 1982 which could be expected with a 7 percent annual growth in municipal expenses. Taking these two growth rates into account the tax rate per $1000 of evaluation would increase from $31.45 in 1972 to $37.96 in 1982. Inclusion of the Seabrook Station value in the tax base would reduce the rate to $1.72 per $1000 evaluation and find the plant taxes amounting to $1,960,000.

However, if we assume that taxes will be assessed by the State at the average proportionality and average tax rate then property taxes on the plant would be:

Investment	x	Proportionality factor	x	Ave tax rate	=	1982 tax
$1,140,000,000	x	.75	x	$40	=	34,200,000

This amount could also be reduced if present efforts to shift the property tax burden to another source are successful.

Earnings

Public Service must also pay a franchise tax to the State amounting to nine percent of net earnings after all taxes including the franchise tax. Assuming that net income will approximate five percent of net plant the franchise tax will be: $570,000,000 x .05 x .09 = $2,565,000 per year. This tax will decline in each subsequent year as the earnings requirements will be less as net plant decreases.

Personal Taxes

As we point out in Section 8.5 below, it would be extremely difficult to measure the burdens placed on local government jurisdictions by the employees of the plant. We, therefore, propose that tax payments by these employees not be considered as part of the benefits of the plant, but rather as an offset to local and state services extended to them. For the same reason we do not propose to estimate the property tax payments of the employees in their respective communities.

8.5 Externalities

Industry Attraction

Electric power is an indispensable input to industrial activity in a modern society. Undoubtedly, the availability of electric power at low cost has contributed to the industrial development of the country. However, variations in electric power rates probably have had little influence on inter-regional growth differences. The explanation for this apparent contradiction is to be found in the wide availability of power throughout the United States and in the relatively low portion of total production costs expended on purchases of electricity.

The factor that electric supply has been widely available throughout the country may account for its slight impact on the locational choices of firms. This point of view is reflected in prevailing regional projection methods, for example, the widely-known regional projections prepared by the Office of Business Economics, Regional Economics Division, United States Department of Commerce for the North Atlantic Regional Water Resources Study Coordinating Committee.

Electric power constitues only a small fraction of value added in manufacturing industries as shown in Table 8.5-1. It is, therefore, not surprising that variations in electric supply prices generally have not exerted an important locational pull (aluminum and a few electrochemical and electrometallurgical plants, which are of little consequence in this region, are exceptions). Locational decisions are more likely to reflect labor supply conditions as well as proximity to final markets and to raw material sources.

New Hampshire has experienced a very rapid rate of increase in its population; from 1960 to 1970 the population increased by 21.5 percent. This rate was far higher than New England's 12.7 percent, or the nation's average increase of 13.3 percent (Reference 1).

The continuing industrial development of this area is particularly important if New Hampshire is to close its income gap relative to the United States average. The per capita income of New Hampshire relative to the United States was 0.88 in 1950, and 0.93 in 1969. It is projected to rise to 0.95 of the United States average in 1990 and to 0.97 in the year 2000 (Reference 2).

While electric power has not in our opinion proved to be an important locational factor, it is obvious that optimal economic growth and adequate employment opportunities presuppose uncurtailed electric supply.

Service Burdens

The direct service requirements of the plant are considered in Chapter 3. We show there that provisions have been made for the plant's requirements for water, sewage, etc., and that no additional service burdens will be placed on any municipality. The services which will be received by the construction employees and ultimately by the operating staff of the plant are most difficult to predict. These will depend on the extant investment in social overhead facilities in the communities where the employees reside, on their marital status, and on the number and age of their children.

If the labor force will draw on local residents there will be no increase, at least in the short run, in the service burden placed upon local governments since the employees already live in the area and are recipients of whatever public services they are entitled to.

More fundamentally, the costs of state and local public services--education, police, etc.--are covered substantially by state and local tax revenues. Reference (3) reports the following for the state of New Hampshire:

	1963/4	1964/5	1965/6	1966/7
General Revenues, Per Capita: ($)	300.46	321.11	344.89	379.23
General Expenditures, Per Capita: ($)	328.16	339.58	377.10	422.10

Tax payments and benefits are not, of course, equal for every household but this is a result of government income redistributional policies. At any rate, one can expect that the tax payments of the employees in the construction and operation of the plant will not fall short of the cost of public services which they receive.

In Reference (4), Gillespie has examined the level of state and local taxes as well as state and local government expenditures by income class. His conclusion is: "The federal pattern of fiscal incidence generally favors low incomes, burdens high incomes, and is mainly neutral over a wide middle income range. The state and local pattern also favors low incomes, but it is essentially neutral over both the middle and upper income ranges."

In summary, it would be very difficult to measure the incremental burden on public services attributable to the construction and operation of the plant without detailed information on the family status and residential pattern of the labor force. One could, of course, estimate average state and local per capita expenditures. But, per capita local and state tax receipts are approximately equal to per capita expenditures on average. We propose, therefore, that local service burdens not be counted on the cost side, and symmetrically with it, that employee-generated local tax revenues, that is, real estate taxes on employees' homes, be excluded from the calculated benefits of the plant.

References

1. _Statistical Abstract of the United States 1971_, United States Department of Commerce, p. 13.

2. _1972 OBERS Projections_, prepared by the United States Department of Commerce, Social and Economic Statistics Administration, Bureau of Economic Analysis, Regional Economics Division, September 1972, Volume 5, Table 1, p. 124.

3. The _1967 Census of Governments_, Volume 6, Topical Studies, Number 5.

4. Gillespie, W. Irwin, "Effect of Public Expenditures on the Distribution of Income", p. 165.

TABLE 8.5-1

COST OF ELECTRIC ENERGY PURCHASED AS A PERCENTAGE OF VALUE ADDED BY TWO-DIGIT MANUFACTURING INDUSTRIES

1967

Manufacturing Industry	Electric Energy Purchased	Value Added by Manufacture	Electric Energy Purchased as a Percent of Value Added
	------($000,000)	---------	(1) ÷ (2)
	(1)	(2)	(3)
Food and Kindred Products	$ 316.2	$ 26,620.9	1.19%
Tobacco	7.9	2,032.0	0.39
Textiles	178.6	8,153.2	2.19
Apparel	67.0	10,064.4	0.67
Lumber and Wood	89.2	4,973.4	1.79
Furniture	37.2	4,169.5	0.89
Paper	209.6	9,756.3	2.15
Printing	88.1	14,355.1	0.61
Chemicals	582.8	23,550.1	2.47
Petroleum	134.5	5,425.8	2.48
Rubber and Plastics	117.3	6,799.5	1.73
Leather	20.6	2,626.5	0.78
Stone, Glass and Clay	200.3	8,333.4	2.40
Primary Metals	693.5	19,978.2	3.47
Fabricated Metal	207.3	18,042.6	1.15
Nonelectrical Machinery	217.2	27,836.4	0.78
Electrical Machinery	199.9	24,487.3	0.82
Transportation Equipment	238.2	28,173.9	0.85
Instruments	34.1	6,418.4	0.53
Misc. Manufacturing	77.3	10,187.2	0.76
All Industries Total	$3,716.8	$261,984.1	1.42%

Source: Col. (1): <u>1967 Census of Manufactures-Summary Statistics, Fuels and Electric Energy Consumed, p. 10-13.</u>
Col. (2): <u>1967 Census of Manufacturers-General Summary</u>, p. 28.

8.6 Other Effects

There do not appear to be any significant further social or economic effects to the region beyond those discussed earlier in this chapter. The applicant does plan to provide certain facilities for education and recreation as discussed in Section 3.1. However, these facilities will not generate any dollar benefits or require any additional services or resources beyond those discussed for the total plant. The recreational facilities proposed are for the use of Seabrook residents. The education center will serve transients in the summer and offer a program of science and ecological information to school children and residents during the winter season.

9. ALTERNATIVE ENERGY SOURCES AND SITES

9 ALTERNATIVE ENERGY SOURCES AND SITES

The need for additional base load units in New Hampshire and New England was demonstrated in Section 1 of this report. The selection of the energy source to satisfy this base load requirement has been nuclear for all cases where time permitted the installation of nuclear units. The reason for the nuclear decision is twofold: first, the nuclear alternative has a considerable cost advantage over fossil and second, environmental considerations favor the nuclear alternative.

Table 9.1-1 shows a comparison of costs of the various alternatives considered to supply 1100 mw of base load generation for New Hampshire. It is obvious that there is considerable saving in building two 1100 mw units and sharing the cost of the units with other parties. New Hampshire findings appear to be born out by other companies in New England in view of the unanimous selection of nuclear generation where enough lead time is available for licensing and construction.

The selection of sites for the generation additions in New England was done as follows. First, each company was asked to supply a list of generation sites in its territory, the type of generation each site would accommodate and the earliest date that generation could be brought on line at each site. New England was divided into areas as shown in Figure 9.2-2 and the balance between load and generation in each area was examined. A review of the available sites and area load and generation by the NEPOOL Planning Committee resulted in the following proposal for generation additions from 1978 through 1982:

1978	Pilgrim No. 2
1979	Millstone No. 3
1979	Seabrook No. 1
1980	Pilgrim No. 3
1980	Rome Point No. 1
1981	Northeast Utilities Unit
1981	Seabrook No. 2
1982	Rome Point No. 2

These additions do as good a job as possible in balancing area load and generation and result in a minimum of transmission expansion.

9.1 Alternatives Not Requiring the Creation of New Generating Capacity

Postponed Retirement

Public Service Company of New Hampshire's load is projected to increase from 975 mw in 1973 to 2110 mw in 1981. This shows an increase of 1035 mw for this time interval. Table 1.1-8 shows retirements of 20 mw of generation during the 1973-1981 time span. Postponing the retirements will have no effect on Public Service Company being able to meet its commitments.

Similarly, the load growth in New England is projected to be 11800 mw during the 1973-1981 period. Table 1.1-4 shows retirements of 192 mw so that delaying these retirements will have no practical effect on New England's ability to meet the projected loads in 1981.

Import Power

The New England utilities have investigated possible sources of power outside of the New England States. The New York utilities do not plan on surplus power that could be imported by New England on a long term basis.

Joint planning studies have been underway for a period of time between the New York systems, New England systems and the Hydro-Electric Power Commission of Quebec. These studies are directed toward the possible purchase of up to 2400 mw of capacity for both New England and New York. The New England share of any such purchase could represent 1,200 mw starting in the early 1980's and could permit a one year delay of one nuclear generating unit in New England. It appears unlikely that this purchase could be made prior to 1981 or 1982 and New England's share of this purchase would only delay one nuclear unit for one year. Public Service Company of New Hampshire's share of this purchase would only amount to about 80 mw which is a small percentage of our total requirement.

The New England utilities have also been engaged in planning studies to determine the feasibility of making capacity purchases from the New Brunswick

Electric Power Commission. An agreement has already been reached for the purchase of 400 mw of capacity starting in 1976. This figure is included in the capacity tabulations in Section 1 of this environmental report. There is a possibility of negotiating a purchase of 800 mw of nuclear generating capacity part of which could be available by 1980. If such a purchase were undertaken, it might defer for a year the need for one of the eight planned New England nuclear generating units. The transmission cost associated with an additional purchase of capacity from New Brunswick would also be very high due to the long distances involved. Public Service Company of New Hampshire's share of the 1976 import from New Brunswick is 30 mw and is included in our capability calculations. The 1980 purchase should yield approximately 55 mw for New Hampshire which does not go very far in supplying the requirements. In addition, there is a reluctance on the part of the New England systems to become unduly dependent on imported power because of the revocable nature of the export permits issued by the Canadian government.

Do Not Construct Proposed Generation

Lengthy delays in construction of the Seabrook units will reduce New England reserves below those required to meet the reliability criteria and leave Public Service Company of New Hampshire with negative reserves or unable to meet its load requirements without allowance for reserves.

Lengthy delays in construction of all the nuclear units proposed will leave New England with negative reserves. Tables 1.1-13 and 1.1-14 show the effect of these long delays.

Other

There is no capacity which could be reactivated in New England. Some rerating of the existing nuclear generating capacity is included in the load and capacity report to reflect anticipated increases in plant rating. Otherwise, there is very little likelihood of upgrading any of the plants within New England. In fact, air and water quality control requirements will probably result in the forced derating of some of the older generating stations.

The consequences of operating the older fossil fuel plants as an alternative to nuclear base load plants has serious environmental implications, and the operation of existing peaking generating capacity to supply base load power requirements would in no way meet the capacity deficiencies outlined in this report.

TABLE 9.1-1

COMPARISON OF VARIOUS ALTERNATIVES FOR SUPPLYING 1100 MW OF BASE LOAD GENERATION FOR NEW HAMPSHIRE

PLAN				ANNUAL SAVING TO N. H. RATE PAYERS IN FAVOR OF THE SEABROOK PROPOSAL
1	Seabrook 1 and 2	vs.	2-1100 mw fossil	$ 19,000,000.00
2	Seabrook 1 and 2	vs.	2-550 mw nuclear	$ 13,000,000.00
3	Seabrook 1 and 2	vs.	1-1100 mw nuclear	$ 5,000,000.00
4	Seabrook 1 and 2	vs.	11-100 mw fossil	$ 40,000,000.00

Note (1) 2-550 mw nuclears produce an annual savings of $11,000,000.00 over 2-550 mw fossils.

Note (2) In each plan Public Service Company of New Hampshire's share of Seabrook 1 and 2 is a total of 1100 mw. Public Service Company of New Hampshire's share of the alternates is also 1100 mw.

9.2 Alternatives Requiring the Creation of New Generating Capacity

The conclusions reached in the Interconnected New England Generation Study, Report No. 4, dated May 1971 were that nuclear generating capacity should be added to provide the base load power requirements of the New England systems, and that this nuclear capacity should be expanded to at least 52 percent of the total New England generating capacity as soon as the load growth will permit. This study represented an in-depth investigation of the economics and reliability of various generation expansion alternatives to provide for the future power requirements of New England.

The study pointed out that the planned nuclear capacity in New England for 1978 will be far below the recommended guidelines and that the planned intermediate fossil capacity will be more than that required. Therefore, there is an obvious need for nuclear base load capacity additions.

The following discussion of "generation mix" is presented to show the role played by each type of generating capacity and to clarify the need in New England to expand nuclear base load generating capacity. Generating facilities have a useful life ranging from thirty to fifty years, and the system at any one point in time will have an inventory of existing units that differ markedly in technology, size, age, efficiency, cost per kilowatt-hour of output, and environmental impact. The planning of new capacity requires a blending of new facilities into this inventory. The three major categories of generating capacity are base load, intermediate, and peaking. The peaking category is in turn divided into hydroelectric and internal combustion subcategories.

Base Load Units

Base load generating units are designed for continuous operation, being shut down only for scheduled maintenance or nuclear refueling. Such units supply the "base" portion of the total load that continues both night and day. Since these units operate for long hours, it is very important that they have low energy cost and a relatively low impact upon the environment.

Both fossil-fuel and nuclear units are used for this purpose. The 4th generation report shows that future base load units should be nuclear.

Intermediate Units

Intermediate generating units are normally used through the working hours of each day to help meet the next segment of total system loads in excess of base load. These units are either (1) older less efficient fossil unit originally used for "base load" service and now used on a "cycling" basis, or (2) newer specially designed cycling units added specifically to serve these intermediate loads.

Peaking Units

Peaking units are used to supply peak loads occurring during a few hours of the day. For this reason they should be capable of a rapid startup and shutdown. Peaking units are broadly classified as hydroelectric or internal combustion.

Hydroelectric units meet the requirements of rapid startup and shutdown. Although a small amount of hydroelectric capacity has been used to supply base load requirements, most of the hydroelectric capacity in New England has traditionally been used for peaking. Many of the existing hydroelectric installations are located on rivers and have limited water storage capability. These units run during the peak hours and are shut down the rest of the time to pond water for the next day's operation. In recent years, the anticipated availability of nuclear power during light load periods has made it economically desirable to install "pumped storage" hydroelectric units. In this application, low-cost "off-peak" nighttime or weekend generation is used to pump water into a storage reservoir at a high elevation. At times of peak demand, power is produced by releasing the stored water to flow back through turbine-generators to a lower reservoir.

Internal combustion generators provide the final increment of peaking power, and are either gas turbine or diesel units. Since these units can be installed for the lowest capital cost of all forms of generation, they are ideally suited to provide system reserve, and since the units are capable of rapid startup and shutdown, they are valuable in meeting system emergencies. Because of their extremely high operating and maintenance costs, the system should be planned and designed for minimal operation of this type of capacity.

In nearly all cases, peaking units are not capable of supplying base load power. In the case of hydro-electric units used for peaking, there is seldom enough water to operate these as base load. The internal combustion units have high maintenance and fuel costs that make them very undesirable base load units.

General

Figure 9.2-1 illustrates the manner in which each of the basic categories of generation is utilized to meet typical winter and summer weekday loads.

Base load units provide the greatest proportion of the energy requirements throughout the twenty-four hours, including the pumping energy associated with the pumped-storage hydro units. Intermediate fossil units are shown operating from twelve to fifteen hours a day, followed by pumped-storage hydroelectric units. Internal combustion and conventional hydroelectric units are operated mostly over the peak hours to supply the remainder of the load.

9.2.1 Selection of Candidate Regions

The New England (later NEPOOL) Generation Task Force, authors of "Interconnected New England Generation Study - Report No. 4" have recommended the generation mix for New England which is principally a nuclear expansion for the period 1978-1982. In the studies to determine general locations for those nuclear units, New England was divided into eight load and capacity sub-areas. These areas closely followed state boundaries except for Massachusetts which was divided into three areas. Figure 9.2-2 shows the geographical location of these areas. The percentage of the 1971 load located within each area is as follows:

Area	Percent 1971 Load	Description
1	7.9	Maine
2	6.8	New Hampshire
3	5.5	Vermont
4N	23.7	N. E. Massachusetts
4S	11.2	S. E. Massachusetts
5	7.3	West. Massachusetts
6	9.6	R. I. and Bordering Mass.
7	27.9	Connecticut

The growth rate in New Hampshire has been higher than most other areas in New England and this may result in a greater precentage of the New England load being in New Hampshire by 1981 than shown above.

The principal reason for splitting New England into these eight areas was an effort to match load with generation in the areas, realizing that this matching of area load with generation minimizes the number and length of transmission lines, the amount of right-of-way required, transmission losses and environmental impact, and at the same time maximizes the reliability of the resulting power supply system. It is also realized that a perfect balance between load and required generating capacity cannot be economically maintained at all times in each area. The economies achieved by building large units and by building back-to-back units would dictate that at one time an area would have a surplus of generation while at another time this surplus would become a deficit and an adjacent area would have the surplus. Sites, in or adjacent to deficient areas, were selected if they were available and deemed obtainable within the time frame required for these generation installations.

Preferred Sites

After review of available sites in each area, the following were selected as the preferred sites for that area:

Area 2 - The Seabrook site is located in the southeastern part of New Hampshire, just north of the Massachusetts border. By 1979 New Hampshire will have a deficit of about 700 mw and by 1982 this figure will be about 1430 mw. Area 2 is adjacent to areas 3 and 4N both of which are also deficient in generation in this time period.

Area 45 - The Pilgrim site is located in Massachusetts approximately 30 miles south of Metropolitan Boston and is adjacent to area 4N and is suitable for 1180 mw units in 1978-1980.

Area 6 - The Rome Point site in Rhode Island is suitable for 900 mw units in 1980 and 1982. This area will be deficient by the time the site is developed. This site is located halfway between the two largest load areas in New England, i.e. Connecticut (area 7) and the Metropolitan Boston area (area 4N).

Area 7 - The Millstone Point site located in Connecticut is suitable for an 1150 mw unit in 1979. The Northeast Utilities 1981 unit site is undetermined at this time.

Table 9.2-1 showing the load and capacity by areas for the period 1971 through 1982 is attached to illustrate this scheduling of generation as it relates to the forecasted loads. For convenience, external purchases are included in the capacity of the area where the purchase enters New England. Uncommitted generation or purchases have been excluded from the table. Undoubtedly additional generation will be committed within the time span covered by the table but this will be of the peaking or cycling type which does not require the lead time of a nuclear plant.

Power Network Considerations

Two - 1100 mw units must be connected to a strong transmission grid. The 115 KV grid in northern New England is not strong enough to handle 1100 mw units, therefore, the 345 KV system is the system that these large units must be connected to.

To determine the location of two - 1100 mw units the major concern is cooling water. The best source of cooling water that could be found in New Hampshire is the Atlantic Ocean. Limited amounts of cooling water are available in the Merrimack and Connecticut Rivers but these are not as good as the Atlantic Ocean. A coastal site also allows barge deliveries of heavy equipment rather than field fabrication.

Table 9.2-1 shows that, without additional generation, both New Hampshire and Northeastern Massachusetts will be deficient in generation by the late 1970's. To stay within or near the generation deficient areas and obtain the economic and environmental benefits of a coastal site the areas which were given a preliminary inspection were: 1) Southern Maine, 2) Southeastern New Hampshire, and 3) Northeastern Massachusetts.

Transmission requirements from a plant of 2200 mw located on the coast of Southeastern New Hampshire or Northeastern Massachusetts to the 345 KV backbone transmission system are very similar and the transmission additions would not influence the location of the plant to any extent. Transmission required from southern Maine will be longer than those from the other two areas and since Maine is not a generation deficient area, site conditions would have to be much better than those in New Hampshire and Massachusetts to warrant consideration. Siting problems on the coast of New Hampshire and Northeastern Massachusetts are very similar and since Public Service Company of New Hampshire has no franchise rights in Massachusetts it was decided that we should build the plant in New Hampshire.

Figure 9.2-3 shows the New England transmission grid as it is expected to be in 1976. The transmission additions required for Seabrook are also shown.

Figure 9.2-4 is a topographic survey map showing the 345 KV transmission network in southern New Hampshire and northern Massachusetts. The transmission additions for Seabrook are also shown.

Figure 9.2-5 is the same topographic survey map showing major dedicated land use areas in the State of New Hampshire. Table 9.2-2 describes the areas noted in the figure.

Figure 9.2-6 is a map of New Hampshire showing the franchised service areas.

Figure 9.2-7 is a map of New Hampshire showing the transmission system, the location of major substations and generating plants.

Energy Type and Source Considerations

Fuels available in New Hampshire include oil, coal and nuclear. The natural gas supply is too limited to consider using it for major electric generation.

Oil is the preferred fuel for coastal plant locations because it can be delivered by tanker. Coal or oil can be used at inland locations. The use of oil for an inland location would require a pipe line from the coast and tanker delivery to the coastal terminal of this pipe line.

The considerable economic advantage of nuclear fuel over fossil fuel noted in Section 9.2 in conjunction with the additional air pollution caused by fossil fuel plants plus the exposure to oil spills if oil were used as fuel caused us to propose the nuclear plant. Present shortages of oil and the great difficulty in obtaining low sulphur coal are other incentives to propose nuclear generation.

9.2.2 Selection of Plant Alternatives

Siting Criteria

In identifying potential electric generating sites the Company has adopted various criteria to assist in the evaluation of different land areas. These criteria have been continually updated to reflect changes in the requirements for environmental protection. In the end a balance of favorable vs. unfavorable factors determines an overall evaluation of each site. Discussed below are these various criteria:

1. Adequate land must be available for the generating station, its switchyard, and cooling facilities. For a nuclear plant additional land is required for exclusion purposes. This means approximately 700 acres are needed to provide the 3,000 foot exclusion radius the Company considers desirable to exercise control over.

2. The site should be appropriate for a power plant and be compatible with the use of the surrounding land.

3. Geological, hydrological, meterological, and seismological conditions must be favorable for the construction and operation of the facility.

4. An adequate source of cooling water must be available for either a once through cooling system, or for make up water for a supplemental cooling water system. This source of water must be large enough or have a flowage rate adequate to absorb the plant discharge heat without an adverse environmental effect upon the water.

5. Various sites may be limited to only one fuel type due to location or accessability. A site which can accommodate more than one fuel source allows a greater flexibility in selecting the proper site.

6. The requirements of transmission facilities for a given site must be integrated with the existing transmission system and cannot adversely affect the overall system planning and reliability of the New England System.

7. The last major criterion is the suitability of the site for construction itself. Construction access must be reasonable, and satisfactory means of transporting the multitude of pieces of equipment and supplies must be available.

Fuel Choices

The Company considers that at the time the Seabrook Plant is to be on line the only viable alternative fuel source will be residual fuel oil. The other sources of fuel which are currently available are not projected to be a dependable supply in the early 1980's. The projected availability and economics of other possible fuels are discussed below.

1. Coal

Low sulfur coal which is expected to be required in all new plants due to the air pollution control laws, is even today in short supply and available only at a high cost. By the 1980's this situation is expected to become worse. Coal also requires a large amount of land for storage and handling, and would have to be shipped by rail to any practical New Hampshire site. This would require for each unit five 100-car trains per week from as far as West Virginia. Existing pollution abatement equipment is probably just adequate to comply with today's air quality standards and may never be satisfactory for location of a coal burning plant into a non-industrial area. Coal is at this time not considered to be an alternative fuel for this plant.

2. Natural Gas

In the New England area the supply of natural gas is very limited, and the Company does not feel that in the next 10 years an adequate supply either from existing sources, or from new sources such as LNG or off-shore gas can be counted upon to supply this plant dependably.

3. Hydroelectric

The area's hydroelectric sources have been utilized to the degree that there are inadequate resources remaining that could be considered as a source for base load power.

4. Residual Fuel Oil

There are existing today adequate resources of residual fuel oil with a low content of sulfur that could fuel this power station, but almost all of the supply exists subject to availability and costs determined by foreign governments. Present United States quota restrictions have limited the amount of fuel oil that can be imported into New England and have in recent years produced shortages of various types of fuel oil. This situation is not expected to improved in the near future. If an inland site were utilized for this plant, an oil pipeline would logically be constructed from the seacoast to the plant site to supply the vast quantities of oil needed. This pipeline would have an environmental affect very similar to an underground transmission line. A similar right-of-way would be required which could not be over planted and would have to be accessable for heavy duty vehicles. Present pollution abatement equipment can handle today's air quality standards but in years to come may not satisfactorily do the job. Although not a good alternative, oil can be considered the only alternative in the New Hampshire area to nuclear fuel.

9.2.3 Candidate Sites

9.2.3.1 Site Selection History

The following comments describe in general the efforts expended by Public Service and its consultants to determine potential power plant sites taking into consideration all factors, including but not limited to environmental effects, esthetics, load centers, economics, interconnections, and reliability of power supply.

Following the completion of Merrimack Station Unit No. 1 in Bow, New Hampshire, located on the Merrimack River which was placed in service in 1960, studies were undertaken to evaluate potential sources for power development throughout the State. It was recognized at that time, and the conclusions drawn then are still valid, that the following methods are basically the only possible ones available to the State of New Hampshire as sources of electric power:

1. Conventional Hydro. The last station constructed in New Hampshire was the Smith Hydro Station in Berlin in 1948. Although some small capacity sites may possibly exist, there are no potential economic sites left in New Hampshire for conventional hydro development of any size.

2. Peaking Hydro. Peaking hydro requires a substantial storage of water and therefore the creation of new large bodies of stored water. The Company carefully studied the site that it considered to have the best potential - namely, Pontook on the Androscoggin River. After spending substantial funds for studies, including core drilling, it was concluded that this site was not competitive with other methods of producing peaking power, and in the process it would have destroyed a natural resource, the 13-mile Woods section of the Androscoggin River, and therefore should not be constructed. There may be other locations in the State where such a large reservoir may be created, but the economics and effects on the environment will be such to discourage or forbid their development.

3. Pumped Hydro. This form of power generation pumps water from a reservoir at one elevation to a reservoir at a higher elevation during periods of off-peak power demands, utilizing lower-cost energy for pumping. The water in the upper reservoir then is released to the lower reservoir during periods of peak power demands, thereby offering a form of power generation which may very well fit into the environment of New Hampshire and meet the power demands during peak periods. The entire State has been studied for pumped-hydro sites. Four of the more promising sites were studied in more detail leading to the conclusion that two of them were suitable for further study.

Pumped hydro is a form of generation which must fit the load curve to be economical and can best be used in connection with a nuclear station since the power for pumping should be as low-cost as possible. Therefore, a system combining nuclear and pumped hydro stations is an excellent solution. There is no requirement that they be located near each other since high voltage transmission can bring the power from the nuclear station to the pumped-hydro site.

4. Purchase Power From Outside the State. This concept has been studied many times. The basic conclusion arrived at each time is that the demand for electric power is growing at such a rate that all possible sites for generation will have to be developed. There are definite disadvantages from obtaining power generated outside of New Hampshire such as reliability and economics. Some power can be purchased from outside the State as discussed in Section 9.1 and Appendix L.

5. Thermal Plants.

A. Fossil fuel-fired units. Most of the power generated in New Hampshire is generated by fossil fuel-fired units. The factors in determining their location are availability of cooling water, facilities for transportation of fuel, load centers, and air and water environmental considerations.

B. Nuclear units. Large quantities of cooling water are required which are most available at tidewater. A tidewater site is also preferable because of the very large components which are used and have to be shipped by barge. Inland sites can be used, either by field-erecting the major components at substantial premiums, or moving the components overland by shoring up bridges and roads to the site, again at a premium. Seismic loadings are more of a concern than with fossil plants, and a site with good rock for foundations is desirable. Nuclear plants have little or no effect upon the air and therefore have a distinct advantage over fossil plants from this point of view.

C. Internal combustion engines. This form of generation is being used extensively for peaking service. The units can be located almost anywhere and meet environmental considerations. However, since they are less efficient, only small blocks of power can be generated by this method.

D. During 1962 Public Service employed a consultant to assist it in the study and analysis of sites for thermal plants. At that time nuclear power was just becoming a factor as a possible use in central generating stations (Yankee-Rowe started generating in 1960). Sites on the Piscataqua, Merrimack, and Connecticut Rivers were studied. Because units up to this time had been small, not as much emphasis had been given to possible effects of releasing heat to rivers from condensers or possible effects upon the environment from releases from stacks from coal or oil fired units. At about this time the benefits from building units of larger size and cost sharing were also being considered.

The conclusions of this siting study completed in February, 1963, were that two sites on the Piscataqua River and two sites on the Merrimack River, including the site used by Merrimack Unit No. 1, were the preferred sites. During this study, the Company considered nuclear units and concluded that a site on the Merrimack River was an excellent site for nuclear development. (This site has since been removed from the list due to changing requirements to meet water quality criteria.) This siting report concluded that the next unit to be built on the Public Service system should be an addition to

Merrimack Station. This was done and the unit placed in service in May, 1968.

E. Realizing that the unit constructed at Merrimack Station in Bow would meet needs only through 1971, Public Service again reviewed and updated its siting studies and evaluations with a completely new study started in September 1966, almost two years before the unit then under construction would be placed in service. The same consultant was retained to maintain a continuity in the studies. By this time, two major changes had taken place; namely, nuclear power was much more proven as a method for producing low-cost power, and the effects of power plant siting upon the environment were much more realized thereby playing a significant role in determining the feasibility of a site.

During these studies, every possible site for a nuclear or fossil unit in New Hampshire was evaluated. One site in Maine was also considered. In New Hampshire, these included sites on the Piscataqua River, three sites directly on the Atlantic Ocean (Seabrook being one), the Androscoggin, Merrimack, and Connecticut Rivers, and one on a large inland reservoir not on a major river. At this time, economics indicated that a nuclear plant should be constructed. The question of siting then became an evaluation of all factors for a nuclear plant. The studies showed that the Newington site on the Piscataqua River was the number one site, with the Seabrook site being a second choice. Public Service decided on the Newington site in 1967 for an in-service date of 1975. It believed this time schedule provided an ample opportunity to fully explore all factors and allow sufficient time to construct the plant to be in service in 1975. The Company started to acquire property and make associated studies involving seismology, hydrology, geology, and meteorology. Discussions were held with local, State, and Federal officials as to the site's acceptability. An extensive core drilling program to ascertain the rock conditions to support such a plant was started which carried through to November 1, 1968. When it was decided that the Newington site would not be licensable because of the proximity to Pease Air Force Base a decision was made to move to Seabrook where similar site studies were undertaken.

9.2.3.2 Inland Sites For Base Load Stations

The report of the previously described 1967 site identification study conducted by Jackson & Moreland for Public Service is incorporated in this report as Appendix M. In addition to the sites reported in the Jackson & Moreland report the qualities of two other inland sites have been reviewed.

Each of the inland sites whether located on the Connecticut, the Androscoggin, the Merrimack or a lake will require the use of supplemental cooling equipment to satisfy water quality regulations. It is appropriate to discuss in a general sense the long-term fresh water development for the watersheds involved. These factors may apply to more than one site.

A. Merrimack River Sites. On the Merrimack River watershed, Public Service has investigated sites at Hillsborough, Concord and Litchfield. The Merrimack has been studied by Federal and State agencies which in-turn have issued reports on its present condition and future.

The most descriptive report was prepared by the U. S. Army Corps of Engineers in conjunction with the Environmental Protection Agency, the New England River Basins Commission, the Commonwealth of Massachusetts and the State of New Hampshire. This report titled, "The Merrimack: Designs for a Clean River" was issued in seven volumes in 1971 (Reference 1). This report also contains an expanded bibliography of reports on the river. A second report of equal interest was prepared in February 1972 by the New Hampshire Water Supply and Pollution Control Commission entitled, "Merrimack River Basin Plan, Staff Report No. 56" (Reference 2). A perspective of the river basin follows which is a synopsis of data from Reference 1.

The Merrimack River Basin lies in central New England and extends from the White Mountain region of New Hampshire southward into the east central part of Massachusetts. It is bounded by the Connecticut River Basin on the west and northwest; and the Saco and Piscataqua River Basins on the northeast and east; New Hampshire and Massachusetts Coastal Streams on the east and southeast; and the Blackstone River Basin, and the Narragansett Bay Drainage Basins on the south. This basin, the fourth largest of those lying wholly in New England, has a maximum length in a north-south direction of approximately 134 miles and a maximum width in an east-west direction of 68 miles. It has an area of 5,010 square miles of which 3,800 are in New Hampshire and 1,210 square miles are in Massachusetts.

The main Merrimack River is formed by the confluence of the Pemigewasset and Winnipesaukee Rivers at Franklin, New Hampshire. It follows a southerly course to Lowell, Massachusetts, where it turns abruptly and flows in a general northeasterly direction to tidewater above Haverhill, Massachusetts and then to the Atlantic Ocean near Newburyport. It has a total length of 116 miles of which the lower 22 miles are tidal. The mean range of tide at the mouth is 7.9 feet, and at Haverhill, 5.1 feet. The extreme ranges, due to the combined effect of wind and other causes, are 11.7 feet at the mouth and 8.0 feet at Haverhill. In the 94 miles of its length above tidewater, the river descends a total of 254 feet at a fairly uniform slope. A map of the river basin is shown in Figure 9.2-8.

The U. S. Geological Survey has published records of streamflow at numerous locations on the mainstream and tributaries of the Merrimack River for various times since 1948. The average annual run-off in the Merrimack River Basin varies from less than 18 inches (1.3 cubic feet per second per square mile) in the lower part of the basin to over 30 inches (2.2 c.s.m.) in the area above Plymouth, New Hampshire, and to an extreme of over 40 inches (3.0 c.s.m.) in the headwaters of the Pemigewasset River. The average annual run-off for the watershed as a whole is 21 inches (1.5 c.s.m.) or approximately one-half of the average annual precipitation. About 50 percent of the annual run-off occurs in the spring months of March, April and May, with the remainder being rather uniformly distributed throughout the rest of the year. The extremes of recorded flow at Plymouth, New Hampshire have ranged from a maximum instantaneous flow of 65,400 c.f.s. (105 c.s.m.) on March 19, 1936, to a minimum instantaneous flow of 39 c.f.s. (less than 0.1 c.s.m.) on October 3, 1948. A minimum monthly flow of 107 c.f.s. (0.2 c.s.m.) was experienced in September 1923. The extremes at Lowell, Massachusetts have ranged from an instantaneous peak of 173,000 c.f.s. (37 c.s.m.) on March 20, 1936 to a minimum daily flow of 199 c.f.s. (less than 0.1 c.s.m.) on September 23, 1923. A minimum monthly flow of 1,249 c.f.s. (0.3 c.s.m.) was recorded in September 1942.

The following flow data has been recorded in the vicinity of the three potential plant sites in the Merrimack Basin (References 1 and 3):

			FLOW (C.F.S.)			
RIVER MILE	SITE NEAREST GAGE	DRAINAGE AREA	DAILY AVE ANNUAL	7-DAY LOW	DAILY MAX	DAILY MIN
93.0	Garvins Falls	2384	4176 (E)	620	127,000(E)	188(E)
69.04	Litchfield	3092	5102	663	150,000	198
Contoocook River	Jackman	427	610	---	5,260	15

(E) = Estimated

The Merrimack River Basin is underlain by unconsolidated deposits formed primarily during and partly after rather recent continental glaciation and by bedrock formed during much earlier periods of geologic time. Most bedrock is hard and dense, having been metamorphosed (altered) from earlier sedimentary, igneous, and volcanic rocks. Some of the younger igneous rocks have not been metamorphosed.

During the Ice Age the Basin was covered by at least two glaciers that moved in a southeasterly direction, commonly smoothing the northwestern slopes of hills, but leaving the leeward slopes rough and irregular. Preglacial valleys were partly filled with material carried and deposited by the glaciers (till) and meltwater streams and lakes (stratified deposits). Now the Merrimack and its larger tributaries flow over these deposits except where erosion has exposed bedrock. Rock basins scoured by the glaciers are now occupied by lakes, such as Lake Winnipesaukee. When the climate finally warmed and the ice withdrew from the southeastern part of the Basin, part of that area was flooded by the sea and marine sediments were deposited over the earlier glacial deposits.

Northeast trending hills and valleys are commonly bedrock controlled, whereas northwesterly trends of the landscape commonly reflect the effects of glaciation.

The Merrimack River Basin can be divided into three classes of aquatic communities based on water temperature and using fish species as indicators. The basin above Penacook, New Hampshire is classified as a cold water community and is characterized by the presence of the Eastern Brook Trout (Salvelinus frontinalis), which cannot tolerate temperatures greater than 68°F.

The aquatic community from Penacook to Manchester, New Hampshire is considered intermediate in temperature based on the presence of small mouth base (Micropterus dolomieui) and walleye (Stizostedion vitreum), which have a maximum temperature tolerance of 75°F.

The southern portion of the Basin, including the Nashua River is considered a warm water community. The predominant fish species include chain pickerel (Esox niger), yellow perch (Perca flavescens) and pumpkinseed (Lepomis gibbosus). These species are not adversely affected until the water temperature reaches a point greater than 80°F.

A river can also be classified according to its distribution of benthic organisms. Portions of the Merrimack River have been classifed as having a bottom fauna consisting of organisms highly tolerant to pollution and those bottom fauna intermediately tolerant to pollution. No reaches of the Merrimack that have been studied contain predominantly benthic organisms sensitive to pollution. Although benthic organisms are usually distributed according to their temperature tolerances, the response in the Merrimack River is masked by the high degree of pollution at specific points. On the main stem of the Merrimack River, intermediate tolerance organisms predominated from slightly below Franklin to Penacook, New Hampshire, from Hooksett to Manchester, New Hampshire, and in three short segments below Haverhill, Massachusetts. Highly tolerant organisms predominated in a short reach below Franklin, New Hampshire, from north of Concord to Hooksett, New Hampshire, and the entire reach of River from Manchester, New Hampshire to below Haverhill, Massachusetts.

Many planning and regulatory agencies have recognized the extension of the river's historical role into the future. Projections, surveys and plans have all called for a restoration of the scenic, healthful and useful qualities of the stream. In "The Merrimack: Designs for a Clean River" (Reference 1), pollution abatement and water reclamation facilities are proposed. One of the requirements placed upon the river is that sufficient flow be present to satisfactorily dilute and carry off waste products.

The information below indicates the dilution effects (Ratio of wastewater to the 7-day, 10-year low flow) for the projected year 1990.

Dilution Effects (Ratio of Wastewater/7 Day-10 Year Low Flow)

	1990 Wastewater (M&I) Flow (MGD)***		Streamflow (7 day-10 yr. low)MGD		Ratio of Cumulative Wastewater to 7 Day-10 Yr. Low Flow
	Flow	Cumulative Flow			
Merrimack River					
Franklin*	11.72 MGD	11.72 MGD	390 MGD	(589 cfs)	3.0%
Concord	13.61	25.33	415 **	(620 cfs)	6.2%
Manchester*	34.10	59.43	440	(663 cfs)	13.5%
Nashua	28.90	88.33	580 **	(870 cfs)	15.2%
Lowell*	31.00	119.33	650	(980 cfs)	18.3%
Lawrence	43.00	162.33	670 **	(1000 cfs)	24.2%
Haverhill	21.61	183.94	690	(1020 cfs)	26.5%

* = Gaging Station
** = Estimated
*** = Excludes contribution on Pemigewasset River above Franklin.

The above wastewater figures do not include stormwater quantities but do include infiltration into the sewer system.

Proposed treatment facilities may, if constructed, reduce the requirements for downstream dilution in the twenty-first century. In the meantime the Federal Water Pollution Control Administration has established the following monthly minimum flow requirements for pollution control on the Merrimack River at Lowell, Massachusetts (Drainage Area = 4,635 square miles):

Period of Year	Min. Monthly Flow Requirements (cfs)
October - May	800
June	1,000
July	1,500
August	1,500
September	1,000

These requirements should be compared with the flow data for the Lowell gaging station given earlier in this section.

The New Hampshire Water Supply and Pollution Control Commission has also developed a plan for the portion of the river basin in New Hampshire (Reference 2). This plan encompasses projects already implemented and those required for the year 2020 and concludes that the Merrimack River will eventually be a major source of domestic water supply.

The diversion requirements projected by the Water Supply and Pollution Control Commission are summarized below:

REGIONAL WATER SUPPLY SYSTEMS AND DIVERSION REQUIREMENTS

Point of Diversion	Service Area	No. of Communities Supplied	Population Served to by (1000's)		Projected Diversion Requirements Year 2020	
			Present	Year 2020	MGD	CFS
Merrimack River at Hooksett	Seacoast Region	35	115	608	106	164
Contoocook River at Concord	Concord Area	16	59	232	36	56
Merrimack River at Hooksett	Manchester Area	8	109	318	55	85
Merrimack River at Merrimack	Nashua Area	17	99	519	87	135
	TOTALS	76	382	1,677	284	440

These projected requirements should be compared with historic flow data given earlier in this section.

In conjunction with the discussion which follows on specific Merrimack Basin sites reference should be made to Appendix M.

B. Litchfield Site. The site considered on the Merrimack River in Litchfield is shown on Figure 9.2-9. At this location, Public Service owns 152 acres of flood-plain farm land. Site studies have considered plants using either fossil or nuclear fuel. This site was studied since it is available and has the outward appearance of suitability. Specific discussion of the points of interest follows.

Seismic investigations were made on the site by Weston Geophysical Research. Figures 9.2-10 and 9.2-11 show the plan and profiles which were obtained. The seismic velocity of the surface overburden material was uniformly 1,000 ft./sec.; indicative of a very loose material which can be easily excavated. The correlation borings and the many auger holes drilled for seismic shot holes showed this material to be fine sand and silt which was quite uniform throughout the site area to the depth of the water table.

The higher overburden velocity of 5,000 ft./sec. is indicative of a water-saturated overburden material shown by the borings to be similar to the overburden materials above the water table. The borings also show that this overburden material becomes a silt below an approximate elevation of 85 to 90 feet. Some coarser materials, sands and gravels were encountered at a depth of Boring 1. The sample from Boring 4 has the appearance of a dense sand and gravel or a reworked till; no indication of higher seismic overburden velocities were noted in this area.

Sample 5 from Boring 1 and Sample 6 from Boring 2 were identical and consisted of ground up and fragmented pieces of bedrock, indicating that the top few feet of the bedrock surface may be weathered.

The log for boring number one is shown in Figure 9.2-12.

The seismicity of the site has not been investigated in the local area specifically for this site. However, Weston Geophysical Research has been consulted and from their knowledge of the region they have advised Public Service that there should be no unusual seismic conditions at the site.

An investigation was conducted to compare the foundation costs for a two-unit plant at Litchfield versus a site at which bedrock was already at grade or foundation level. It is felt that in 1972 dollars foundation costs would be $15 million greater at Litchfield than at Seabrook or another bedrock site.

The primary hydrological feature of the site is the Merrimack River itself. The elevation of the presently owned property is about 120 feet MSL. Reference to Corps of Engineers Plan and Profile Sheet No. 6 for the Merrimack River shows the natural flood profile in this area during the 1936 flood was 133.0 feet MSL. The extrapolation of the current standard project flood to the site shows a natural flood profile of 140.2 feet MSL. To site a nuclear plant under these conditions would require acquisition of additional high land bordering a State Forest or extensive earth works. The latter approach could prove undesireable if it caused a choking effect in the valley.

The Litchfield site is located between the cities of Manchester (1970, population 87,754) and Nashua (1970, population 55,820). The distance from the site to the nearest boundary of Manchester is 2.8 miles. Based on 1970 statistics the following population versus distance data is estimated:

DISTANCE	POPULATION
1 mile	700
5 miles	16,900
10 miles	156,700

The probable exclusion radius would be 1,500 feet.

Railroad access to the site is not currently present but can be obtained by constructing either a 3-mile spur or a river crossing. Even with a railroad spur to the site, heavy NSSS components would still have to be transhipped from the coast at a cost estimated at $3 million dollars.

The cooling water system for the plant would utilize spray modules or wet cooling towers. Dry cooling towers are not sufficiently developed and proven to consider them technically feasible for a plant to be in operation in 1979. For a plant with a 2400 mwe nameplate the evaporative losses and drift were calculated to be 73 CFS for a power spray module system and 59 CFS if natural draft cooling towers were used. The 7-day in 10 year low flow in this reach of the river is given by the USGS as 663 CFS. The minimum recorded flow was 198 CFS (Reference 1).

The aquatic habitat at Litchfield has been described in general earlier in this section. It is similar in detail to the conditions at the Garvins Falls site described later. Aside from the reduction in flow due to evaporative consumption by the cooling system the plant should have no significant effect on the aquatic ecology.

Two airfields lie within six miles of the site. In Nashua, Boire Field is capable of handling small jet aircraft. The end of the runway at this field is 5.75 miles from the reactor site. The range to the site is perpendicular to the runway centerline. This field is not equipped with instrument approach facilities and, in 1972, had no control tower or FAA control zone.

The airport closest to the site is Grenier Field in Manchester. The end of the nearest runway is 4.95 miles from the reactor site. The site lies in neither of the approach paths of either major runway. The nearest point of the approach fan to runway 624 lies 1.2 miles northwest of the site. This runway is only for VFR traffic. The nearest point of runway 1735 approach fan lies 3.4 miles east of the reactor site. This runway has ILS capability. Beside domestic airline flights, both military and private jet craft use this field.

Transmission line access to the site is feasible. Since the distance to Scobie Pond Substation is less than from Seabrook, transmission costs could be somewhat less than for the proposed site. Detailed studies would be required to verify that, however. It is felt that certification of a plant at this location would be difficult to obtain at best considering the plant's evaporative consumption of cooling water in the light of State plans for the River's improvement and useage.

In summary, the Litchfield site is one which will bear continued review in the future. However, it is not the prime site available to the Company today when technology, costs, environmental effects and the regulatory climate are considered.

C. Garvins Falls Site. The Garvins Falls site located at mile 87 on the Merrimack River in the City of Concord, New Hampshire is shown in Figure 9.2-13. This site has been devoted to energy conversion since 1813 when the first dam was placed across the river at this location. Through a series of purchases and mergers, Public Service Company has come to own the site which now comprises approximately 600 acres. A dam and small hydro-electric plant are currently functioning at the Falls.

The application for relicensing the Garvins Falls Hydroelectric Plant was filed with the Federal Power Commission December 15, 1972, as Project No. 2140. That application discusses in detail historical, hydrological and recreational features of the site. A summary on the effect of the project on fish and wildlife is also included.

The site is wooded and the New Hampshire Highway Department has preliminary plans to use part of the area for an enlarged interchange between Interstate-89 and the F. E. Everett Turnpike. Figure 9.2-15 shows the site area as it might be developed for recreation, power generation and transportation.

The geological and seismological features of the site should be favorable for nuclear development. Bedrock is present on the surface and no unusual seismic history for the area is known.

The hydrology of the site is dominated by the Merrimack and Soucook Rivers. The maximum recorded flow in the Merrimack occurred in March 1936 when 122,000 cubic feet per second passed the site. During that period 13.9 feet of water flowed over the existing dam. The Corps of Engineers standard project flood predicts a flow of 155,000 cfs at the site with a depth over the crest of the dam of 16.8 feet. Sufficient land exists above this elevation to permit plant siting.

The 7-day in 10 year low flow at Garvins is given by the USGS as 620 cfs. The minimum recorded flow is 188 cfs. The flow duration curve for the Amoskeag dam in Manchester 20 miles downstream is given in Figure 9.2-16.

The site is located within the corporate boundary of the City of Concord which had a population in 1970 of 30,022. The requirements of 10 CFR 100 for a population center distance appear to make it fruitless to consider this site for a nuclear plant in today's regulatory climate.

Highway access to the site is good. An old railroad bed remains on the east side of the river but the bridge no longer exists. Rail service could be restored. Delivery from the coast of the large NSSS components has not been reviewed. If it were possible, the penalty should be approximately the same as reported previously for the Litchfield site. If shop-fabricated components could not be brought over land to the site, field fabrication would be required at a cost penalty of several million dollars.

Condenser cooling will require the use of cooling towers and make up of evaporative losses from the river. The requirements description given earlier in connection with the Litchfield site is application to a system installed at this site. The only difference is that the river is a little drier.

The reaches of the Merrimack above and below the dam are both classed as intermediate water streams in regards to temperature classification. Studies have been conducted by the New Hampshire Fish and Game Department (Reference 4) and by Normandeau Associates, Inc. (References 5 and 6) on the river below Garvins Falls. In general, the information obtained is applicable to the pond above the falls.

The tabulation below shows the common and scientific names of fish species encountered during the population studies on the Merrimack River and its tributaries.

COMMON NAME	SCIENTIFIC NAME
Walleye	Stizostedium vitreum
Largemouth bass	Micropterus salmoides
Smallmouth bass	Micropterus dolomieui
Chain pickerel	Esox niger
Yellow perch	Perca flavescens
Yellow bullhead	Ictalurus natalis
White perch	Morone americana
Brown bullhead	Ictalurus nebulosus
Pumpkinseed	Lepomis gibbosus
Fallfish	Semotilus corporalis
White sucker	Catostomus commersoni
Golden shiner	Notemigonus crysoleucas
American eel	Anquilla rostrata
Blacknose dace	Rhinichthys atratulus
Longnose dace	Rhinichthys cataractae
Eastern madtom	Notorus sp.
Burbot (cusk)	Lota lota
Landlocked salmon	Salmo salar
Redfin shiner	Notropis umbratilis
Redbreast sunfish	Lepomis auritus

The sport fishery of this area presently centers around the Bass, Pickerel, Perch, Walleye, and Bullhead species with the Trout and Sunfish fished to a lesser degree. Bass fishing is considered to be the principal sporting utilization of these waters. They are taken from shore and by boat using a wide variety of angling techniques; however, their worth as a food fish is probably subordinate to their sporting value. In terms of total numbers caught, the Yellow Perch probably far exceeds all others. They are heavily fished, especially in the spring when the meat is firmer, free of parasites, and considered tastier. The most important food fish in this region of the river may in fact be the Bullhead which is abundant and highly prized by many as a food fish. Trout and Walleyes are not caught in large numbers compared with others discussed, but they are considered excellent eating. Sunfish and Pickerel are abundant and caught in relatively large numbers, but not often kept for human consumption. Many fishermen will not keep their catches for family consumption, regardless of the species, because of the obvious presence of domestic waste in these waters.

The Technical Committee for Fisheries Management of the Merrimack River Basin, a group composed of representatives from the States of New Hampshire and Massachusetts plus two Federal agencies, the National Marine Fisheries Service and United States Bureau of Sport Fisheries and Wildlife, has classified the Merrimack River as Salmonid waters.

The Anadromous Fish Restoration Program being carried out by the State Fish and Game Departments of Massachusetts and New Hampshire and the Bureau of Sport Fisheries and Wildlife and the National Marine Fisheries Service will enhance the recreational value of the Merrimack considerably. This program is intended to re-establish American Shad and Atlantic Salmon in the Merrimack and its headwaters which will require the construction of fish ladders at dams from the Atlantic to at least as far north as Franklin, New Hampshire, for the Shad and to the headwaters for complete restoration of Salmon. Another phase of this program which is already underway involves stocking of Shad eggs in the Merrimack. It is believed that this area could support approximately a million Shad and 11,000 Salmon.

Historically, Salmon ran up the Merrimack to the Pemigewasset River where their spawning grounds were located. Shad runs were reported up to the

Winnipesaukee River and thence into the lake; however, Shad spawning in Lake Winnipesaukee is not considered factual by many. A decline in Salmon and Shad numbers precipitated the formation of the New Hampshire Fish and Game Department 104 years ago, whose prime objective is the restoration of this fishery. Its early efforts at restoration of this fishery were generally unsuccessful, being hindered by inadequate fish passage facilities and lack of control of indiscriminate netting by Massachusetts fishermen. After these efforts were discontinued, the fishery was further damaged by the construction of a paper mill on the prime Salmon spawning stream. Recently there has been a renewal of interest supported by more effective pollution abatement laws, federally supported fisheries research and development acts and the increased awareness of environmental preservation and improvement.

The fishery resource, then, can be viewed in two distinct perspectives, the presently established warm water populations around which the current recreational utilization centers and the planned future cold water species which foreseeably would provide a potential sports fishery believed preferable by many.

The wildlife present in addition to the fish of this area include a sizable waterfowl resource. Nesting ducks of this area include:

Black Duck	Common Merganser
Wood Duck	Hooded Merganser

Numerous Mallards have been introduced into these waters by riparian residents and, no doubt, some have become feral. In addition to nesting birds, there are numerous migratory ducks which utilize these open waters during seasonal flights. Migratory inhabitants would include:

Green-winged Teal	Scaup
Blue-winged Teal	Bufflehead
Golden Eye	Pintail
Ringneck	Canada Geese
Widgeon	Snow Geese

The Concord Municipal Airport is located approximately 12,000 feet north of the site. The airport logged 16,921 operations in 1972.

The projected recreational use for the area is described in the previously referenced FPC filing for Project No. 2140.

Transmission rights-of-way exist through the site which would have to be expanded or paralleled if a large plant were built here. Costs for such an expansion would be comparable to the cost forecast for Seabrook transmission.

When consideration is given to the proximity to Concord and the developing Anadromous Fish Program for the river it is very doubtful that State certification could be obtained for this site as long as salt water sites are available.

To summarize, the Garvins Falls location is considered inferior to the Seabrook site in today's regulatory climate and with today's condenser cooling technology.

D. Jackman Reservoir. Jackman Reservoir (Lake Franklin Pierce) is located in Hillsboro and Antrim, New Hampshire. Its location near the Franklin Pierce birthplace is shown in Figure 9.2-17. The man-made reservoir with a surface area of 500 acres was formed by constructing a concrete dam across the North Branch of the Contoocook River. The drainage area upstream of the pond is 66.5 square miles. The area around Jackman Reservoir has developed for recreational housing over the years, a fact that would cause any power facility to have an unpopular impact on man.

The site was included among those investigated by Public Service since the Company does have control over the flowage. Whether the stored water and the flow of the river could be used legally for evaporative cooling either as a pond or in towers is a real question. Jackson & Moreland calculated that for only a 1600 mw installation evaporation would exceed the river flow in summer and raise the pond temperature to 110°F (Appendix M).

Access to the site for construction and transmission rights-of-way are poorer than for the other sites in the Merrimack Basin. It is very improbable that certification could be obtained for the site since all that has been said previously about water requirements for the down stream sites is more true for Jackman.

E. Connecticut River - Moore Pond Site. The location of the Moore Pond Site in Littleton, New Hampshire is shown in Figure 9.2-18. The latest USGS map for the area (Littleton, Vermont, New Hampshire) published in 1932 does not show the Moore dam or pond. The approximate location of these has been marked in on Figure 9.2-19.

The Moore hydroelectric project, completed in 1956, is located at river mile 288 above the mouth and is the largest of the plants on the river, both in its capability of 200,000 kw and its reservoir, whose usable capacity is over 114,000 acre-ft. The surface area of the pond is 3,500 acres and its length is 12 miles.

This potential site was considered in the search for potential nuclear sites as a result of the stored water behind Moore dam and since it is a location already devoted to power production.

The geology of the region was studied and reported by Billings in 1935 in "Geology of the Littleton and Moosilauke Quandrangles" published by the New Hampshire State Planning and Development Commission. Several local studies were conducted around the site area in 1928, 1932, 1952 and 1954 preparatory to construction of the Moore dam. The geology and seismicity of the potential site are suitable for nuclear plant siting.

The hydrology of the potential site is dominated by the Connecticut River. The drainage area at the head of the pond below Gilman is 1,514 square miles. The maximum record flow at Gilman was 48,300 cfs on March 20, 1936. The minimum recorded flow of 115 cfs occurred in October 1937. The average discharge is 2,843 cfs (Reference 3).

Operation of the Moore station results in short-period pond level change of about 8 feet. Seasonal variations as great as 40 feet occur. Any thermal generating station located on this pond would have to be designed to accomodate these fluctuations.

Littleton originally was settled as an agricultural community with a village center supplying mill work and a trading center. The available water power of the Ammonoosuc River was then the source of industrial power. Further outgrowth of industry developed from the established locations.

In addition, resulting growth has been contained naturally by the hilly terrain, which has meant dense development along a narrow valley. The amount of undeveloped land presents opportunities for continued growth, but existing land characteristics will have to be considered.

Six percent of the land area in Littleton is currently devoted to residential, commercial and community service activities. Of the remaining area, approximately 2550 acres are water area, 3700 acres are farmed and 27,500 acres are classed as undeveloped land. The 1970 population of Littleton was 5,290. Nearby St. Johnsbury, Vermont had a population in 1970 of 8,409.

New Hampshire depends heavily upon recreation as an important part of its economy. Within a 45-50 minute drive of the potential site are found a number of major recreational areas. Included in these areas are: Cannon Mountain, Mittersill and Loon Mountain (ski areas); Bethlehem Municipal Country Club, Maplewood Country Club, Profile Club, and Tree Top Lodge (golf courses); Franstead Campsite, Lafayette Campground, Forest Lake State Park, Franconia Notch State Park, The Flume, The Basin, The Old Man of the Mountains, and the Aerial Tramway; many of which are located in the White Mountain National Forest or State Parks.

In a 1958 report entitled "NEW ENGLAND HERITAGE (The Connecticut River National Recreation Area Study)" the (Federal) Bureau of Outdoor Recreation proposed the establishment of an Interstate Park along the backwaters of the Moore-Comerford Reservoirs on the Connecticut River.

Presently, the New England Power Company owns approximately 6,000 acres at the subject location. The power company has developed several day-use public picnic areas and allows public use of the backwater area of the Moore Dam. The recreational development of this area is presently hindered by the existing polluted state of this portion of the river which results from municipal and industrial wastes. Boating and fishing are presently allowable activities, but swimming is not. The Bureau's report urged the States of New Hampshire and Vermont to "...undertake a joint program with the New England Power Company to develop the Moore and Comerford Reservoirs into a major Interstate Park. This report recommends that the States and the Power Company increase the development of company-owned lands, and that the States acquire 9,400 acres in fee and less-than-fee to round out the Company's present 6,000 acre holdings into a 15,400 acre Moore-Comerford Interstate Park." "...Both New Hampshire and Vermont have recognized that great undeveloped potential of the area, and each has noted recommended actions in its statewide outdoor recreation plan which would realize this potential."

In June of 1970, as a result of a six-year study, the Connecticut River Basin's Coordinating Committee published a ten-volume report entitled "Comprehensive Water and Related Land Resources Investigation - CONNECTICUT RIVER BASIN" (Reference 7). This report covers the Connecticut River in its entirety from Canada to Long Island Sound and presents a proposed plan for the preservation, development, and management of the water and related land resources of the Connecticut River Basin. The report stands subject to review by interested Federal agencies, by the Governors of the affected States, and other State and Regional agencies prior to its transmittal to the Congress for its action on those Federal items in the plan.

In May 1972, the New Hampshire Department of Public Works and Highways submitted its Draft Environmental Statement for Interstate 93 Littleton, N.H.-Waterford, Vt. (Reference 8). This report discusses more details of the region and the impact of heavy construction in the area of the potential site.

Littleton is served by Interstate highways and the Boston and Maine Railroad. Rail service does not exist to the proposed site. Field-fabricated NSSS components would be a necessity.

The condenser cooling system would have to be based upon evaporative cooling equipment. The requirements for such a system were discussed previously in connection with the discussion of the Litchfield site.

The River Basin Plan (Reference 7) calls for a minimum release of 0.2 cfs per square mile from main stream dams below McIndoes with a recommendation that further study be given to a minimum release from all dams in the basin of 0.2 cfsm. If this were required from Moore, the minimum release would be 30 cfs. The make-up for evaporative cooling equipment would be over twice the proposed minimum discharge. Taken together, they would nearly equal the historical low flow.

The aquatic life of the Moore Pond was studied in 1969 by the Vermont Department of Water Resources (Reference 9). The findings are summarized below.

Benthos studies were made in the Moore and Comerford Reservoirs during July and November 1969. This type of life found in the sediments of the reservoirs consisted of diptera larvae (Chironomus) and Oligochaetes.

The results of the summer and fall plankton study from the Moore and Comerford Reservoirs indicated a water quality in the reservoirs which was sufficient to maintain a diversity of genera. Most of the phytoplankton in the reservoirs in July 1969 were either Chrysophyta or Chlorophyta and there was a noticeable lack of the often troublesome Chyanophyta usually associated with domestic pollution.

The aquatic life found in the littoral zone of a storage reservoir may be limited by the drawdowns. If drawdowns occur frequently and cause substantial raising and lowering of the water level, life in the littoral zone may tire of having to migrate in accord with the fluctuations. Both the Moore and Comerford Reservoirs may have short term fluctuations as great as six to nine feet and the Moore Reservoir has seasonal fluctuations as great as forty feet. Therefore, if the life in the littoral zone is found to be sparse, industrial pollution may not be the sole cause. There was little work done of the littoral aquatic life during this study.

The dissolved oxygen concentrations are severely diminished at the confluence of the Upper Ammonoosuc River and the Connecticut River and downstream. During the river's 25 mile flow to the Moore Reservoir the dissolved oxygen levels improve somewhat. The biochemical oxygen demand values varied inversely to the dissolved oxygen concentrations. The Moore and Comerford Reservoirs detain the flow of the river and the quality of the water within these impoundments is severely degraded. Throughout the reservoirs there were dissolved oxygen deficiencies and certain areas within the Moore Reservoir were devoid of oxygen.

Because of the oxygen deficiency, very little fish life and almost no game fish inhabited the Moore Reservoir in 1956. Based on the results of this survey, this is probably still true today (1969). This diminishes the recreational potential of the reservoir (Reference 9).

Obtaining state licenses for this potential site could be difficult when river improvement and recreational development programs are considered.

Preliminary load-flow studies indicate that two 765-kv transmission lines would have to be constructed from the potential site to Tewksbury, Massachusetts to reliably tie the plants into the transmission grid. This would entail 134 miles of double-circuit right-of-way covering 7000 acres of land. Cost of this line is estimated to be approximately $250,000 per circuit mile or approximately $70 million; over five times the cost of Seabrook-related transmission facilities.

The comparative remoteness of the potential site would cause a definite labor cost penalty to be ascribed to this location.

After consideration of environmental effects and construction and transmission penalties, the site study concluded that this site was less favorable than one located on salt water.

9.2.3.3 Salt-Water Sites

In the 1967 site study (Appendix M) several sites were investigated which would utilize estuarine or ocean waters for condenser cooling. These included: Fox Point and Durham Point on Little Bay; Rollins Farm on the Piscataqua River; Odiornes Point and Gerrish Island on the ocean at the outlet of the Piscataqua River, and the preferred site at Seabrook. The 1967 study concluded that the preferable site would be Rollins Farm. With the exception of Seabrook these locations are shown in Figure 9.2-20.

The criteria for licensing a nuclear plant in the vicinity of an airport became more stringent with the processing of the Three Mile Island application in 1968 and 1969. As a result, several sites within the influence of Pease Air Force Base including the Rollins Farm site could not be licensed either at all or without the additional investment of tens of millions of dcllars. As the Applicant understands the existing licensing criteria with respect to airports, the Rollins Farm, Fox Point and Dover Point sites would not be acceptable. Therefore, they will not be discussed further herein. The Odiornes Point and Gerrish Island locations are outside the area encompassed by the criteria but still much more under the influence of Pease Air Force Base than Seabrook.

A. <u>Gerrish Island</u>. The Gerrish Island location in Maine was investigated in some detail prior to the selection of the Wiscasset, Maine site for the Maine Yankee Atomic Power Station. The comparison of alternative sites including Gerrish Island for Maine Yankee was described in the Maine Yankee Environmental Report (Docket 50-309). A summary of the site features is given below.

The Gerrish Island site is underlain with competent bedrock of different formations. The seismicity of the area is comparable to that described for the Seabrook area. Wave run-up calculations, when performed, could show that extensive super elevation or diking of the site would be necessary to license the site for the maximum horendous storm.

Access to the site by road would require two miles of new or extensively rebuilt roads and bridges. Railroad access would require over six miles of new track and several major bridges to be constructed.

The potential site is located in Kittery, Maine which had a population of 11,028 in 1970. The closest corporate boundary of Portsmouth, New Hampshire is 14,000 feet. Portsmouth had a population in 1970 of 25,717. Pease Air Force Base is approximately six miles distant.

The cooling water supply would be the Atlantic Ocean. The ecological features of the site have not been studied in detail. However the waters in the area of the potential site are generally familiar as a result of the Seabrook and Piscataqua River Studies. There does not appear to be any significant difference in the aquatic species present around Gerrish Island from that of Hampton Beach. In the design of the circulating water system the effects of flow to and from the Piscataqua estuary opening near this site would have to be considered. The net daily flushing rate upstream at Rollins Farm was calculated to be 9,100 cfs based on dye release studies.

The portion of the Island shown as Fort Foster is now a Town Park of scenic, historic and recreational merit.

Transmission access to the site wuld be difficult and possibly require underground lines if sufficient right-of-way width for overhead lines could not be purchased.

Consideration of Gerrish Island and other sites outside the State of New Hampshire by Public Services raises the question of availability. It is easy to point out a spot on the map and inquire if it has been considered and even to suggest that it is quite possibly preferable to the proposed site. Regulatory Guide 4.2 seems to recognize the realisms of availability when it seeks the basis for the applicant's choice from "available alternative sites". Among other things, the ability of the applicant to obtain clear title to the site property for financial and control purposes is inherent in the concept of availability. Title to a property can be obtained as a result of agreements reached by a willing buyer and a willing seller or through condemnation. In the case of the former, if the present owner does not wish to sell or discuss a sale that avenue is closed. In the latter, if the utility does not have the right to condemn land for a power generating facility the potential site can only be considered unavailable at the time.

Gerrish Island, while a potential site, is not an available site since the present owner of the major parcel is not interested in selling his land. Acquisition through condemnation is not possible, even if desirable, the eminent domain powers which utilities have under Maine law presently extend only to takings of land for transmission and distribution lines and their appurtenances. Dwellings may not be condemned for any reason and land may not be condemned for a power plant. Furthermore, the powers of eminent domain given to utilities under present Maine law are given only to utilities which are corporations organized under the laws of Maine (35 M.R.S.A. §2306). Since Public Service Company of New Hampshire is a New Hampshire and not a Maine corporation it has no eminent domain powers under the Maine statute.

B. Odiornes Point. The description of the Odiornes Point location is very similar to the one given above for Gerrish Island with slight changes in distances. The geology and seismicity of the site appear to be suitable for licensing and construction. A substantial amount of fill would be required to elevate the plant above the maximum wave runup. It is quite probable that some salt marsh, known as Fairhill Swamp, would have to be filled for the plant and highway relocation. Railroad access, if constructed, would entail four miles of trackage, a portion of which would be laid across marsh land.

The cooling water and ecological features of this site are very similar to those described for Gerrish Island. Odiornes Point is approximately 8,000 feet from the Portsmouth City Boundary, and has become a state park since the 1967 site survey was conducted. Pease Air Force Base is four miles distant from the Point.

Public Service concludes that this site is less favorable than the Seabrook Site from a land use and licensing point of view.

9.2.3.4 Island and Floating Sites

The use of the Isle of Shoals or a barge-mounted plant have been considered as alternatives to the proposed site. The use of the Isle of Shoals was ruled out due to the technical uncertainties inherent today in deep-sea, 345 KV transmission. The paucity of land for construction and plant facilities make it very improbable that a plant could be economically constructed on the Isles. The major island and the only one that conceivably has sufficient land area for a plant is in Maine as shown in Figure 9.2-21. In addition, the historic, religious and ecological qualities of the Isles make it improbable that licenses from Maine and New Hampshire could be obtained.

The need for power discussed earlier in this report showed that the proposed units were required to be in service in 1979 and 1981. Public Service was advised that the manufacturer could not supply the initial unit for service in that time frame. For the additional reasons of licensing, economics, and transmission feasibility Public Service concludes that the Seabrook Site is preferable to an offshore plant.

The applicant knows of no other sites available to it for the proposed plant.

9.2.3.5 Site Reviews by Other Agencies

Subsequent to the site reviews conducted by Jackson & Moreland for Public Service in 1967 and by the Applicant in 1969 two other agencies reviewed sites available to Public Service for a large nuclear plant.

The New England Regional Commission published "A Study of the Electric Power Situation in New England 1970-1990" in September 1970. This report stated in regard to siting a nuclear plant in New Hampshire that:

> "Possible sites for large thermal electric generating stations on the New Hampshire coast are limited and extreme care must be exercised in site selection. Nevertheless, two or more such sites should be available. One of these could be the Seabrook site for which the planned construction of an 860 MW plant has been postponed."

and in regard to lake sites:

> "The larger lakes are in northern New Hampshire and Maine and the cost of transmission to the large southern load centers tends to make them economically unattractive but they should not be ruled out as possible future sites."

The consultants who prepared this report for the New England Regional Commission appear to have concluded that there must be another site somewhere if one looks again. But they apparently did not look closely themselves. The preceding discussion shows that there are other potential salt-water sites that have been reviewed by the applicant and his consultants and which as a result have been found less acceptable than the proposed site.

The large lake in New Hampshire which the report suggests as a future site seems to be Lake Winnipesaukee. This is a highly protected, Class B water body devoted to recreational purposes. Existing regulations and land use rule this out as a potential site area.

In January 1971 the New England River Basins Commission issued its "Environmental Evaluation of Seabrook, New Hampshire Nuclear Power Plant" (Reference 10). This report was prepared by the professional staff of the NERBC working with staff members of the AEC, USPHS, FPC, USGS, USFWA, USDA, USBSF, NHF&GD and the NHWS&PCC. As a result, it is based on a careful review of the concerns now embodied in NEPA. Of interest here is the conclusion related to site selection:

> "There appears to be no better alternate site for a nuclear power plant available to the Public Service Company of New Hampshire."

The report has provided guidance to the applicant in the present plant in the area of environmental studies and circulating water system design.

June 1973

References

1. U. S. Army Corps of Engineers, "The Merrimack: Designs for a Clean River" with appendices I through IV and annexes A through C, August 1971.

2. New Hampshire Water Supply and Pollution Control Commission, "Merrimack River Basin Plan", February 1972.

3. U. S. Department of Interior Geological Survey, "Water Resources Data for Massachusetts, New Hampshire, Rhode Island, Vermont", 1970.

4. New Hampshire Fish and Game Department, "Merrimack River Thermal Study", 1971.

5. Normandeau Associates, Inc., "Merrimack River Monitoring Program 1971", April 1972.

6. Normandeau Associates, Inc., "Merrimack River Monitoring Program 1972", May 1973.

7. New England River Basins Commission, "Connecticut River Basin - Comprehensive Water and Related Land Resources Investigation", 1972.

8. New Hampshire Department of Public Works and Highways, "Draft Environmental Statement for I-93 Littleton, New Hampshire - Waterford, Vermont, I-93.3 (34) 125; P. 3874", 1972.

9. Vermont Department of Water Resources, "Effects of Industrial Wastes on the Upper Connecticut River", 1969.

10. New England River Basin Commission, "Environmental Evaluation of Seabrook, New Hampshire Nuclear Power Plant", January 1971.

11. New England Energy Policy Staff, "Analysis of Need for Future Generating Capacity in New England and New Hampshire", January 1973.

12. Southeastern New Hampshire Regional Planning Commission, "Future Land Use Plans", May 1, 1972.

13. Central Survey, Inc., "An Opinion Survey Regarding Seabrook Nuclear Plant Site", August 28 - September 7, 1972.

TABLE 9.2-1

LOAD AND CAPABILITY BY NEW ENGLAND LOAD AREAS

(Load Responsibility = Load Plus Reserve) (Showing Committed or Planned Units Only)

MW	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Area I (Maine)												
Capacity	1239	1775	1769	1914	1755	2184	2786	2786	2786	2786	2786	2786
Load & Reserve	1201	1332	1413	1537	1652	1749	1880	2034	2238	2416	2611	2795
Difference	38	443	356	377	103	435	906	752	548	370	175	-9
Area II (N.H.)												
Capacity	1082	1081	1059	1459	1459	1458	1458	1458	2608	2608	3759	3759
Load & Reserve	957	1086	1184	1321	1448	1571	1729	1917	2159	2388	2638	2894
Difference	125	-5	-125	138	11	-113	-271	-459	449	220	1121	865
Area III (Vt.)												
Capacity	577	1143	1143	1170	1170	1170	1443	1443	1443	1443	1443	1443
Load & Reserve	769	948	1044	1174	1298	1412	1560	1733	1960	2177	2413	2657
Difference	-192	195	99	-4	-128	-242	-117	-290	-517	-734	-970	-1214
Area IVN (NE Mass.)												
Capacity	2252	2693	2655	2665	3244	3244	4138	4138	4138	4138	4138	4138
Load & Reserve	3508	3848	4101	4462	4744	5004	5349	5751	6273	6736	7196	7560
Difference	-1256	-1155	-1446	-1797	-1500	-1760	-1211	-1613	-2135	-2598	-3058	-3422
Area IVS (SE Mass.)												
Capacity	1294	1913	1896	1896	2491	2494	2494	3678	3678	4827	4827	4827
Load & Reserve	1619	1801	1892	2029	2137	2224	2347	2491	2691	2853	3018	3164
Difference	-325	112	4	-133	354	270	147	1187	987	1974	1809	1663
Area V (W. Mass.)												
Capacity	1036	1286	2020	2645	2645	2645	2645	2645	2645	2645	2645	2645
Load & Reserve	1021	1196	1279	1398	1500	1591	1714	1856	2046	2217	2394	2567
Difference	15	90	741	1247	1145	1054	931	789	599	428	251	78
Area VI (R.I.+)												
Capacity	1969	1969	2040	2504	2467	2467	2467	2467	2467	3367	3367	4267
Load & Reserve	1342	1572	1664	1809	1921	2017	2148	2302	2523	2704	2903	3115
Difference	627	397	376	695	546	450	319	165	-56	663	464	1152
Area VII (Conn.)												
Capacity	5078	5031	5431	6261	6706	6706	6706	6706	7856	7856	9005	9005
Load & Reserve	3902	4593	4941	5417	5844	6235	6750	7351	8142	8863	9626	10408
Difference	1176	438	490	844	862	471	-44	-645	-286	-1007	-621	-1403
Total New England												
Capacity	14527	16891	18013	20514	21937	22368	24137	25321	27621	29670	31970	32820
Load & Reserve	14319	16376	17518	19147	20544	21803	23477	25435	28032	30354	32799	35160
Difference	208	515	495	1367	1393	565	660	-114	-411	-684	-829	-2290

TABLE 9.2-2

Description of Areas Identified In Figure 9.2-5

Airports

1. Claremont, Municipal
2. Concord, Municipal
3. Deering, Private
4. Hampton, Private
5. Hooksett, Private

6. Jaffrey, Municipal
7. Keene, Municipal
8. Laconia, Municipal
9. Lebanon, Regional
10. Manchester, Municipal

11. Nashua, Municipal
12. Newport, Municipal
13. Rochester, State of New Hampshire
14. Salem, Private
15. Wolfeboro, Private

16. Portsmouth-Newington Pease A.F.B., Military
17. Brookline
18. Gilmanton
19. Kensington
20. New Boston

21. North Sutton
22. Tilton

Scenic and/or Natural Areas

23. Rock Rimmon State Forest, Kingston
24. Cedar Swamp, Kingston
25. Great Bog, Portsmouth
26. Fort Dearborn, Rye (Owned by State of New Hampshire)

Natural Area

27. Cedar Swamp, New Durham
28. Mast Yard State Forest, Hopkington
29. Black Water River Basin, Salisbury (From U. S. Corp. of Eng. Dam)
30. Knox Mt. Pemigewasset Flood Control Area, Sanborton (Federal)
31. State Forest, Litchfield

32. Dublin State Forest, Dublin
33. Bingham Hill State Forest, Gilsum
34. Honey Brook State Forest, Marlow
35. Table Rock State Forest, Charlestown

Natural Area (continued)

36. Croydon Park, Croydon
37. Shadow Hill State Forest, Sutton

State Parks

38. Bear Brook State Park, Allenstown
39. Cardigan State Park, Orange
40. Clough State Park, Weare
41. Ellacoya State Beach, Gilford
42. Elm Brook State Park, Hopkington

43. Greenfield State Park, Greenfield
44. Hampton Beach State Park, Hampton
45. Kingston State Park, Kingston
46. Miller State Park, Peterborough
47. Monadnock State Park, Jaffrey

48. Mt. Sunapee State Park, Newbury
49. Otter Brook State Park, Keene
50. Pawtuckaway State Park, Nottingham
51. Pillsbury State Park, Washington
52. Rhododendron State Park, Fitzwilliam

53. Rollins State Park, Warner
54. Rye Harbor State Park, Rye
55. Silver Lake State Park, Hollis
56. Wadleigh State Park, North Sutton
57. Wallis Sands State Park, Rye

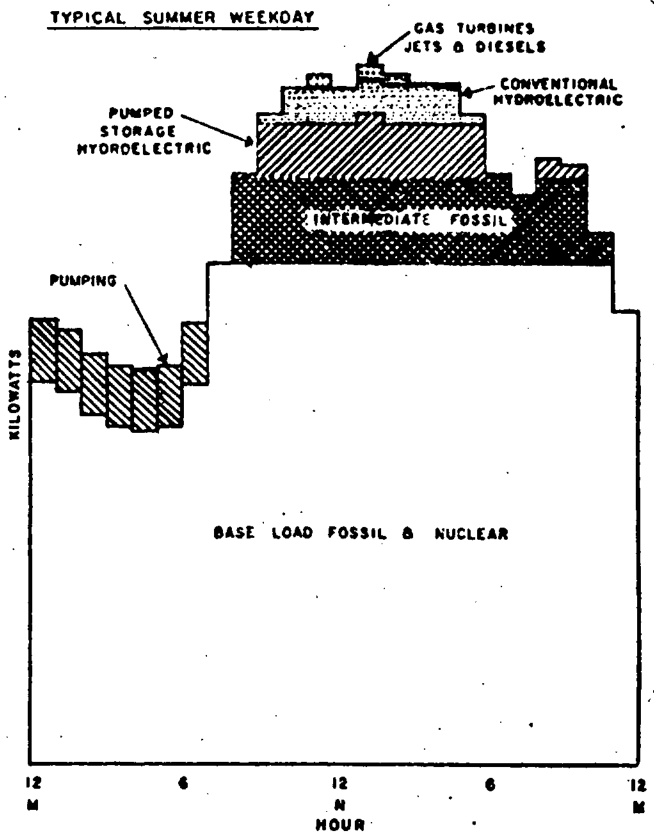
58. Wentworth State Park, Wolfeboro
59. Winslow State Park, Wilmot
60. Annett State Forest
61. Fox State Forest, Hillsborough
62. Gunstock, (Belknap County Area) Gilford

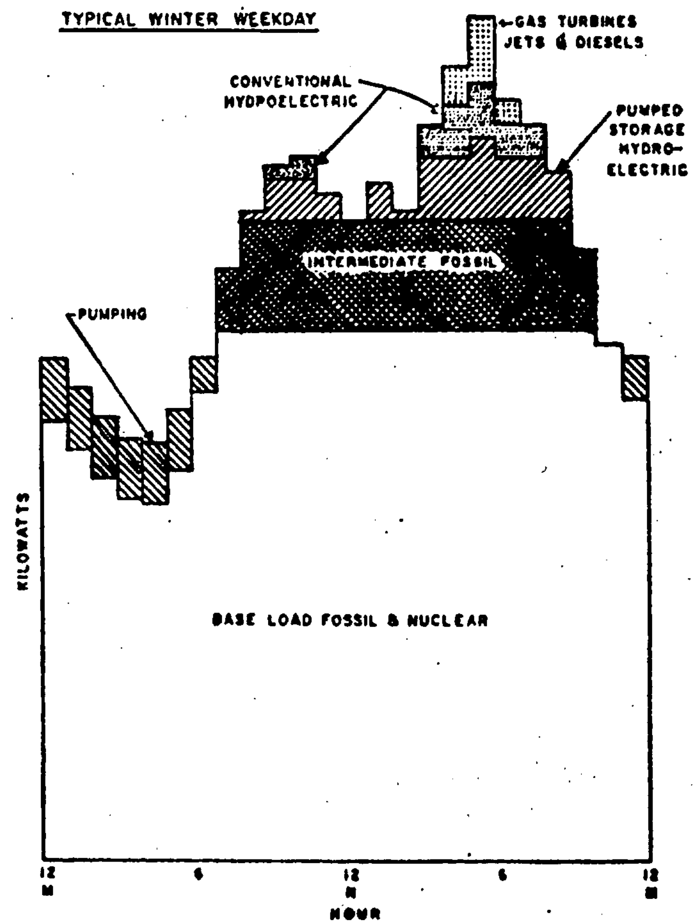
63. Hilton Park, Dover (N.H. Highway Dept.)

Historic Sites

64. Fort William and Mary, Newcastle
65. Strawberry Bank, Portsmouth
66. Odiornes Point, Rye - First N.H. Settlement
67. Boundry Rock, Seabrook
68. Indian Mounds, Route 9 Barrington

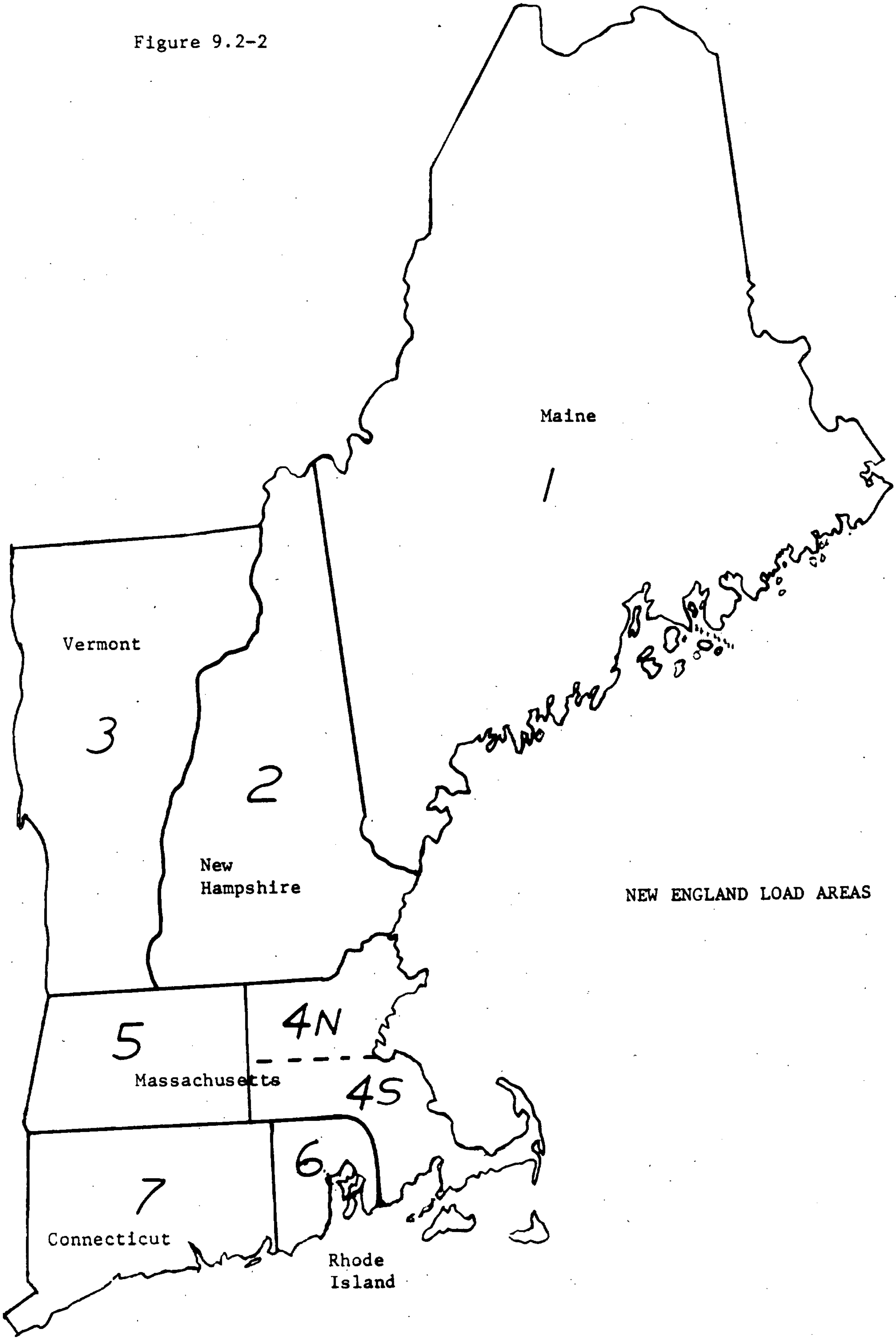
69. Town Pound, Durham, Oldest Pound in Existence, 1709
70. Mary Baker Eddy Birthplace, Bow
71. Daniel Webster Home, Franklin
72. Franklin Pierce Birthplace, Hillsboro





PSNH SEABROOK STATION	TYPICAL DAILY LOAD CURVES SHOWING ALLOCATION OF GENERATION MIX	FIGURE 9.2-1

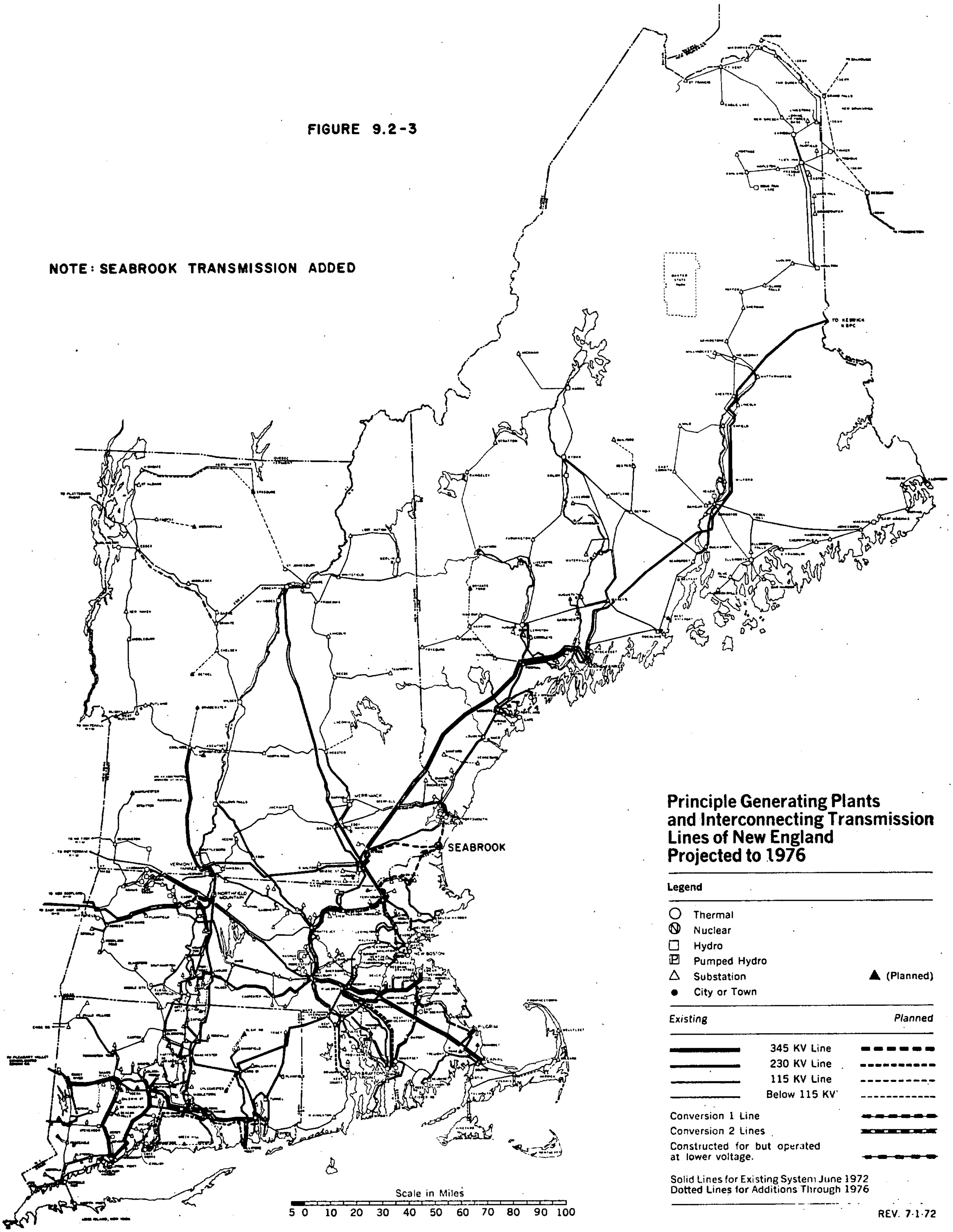
Figure 9.2-2



NEW ENGLAND LOAD AREAS

FIGURE 9.2-3

NOTE: SEABROOK TRANSMISSION ADDED



Principle Generating Plants and Interconnecting Transmission Lines of New England Projected to 1976

Legend

- Thermal
- Nuclear
- Hydro
- Pumped Hydro
- Substation — (Planned)
- City or Town

Existing		*Planned*
	345 KV Line	
	230 KV Line	
	115 KV Line	
	Below 115 KV	

Conversion 1 Line

Conversion 2 Lines

Constructed for but operated at lower voltage.

Solid Lines for Existing System June 1972
Dotted Lines for Additions Through 1976

REV. 7-1-72

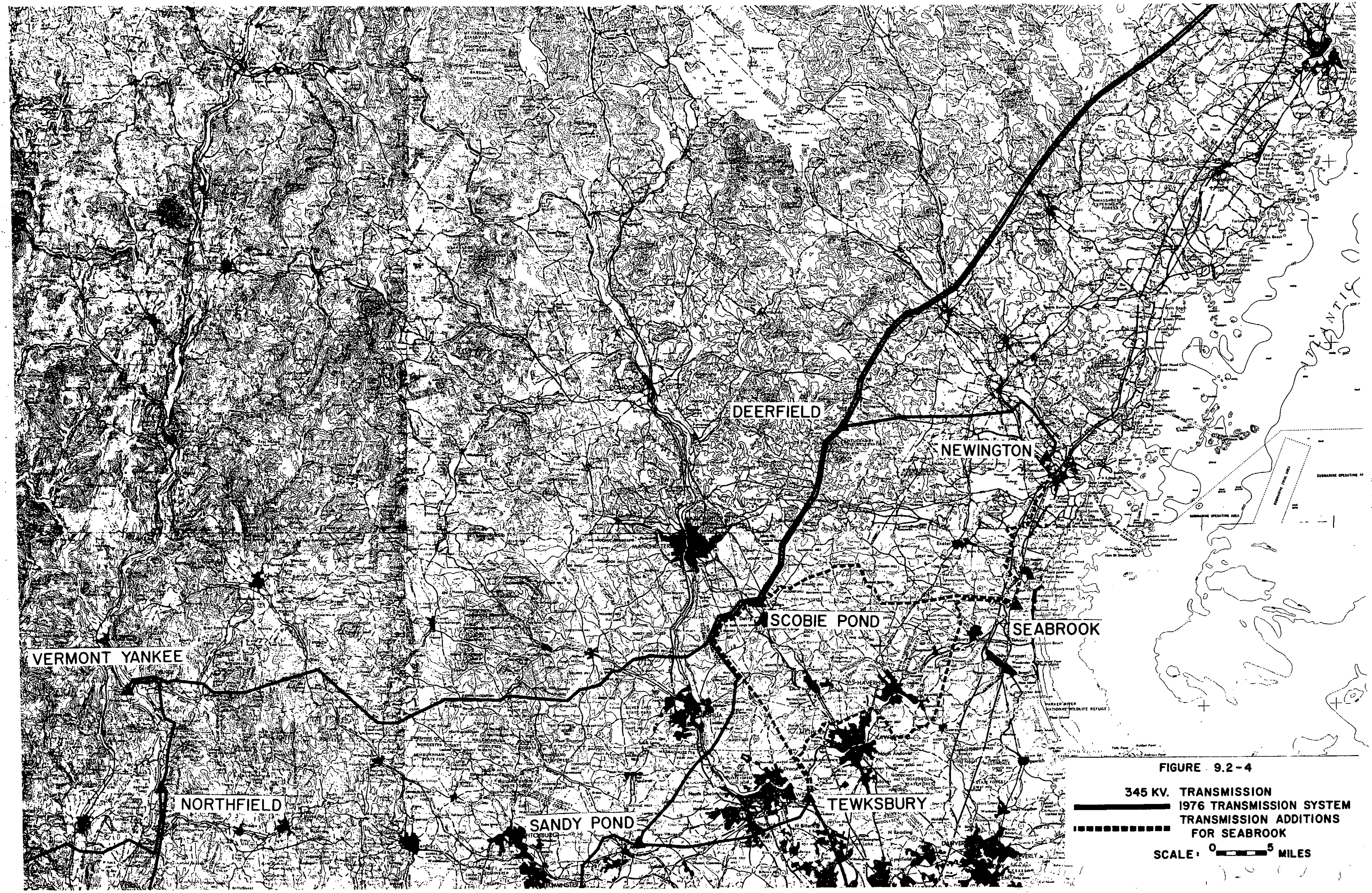


FIGURE 9.2-4

345 KV. TRANSMISSION
1976 TRANSMISSION SYSTEM
TRANSMISSION ADDITIONS FOR SEABROOK

SCALE: 0 — 5 MILES

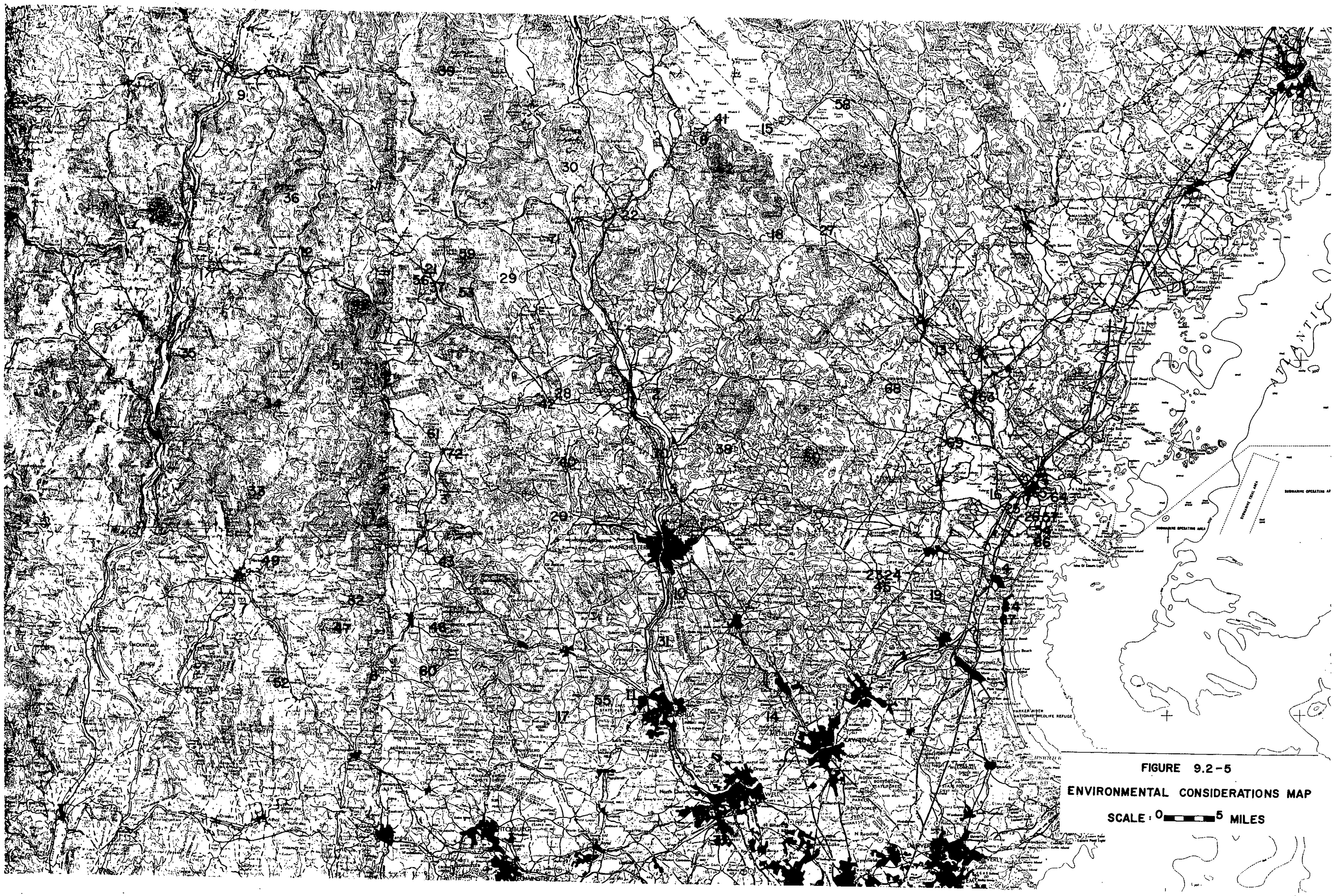
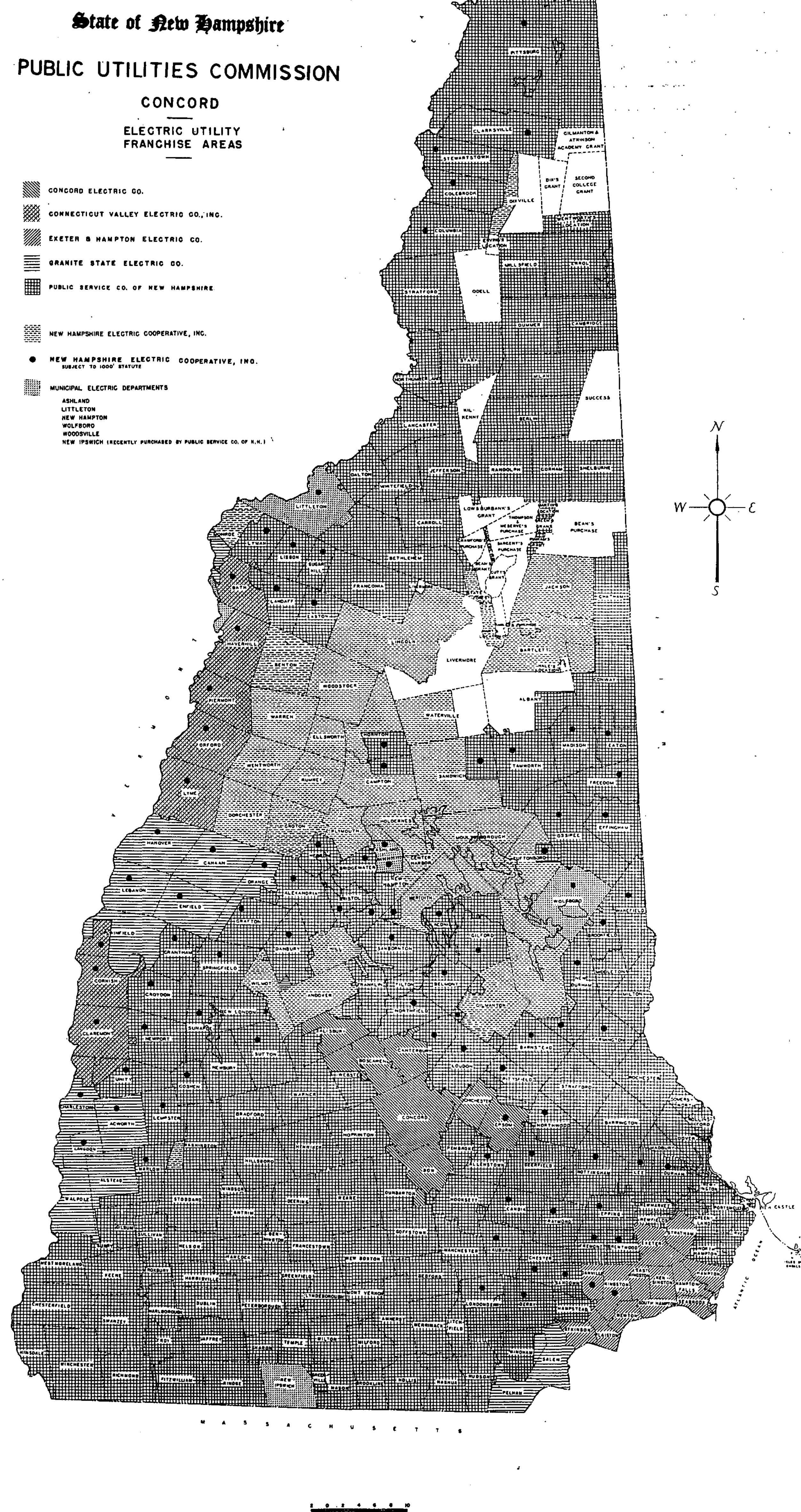


FIGURE 9.2-5

ENVIRONMENTAL CONSIDERATIONS MAP

SCALE: 0 — 5 MILES

FIGURE 9.2-6


State of New Hampshire
PUBLIC UTILITIES COMMISSION
CONCORD
ELECTRIC UTILITY FRANCHISE AREAS
CONCORD ELECTRIC CO.
CONNECTICUT VALLEY ELECTRIC CO., INC.
EXETER & HAMPTON ELECTRIC CO.
GRANITE STATE ELECTRIC CO.
PUBLIC SERVICE CO. OF NEW HAMPSHIRE
NEW HAMPSHIRE ELECTRIC COOPERATIVE, INC.
NEW HAMPSHIRE ELECTRIC COOPERATIVE, INC. SUBJECT TO 1000' STATUTE
MUNICIPAL ELECTRIC DEPARTMENTS
ASHLAND
LITTLETON
NEW HAMPTON
WOLFBORO
WOODSVILLE
NEW IPSWICH (RECENTLY PURCHASED BY PUBLIC SERVICE CO. OF N.H.)
N
W
E
S
MASSACHUSETTS
ATLANTIC OCEAN
Scale of Miles
REVISED DECEMBER 31, 1971

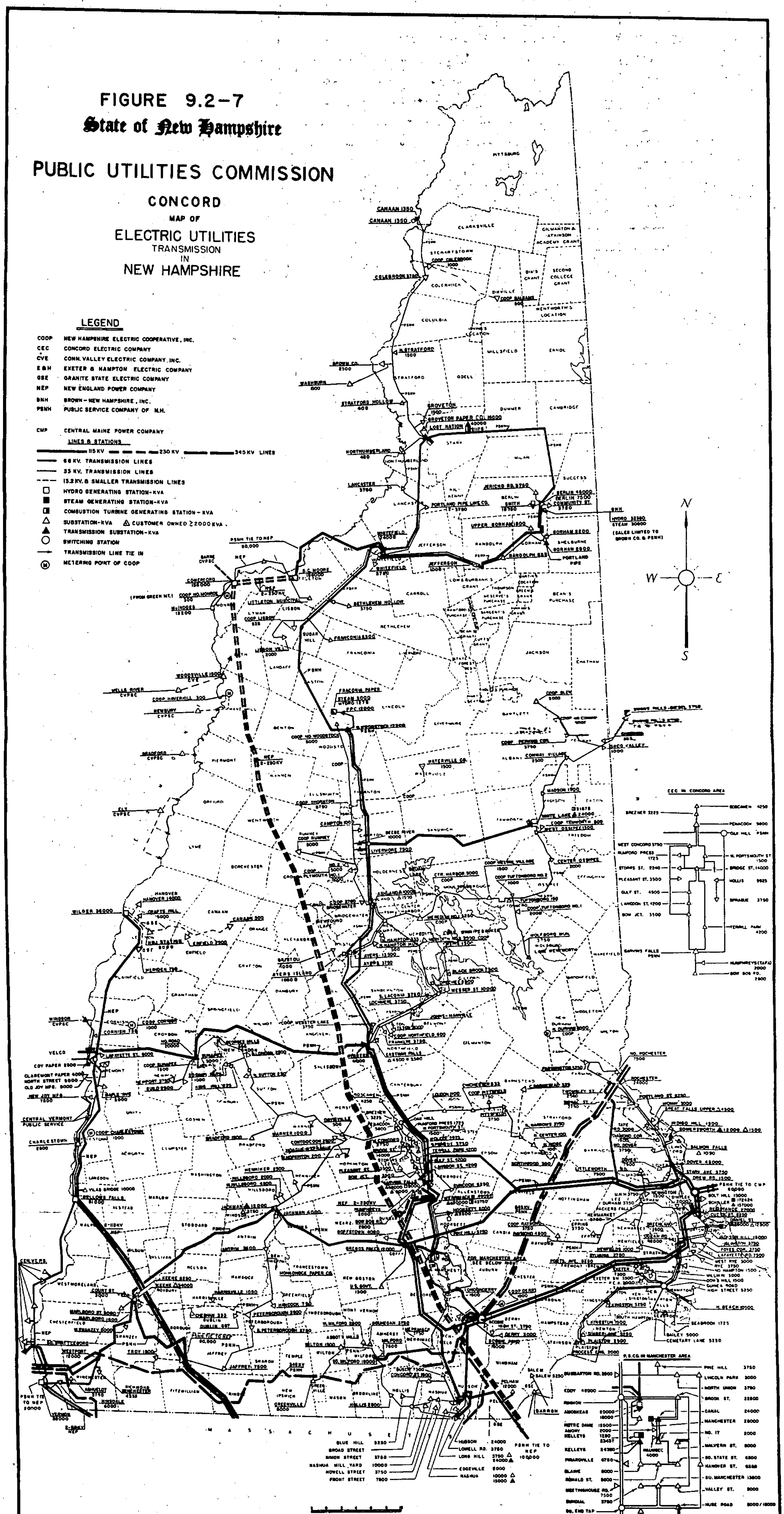
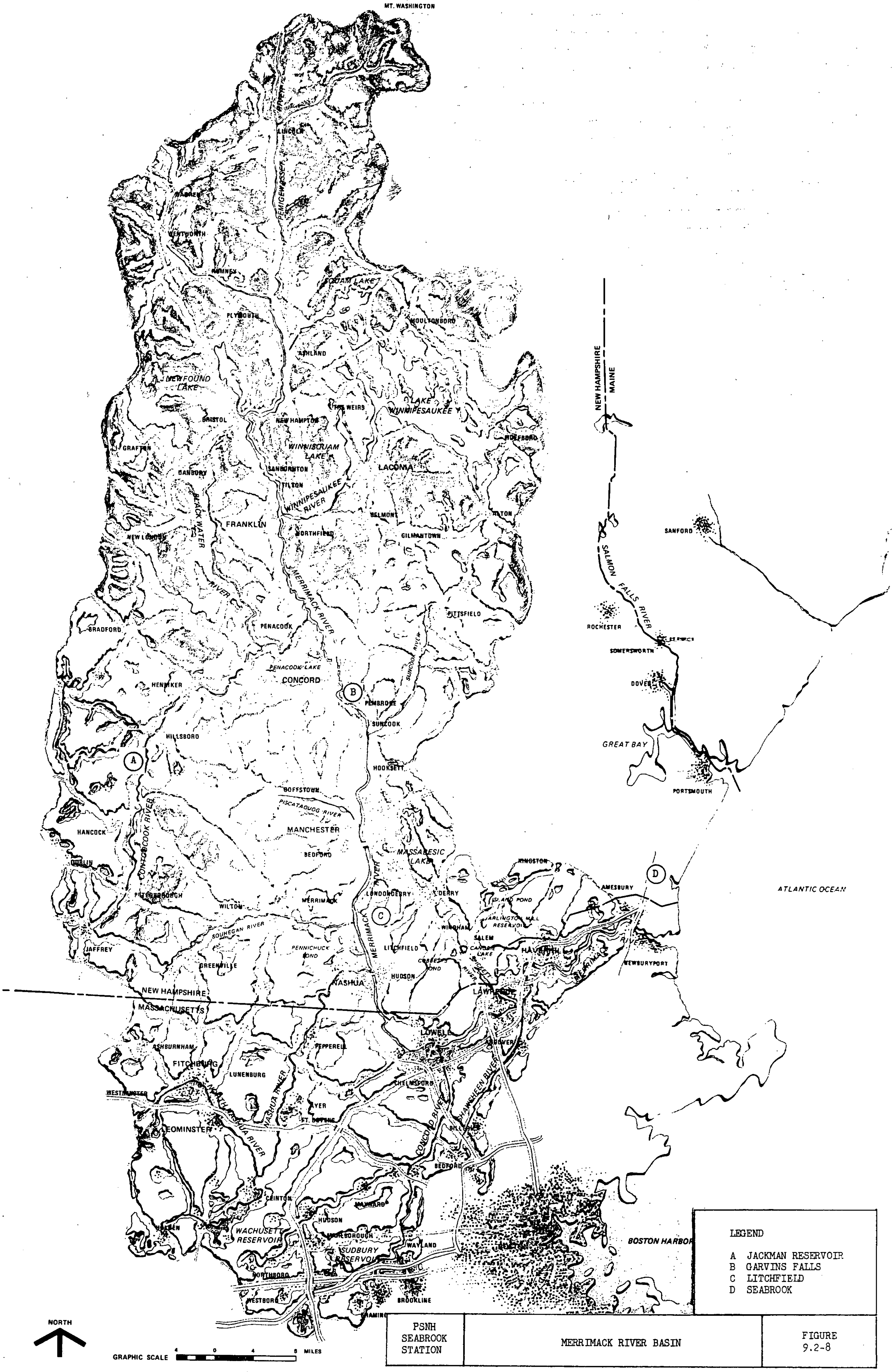


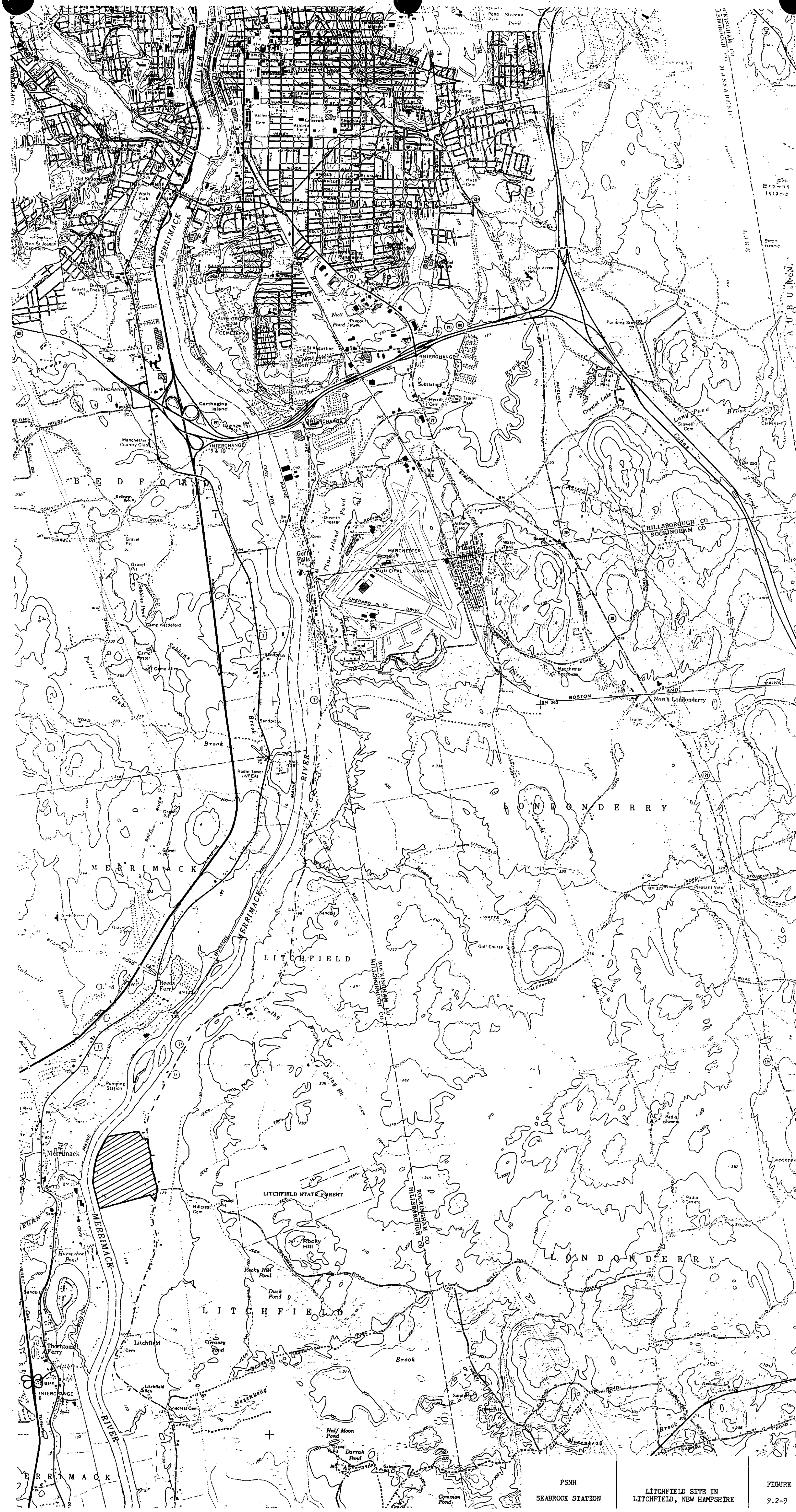
FIGURE 9.2-7
State of New Hampshire
PUBLIC UTILITIES COMMISSION
CONCORD
MAP OF
ELECTRIC UTILITIES
TRANSMISSION
IN
NEW HAMPSHIRE
LEGEND
COOP NEW HAMPSHIRE ELECTRIC COOPERATIVE, INC.
CEC CONCORD ELECTRIC COMPANY
CVE CONN. VALLEY ELECTRIC COMPANY, INC.
E&H EXETER & HAMPTON ELECTRIC COMPANY
GSE GRANITE STATE ELECTRIC COMPANY
NEP NEW ENGLAND POWER COMPANY
BNH BROWN - NEW HAMPSHIRE, INC.
PSNH PUBLIC SERVICE COMPANY OF N.H.
CMP CENTRAL MAINE POWER COMPANY
LINES & STATIONS
115 KV
230 KV
345 KV LINES
66 KV. TRANSMISSION LINES
35 KV. TRANSMISSION LINES
13.2 KV. & SMALLER TRANSMISSION LINES
HYDRO GENERATING STATION-KVA
STEAM GENERATING STATION-KVA
COMBUSTION TURBINE GENERATING STATION-KVA
SUBSTATION-KVA
CUSTOMER OWNED ≥ 2000 KVA
TRANSMISSION SUBSTATION-KVA
SWITCHING STATION
TRANSMISSION LINE TIE IN
METERING POINT OF COOP
N
W
E
S
REVISED DECEMBER 31, 1971



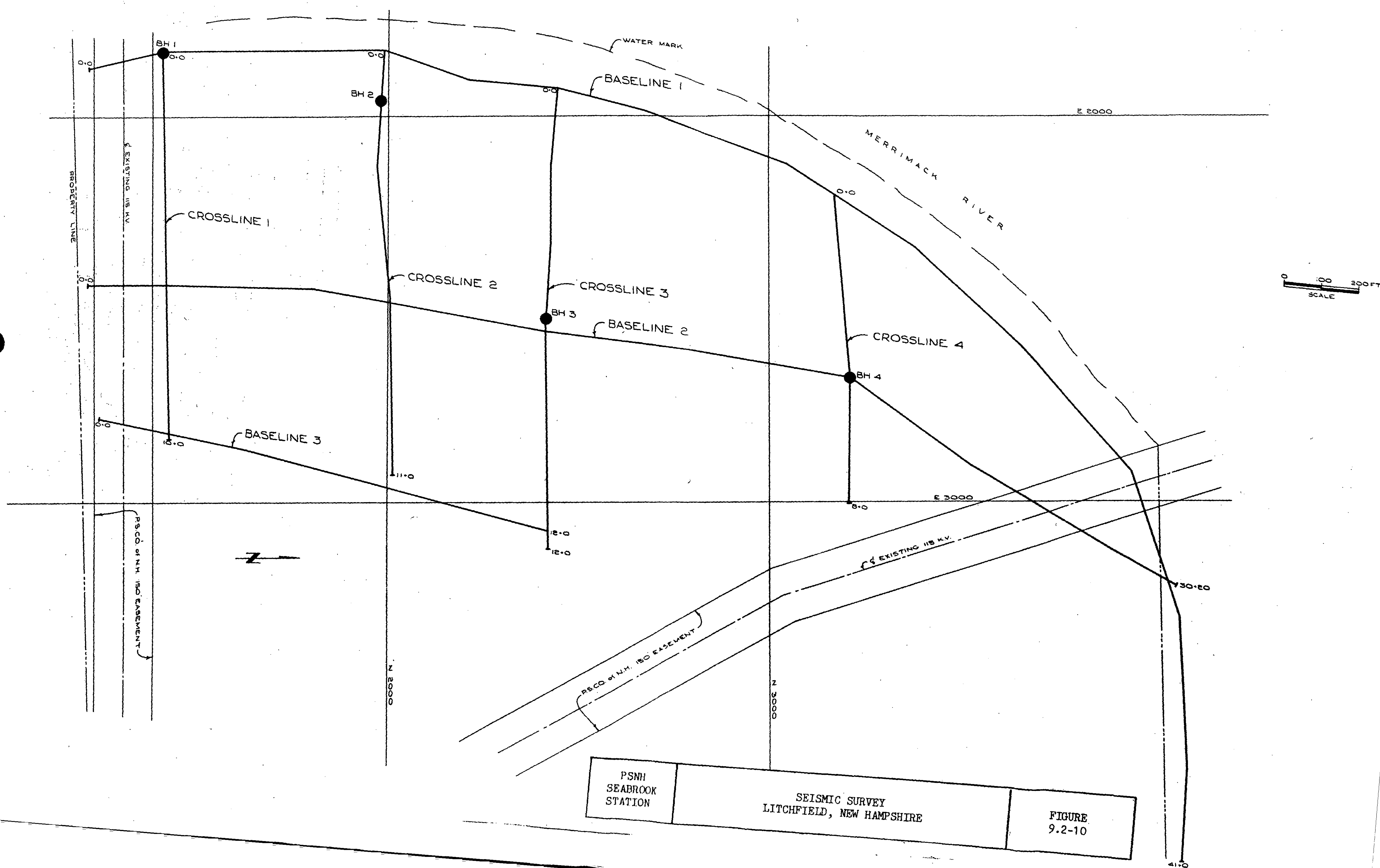
LEGEND

A JACKMAN RESERVOIR
B GARVINS FALLS
C LITCHFIELD
D SEABROOK

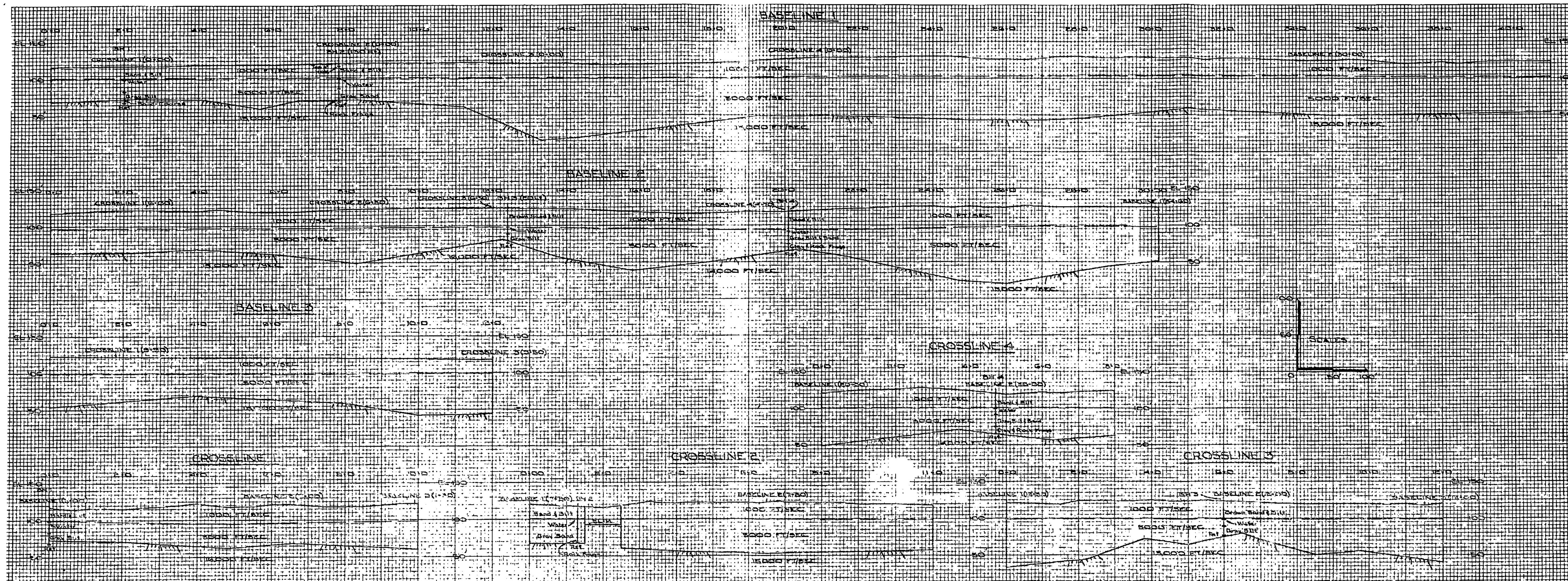
PSNH SEABROOK STATION	MERRIMACK RIVER BASIN	FIGURE 9.2-8



PSNH	LITCHFIELD SITE IN	FIGURE
SEABROOK STATION	LITCHFIELD, NEW HAMPSHIRE	9.2-9



PSNH SEABROOK STATION	SEISMIC SURVEY LITCHFIELD, NEW HAMPSHIRE	FIGURE 9.2-10



PSNH SEABROOK STATION	SEISMIC SURVEY LITCHFIELD, NEW HAMPSHIRE	FIGURE 9.2-11

BORING #3

CASING: 6" HOLLOW STEM AUGER
SAMPLER: 2" SPLIT SPOON
HAMMER WT. - 140 lb
HAMMER FALL - 30"
GROUND WATER AT 27'

SAMPLE NO.	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER
1	15-17	4/5/5/6
2	25-26.5	5/5/7
3	35-36.5	13/16/18
4	44-46	3/4/4/4

DEPTH (ft.): 0, 10, 20, 30, 40, 50

Topsoil
Light Brown Fine Sand & Silt
Brown Silt & Fine Sand
Gray Silt & Fine Sand
REFUSAL

BORING #4

CASING: 6" HOLLOW STEM AUGER
SAMPLER: 2" SPLIT SPOON
HAMMER WT. - 140 lb
HAMMER FALL - 30"
GROUND WATER AT 27'

SAMPLE NO.	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER
1	15-16.5	6/7/9
2	25-26.5	7/9/11
3	35-37	3/4/4/5
4	45-46.5	17/21/42

DEPTH (ft.): 0, 10, 20, 30, 40, 50

Topsoil
Light Brown Fine Sand & Silt
Brown, Fine to Medium Sand, Some Silt
Gray Silt, Some Fine Sand
Gray Sand and Gravel Some Silt - Possible Till
REFUSAL

PSNH SEABROOK STATION	LOG OF BORINGS LITCHFIELD, NEW HAMPSHIRE	FIGURE 9.2-12 SHT 1 of 2

BORING #1

CASING: 6" HOLLOW STEM AUGER
SAMPLER: 2" SPLIT SPOON
HAMMER WT. - 140 lb
HAMMER FALL - 30"
GROUND WATER AT 21'

SAMPLE NO.	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER
1	15-16.5	2/1/3
2	25-26.5	2/2/3
3	35-36.5	4/6/6
4	44-46	9/37/81/44
5	50.5-51	300

DEPTH (ft)	Strata
0	Topsoil
10	Light Brown Fine Sand & Silt
35	Gray Silt, Some Fine Sand
44	Fine to Coarse Sand and Gravel
50	Ground up Rock Fragments - Possible Weathered Rock
	REFUSAL

BORING #2

CASING: 6" HOLLOW STEM AUGER
SAMPLER: 2" SPLIT SPOON
HAMMER WT. - 140 lb
HAMMER FALL - 30"
GROUND WATER AT 21'

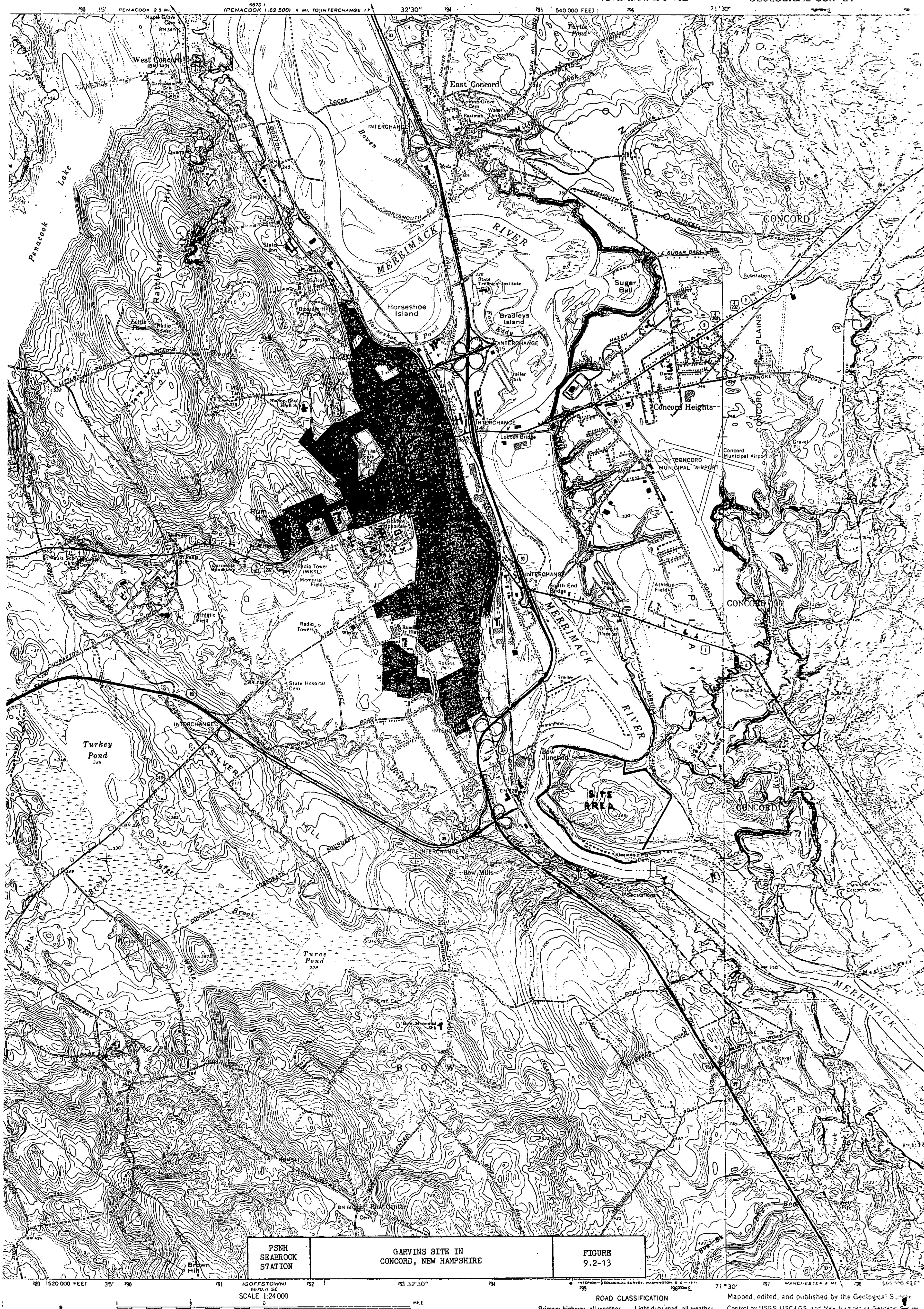
SAMPLE NO.	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER
1	15-16.5	4/6/6
2	25-26.5	3/5/5
3	32-33.5	6/8/7
4	35-37	3/4/6/6
5	45-46.5	5/5/5
6	53-53.5	

DEPTH (ft)	Strata
0	Topsoil
10	Light Brown Fine Sand & Silt
35	Gray Silt, Some Fine Sand
50	Ground Up Rock Fragments - Possible Weathered Rock
	REFUSAL

PSNH SEABROOK STATION	LOG OF BORINGS LITCHFIELD, NEW HAMPSHIRE	FIGURE 9.2-12 SHT 2 of 2

CONCORD QUADRANGLE
NEW HAMPSHIRE – MERRIMACK CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 CONCORD 15' QUADRANGLE

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



PSNH SEABROOK STATION	GARVINS SITE IN CONCORD, NEW HAMPSHIRE	FIGURE 9.2-13

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

UTM GRID AND 1967 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, all weather, hard surface	Light-duty road, all weather, improved surface
Secondary highway, all weather, hard surface	Unimproved road, fair or dry weather

Interstate Route — U. S. Route — State Route

Mapped, edited, and published by the Geological Survey

Control by USGS, USC&GS, and New Hampshire Geodetic Survey

Topography by photogrammetric methods from aerial photographs taken 1967. Field checked 1967

Polyconic projection. 1927 North American datum. 10,000-foot grid based on New Hampshire coordinate system. 1000-meter Universal Transverse Mercator grid ticks, zone 19, shown in blue

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

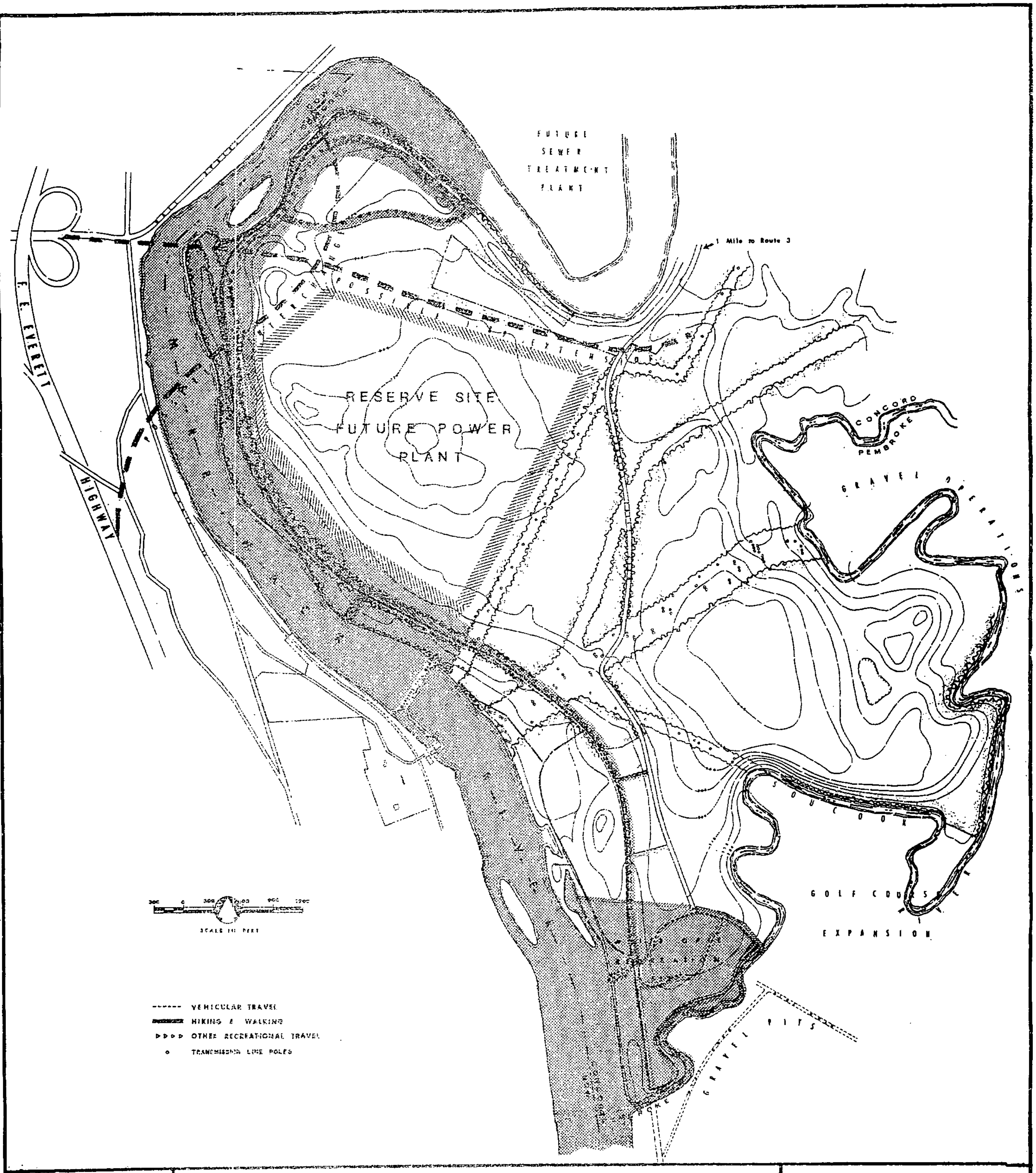
CONCORD, N. H.
NE/4 CONCORD 15' QUADRANGLE
N4307.5—W7130/7.5

1967

AMS 6670 II NE—SERIES V812

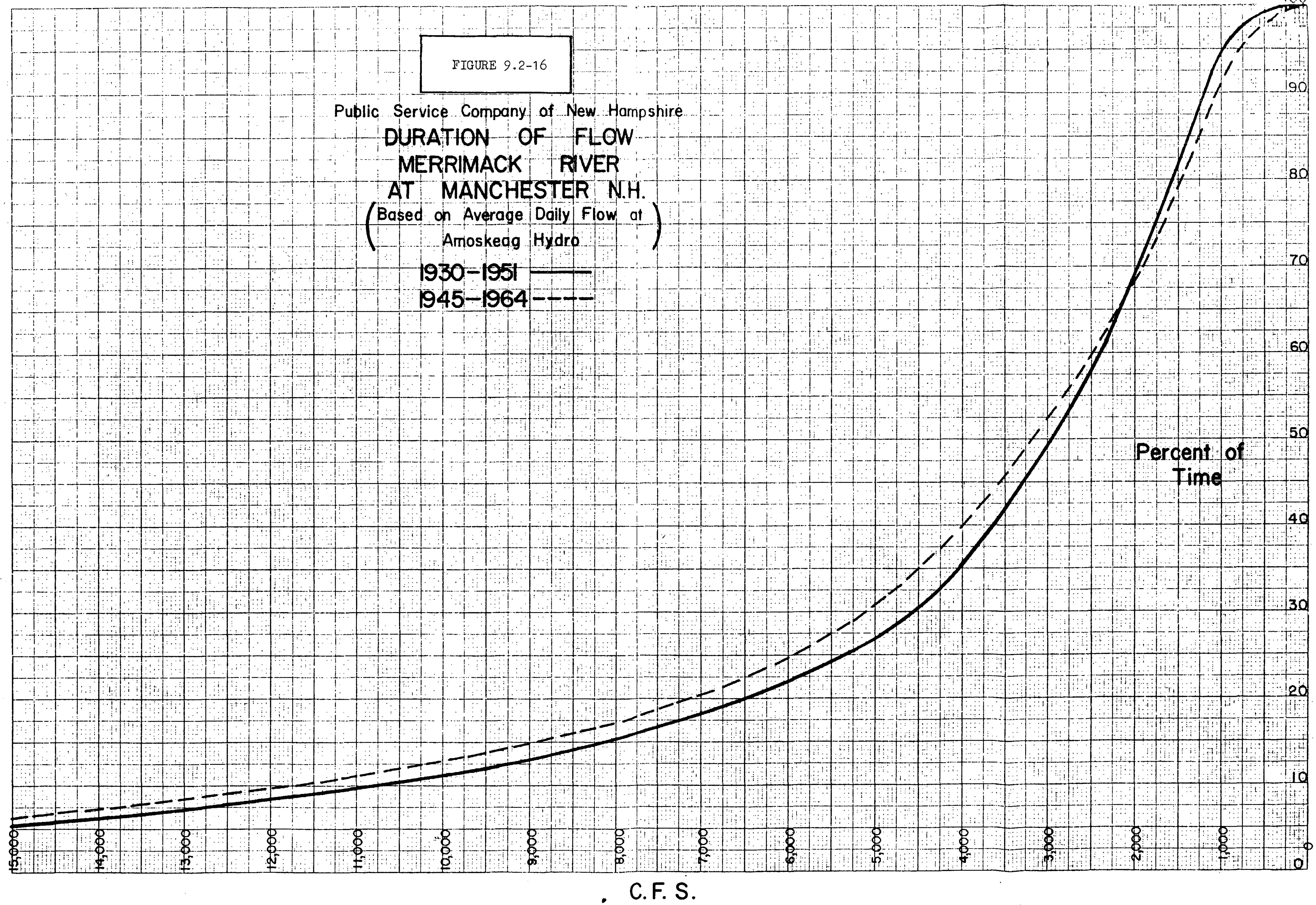
This figure has been deleted

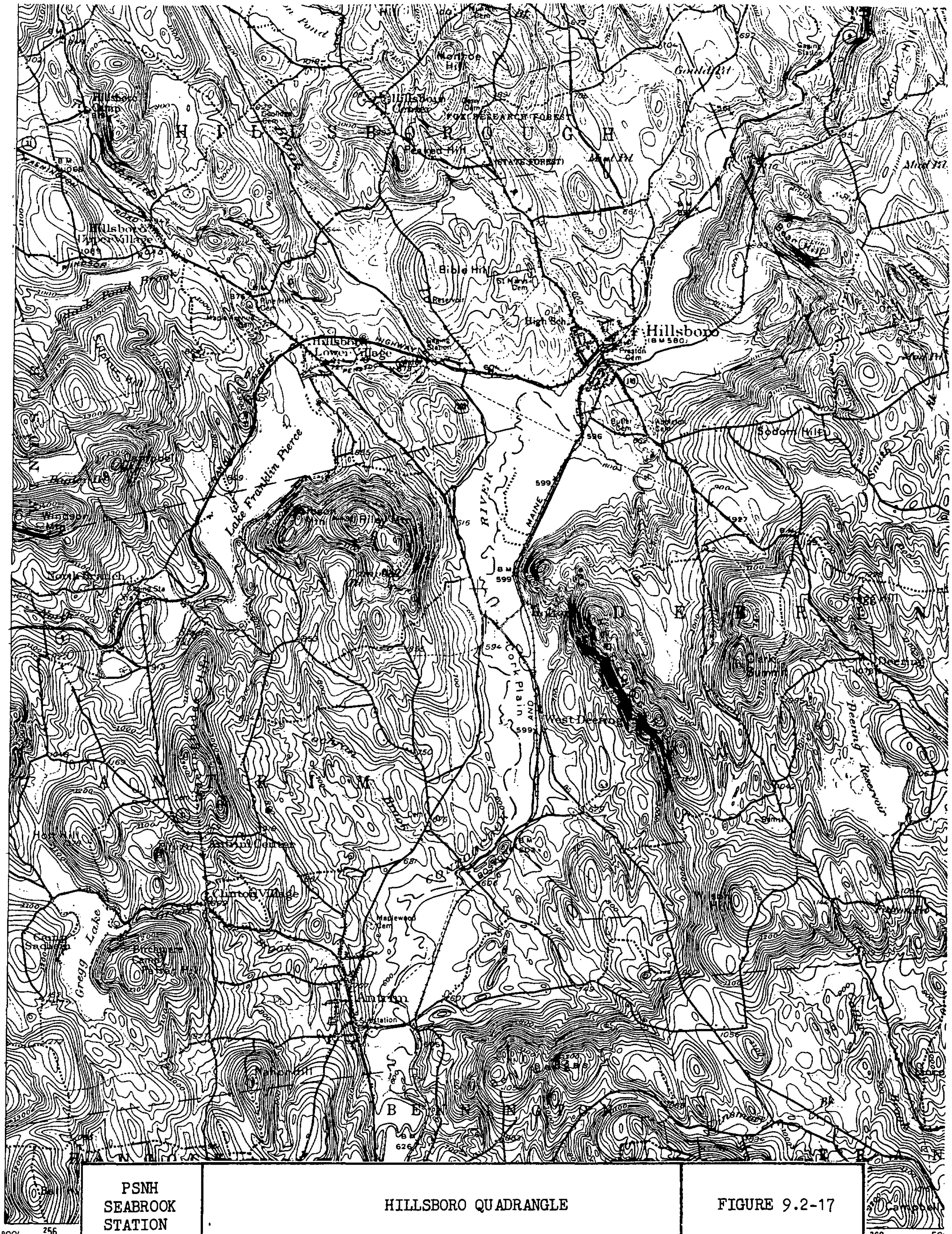
Figure 9.2-14



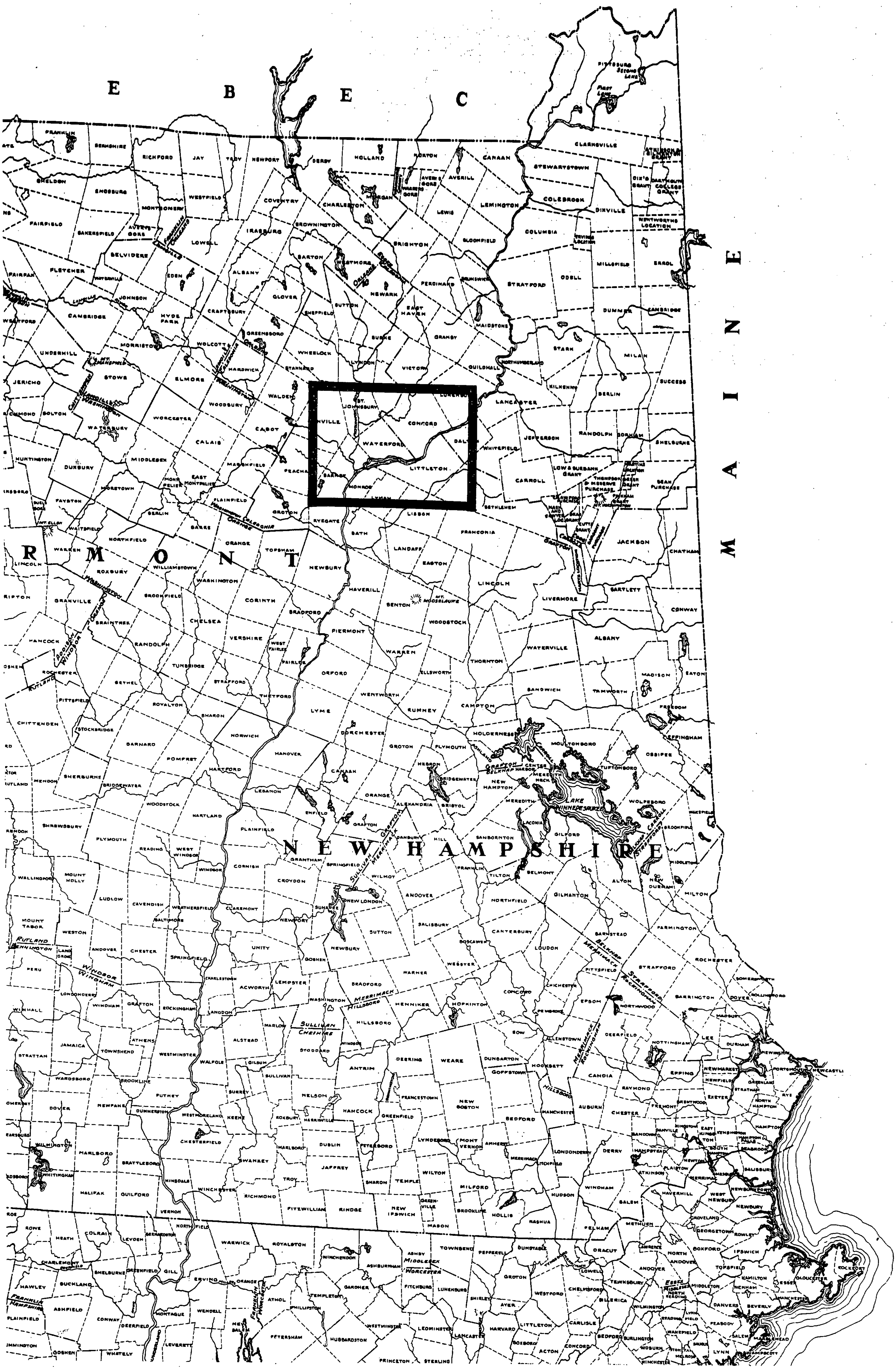
PSNH SEABROOK STATION	GARVINS FALL AREA	FIGURE 9.2-15

FIGURE 9.2-16

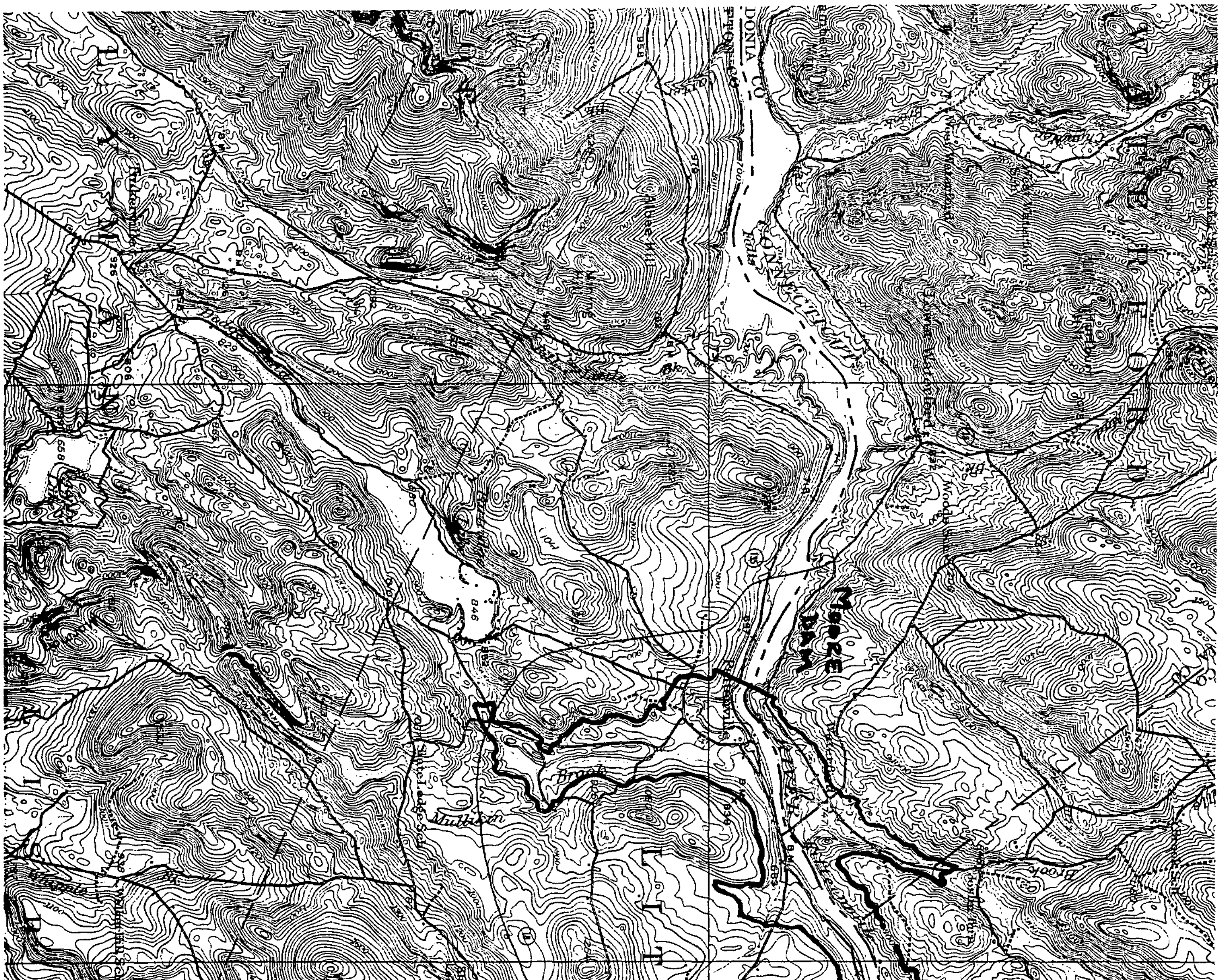

Public Service Company of New Hampshire
DURATION OF FLOW
MERRIMACK RIVER
AT MANCHESTER N.H.
(Based on Average Daily Flow at Amoskeag Hydro)
1930-1951 ———
1945-1964 - - - -
Percent of Time
100
90
80
70
60
50
40
30
20
10
0
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
C.F.S.



PSNH SEABROOK STATION	HILLSBORO QUADRANGLE	FIGURE 9.2-17

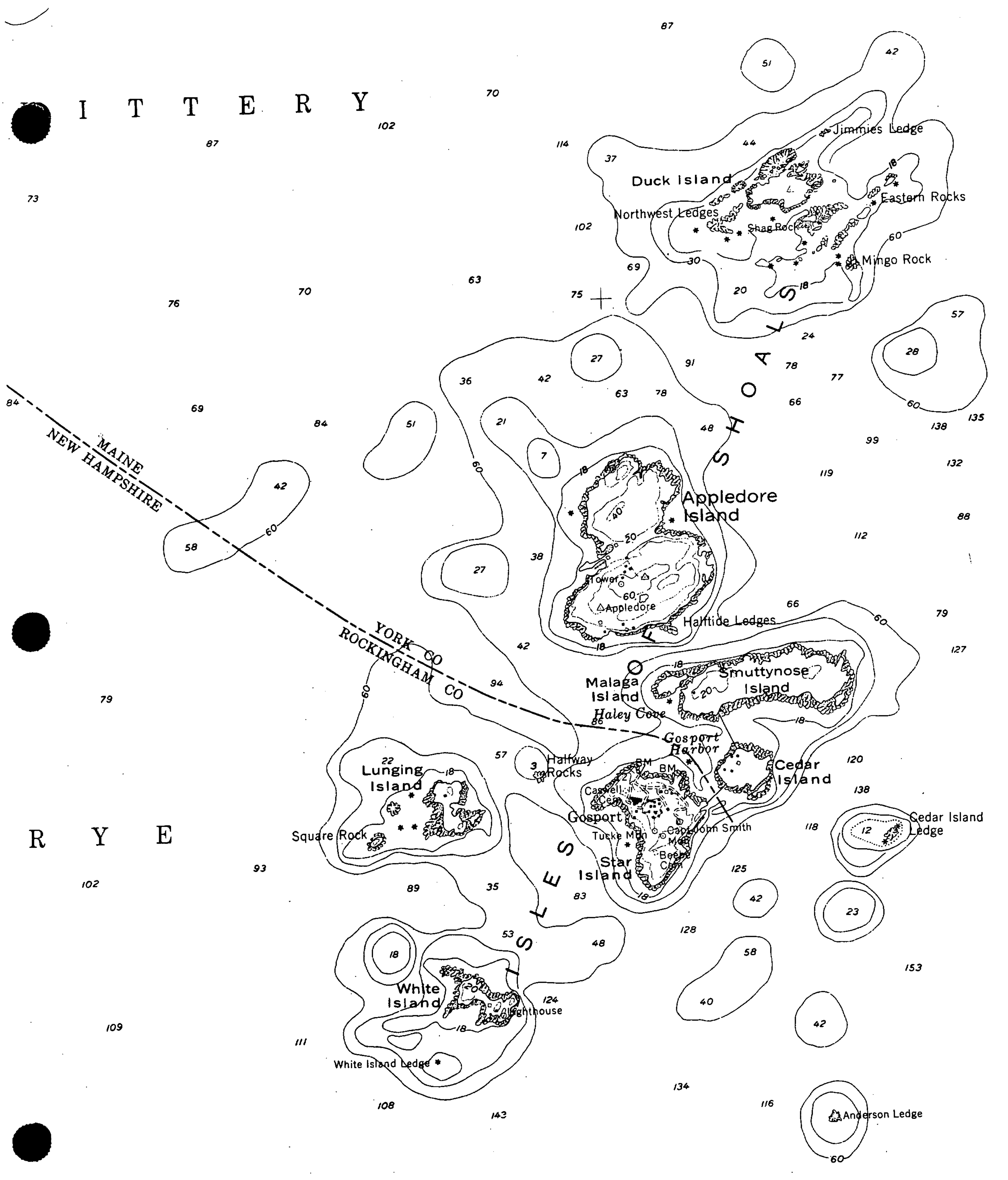


PSNH SEABROOK STATION	STATE OF NEW HAMPSHIRE	FIGURE 9.2-16



PSNH SEABROOK STATION	TOPOGRAPHY OF MOORE POND AREA	FIGURE 9.2-19

PSNH SEABROOK STATION	POTENTIAL SITES IN THE PORTSMOUTH AREA	FIGURE 9.2-20



PSNH SEABROOK STATION	ISLES OF SHOALS	FIGURE 9.2-21

9.3 Comparison of Practicable Alternatives and the Proposed Facility

In the selection of the final sites to be considered as alternatives to the Seabrook Site, the options to the Company were an inland river or an ocean front site. The overriding concern was the cooling water supply and its resulting environmental impact.

A nuclear plant of approximately 2280 MW has a need for approximately 700,000 gpm of cooling water for a once-through system. No inland river site considered available to Public Service Company of New Hampshire has a dependable year-round flow of this magnitude. If a supplemental cooling system is employed approximately 100 cfs of make-up water must be supplied. The Merrimack River, upon which the Garvins and Litchfield sites are located, has been known to have seasonal flows that do not exceed 1,000 cfs. A nuclear plant built along the Merrimack River even with supplemental cooling means could take more than 10 percent of the periodic low flows of the river as make-up water. The Garvins and Litchfield sites, therefore, are less desirable site alternatives for nuclear plants under the technology available today to remove heat from a turbine generator condenser.

A fossil plant of 2280 MW would use approximately 60 percent of the water required for a similar sized nuclear plant for a once-through system. A closed system would correspondingly use less water. Although the amount of water needed for make-up at Garvins and Litchfield with a closed cooling system could still be a sizable percentage of the possible low flow of the river, it is felt that a fossil plant could be built at either the Garvins or Litchfield site. To do this probably would have some adverse environmental impact but this would have to be weighed against the favorable characteristics of the sites.

Of the several possible fuel sources which are possible for use by this station, the Company considers only residual fuel oil as the only practical, but not desirable, alternative. There are both economic and environmental advantages to using nuclear energy over residual fuel oil.

The Company estimates the economic advantage of a nuclear plant over a residual fuel oil plant at an average of $39 million a year for the owners of the Seabrook Plants, and therefore over $19 million a year to the rate payer of New Hampshire (See Table 9.3-1). The added capital costs for a nuclear plant are estimated to be approximately $338 million or $148 per KW over an oil-fueled plant. This added cost is offset by a benefit of $90 million in operating costs. The major factor here is an estimated fuel cost benefit of $5.60 per MWH for nuclear fuel. Over the life of the plant the total savings will run in many hundreds of millions of dollars to the rate payers of New Hampshire and New England.

Environmentally, a nuclear plant located at Seabrook will have much less impact than a comparable oil-fired plant. The discharge of heated water will be greater from a nuclear plant but with the ocean as a heat sink, and with proper engineering design, this impact will be minimal. The fuel for a nuclear plant would be trucked to the site every year, whereas an oil plant would need a large area for fuel tanks and facilities for docking large ocean-going oil tankers. The environmental impact may not be any greater for oil if you disregard the land use for the fuel tanks, but the risk of an oil spill enroute from the foreign oil fields; or even worse off, New Hampshire's beaches, has the potential for a serious impact upon the beaches and salt marshes.

The standards for air quality as set forth in EPA Standards of performance for new stationary sources (42CFR466) and by the State of New Hampshire Air Pollution Control Agency require the control of particulate matter, and sulfur and nitrous oxide gases. These standards have been lowered considerably over the past few years as environmental awareness has made everyone more conscious of the need for cleaner air, and by 1980 more restrictive legislation could be put in effect.

To meet these standards new power stations would probably utilize low sulfur fuels, specialized firing processes and precipitators, but based upon the existing standards it could be expected that two 1140 MW oil-fired plants built in place of Seabrook Nuclear Units 1 and 2 could release annually to the atmosphere the following:

Effluent	Emission Standard in lbs/MBTU EPA	N.H.*	Total Emissions*** ton/year
Particulate Matter	0.2	.12	8,400
Sulfur Dioxide	0.8	**	56,000
Nitrous Oxides	0.3	-	21,000

* For oil fired plants.
** Minimum of 1% sulfur fuel oil required.
*** Based upon lower of EPA or State standard for 7,000 hours of operation per unit

The above standards do not include the requirement for ambient air quality which would have to be developed in detail for a particular site.

The possibility of radiation releases from a nuclear plant either low level or through a major incident could have considerable environmental effects, but the probability of this is considered remote and is covered in detail elsewhere in this report.

By comparing fossil plants with nuclear plants, the Company has shown that a nuclear plant is economically and environmentally more desirable. The Seabrook Site is in balance the best site for either a fossil or a nuclear plant available to the Company at this time. The selection of Seabrook for a nuclear plant then follows as the best fueled plant at the best location.

The Seabrook Site has been studied by other government agencies for suitability. In its 1971 report (Reference 2) the New England River Basin Commission found that "There appears to be no better alternate site for a nuclear power plant available to Public Service Company of New Hampshire". Although this report was made for one 860 MW unit which was deferred in November 1969, it is believed that the findings still hold true. The cautions suggested in the report have largely been overcome by the ocean intake and discharge design which the Company now plans to use. A 1973 report by the New England Energy Policy Staff

(Reference 3) also found that "The general location of the proposed unit seems well suited to anticipated load-growth patterns for both the state and region." On a regional level, the Southeastern New Hampshire Regional Planning Commission in their 1972 report (Reference 4) on future land use plans have included the projected generation plans for the Company in the report. The reports show that the Company's plans (including Seabrook) can be integrated into the regions plans for an orderly land use planning.

Surveys (Reference 5) taken in Seabrook and the surrounding areas during the end of August 1972, by the Central Survey, Inc. showed that nuclear fuel is favored over conventional fuel by a 5-to-1 ratio for the production of electricity. Also the majority of residents questioned believed that the plant would be a good thing for the area. The primary concern regarding the plant was the effect it might have on the marshes and the animal and marine life of the area. There was relatively little concern about alleged dangers of radiation or nuclear explosions.

The needed transmission line rights-of-way of this site have been carefully discussed with the local Seabrook officials and with other town and regional officials along the new routes as well as environmental groups in the area. The comments solicited from these groups were considered in the final planned routes and in most instances suitable accommodating allowances were made.

On the plant site itself, the Company has engaged Kling/Planning of Philadelphia to assist in the land use and site design (Appendix I). Their reports and continuing assistance will ensure that the plant site is developed in a manner that will be aesthetically pleasing and environmentally considerate.

References

1. Jackson & Moreland, "Nuclear Plant Site Study for Public Service Company of New Hampshire", April 14, 1967.

2. New England River Basin Commission, "Environmental Evaluation of Seabrook, New Hampshire Nuclear Power Plant", January 1971.

3. New England Energy Policy Staff, "Analysis of Need for Future Generating Capacity In New England and New Hampshire" - January 1973.

4. Southeastern New Hampshire Regional Planning Commission, "Future Land Use Plans", May 1, 1972.

5. Central Survey, Inc., "An Opinion Survey Regarding Seabrook Nuclear Plant Site", August 28 - September 7, 1972.

TABLE 9.3-1

ECONOMIC COMPARISONS OF NUCLEAR VS. RESIDUAL OIL FUEL ALTERNATIVES OF TWO 1140 MW GENERATING PLANTS AT SEABROOK SITE

	Nuclear Investment (Millions)	Nuclear $/KW	Oil Fired Fossil Investment (Millions)	Oil Fired Fossil $/KW
1. Capital Costs				
a. Generation Plant	$ 1040	$ 456	$ 702	$ 308
b. Cooling Water Supply	100	44	100	44
c. Switchyards	5	2	5	2
d. Transmission	10	5	10	5
e. Other	0	0	0	0
TOTALS	$ 1155	$ 507	$ 817	$ 359

	Nuclear Cost (Millions)	Nuclear $/MWH	Oil Fired Fossil Cost (Millions)	Oil Fired Fossil $/MWH
2. Annual Costs*				
a. Fixed Charges on Investment and Insurance	$ 177	$11.10	$ 126	$ 7.90
b. O & M	24	1.50	24	1.50
c. Fuel Costs	27	1.70	117	7.30
TOTALS	$ 228	$14.30	267	16.70
			228	
Average Annual Savings			$ 39	

* Levelized fixed charges and average operating expenses at 80 percent plant factor.

NOTE: Estimated costs (including interest during construction) are in 1979 and 1980 dollars for Units I & II, respectively.

10. PLANT DESIGN ALTERNATIVES

CHAPTER 10

PLANT DESIGN ALTERNATIVES

In any facility as large and complex as a nuclear generating station there are of necessity several interfaces between the plant and its environment. At such points, there generally is available to the designer a choice of equipment or systems for use in making the interface and therefore, the ability to control the decree of impact of the facility in a particular area.

In the case of Seabrook Station this is true. Plant designers will have several options to choose from in selecting influent and effluent equipment, structures and systems. The plant design must provide the means to discharge heat from the power conversion cycle. Sanitary and process wastes are produced and must be disposed of. Demineralized water is needed for makeup to the plant fluid cycles. The power generated on the site must be transmitted to the owners' load areas.

The design for each of these environmental interfaces can be adjusted to reduce an impact or shift its point of emphasis. In no case is elimination of the interface a true option but shifting or altering may be. In this section the alternative environmental systems considered before arriving at the proposed design are discussed. Selection of a proposed alternative has been based not only on environmental impacts but also upon the effects on plant performance, capability and costs.

Compliance with regulations of State and federal agencies also dictates features of design and levels of performance. At this point, we are sure that all the regulations which will ultimately be applicable to the station have not been promulgated. With this in mind the design for each of the environmental systems has the ability to be altered. Although in some cases this would involve substantial costs, the design is nevertheless not immutable.

10.1

10.1 Cooling System

10.1.1 Background Information

Seabrook was first proposed as a nuclear plant site in an AEC License Application dated April 9, 1969. That earlier project was suspended on November 7, 1969 when agreements between potential owners could not be effected. The design review did progress to the point that AEC and other agencies had the opportunity to examine the proposed design.

The cooling system for the 1969 plant was based upon once-through cooling using 440,000 gallons per minute of salt water. A canal was proposed to be dredged across the salt marsh from Hampton Harbor to the plant. Circulating water pumps at the end of the canal on the site would pump the required water through the condensers and a discharge pipe laid under the marsh, harbor, and Hampton Beach State Park to an offshore, single-port discharge. Environmental studies were conducted to determine this system's effect on the harbor ecology. These included hydraulic model studies at Alden Research Laboratories, dye diffusion studies and investigations on the existing ecology.

Normandeau Associates, Inc., the bio-environmental consultant who performed the field work, arrived at certain conclusions on the 1969 proposed system: (Reference 1).

1) The harbor intake would not affect the biotic community except for the area lost in dredging the canal.

2) Passage of fish within the estuary should not be a problem with adequate precautions at the intake.

3) Entrained plankton would suffer a high mortality but passage of zooplankton and phytoplankton through the cooling system should not have detectable effects on the general ecology of the area.

Normandeau Associates could not conclude at that point that there definitely would not be an effect upon the soft-shelled clam population. The next year further studies were commissioned to gather information on important life cycle characteristics of the soft-shelled clam. The New England River

Basins Commission in its very comprehensive study of the Seabrook site identified the unknown effects of the harbor intake upon the clam population as the central environmental issue (Reference 2).

When it became possible to reopen the Seabrook Project in February 1972, following the acceptance of the New England Power Pool (NEPOOL) Agreement, the knowledge and concerns from the 1969 project were fully considered. Certain of the Company consultants felt that placing the cooling water inlet for the plant in the estuary probably would not endanger the estuary ecologically. Nevertheless it seemed to be a very difficult task to prove sufficiently for public and regulatory acceptance that lasting damage indeed would not result from a harbor inlet. The latent uncertainty on biological effects and the high probability that severe delays along the licensing route would result caused the applicant to review in depth potential cooling systems designs.

10.1.2 Range of Alternatives

In February 1972, Chas. T. Main, Inc. was retained to perform an independent analysis of condenser cooling systems. This study was performed and reported upon publicly. The condensing water study report is included in this report as Appendix F. It is this work which identified the alternative cooling systems and provides the cost data to evaluate them. Since this study was performed early in the project life, C. T. Main was not given a precise set of economic evaluation factors to work with. Rather, they were left to set the bounds of the study and evaluate the alternatives with little intervention by PSNH. As a result, the study represents an independent assessment of alternatives using economic evaluation factors computed by C. T. Main. In some cases these factors differ slightly from those used in other PSNH studies but not enough to alter the conclusions of the study.

The scope of the C. T. Main study embraces all types of condenser cooling which were considered feasible for two approximately 1200 MW nuclear units. These types of cooling are:

1. Once-through open cycles using ocean water discharged back into the ocean. Variations in this type of cooling included temperature rises of 45°F and alternately 15°F, and various arrangements of intake structure location.
2. Closed cycle cooling towers using evaporative cooling of condensing water. Both the natural draft and mechanical draft towers were included in the study.
3. Closed cycle condensing water canal using power spray modules to cool the condensing water by evaporative cooling of the sprayed water.
4. Closed cycle dry cooling towers which cool the condensing water by recirculation through finned-tubed heat exchangers over which air is blown by mechanical draft fans.

The study consisted of the preparation of conceptual design drawings of each of the various plans; investment estimates of all plans, both at the 1972 price level and at the estimated price level expected to prevail at the actual time of construction; economic evaluations of each plan which embrace all costs to own and operate and include:

1. Fixed charges on investment.
2. Fuel cost resulting from turbine exhaust pressure variations.
3. Pumping, spray and fan power cost.
4. Other operating and maintenance cost.
5. Generating capability penalities resulting from relative turbine back pressure and pump spray and fan power.

Optimization studies were made to determine the most ecomomical design features of each plan, such as, condenser temperature rise; pipe size; cooling tower cooling range and cooled water temperature approach to a selected design ambient wet bulb temperature; number and arrangement of spray cooling modules; and condenser surface, tube size and length, etc.

More detailed descriptions and drawings for each cooling configuration are to be found in Appendix F. Only alternatives which could be physically adapted to the site were considered seriously. For example, a cooling pond without spray modules was not investigated in depth since it would obviously require destroying many acres of salt marsh or extensive encroachment upon the nearby residential area.

Having completed this evaluation and selected once-through cooling as the best alternative, a further study was undertaken to assess the feasibility and acceptability of using bedrock tunnels instead of buried conduits. The results of this evaluation indicate that the tunnel concept is economically more attractive and requires less disruption of the marshy harbor, state park and offshore area during construction of the cooling system.

10.1.3 Effects on Plant Generation

The cooling system configuration can greatly affect the station electrical output. All other factors being equal, the cooling system requiring the least auxiliary power and which allows turbine operation at the lowest back pressure will enable the plant to deliver the largest amount of energy to the transmission system. Conversely cooling systems with characteristics that result in a higher condenser back pressure or higher auxiliary power requirements leave less energy for the ultimate user. The power consumed in the cooling system operation and any power not available due to high back pressure conditions will have to be generated at some other facility with its own environmental impact.

The effect on plant (2 units) net generation for each of the cooling systems studied is tabulated below in terms of power to operate the cooling system equipment and the cooling system effect on generating capability due to high back pressure.

Once-Through Systems		Cooling System Operation-KW	Differential Max. Generating Capability-KW	Net Differential Plant Generating Capability Loss-KW
Ocean Intake	15° Rise	28,400	Base	10,250
	45° Rise	22,000	- 45,080	49,180
Inland Intake	15° Rise	17,900	Base	Base
	45° Rise	17,300	- 45,080	44,480
Storage Reservoir	15° Rise	39,900	Base	22,000
	45° Rise	22,180	- 45,080	49,360
Closed Cycle Systems				
Natural Draft Tower		24,860	-105,340	112,300
Forced Draft Tower		35,760	- 77,800	95,660
Power Spray Modules		28,560	-160,464	171,124
Dry Cooling Towers		76,600	-314,000	372,700

This analysis which is discussed in more detail in Appendix F takes into account the fact that generation will have to be reduced at times of high circulating water temperature. This may well occur when portions of the NEPOOL system are experiencing summer peaks of demand. To the extent these occurrrences can be forecast, system generating capacity would have to be increased at other sites to replace the generation lost from Seabrook Station due to cooling system and plant performance.

10.1.4 Monetized Costs

Details of the cost evaluation of the several alternatives studies by C. T. Main are given in Appendix F along with the assumptions used in the analyses. The components for each system are tabulated and priced out with operating costs. A summary cost comparison appears in Table 10.1-1 calculated as of the operating dates of the two units.

10.1.5 Environmental Costs

The environmental effects of the alternative cooling systems vary in magnitude and point of impact. The once-through systems place the greatest impact on the offshore biotic community in the form of entrainment, entrapment and some exposure to warmed water. The two systems studied which use offshore intakes have effects differing in magnitude as a result of the volume of cooling water passed through the plant. The design based upon a 15 degree condenser rise will require three times the water flow that a 45 degree rise system would. This means that three times the number of entrained organisms would be passed through the plant. Organisms passing through the system will experience mechanical abrasion, pressure and velocity differences and a 38 minute travel time at the elevated temperature.

It is felt that even with a 15 degree condenser rise a large percentage of the entrained organisms will be killed. Some might survive, but it is difficult to predict what fraction. With a 45 degree rise condenser, it is likely that all entrained organisms will be killed. If only one-third of the organisms passing through the 15 degree rise system are killed, the total number of mortalities would be no greater than with the 45 degree judgment of the applicants' consultants that more than one-third of the entrained organisms would be killed in the 15 degree system. Hence from an entrainment point of view the 45 degree rise system has the lesser impact of the two.

Closed-cycle, evaporative cooling systems have impacts of a different nature on the environment. They will still require salt water for makeup of evaporative losses and to blowdown or dilute the brine in the cooling tower or spray module basin and to dilute the waste disposal system output. The effect of the highly saline blowdown would have to be considered at its point of return to the ocean or estuary. In addition the closed cycle systems will require much more land for the cooling structures. In the case of the spray modules nearly all of the remaining site above high tide would be used for the cooling canal. Next to the increased land use, the greatest effect of the evaporative cooling systems would be the visible plume and drift of salt water from the towers or spray modules.

The dry cooling tower design was investigated by C. T. Main even though the system is not considered technically feasible for a plant of this size at this time. The environmental impact of a dry cooling system would shift entirely from the marine community to the terrestrial. The coolers would require clearing of nearly all the high ground of the site. Of all the systems studied this one would produce the most objectionable sound levels from the many and large high speed fans. The dry towers, covering over twice the area of the power plant structures, would be visible from many offsite areas.

An attempt has been made to quantify the environmental effects of the alternative cooling systems. The results are given in Table 10.1-4. In spite of the comprehensiveness of the environmental studies in the area of the inlet and discharge, many of the suggested environmental costs are difficult to quantify. The proposed inlet and discharge design incorporates many features designed to alleviate potential problems. Because of these features the Seabrook system is unique in this region of the country and hence difficult to assess with exactitude.

10.1.6 Fish Entrapment

The magnitudes of the primary impacts of the systems were estimated using the assumptions or bases described in the following paragraphs.

The estimated pounds of entrapped adult fish were calculated on the basis of studies at the Public Service Company of New Hampshire Schiller Station. This plant is located near the mouth of the Piscataqua River estuary. Studies on entrapment have been conducted for 2 years on the intake to unit 4, a 48 MW fossil unit using a condenser cooling water flow of 28,200 gpm. The intake is at the river bottom level with a velocity of over 2 feet per second at the travelling water screens.

Entrapment at Schiller has been at the approximate rate of one fish per three operating hours. The Seabrook inlet will be above the ocean floor and away from the shore and will have a lower inlet velocity so an extrapolation of Schiller data to Seabrook conditions may exaggerate a condition. Nevertheless, using the ratio of cooling water flows to estimate the fish entrapped gives 202 fish per day or 73,500 per year for Seabrook. Cunner and pollock are two species which potentially will be entrapped. Adults of these species typically weigh one-half and two or three pounds respectively. On this basis, the entrapped fish might weigh in total 147,000 pounds per year. The value of these, if priced at the current 10 cents per pound dock side value of Pollock, would be $14,700 per year. Cunner are essentially without commercial value therefore this figure is probably over estimated.

The fish entrapment for a 15 degree rise system would be three times that of the 45 degree rise system since flows and inlet dimensions features of the design would be increased proportionately.

Fish entrapment with an inlet canal off the estuary could result in a change in species entrapped and in total quantity. As an approximation the average weight is assumed to be less but the numbers greater with the same estimate of total pounds entrapped of 147,000 pounds.

The flows taken for cooling tower or spray module makeup are appreciably less than for once-through with an assumed proportionate reduction in entrapped fish. The makeup flow would be 50,000 gallons per minute with an estimated entrapment of 9800 pounds per year.

10.1.7 Plankton Entrainment

The entrainment of zooplankton is estimated below using two approaches.

a) Sherman (Reference 12) shows that there are about 10 cc of general zooplankton per 100 cubic meters of ocean water in the neritic zone of the Gulf of Maine. Assuming that the specific gravity of general zooplankton is 1.4, the proposed Seabrook cooling system would entrain 356,000 pounds per year (Reference 13).

b) Another method of estimating the pounds per year of zooplankton which might be entrained is based on the Normandeau Associates, Inc. Phase III study which measured about 3000 zooplankters per 100 liters. Assuming a typical zooplankter weighs about 5 micrograms, the entrained zooplankton would weigh 393,000 pounds per year (Reference 14).

Phytoplankton entrainment may also be estimated in more than one way.

a) One method uses the ratio of phytoplankton to zooplankton. Based on the work of Riley & Bumpus (Reference 15) a ratio of 2:1 is assumed which indicates that approximately 786,000 pounds of phytoplankton might be entrained per year.

b) A second approach is based upon chlorophyll content determinations. Typical phytoplankters are about 50 percent carbon of which about 10 percent is chlorophyll. Therefore, dry weight is estimated at chlorophyll content times 100. Plankton studies in the Piscataqua River and at Seabrook show chlorophyll values of 1 to 4 mg per cubic meter. This yields an entrainment quantity of about 235,000 pounds per year of phytoplankton.

Fish equivalents for entrained plankton are based on an estimated ecological efficiency of conversion of energy from one trophic level to the next. Although the percent of ecological efficiency varies from food chain to food chain and from link to link within a specific food chain, fifteen percent is considered a conservatively reasonable number (Reference 16). Another assumption implicit in the calculations is that there are three links in the food chain under consideration:

Phytoplankton → zooplankton → Carnivorous invertebrates → fish
(producer level) (1st Order Consumer) (2nd Order Consumer)

Fish equivalents may easily be figured from either the phytoplankton abundance (three-linked chain) or from the zooplankton abundance (two-linked chain). Since both plankton abundances are based on dry weights, fish equivalents in wet weights involve a multiplication of 5 times the dry weight.

Example - using the phytoplankton abundance from the Piscataqua study:

	15%		15%		15%	
Phytoplankton	→	Zooplankton	→	Carnivorous Invertebrate	→	Fish
235,000 pounds	→	45,000 pounds	→	5,300 pounds	→	800 pounds

800 pounds dry weight = 4000 pounds of fish equivalent per year

Following the same reasoning using the methods of Sherman based upon zooplankton abundance, an equivalent wet weight of fish of 356,000 x $(.15)^2$ x 5 equaling 40,000 pounds per year would be calculated. The estimate based upon local data is expected to be the more realistic; however for conservatism the number based upon the Sherman study is reported.

It is calculated that the plant circulating water flow equals .01 percent of the top 100 feet of the Gulf of Maine per month. The constant circulation of this gyre makes that resource available to the plant. Saying it another way, for every organism entrained 9999 organisms are not entrained.

10.1.8 Fish Entrainment

Entrainment estimates for ichthyoplankton are based upon larval fish densities as reported by the staff of the National Marine Fisheries Service Biological

Laboratory, West Boothbay Harbor, Maine. In 1972 a series of four autumn cruises were undertaken to ascertain the coastal distribution, abundance, and dispersion of larval herring. The cruises were part of a cooperative survey of the Northwestern North Atlantic (U. S., France, Federal Republic of Germany, U.S.S.R., and Canada). Three of these cruises included sample stations near the area of the proposed Seabrook Station intake structure. Specifically these are designated as Stations 13 and 14 of M/V Rorqual Cruise R-2-67. The cruises which gathered data on the abundance of clupeid larvae are: Albatross IV, 72-7 in September; Duchess II, 72-1 in October; and Duchess II, 72-2 in November. These collection times were scheduled to coincide with the expected period of maximum larval clupeid abundance. From these data the applicant estimates about 1 larval clupeid per 100 cubic meters of water (actually for Station 13, 1.03 larvae/100 M^3 and for Station 14, 1.10 larvae/100 M^3). From this figure one may extrapolate a crude estimate of the amount of fish larvae expected to be entrained per year. Expressing this in pounds per year requires an assumption that there are about 200 fish larvae per pound. Consider that the Seabrook Station pumps about 700,000 gallons per minute which equals about 2800 cubic meters per minute within which there may be about 28 larval fish. This amounts to 1680 larvae per hour, 30,320 per day and 11,066,800 (say 12 million larvae per year). If we assume there are about 200 larvae to the pound than we can estimate that about 60,000 lbs of larvae are entrained per operating year.

Assuming natural mortality for the progeny of one spawned female generally accounts for the loss of all but about two individuals prior to attainment of maturity and capacity for reproduction then for herring about 2 out of 20,000 survive (a survival percentage from egg to adult of about .0001 percent). Let us further assume that at the stage of collection as larval fish they have already suffered a substantial part of the total egg to adult mortality, say 50 percent. This then suggests that the remaining survival percentage from catchable larvae to adult fish is .01 percent. One can now estimate that the 12 million larvae entrained per year would under natural conditions result in only 1200 mature adults. At 1 pound per fish, this is 1200 lbs/year.

There are many assumptions required by this method of estimation, some tending to make it an underestimate and others an overestimate. To name a few, there are no reliable figures on larvae abundance other than clupeids, the data were collected at a time when maximum clupeid larvae are present, the power plant may not operate at full capacity throughout the year and the estimate assumes equal vertical distribution of larvae.

10.1.9 Discharge Area and Thermal Plume

The plant will discharge 16 billion BTU per hour when both units are operating at full output.

The thermal and flow modeling of the discharge area being performed at the Alden Research Laboratories in 1973 will be used to determine the discharge configuration for the proposed once-through system. Results of tests with different configurations will be available to allow regulatory agencies to establish meaningful design criteria prior to licensing. At the time this is written it would be speculative to estimate the surface area between different isotherms since testing has not been performed and the type of discharge; that is, single port or diffuser has not been selected.

In Section 10.3 discharge system alternatives are discussed more fully. From that discussion it is estimated that if a single-port discharge were chosen the surface area inside the 5°ΔT isotherm would be approximately eight acres with a corresponding volume of 250 acre-feet. If a multiport diffuser were selected, the area on the surface with a 5° ΔT could be zero.

The dissolved oxygen content of the water coming into and going out of the estuary was discussed in subsection 2.5.1.1.3. The dissolved oxygen content of the waters was never found below 5 ppm. Since the saturation concentration of oxygen at 100°F is 7 ppm and since the discharged water will rapidly entrain ambient water in approximately a ten-to-one ratio, there should be no water volume with a dissolved oxygen content of 5 ppm or less.

The effect on aquatic organisms in the discharge area could potentially be manifested by several mechanisms. However, none of these is expected to have more than a negligible effect. Whichever scheme of discharge is chosen (single or multi-port), the point of discharge will be designed so that bottom scouring does not occur and benthic life is not affected from scour. Entrained organisms which are converted to detritus by passage through the condensers will be transported in the discharge plume prior to deposition. The low density of this material, the discharge-induced hydraulic currents, and the naturally active conditions of the sea in the discharge area will all contribute to its dispersion rather than a concentrated deposition. Local filter feeders and deposit feeders will quickly utilize this food source.

In the very immediate area of the discharge ports there will be a small potential for some effect on aquatic organisms from temperature and velocity effects. Subsurface velocity and temperature profiles will be available when discharge model testing is completed at Alden Laboratories. On the basis of previous tests and the rapid reduction in velocity and temperature as a result of the ten-to-one entrainment of ambient waters these effects are expected to be too small to be measured. All effects taken together, are expected to have an insignificant effect on the aquatic life in the discharge area.

Benthic-feeding sea ducks are observed generally off the coast. No population count is known to exist which would allow a comparison to be made of the duck population in the discharge area with other shoreline areas. Casual observation, however, does not indicate that the duck population in the discharge area is unusual. Bottom dwellers even in the small area beneath the discharge plume are not expected to be affected by the discharge. Therefore, there is not any expected effect on sea ducks. If an evaporative cooling system were adopted, bird life could be locally reduced as a result of land clearing for the cooling towers or spray modules and the ensuing loss of habitat. The tidal reservoir concept would convert approximately 100 acres of salt marsh to a salt pond and thereby lessen its value to aquatic animals and birds.

The area of the proposed discharge is not part of any identified route for migrating fishes. Such migrants as striped bass, alewives, smelt and eels are found in the area and do enter and leave the estuary. None of the proposed discharge schemes will lead to thermal blockage of the estuary or travel along the coastline. No fish should, therefore, be blocked from reaching a spawning or feeding area.

10.1.10 Chemical Effluents

All wastes from the plant will be pumped into the circulating water discharge line and diluted by that flow. Chemical constituents in the discharge may be increased slightly by circulating water system Marine fouling control in the vicinity of the condenser (Section 5.4), treated sanitary system wastes (Section 5.5) and operation of the demineralized water treatment equipment (Section 5.4). As discharged, state standards are satisfied without further dilution. With the reduced discharge to the ocean under the evaporative cooling schemes, slightly higher chemical concentrations would exist in the discharge flow. These would still be within appropriate standards.

If evaporative cooling were used, naturally occurring chemicals in the seawater would be concentrated and discharged with the system blowdown. This flow would be discharged through a single-port diffuser and mixed with the ambient water resulting in concentration levels below those considered deleterious to aquatic life.

10.1.11 Radionuclide Discharge

The radioactive liquid treatment systems described in subsection 3.5.1 are designed to meet the guidelines of proposed 10CFR50 Appendix I. The radiological environmental impact of radioactive liquid releases from the site is dependent upon the amount of dilution water available for the discharge and is therefore dependent upon the cooling system. This dependence is reflected in Table 10.1-4.

10.1.12 Plant Construction

Section 4.1 discusses the construction methods for various sections of the condenser cooling water system. The bedrock tunnel portion from the site to the offshore inlet and discharge structures has no potential for environmental impact upon the marsh, harbor, state park or offshore area. A very slight amount of dredging may be required at the offshore inlet and discharge to implace these structures and secure them to the seabed and tunnel viser shaft.

Drainage of the site during construction will be handled so that turbidity in the Brown's River is kept to an acceptable level.

10.1.13 Ground Water

The make-up water for the plant fluid systems and fresh water for employee consumption will be obtained from the Seabrook town water supply. The Applicant is assisting the town in developing its ground water sources to furnish the 200 gpm anticipated requirements. Exploratory drilling indicates the requirements can be met without detriment to existing wells. The municipal wells are several miles from the site. Ground water hydrology studies show that any activities on the site will not have a polluting effect on any public or private water sources.

10.1.14 Air

The once-through alternatives will not have an effect on the atmosphere of sufficient magnitude to affect transportation in the discharge area. The greatest effect that can be predicted would be very occasional vapor wisps when the ocean surface is calm and warmer than the air above.

The NUS Corporation calculated the potential ground fogging induced by evaporative cooling systems and its effect on highway visibility (References 3 and 4). Table 10.1-5 indicates that ground fogging will frequently occur close to the spray channel system and the mechanical towers; these incidents would most frequently be observed under high wind conditions, when the visible plume from the cooling system is brought into contact with the ground. (During the winter, it is predicted that winds from the west-northwest, northwest, and north-northwest will cause ground fogging within 350 feet of the spray channel an estimated 35 percent of the total wintertime hours.) Induced fog probability then decreases with increasing distance up to about 3.0 kilometers. Beyond 3.0 kilometers the probability of induced fog increases somewhat. This effect is due to the downward dispersion of moisture from elevated plumes.

Table 10.1-6 shows that induced fog will often be formed with ambient temperatures below freezing during the winter. The high incidence of induced fogging in the immediate vicinity of the spray channel system and the mechanical draft towers will cause restrictive visibility conditions and potential icing of transmission lines and buildings to occur more often on-site than off-site.

Table 10.1-7 shows the increased probability of fog predicted for several points on roadways in the vicinity of the plant site. The greatest increase in fog probability occurs from mechanical draft towers due to downwash effects. It should be noted, however, that the analysis of spray systems was based on an average plume rise for the total system in the present study. Consideration of variability of plume rise (hot to cold end) may increase somewhat the probability of fog occurrence.

Evaporative cooling systems will have an effect upon the environment as a result of airborne salt drift and vapor plumes.

The NUS Corporation also calculated the potential salt drift and estimated its effect on the surrounding areas (References 3 and 4). Their study also determined the potential for fogging and visible plume formation. Table 10.1-2 shows the calculated salt deposition for each of the evaporative systems. Table 10.1-3 shows the estimated occurrences of a visible plume for each of the evaporative systems.

The impact of increased salt fallout on the forested areas is difficult to predict because of a large number of variables. The predicted maximum salt deposition on land by the natural draft cooling tower is 50-60 pounds/acre/year. Neither amount appears to be great enough to produce immediate damage in the forest flora.

These amounts of salt could effectively double background salt concentrations normal to the area and might impart a slight fertilizing effect (References 5 and 6). Cassidy (Reference 7) implied that small amounts of salt in the air may be passively absorbed through the stomata of plants and may possibly produce a number of diseases whose causes are presently unknown. This idea and the possibility of damage from cumulative effects over several years make the conclusion that low rates of salt deposition have no effects somewhat questionable (References 8 and 9).

The salt deposition from the spray canal would be much more limited in range than that from either of the cooling towers. The ecological effects, however, could be quite severe within a certain distance of the canal. Forest vegetation within 500 feet of the site would probably be greatly altered, with more sensitive species being completely destroyed. Thus, based upon predicted salt fallout, the spray canal system would have a considerable impact on immediately surrounding areas, but no major short-term impact from spray would be expected more than 600 feet away. The concentration of salt in the runoff from the spray system, however, might be high enough to produce more extensive effects in the salt marsh (Reference 4). Since the spray modules will not put the salt spray very high into the air it may be traveling away from the canal relatively close to the ground. Consequently, larger quantities of salt than predicted could perhaps accumulate at the forest edge. This would reduce the amount of salt traveling beyond the forest edge, and also result in the death of the bordering trees.

The above predicted effects for the three alternative cooling systems are general. Due to the varying tolerances of the forest species present, there will be a selection for vegetation tolerant to salt in the exposed areas. The oak species are all relatively tolerant while the poplars and birches are somewhat less tolerant. White pines, hemlocks, alders, gums, hickories and maple could be killed in an area of high salt deposition leaving a stand of oak-birch. Selective cutting of the affected species could be initiated as damage occurred, although opening the forest in this manner would represent significant ecological damage. Other species not mentioned thus far include the pear, apple, and peach trees, all of which are sensitive and might be damaged by some of the lower salt concentrations. Some of the orchard areas within the range of fallout from the mechanical draft cooling tower could conceivably be affected. Understory species in the forests will also be affected but may be replaced more quickly than trees if killed. However, many of the most common understory species of the Seabrook Site are among those least salt tolerant.

The salt marsh surrounding the Seabrook Site is perhaps the most unique area ecologically. The effects of salt spray on this community are expected to be less than for the forests. Oosting (Reference 10) experimentally sprayed a number of plants with seawater and found this treatment has no effect on Spartina patens, one of the major plants of the Seabrook salt marsh. This plant and the other species obviously must have a high degree of salt tolerance to grow in a salt water environment. However, Adams (Reference 11) determined that most salt marsh species exhibited decreased fertility and growth at increasing salinities, and that at concentrations twice that of normal seawater, all species failed to survive. This might indicate that any great amount of salt runoff could affect the salt marsh community. Also the exceedingly heavy salt fallout within a quarter of a mile of the spray canal could have other serious effects if it became encrusted on the soil and plants. No impact on the salt marsh is anticipated from the salt fallout of either type cooling tower.

The tolerance of non-forest species to salt is not well documented. In general, grassy vegetation is more salt tolerant than woody vegetation. The U. S. Salinity Laboratory (cited in Hayward and Bernstein, 1958) has summarized its own experimental data, as well as that from the literature, on salt tolerances of forage crops (Reference 8). Although these data are expressed in relation to soil conductivity, and are not convertible to salt deposition rates, they indicate that there are a number of very salt tolerant grasses that are useful as forage. Most of the major field crops have "medium to good salt tolerance" (Reference 8). Most cereal crops have medium tolerance. Beans, celery, radish, and peas are salt sensitive and other vegetables less so (Ibid). Crops over one half mile from the spray canal cooling system would probably not be affected. As mentioned above the mechanical draft towers might have some effect on orchards and gardens over one-half mile from the site. The acreage under cultivation including orchards is unknown so the effect is reported as a small one.

10.1.15 Land

Salt deposition on the land is not expected to affect any sources of potable water.

Section 2.1 describes the plant site which will encompass 660 acres inside a 3000 foot exclusion boundary. Of this total 440 acres are salt marsh and 220 acres are above high tide. The high ground is predominantly second growth woods. Two open dumps are currently in operation on site and occupy approximately 10 acres. The area actually used for plant facilities will be only a small part of the total owned. The proposed plant facilities will occupy approximately 30 acres plus about 10 more for an environmental and nuclear energy education center. If evaporative cooling is required approximately 100 additional acres must be cleared for that purpose.

Noise levels from mechanical draft cooling towers may be objectionable during quiet evening period to residents in the 16 nearest residences. Based upon a "Walk-away" test described in the HUD Noise Assessment Guidelines, it is felt that these residences would fall in a "clearly acceptable" area. However, since there may be some question by the residents of that fact they are listed as normally acceptable indicating normal conversation could be understood with up to 70 feet between conversants.

Increased depreciation of structures and personal property may occur in certain areas if mechanical draft cooling towers are used. Since the area is already exposed to salt deposition of varying quantities from the ocean, it is difficult to separate out an increased effect due to the towers. The spray modules would have a noticeable salt deposition effect on the plant facilities proper.

10.1.16 Assessment

An evaluation of the cooling system alternatives based solely on economics was made by C. T. Main in Appendix F. They studied more alternatives than are itemized in Table 10.1-4. For completeness the differential evaluated costs for all alternatives escalated to the date of operation are repeated here:

	Differential Evaluated Costs in $1,000 Escalated for 1979-80 Operation
Once-Through Open Systems	
Intake on Ocean Shore	
15°F Temperature Rise	
Pipe Inlet to Intake	77,416
Channel Inlet to Intake	80,728
45°F Temperature Rise	
Pipe Inlet to Intake	22,695
Channel Inlet to Intake	35,376
Inland Intake Near Plant	
15°F Temperature Rise	
Pipe Inlet to Intake	102,230
Channel Inlet to Intake	41,383
45°F Temperature Rise	
Pipe Inlet to Intake	32,720
Channel Inlet to Intake	Base
Storage Reservoir System for Low Tide Operations	
15°F Temperature Rise	60,091
45°F Temperature Rise	10,220
Closed Systems	
Wet Cooling Towers	
Natural Draft Towers	34,756
Mechanical Draft Towers	21,907
Power Spray Modules	18,668
Dry Cooling Towers	126,545

The most economical plan is a once-through open system with intake near the plant, 45°F Temperature rise, with an open channel inlet to the intake structure and with pipe discharge of condensing water to the ocean approximately 4000 feet off-shore into water approximately 40 feet deep.

The next most economical plan is similar to the base plan described above, but utilizing a storage reservoir of 45 acres west of the railroad to supply water to the condensing water pumps during each low cycle of the tide when the water falls to mean sea level. During rising tides above mean sea level the storage reservoir would be refilled by separate pumps located near the intake structure. In this plan, no inlet channel dredging is required, except near the intake structures in order to obtain a suitable water flow when the tide is at mean sea level or higher.

The next most economical plans, at approximately the same cost level, are:

a. Once-through open system with intake on ocean shore - 45° Temp. Rise, and

b. Closed system with loop canal and power spray modules.

These latter plans range in evaluated cost approximately $17,000,000 above the most economical plan. When environmental effects were weighed with the evaluated costs and the realities of licensing considered the Applicant selected the ocean-intake, once-through, 45° rise using bedrock tunnels for conveyance as the recommended system.

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TABLE 10.1-1

SUMMARY OF EVALUATED COSTS
CONDENSING WATER STUDY

COSTS ESCALATED FOR 1979 - 81 OPERATING DATES $1000

	ONCE - THROUGH - OPEN SYSTEMS						CLOSED SYSTEMS			
	INTAKE ON OCEAN SHORE		INLAND INTAKE NEAR PLANT				WET COOLING TOWERS		POWER SPRAY MODULES	DRY COOLING TOWERS
					STORAGE RESERVOIR FOR LOW - TIDE OPERATION		NATURAL DRAFT	MECH. DRAFT		
TEMPERATURE RISE °F	15	45	15	45	15	45	25	27	25	37
TYPE OF INLET TO INTAKE	PIPE	PIPE	PIPE	CHANNEL	PIPE	CHANNEL	PIPE	CHANNEL	PIPE	CHANNEL
ESTIMATED COMPARABLE INVESTMENT	140165	79154	166169	58224	120700	66694	74623	65889	47650	122433
CAPITALIZED DIFFERENTIAL ANNUAL FUEL COST RESULTING FROM BACK PRESSURE	BASE	570	BASE	570	BASE	570	3388	973	5534	5081
CAPITALIZED ANNUAL PUMPING, FAN, AND SPRAY POWER COST	2215	1715	1825	1150	2255	1440	1939	2789	2228	5975
CAPITALIZED OTHER ANNUAL OPERATING & MAINTENANCE COST	BASE	BASE	BASE	BASE	260	260	3200	3600	2600	BASE
NET GENERATING CAPABILITY PENALTY @ $160 / KW	1680	7900	880	6700	3520	7900	18250	15300	27300	59700
TOTAL COMPARABLE EVALUATED COST	144060	89339	168874	66644	126735	76864	101400	88551	85312	193189
DIFFERENTIAL EVALUATED COST	77416	22695	102230	BASE	60091	10220	34756	21907	18668	126545

TABLE 10.1-2

ESTIMATED ANNUAL BRINE GROUND DEPOSITION
(LB. PER ACRE-YR.) FROM THE THREE EVAPORATIVE COOLING
SYSTEMS IN THE SECTOR EAST-SOUTHEAST OF THE PLANT SITE

Distance (km)	Spray Channel	Mech. Towers	Natural Draft Towers
0.1	688	--	--
0.2	28.5	--	--
0.4	1.4	5.6	--
0.8	0.1	16.1	11.2
0.9	0.1	14.1	17.2
1.0	0.1	20.5	10.5
1.2	0.1	19.4	20.1
1.5	0.1	22.6	18.7
2.0	0.1	175	20.1
2.5	0.1	145	30.2
3.0	0.1	151	38.7
3.5	0.1	230	35.9
4.0	0.1	195	56.1
4.5	0.1	177	53.6
5.0	0.1	155	56.9
6.0	0.1	87.2	63.6
8.0	0.1	78.8	65.6
10.0	0.1	62.0	57.3
20.0	0.1	12.8	16.5

TABLE 10.1-3

ESTIMATED ANNUAL OCCURRENCE OF A VISIBLE PLUME OVER SELECTED SITES IN THE VICINITY OF THE SEABROOK NUCLEAR PLANT

Location	Direction From Cooling System	Approximate Distance From Cooling System (m)	No. of Hr. Per Year a Visible Plume From the PSM System Will Pass Over Site	No. of Hr. Per Year a Visible Plume From the Mech Draft System Will Pass Over Site	No. of Hr. Per Yr. A Visible Plume From the Nat. Draft System Will Pass Over Site
Hampton	NNE	5000	1	2	6
The Plantation	NE	5400	0	2	5
Hampton Beach	E	3300	2	3	6
Seabrook Beach	ESE	3400	2	8	12
The Sands	ESE	3400	2	8	12
Seabrook Station	SSW	1300	10	24	59
Dearborn Academy	WNW	1300	6	39	45
Hampton Falls	NNW	2100	6	18	26

TABLE 10.1-4 COST DESCRIPTION - ALTERNATIVE COOLING SYSTEMS (Continued)

ENVIRONMENTAL COSTS	UNITS	ALTERNATIVES A. OCEAN 45° MAGNITUDE	Sec.	B. OCEAN 15° MAGNITUDE	Sec.	C. INLAND 45° MAGNITUDE	Sec.	D. RESERVOIR 45° MAGNITUDE	Sec.	E. MECH.DRAFT MAGNITUDE	Sec.	F. PSM MAGNITUDE	Sec.
1.6 Consumptive use (evaporative losses)													
1.6.1 People	Gal/Year					NO EFFECT - SALT WATER							
1.6.2 Property	Acre Ft/Year					NO EFFECT - SALT WATER							
1.7 Plant construction (including site preparation													
1.7.1 Water quality, physical	Acre Ft Acres					MINOR EFFECT							
1.7.2 Water quality, chemical	Acre Ft					MINOR EFFECT							
1.8 Other impacts NONE													
1.9 Combined or interactive effects	COMBINED EFFECTS NOT SIGNIFICANTLY GREATER THAN INDIVIDUAL EFFECTS												
1.10 Net effects													
2. Groundwater													
2.1 Raising/lowering of ground water levels													
2.1.1 People						NO EFFECT							
2.1.2 Plants						NO EFFECT							
2.2 Chemical contamination of ground water (excluding salt)													
2.2.1 People						NO EFFECT							
2.2.2 Plants						NO EFFECT							
2.3 Radionuclide contamination of ground water													
2.3.1 People						NO EFFECT							
2.3.2 Plants and animals						NO EFFECT							
2.4 Other impacts on ground water						NONE							
3. Air													
3.1 Fogging & icing (caused by evaporation and drift)													
3.1.1 Ground transportation	Hrs/Year	No Effect		No Effect		No Effect		No Effect		33		32	
3.1.2 Air transportation	Hrs/Year	No Effect		No Effect		No Effect		No Effect		NO AIRPORT CLOSINGS			
3.1.3 Water transportation	Hrs/Year	No Effect		No Effect		No Effect		No Effect		NO EFFECT ON SHIPPING			
3.1.4 Plants	Acres	No Effect		No Effect		No Effect		No Effect		Small Effect		No Effect	
3.2 Chemical discharge to ambient air	Pounds/Year												
3.2.1 Air quality, chemical		No Effect		No Effect		No Effect		No Effect		No Effect		No Effect	
3.2.2 Air quality, odor		No Effect		No Effect		No Effect		No Effect		No Effect		No Effect	
3.3 Radionuclides discharged to ambient air & direct radiation from radioactive materials (in-plant or being transported)													
3.3.1 People, external	Rem/Year Man-rem/Yr					Not Applicable							
3.3.2 People, ingestion	Rem/Year Man-rem/Yr					Not Applicable							
3.3.3 Plants and animals	Rad/Year					Not Applicable							
3.4 Other impacts on air		None		None		None		None		Visible Plume		Visible Plume	

TABLE 10.1-4 COST DESCRIPTION - ALTERNATIVE COOLING SYSTEMS (Continued)

ENVIRONMENTAL COSTS	UNITS	ALTERNATIVES A. OCEAN 45° MAGNITUDE	Sec.	B. OCEAN 15° MAGNITUDE	Sec.	C. INLAND 45° MAGNITUDE	Sec.	D. RESERVOIR 45° MAGNITUDE	Sec.	E. MECH.DRAFT MAGNITUDE	Sec.	F. PSM MAGNITUDE	PAGE
4. Land													
4.1 Site selection													
4.1.1 Land, amount	Acres	660	2.1	660	2.1	660	2.1	660	2.1	660	2.1	660	2.1
4.2 Construction activities (including site preparation)													
4.2.1 People (amenities)		19 RESIDENCES ALONG ROCKS ROAD AFFECTED BY NOISE FOR 5 YEARS											
4.2.2 People (accessibility of historical sites)		NO HISTORIC SITES IN AREA OF PLANT											
4.2.3 People (accessibility of archeological sites)		NO ARCHEOLOGICAL SITES IN AREA OF PLANT											
4.2.5 Land (erosion)		NO EFFECT ON LAND FROM EROSION											
4.3 Plant operation													
4.3.1 People (amenities)	Noise Effect	No Effect		No Effect		No Effect		No Effect		16 NORMALLY ACCEPTABLE		No Effect	
4.3.2 People (aesthetics)		MINOR EFFECT VIEWED 1.5 MILES AWAY											
4.3.3 Wildlife		NO EFFECT											
4.3.4 Land, flood control		NO FLOOD CONTROL IMPLICATIONS											
4.4 Salts discharged from cooling towers													
4.4.1 People	Pounds/Acre/Year	No Effects		No Effects		No Effects		No Effects		230		688	
4.4.2 Plants and animals	Acres	No Effects		No Effects		No Effects		No Effects		Small Effect		100	
4.4.3 Property resources	$/Yr	No Effects		No Effects		No Effects		No Effects		Some Increase		Owners Property	
4.5 Not applicable													
4.6 Not applicable													
4.7 Not applicable													
4.8 Other land impacts		NONE											
4.9 Combined or interactive effects		COMBINED EFFECTS EQUAL SUM OF INDIVIDUAL EFFECTS											
4.10 Net effects		SEE DISCUSSION IN TEXT SECTIONS 5.8 and 10.1											

TABLE 10.1-4 COST DESCRIPTION - ALTERNATIVE COOLING SYSTEMS
(exclusive of intake and discharge)

	ALTERNATIVES	A. OCEAN 45°		B. OCEAN 15°		C. INLAND 45°		D. RESERVOIR 45°		E. MECH.DRAFT		F. PSM	
INCREMENTAL GENERATING COST	1979 Present Worth $	22,695,000		77,416,000		BASE		10,220,000		21,907,000		18,668,000	
REDUCTION IN CAPABILITY KW		49,180		10,250		BASE		49,360		95,660		171.124	
ENVIRONMENTAL COSTS	UNITS	MAGNITUDE	SEC.*	MAGNITUDE	SEC.	MAGNITUDE	SEC.	MAGNITUDE	SEC.	MAGNITUDE	SEC.	MAGNITUDE	SEC.
1. Natural Surface Water Body													
1.1 Impingement or entrapment by cooling water intake structure 1.1.1 Fish	Pounds/Year	147,000	10.1	441,000	10.1	147,000	10.1	147,000	10.1	9,800	10.1	9,800	10.1
1.2 Passage through or retention in cooling systems													
1.2.1 Phytoplankton & zooplankton 1.2.2 Fish	Pounds/Year	40,000 1200	10.1	120,000 3600	10.1	40,000 1200	10.1	40,000 1200	10.1	2,660 Minor	10.1	2,660 Minor	10.1
1.3 Discharge area and thermal plume													
1.3.1 Water quality, excess heat	Acres & A-Ft.	TO BE	REPORTED	AFTER MODEL	STUDIES	COMPLETED IN	1973			Negligible		Negligible	
1.3.2 Water quality, oxygen avail.	Acre Feet	----------	----------	----------	----------	INSIGNIFICANT	EFFECT	----------	----------	----------	----------	----------	----------
1.3.3 Aquatic organisms	Pounds/Year	----------	----------	----------	----------	INSIGNIFICANT	EFFECT	----------	----------	----------	----------	----------	----------
1.3.4 Wildlife (including birds, aquatic & amphibious mammals & reptiles)	Acres	----------	----------	INSIGNIFICANT	EFFECT	----------	----------	100		50		100	
1.3.5 Fish, migratory	Pounds/Year	----------	----------	----------	----------	NO EFFECT	----------	----------	----------	----------	----------	----------	----------
1.4 Chemical effluents													
1.4.1 Water quality, chemical	Acre Feet	----------	----------	----------	----------	INSIGNIFICANT	EFFECT	----------	----------	----------	----------	----------	----------
1.4.2 Aquatic organisms	Pounds/Year	----------	----------	----------	----------	INSIGNIFICANT	EFFECT	----------	----------	----------	----------	----------	----------
1.4.3 Wildlife (including birds, aquatic & amphibious mammals & reptiles)	Acres	No Effect		No Effect		No Effect		No Effect		No Effect		No Effect	
1.4.4 People	Lost Use	No Effect		No Effect		No Effect		No Effect		No Effect		No Effect	
1.5 Radionuclides discharged to water body													
1.5.1 Aquatic organisms	Rad/Year	5.2×10^{-5}	5.2.3	1.7×10^{-5}	5.2.3	5.2×10^{-5}	5.2.3	5.2×10^{-5}	5.2.3	7.8×10^{-4}	5.2.3	7.8×10^{-4}	5.2.3
1.5.2 People, external	Rem/Year	3×10^{-9}	5.3.2	1×10^{-9}	5.3.2	3×10^{-9}	5.3.2	3×10^{-9}	5.3.2	4.5×10^{-8}	5.3.2	4.5×10^{-8}	5.3.2
	Man-Rem/Year	6.4×10^{-4}	5.3.2	2.1×10^{-4}	5.3.2	6.4×10^{-4}	5.3.2	6.4×10^{-4}	5.3.2	9.6×10^{-3}	5.3.2	9.6×10^{-3}	5.3.2
1.5.3 People, ingestion	Rem/Year	6.3×10^{-4}	5.3.2	2.1×10^{-4}	5.3.2	6.3×10^{-4}	5.3.2	6.3×10^{-4}	5.3.2	9.5×10^{-3}	5.3.2	9.5×10^{-3}	5.3.2
	Man-Rem/Year	1.4×10^{-2}	5.3.2	4.7×10^{-3}	5.3.2	1.4×10^{-2}	5.3.2	1.4×10^{-2}	5.3.2	1.4×10^{-2}	5.3.2	1.4×10^{-2}	5.3.2

* Applicable section of this report.

TABLE 10.1-5

INDUCED FOG OCCURRENCE
FROM THE THREE EVAPORATIVE COOLING SYSTEMS
AS A FUNCTION OF THE DOWNWIND DISTANCE,
FOR THE SECTOR SOUTH-SOUTHEAST OF THE SITE

WINTER (December, January, February)

Distance (km)	Increased Prob of Fog(%) From Spray Channel System	Increased Prob of Fog(%) From Mech Towers	Increased Prob of Fog(%) From Nat. Draft Towers
0.1	9.38	7.46	0
0.2	8.14	7.12	0
0.4	4.45	5.11	0
0.6	2.16	2.90	0
1.0	0.90	1.22	0
1.1	0.75	1.05	0
1.2	0.64	0.91	0
1.3	0.54	0.80	0
1.7	0.31	0.48	0
2.0	0.01	0.35	0
2.1	0.01	0.12	0
2.2	0.01	0.01	0
2.4	0.01	0.01	0
3.0	0.06	0.01	0
3.3	0.10	0.03	0
3.4	0.12	0.04	0
5.0	0.36	0.22	0
10.0	0.55	0.53	0
15.0	0.47	0.46	0

2190 Total Hr/winter

TABLE 10.1-5 (Continued)

INDUCED FOG OCCURRENCE
FROM THE THREE EVAPORATIVE COOLING SYSTEMS
AS A FUNCTION OF THE DOWNWIND DISTANCE,
FOR THE SECTOR SOUTH-SOUTHEAST OF THE SITE

Distance (km)	Increased Prob of Fog(%) From Spray Channel System	Increased Prob of Fog(%) From Mech Towers	Increased Prob of Fog(%) From Nat. Draft Towers
ANNUAL			
0.1	5.26	3.80	0
0.2	4.01	3.23	0
0.4	2.02	2.10	0
0.6	1.01	1.17	0
1.0	0.46	0.54	0
1.1	0.39	0.50	0
1.2	0.33	0.42	0
1.3	0.28	0.38	0
1.7	0.15	0.24	0
2.0	0.01	0.12	0
2.1	0.01	0.03	0
2.2	0.01	0.01	0
2.4	0.01	0.01	0
3.0	0.04	0.01	0
3.3	0.07	0.02	0
3.4	0.08	0.03	0
5.0	0.21	0.13	0
10.0	0.30	0.28	0
15.0	0.26	0.25	0

8760 Total Hr/yr

TABLE 10.1-6

INDUCED FOG OCCURRENCE UNDER FREEZING CONDITIONS
FROM THE THREE EVAPORATIVE COOLING SYSTEMS
AS A FUNCTION OF THE DOWNWIND DISTANCE,
FOR THE SECTOR SOUTH-SOUTHEAST OF THE SITE

WINTER (December, January, February)

Distance (km)	Increased Prob of Fog(%) From Spray Channel System	Increased Prob of Fog(%) From Mech Towers	Increased Prob of Fog(%) From Nat. Draft Towers
0.1	7.52	6.31	0
0.2	6.96	6.23	0
0.4	4.12	4.79	0
0.6	2.02	2.80	0
1.0	0.85	1.19	0
1.1	0.71	1.02	0
1.2	0.60	0.89	0
1.3	0.52	0.78	0
1.7	0.29	0.47	0
2.0	0.01	0.34	0
2.1	0.01	0.12	0
2.2	0.01	0.01	0
2.4	0.01	0.01	0
3.0	0.06	0.01	0
3.3	0.10	0.03	0
3.4	0.11	0.03	0
5.0	0.34	0.21	0
10.0	0.51	0.50	0
15.0	0.43	0.44	0

2190 Total hr/winter

TABLE 10.1-6 (continued)

INDUCED FOG OCCURRENCE UNDER FREEZING CONDITIONS
FROM THE THREE EVAPORATIVE COOLING SYSTEMS
AS A FUNCTION OF THE DOWNWIND DISTANCE,
FOR THE SECTOR SOUTH-SOUTHEAST OF THE SITE

Distance (km)	Increased Prob of Fog(%) From Spray Channel System	Increased Prob of Fog(%) From Mech Towers	Increased Prob of Fog(%) From Nat. Draft Towers
ANNUAL			
0.1	1.89	1.44	0
0.2	1.74	1.42	0
0.4	1.03	1.09	0
0.6	0.51	0.64	0
1.0	0.21	0.27	0
1.1	0.18	0.23	0
1.2	0.15	0.20	0
1.3	0.13	0.18	0
1.7	0.07	0.11	0
2.0	0.01	0.08	0
2.1	0.01	0.03	0
2.2	0.01	0.01	0
2.4	0.01	0.01	0
3.0	0.01	0.01	0
3.3	0.02	0.01	0
3.4	0.03	0.01	0
5.0	0.09	0.05	0
10.0	0.13	0.12	0
15.0	0.11	0.10	0

8760 Total hr/year

TABLE 10.1-7

ESTIMATED ANNUAL INDUCED FOG OCCURRENCE FROM THE THREE EVAPORATIVE COOLING SYSTEMS AT LOCATIONS IN THE VICINITY OF THE PLANT

Road	Direction from Cooling System	Approximate Distance From Cooling System (m)	Induced Fogging From The Spray Channel System		Induced Fogging From The Mech. Draft Towers		Induced Fogging From The Nat. Draft Towers	
			%	No. of Hr.	%	No. of Hr.	%	No. of Hr.
I-95	W	2000	0	0	0.07	6	0	0
	WNW	2000	0	0	0.01	1	0	0
Rt. 1	WNW	1200	0.14	12	0.15	13	0	0
	NW	1200	0.06	5	0	0	0	0
Depot Rd.	SSE	1300	0.28	25	0.38	33	0	0
	S	1300	0.29	25	0.27	24	0	0
Brimer Lane	NNW	1100	0.08	7	0.07	6	0	0
	N	1100	0.18	16	0.16	14	0	0
Hampton	NNE	5000	0.14	12	0.01	1	0	0
The Plantation	NE	5400	0.17	15	0.01	1	0	0
Hampton Beach	E	3300	0.01	1	0	0	0	0
Seabrook Beach	ESE	3400	0.03	3	0	0	0	0
The Sands	ESE	3400	0.03	3	0	0	0	0
Seabrook Station	SSW	1300	0.36	32	0.27	24	0	0
Dearborn Academy	WNW	1300	0.12	10	0.13	11	0	0
Hampton Falls	NNW	2100	0	0	0	0	0	0

10.2 Alternate Intake Systems

The circulating water is drawn from the Atlantic Ocean at an inlet structure located approximately 3000 feet east of Hampton Beach. This structure is firmly anchored to the sea bed to withstand hydrodynamic forces associated with the passage of storm waves. Water depth in the vicinity of the inlet is about 30 feet mean low water and it draws water from just below mid-depth.

The following factors are included as design considerations for the offshore inlet:

- Fish entrapment
- Bottom scour
- Debris removal
- Navigation effects
- Maintainability

The design of the inlet to the system relies upon a combination of approach velocity and direction of current as well as physical barriers and elevation to discourage fish from entering the inlet. The basic design concept is to provide a sufficiently large cross-sectional entrance to induce a low horizontal inflow velocity. This permits normal movement of fish in the area and allows fish to perceive the current, orient to it (facing "up stream") and thereby avoid entrapment. Final design of the inlet is scheduled to allow inlet performance information from other plants to be factored into the design.

Two inlet designs are being considered. In design Concept I, the inlet is a vertical open end cylinder which creates a vertical inflow velocity. In design Concept II, the same structure is used but the velocity profile is essentially horizontal due to a velocity cap placed just above the inlet opening.

For both design concepts the velocity at the point where cooling water enters the inlet structure is no greater than 1.5 fps. The primary differences between the alternate concepts is that Concept I creates vertical inflow while Concept II causes horizontal inflow.

Studies have shown that fish tend to avoid regions of high horizontal velocity. It is also known that fish tend to orient to current, facing into it even though they are being carried backwards by the current. As a result, inlet openings are approached tail first. Fish approaching an obstruction in this manner can avoid being carried into it by moving directly away from it or laterally to the side. In the ocean fish naturally encounter horizontal velocities which they can resist but a vertical velocity flow is unfamiliar and fish generally do not orient to it. Consequently, inlets with primarily vertical inflow are known to entrap greater numbers of fish than those with essentially horizontal inflow (Reference 1).

A velocity cap is essentially a flat plate positioned just above the opening to the vertical inlet cylinder. This changes the inflow direction from vertical to horizontal. The effectiveness of the velocity cap has been demonstrated at several offshore inlets of the Southern California Edison Company. At these inlets the use of the velocity cap is reported to reduce fish entrapment by about 95 percent (Reference 1).

The design of the offshore inlet of the Seabrook Station makes use of the velocity cap to induce horizontal inflow as a means of minimizing fish entrapment. Section 3.4 of this report describes the offshore inlet structures.

References

1. "Ocean Cooling Water System for 800 MW Power Station" by Robert H. Weight Journal of the Power Division, Proceedings of the American Society of Civil Engineers, Proceedings Paper No. 1888, December 1958.

10.3 Alternate Discharge Systems

The Public Service Company of New Hampshire proposes to consider a number of thermal discharge schemes for the Seabrook Station. Each scheme will be subjected to detailed testing in a physical hydraulic model for the purpose of predicting temperatures and velocities induced in the vicinity of the heated discharge.

These schemes will be evaluated from the viewpoint of their probable effect on the marine ecology as a basis for selecting the particular scheme with the least impact on the water environment.

Two design alternatives are being considered for the thermal discharge. The first concept is that of a single port of "submerged buoyant jet" which discharges the heated circulating water for each unit through a single port located some distance above the ocean bottom. The second concept is that of a submerged multi-port diffuser in which the discharge from each unit is discharged through a number of ports spaced along a diffuser pipe. For both concepts the total amount of heat rejected is 16×10^9 BTU/hour. A description of each concept is given in the following subsections.

Design Description

10.3.1 Single Port Discharge

The single port discharges, one for each unit, would be located in a water depth of 35 feet or more. The discharge port would be above the sea bed and the flow would be directed horizontally or at a small upward angle in order to minimize scour and bottom effects. The two ports would be spaced sufficiently far apart to ensure that the heated plumes do not interfere with each other. The discharge pipes leading to the single ports are 11 feet in diameter and the discharge port is 9.5 feet in diameter.

A buoyant jet discharge model study of the single-port discharge concept was performed for the Public Service Company of New Hampshire in 1969 by

Alden Research Laboratories. This model study was undertaken to determine the thermal dilution pattern and hydrodynamic effects of the single-port ocean discharge. Operational parameters were assumed to be those of the first Seabrook Nuclear Station design which is close, but not identical, to the present design. Through analytical methods the results of the 1969 study are used to provide a preliminary prediction for the present design.

The first model study also investigated velocities along the sea bed due to the single-port horizontal discharge. Results of the tests showed for a flow of 980 cubic feet per second, yielding an initial velocity of 14 feet per second that at 25 feet from the conduit exit the velocity was 10 feet per second, but reduced to 6 feet per second at 140 feet. At 200 feet the center line velocity was 4 fps and at 260 feet less than 2 fps.

Other tests to determine bottom velocities showed that for a flow of 600 cubic feet per second yielding an initial velocity of 8.5 fps the maximum bottom velocity was 6 fps at 85 feet from the point of discharge with a reduction to about 3.5 fps at 140 feet. At 200 feet, the velocity was 2.5 fps and at 260 feet less than 2 fps. The present design for the Seabrook Station specifies about 918 cfs discharge per unit yielding an exit velocity of 13 fps from an open end 9.5 foot diameter pipe. This suggests that the expected bottom velocities for the present design lie between the respective values for the two tests described above.

10.3.2 Multi-Port Diffuser Discharge

A number of alternatives are possible within the multi-port diffuser concept. An important consideration in optimizing the performance of a multi-port is the orientation of the diffuser with respect to the shore line. The orientation of the diffuser and nozzles is determined by the magnitude and direction of the ambient ocean currents in the vicinity of the diffuser site.

The diffuser consists of a large diameter pipe with many smaller diameter ports through which the heated discharge is injected into the receiving body of water. Although the same quantity of heat (BTU's) is released, the multi-port diffuser is capable of achieving a greater dilution and temperature reduction than is the single port outfall at the same location because more ambient ocean water is entrained with the discharge water. The more rapid mixing process induced by the action of the many diffuser jets can achieve a lower temperature rise at any given depth adjacent to the point of discharge as well as in the flow away zone (surface layer) emanating from the near-field mixing area. By careful design it is possible to achieve a vertical temperature stratification, rather than a fully mixed region, in order to minimize blockage which might be caused by temperature and velocity effects.

The details of the diffuser design and location are being determined through the use of field surveys, hydro-thermal model studies and analytical methods. This work is now in progress, and the design details have not yet been firmly established. Enough is known about diffuser design and performance to be certain that a design can be developed to satisfy environmental protection criteria. The diffuser will be located approximately 1500 feet southeast of the Outer Sunk Rocks in a depth of about 45 feet mean low water. The main barrel will be a partially or fully buried pipe of about 11.0 feet inside diameter. Discharge water will flow through a series of nozzles or holes provided along the main barrel. The exact spacing, injection angle and diameter of these discharge holes will be determined from hydro-thermal model studies and from analytical techniques. The injection angle of the individual jets will be slightly above horizontal to avoid bottom scour effects. Jet velocities will be about 12 - 15 feet per second at the points of discharge beyond which they will rapidly decelerate. The ports will be oriented to achieve optimum dilution and mixing with the ambient water entrained by the jet's momemtum. This orientation is to be determined from field survey data on local ocean currents and on the prevailing circulation pattern of the waters in the vicinity of the diffuser. Field surveys to determine these natural currents are now underway. The precise location of the diffuser will be determined when more field data is available. It will be selected to avoid creating a thermal block at the entrance of Hampton Harbor and to comply with mixing zone specifications prescribed by appropriate regulatory agencies.

10.4 Chemical Systems

10.4.1 Industrial Waste System

No adverse environmental effects are expected from the proposed system, therefore, alternative systems have not been evaluated. Also, there are no other practical physical and chemical treatment methods available that would have less overall impact.

10.5

10.5 Biocide Systems

The intake conduit of the circulating water system, the pumphouse, the condensers, and the service water system are the four parts of the Seabrook plant that are subject to fouling by marine organisms.

For the circulating water system intake conduit two methods of control of marine growth (mussels) were considered - a hot water backflush in which heated condenser effluent is routed through the intake conduit, and the use of a chemical biocide. The hot water backflush method was selected since it has the least effect on the environment and because of the large amount of chemical biocide that would be required.

To prevent condenser fouling either a chemical or a mechanical system can be used. The chemical system is the intermittent injection of chemical biocide into the cooling water. The mechanical alternate is the Amertap system which injects sponge rubber balls into the condenser and retrieves them downstream. To prevent fouling in the service water system, a chemical biocide must be used intermittently. For Seabrook, intermittent chlorination was selected for prevention of fouling in both the condenser and service water system. The Amertap system could not be used for the service water system and, as pointed out in Section 5.5, there are no significant active chlorine residues discharged to the ocean. No chemical biocides with less severe environmental effects than active chlorine are available.

10.6 Sanitary Waste System

No adverse environmental effects are expected from the proposed system. However, a physical - chemical type treatment system can yield an effluent equal to that described in Sections 3.7 and 5.5; therefore, the option to use such a system is retained although current economics are not in its favor. Also, other biological systems, using trickling filters or disc contactors, can yield equivalent treatment, but at higher cost. Processes employing incomplete or complete secondary treatment were not considered since they do not meet present or future regulatory requirements.

10.7 Liquid Radwaste Systems

The amount of radioactivity in liquid effluents from the Seabrook site, as described in subsection 3.5.1, is within the numerical guides for design objectives and limiting conditions of operation set forth in the proposed Appendix I to 10 CFR 50. Thus, no analysis of liquid radwaste treatment system alternatives is required.

10.8 Gaseous Radwaste Systems

The amount of radioactivity in gaseous effluents from the Seabrook site, as described in subsection 3.5.2, is within the numerical guides for design objectives and limiting conditions of operation set forth in the proposed Appendix I to 10 CFR 50. Thus, no analysis of gaseous radwaste treatment system alternatives is required.

10.9 Transmission Facilities

The proposed transmission facilities to be associated with Seabrook Station are described in Section 3.9. The alternative transmission line routings which were considered to tie Seabrook Station to the transmission system are described as Alternative 1 and Alternative 2.

Alternative 1 - Figure 10.9-1

1 - 345 KV Line - Seabrook Substation to Newington Substation
2 - 345 KV Lines - Seabrook Substation to Scobie Substation
2 - 345 KV Lines - Seabrook Substation to Tewksbury Substation

Alternative 2 - Figure 10.9-2

1 - 345 KV Line - Seabrook Substation to Newington Substation
2 - 345 KV Lines - Seabrook Substation to Tewksbury Substation
1 - 345 KV Line - Seabrook Substation to Scobie Substation

Compared to the proposed routing of transmission lines shown on Figure 9.2-4, Alternative 1 requires 35.6 miles of additional line be constructed and an additional 70.5 miles of right-of-way be purchased. Alternative 2 requires 36.4 miles of additional line be constructed and an additional 36.4 miles of right-of-way be purchased.

The parallel lines on the same rights-of-way in Alternatives 1 and 2 must be reliable and satisfy the condition that one line will not affect the other; to accomplish this the lines must be constructed on individual structures.

Wood H-Frame construction is used for the majority of these lines because approximately 80 percent of these lines are proposed to be constructed through wooded areas with mixed second and third growth hardwood and softwood. The FPC booklet "Electric Power Transmission and the Environment" states this is the type of structure which should be considered in forest or timber areas.

The additional right-of-way width needed when two lines are constructed side-by-side creates an impact at road crossings because in many cases this would require the purchase of a residence. If only one line is constructed there is generally space for the right-of-way and a screen belt to the residences on each side.

The lengthening of the transmission lines in either Alternative 1 or Alternative 2 has a detrimental effect on the stability of the units at Seabrook and thereby affects the reliability of the system.

The following estimated costs for construction of the proposed lines and Alternative 1 and Alternative 2 do not include right-of-way costs.

Proposed Lines	Facility Costs
(Seabrook - Newington; Seabrook - Scobie; Seabrook - Tewksbury)	$12,253,000
Alternate 1	
(Seabrook - Newington; 2 Lines Seabrook - Scobie; 2 Lines Scobie - Tewksbury)	$16,525,000
Alternate 2	
(Seabrook - Newington; 2 Lines Seabrook Tewksbury; 1 Line Scobie - Tewksbury)	$16,521,000

The lines associated with Alternates 1 and 2 use the same routes as the proposed system so the same sensitive areas need to be crossed. In Alternate 1: Seabrook - Scobie, the second line across the natural area of Cedar Swamp would create a greater environmental impact because of the stands of Atlantic white cedar which would be disturbed. One line is positioned such that very little of the cedar is cut. The Scobie - Tewskbury Lines cross the Merrimack River west of Lowell. There are other lines crossing at this location including two 230 KV lines. The banks would be properly screened, but additional overhead wires would be visible.

In Alternate 2: The Seabrook - Tewksbury lines cross the Merrimack River three times and cross near two major intersections. The three river crossings parallel existing overhead transmission lines. The environmental impact due to the additional 345 lines would be largely visual. The clearing on or near the river banks would be carefully controlled. No construction within the river bank would be allowed. The Scobie - Tewksbury line crosses the Merrimack River once parallel to the Seabrook - Tewksbury lines. Again, the environmental impact is a visual one.

COST DESCRIPTION-ALTERNATIVE TRANSMISSION ROUTES

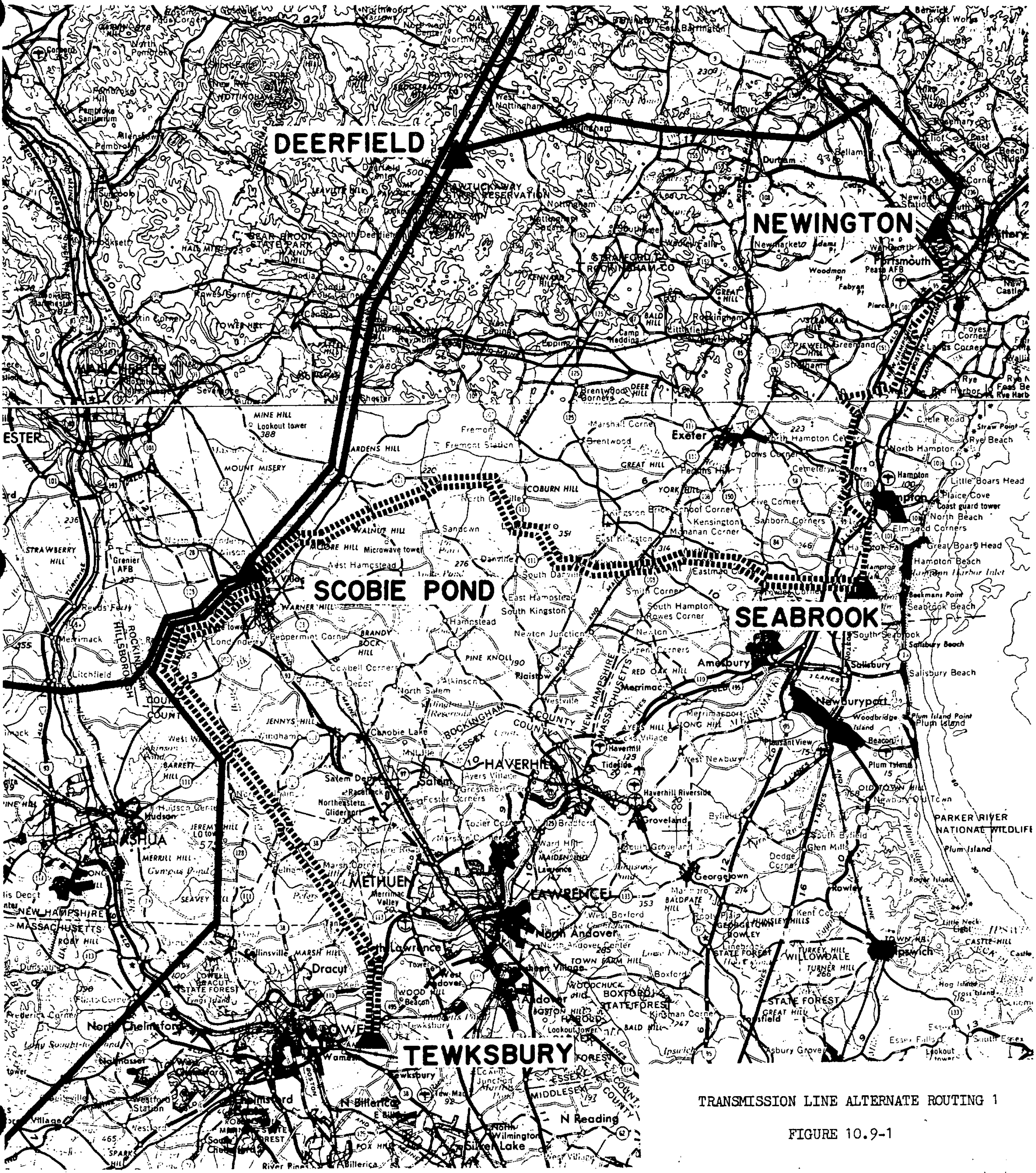
Environmental Costs	Alternatives Units	[A]Proposed Route Magnitude	Page	[B]Alternate 1 Magnitude	Page	[C]Alternate 2 Magnitude	Page
1. Land Use (Rank alternative routes in terms of amount of conflict with present and planned land use)	Rank	1		3		2	
2. Property Values (Rank alternative routes in terms of total loss in property values)	Rank	1		3		2	
3. Multiple Use (Rank alternative routes in terms of envisioned multiple use of land preempted by rights-of-way)	Rank	1		1		1	
4. Length of new rights-of-way required	Miles	48.6		119.1		85.0	
5. Number and Length of new access and service roads required	Miles	3 miles permanent roadway 54 miles temp. access road		52.75 miles temp. access road		3 miles permanent 31.25 miles temp. access road	
6. Number of major road crossings in vicinity of intersection of interchanges	Quantity	3		1		3	
7. Number of major waterway crossings	Quantity	3		1		3	
8. Number of crest, ridge, or other high point crossings		Little difference in all three.					
9. Number of "long views" or transmission lines perpendicular to highways and waterways		No difference - Screening available					

COST DESCRIPTION-ALTERNATIVE TRA ISSION ROUTES (Continued)

Environmental Costs	Units	ALTERNATIVES A Magnitude	A Page	B Magnitude	B Page	C Magnitude	C Page	
10. Length of above transmission line in or through the following visually sensitive areas								
10.1 Nature water body shoreline	Miles	0		0		0		
10.2 Marshland along R.R. tracks	Miles	2.0		2.0		2.0		
10.3 Wildlife refuges		0		0		0		
10.4 Parks		0		0		0		
10.5 National and state monuments	Miles	0		0		0		
10.6 Scenic areas	Miles	1.0		1.2		.5		
10.7 Recreation areas	Miles	0.3		0		0.6		
10.8 Historic areas		0		0		0		NOTE: Assumed 300 Feet for each road crossing on each line.
10.9 Residential areas actual use	Miles	2.7		3.8		3.6		
10.10 National forests and/or heavily timbered areas		0		0		0		
10.11 Shelter belts		0		0		0		
10.12 Steep slopes		0		0		0		
10.13 Wilderness areas		0		0		0		

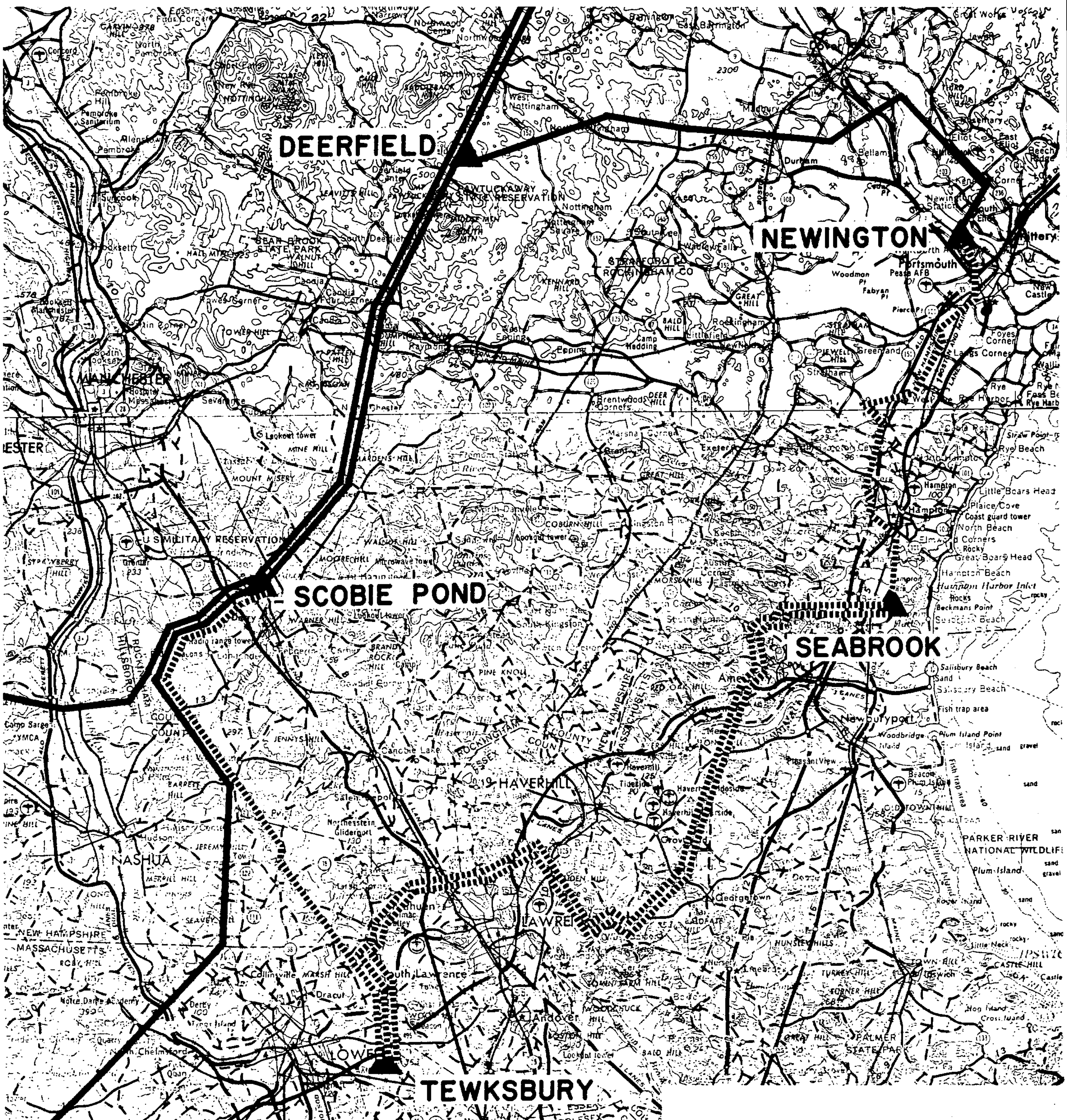
COST DESCRIPTION-ALTERNATIVE T[illegible]NSMISSION ROUTES (Continued)

Environmental Costs	Units	ALTERNATIVES A Magnitude	A Page	B Magnitude	B Page	C Magnitude	C Page
10.14 (Other sensitive or critical areas, specify)							
10.15							
10.16							
10.17							
10.18							
10.19							
10.20							
10.21 Total length through sensitive areas (sum 10.1-10.20)		6.0		7.0		6.7	
10.22 Total net length through sensitive areas (sum 10.1-10.20 eliminate duplication)		6.0		7.0		6.7	



TRANSMISSION LINE ALTERNATE ROUTING 1

FIGURE 10.9-1



TRANSMISSION LINE ALTERNATE ROUTING 2

FIGURE 10.9-2

10.10 Other Systems - Service Water

10.10.1 General

Ocean water from the Gulf of Maine is used as the cooling medium for the service water system. The main circulating water system conduits are used to transport the necessary ocean water to the service water intake structure at the plant site during both normal and accident conditions.

During normal operation the circulating water pumps provide the driving force necessary to pump the ocean water through the main circulating water conduit to the plant. In the event power to the pumps were lost, a bypass line around these pumps automatically opens and allows ocean water to be gravity fed to the service water intake structure under all sea level conditions.

Under normal operating conditions 44,000 gpm is required for service water cooling. This produces a temperature increase of 16°F. During cooldown, the situation in which the greatest temperature rise is encountered, 22,000 gpm per unit is the required flow producing a 35°F temperature rise. The service water system is further described in Section 3.3.

Three alternate service water system concepts were considered for Seabrook Station. They are:

1. Cooling Towers
2. Ocean Water Cooling
3. Cooling Pond

The important features of each alternative are summarized briefly below. The evaluation of these alternatives was done on the basis of feasibility, design, cost and their effect on the environment. The system described above was selected because it met all the design requirements and was evaluated as having the least effect on the environment.

10.10.2 Cooling Towers

General Description

During normal operation, the service water is tapped off the circulating water intake conduits. The service water pumps supply water for the equipment heat loads and discharge back into the circulating water discharge conduits. For an accident condition, the service water discharge is automatically shifted to towers. The towers and makeup reservoir are then used as a heat sink. The cooling tower system is located adjacent to the station and is designed to handle the loads from one unit under an accident condition and the second unit under a cooldown condition.

Design Basis

Each cooling tower is designed to dissipate a maximum heat load of 208 x 10^6 BTU/hr to the atmosphere with a service water flow of 10,100 gpm in the event of a loss of coolant accident and a maximum heat load of 395 x 10^6 BTU/hr with a service water flow of 12,200 gpm for an accident in one unit coincident with a cooldown of the other unit. A redundant tower, sized for the above heat loads, is additionally supplied as a precaution against any single failure.

The cooling towers would be built east of Unit 1 and would be composed of two towers and two reservoirs. Each tower would be 88' by 46' by 44' in size taking up a total area of 7,744 square feet. The reservoirs would hold 6,000,000 gallons and would be 149' by 149' by 36' in depth, each taking up a total area of 22,201 square feet and would be located either underneath or adjacent to the towers.

A cost comparison was made between the cooling tower concept and the present design. This comparison indicated the present design, utilizing ocean water and circulating water conduits to be approximately $5 million less than the cooling tower concept.

10.10.3 Ocean Water Cooling

General Description

Two ocean water cooling systems other than the one described in subsection 10.10.1 were investigated. The first design had the service water intake structure and pumps located at Hampton Beach and its own piping back to the plant site. The second design located the pumps on the plant site with gravity flow from the ocean through intake pipes.

Design Basis

Both systems were sized to remove 462×10^6 BTU/hr; this coincides with a cooldown heat load on one unit and an accident condition on the other unit. For this condition, ocean water temperature would be increased by 100°F and a flow of 9350 gpm would be required.

Estimates of the costs associated with either system showed them to be approximately $15 million to $40 million more expensive than the costs for any of the other concepts.

These very substantial increases are the result of:

1. Additional piping required to transport the ocean water to the plant.

2. In the case of the first system, providing separate power supplies for the service water pumps at Hampton Beach.

10.10.4 Cooling Pond

General Description

For this concept, the heat sink is a cooling pond located to the west of the plant site. The pond would be created by constructing a reservoir that would be flooded by salt water at high tide. The reservoir would be sized to trap enough water to supply the service water pumps for one tide cycle. The heated pond water would then be discharged to the circulating water discharge conduits in a once through system.

Design Basis

This concept was designed to dissipate a heat load of 462×10^6 BTU/hr with a service water flow of 12,450 gpm and a cooldown of one unit with an accident in the other. The reservoir would hold approximately 10 million gallons.

This system was not economically evaluated because of the large area of marsh which would have had to be flooded.

10.10.5 Assessment of the Ecological Impact of the Alternative Service Water Cooling Systems

The cooling tower alternative involves the construction of major pieces of additional equipment, and therefore additional disruption of the plant's surrounding environment. A small amount of fogging would have also been seen coming from the towers.

Ocean Cooling

Either of the two systems discussed in the ocean water cooling concept would have substantial disadvantages ecologically as well as economically. Both concepts require two separate service water pipes running from the ocean to the plant. Thus additional marshland would have to be disturbed for laying the two pipes. Also in the case of the pumps at Hampton Beach, additional beach property would be required for locating the pumps.

Cooling Pond

The cooling pond concept was not fully evaluated due to the amount of area that would have to be flooded.

10.11 The Proposed Plant

The benefits from the proposed Seabrook Station which can be quantified are listed in Table 10.11-1.

The cost description of the proposed facility is summarized in Table 10.11-2. The calculated levelized annual generating cost of $237.3 million is based upon the costs and factors described below:

Total Cost of Construction at Time of Unit Startup	$1,140,000,000
Levelized Fixed Charge Rate for 30 Year Life	16.34 percent
Fuel Cost	$1.70/MWHe
Operation and Maintenance	$1.50/MWHe
Net Output	2300 MWe
Plant Factor	80 percent

TABLE 10.11-1

BENEFITS FROM THE PROPOSED FACILITY

DIRECT BENEFITS

Expected Average Annual Generation in Kilowatt-Hours	13,216,000,000
Capacity in Kilowatts	2,300 MWe Net
Proportional Distribution of Electrical Energy Expected Annual Delivery in Kilowatt-Hours:	
Industrial	3,500,000,000
Commercial	1,100,000,000
Residential	4,400,000,000
Other	4,216,000,000
Expected Average Annual Btu (in millions) of Steam Sold from the Facility	NA
Expected Average Annual Delivery of Other Beneficial Products (appropriate physical units)	NA
Revenues from Delivered Benefits:	
Electrical Energy Generated (minimum estimate)	$ 255,068,800
Steam Sold	NA
Other Products	NA

INDIRECT BENEFITS (as appropriate)

Taxes (annual payments to Town of Seabrook, State of New Hampshire)	$36.7 million
Research one-half cost pre-op environmental studies	1.5 million
Regional Products	25.0 million
Environmental Enhancement:	
Recreation for Town Residents	Yes
Navigation	NA
Air Quality from not burning oil:	
SO_2	192 T/day
NO_x	72 T/day
Particulates	48 T/day
Employment--Construction/Permanent	2000/125
Education--Estimated Annual Visits to ED Center	25,000

TABLE 10.11-2

COST DESCRIPTION OF PROPOSED FACILITY AND TRANSMISSION HOOK-UP

(All monetized costs expressed in terms of their present and annualized values)

Generating Cost	Present Worth (1979 $)	1,140,000,000
	Annualized	237,300,000
Transmission and Hook-up Cost	Present Worth (1973 $)	13,500,000
	Annualized	2,500,000

Environmental Costs	UNITS	MAGNITUDE
1. Natural surface water body		
1.1 Impingement or entrapment by cooling water intake structure		
1.1.1 Fish	Pounds/Year	147,000
1.2 Passage through or retention in cooling systems		
1.2.1 Phytoplankton and zooplankton	Pounds/Year	40,000
1.2.2 Fish	Pounds/Year	1,200
1.3 Discharge area and thermal plume		
1.3.1 Water quality, excess heat	Acres	To Be Reported 1973
1.3.2 Water quality, oxygen availability	Acre-Feet	Insignificant
1.3.3 Aquatic biota	Pounds/Year	Insignificant
1.3.4 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)	Acres	Insignificant
1.3.5 Fish, migration	Pounds/Year	No Effect
1.4 Chemical effluents		
1.4.1 Water quality, chemical	Acre-Feet	Insignificant
1.4.2 Aquatic organisms	Pounds/Year	Insignificant

TABLE 10.11-2

COST DESCRIPTION OF PROPOSED FACILITY AND TRANSMISSION HOOK-UP
(Continued)

Environmental Costs	UNITS	MAGNITUDE
1.4.3 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)	Acres	No Effect
1.4.4 People	Lost Use	No Effect
1.5 Radionuclides discharged to water body		
1.5.1 Aquatic organisms	Rad/Year	5.2×10^{-5}
1.5.2 People, external	Rem/Year	3×10^{-9}
1.5.3 People, ingestion	Rem/Year	6.3×10^{-4}
1.6 Consumptive use (evaporative losses)		
1.6.1 People	Gal/Year	No Effect
1.6.2 Property	Acre Ft/Year	No Effect
1.7 Plant construction (including site preparation)		
1.7.1 Water quality, physical	Acre-Feet	Minor Effect
1.7.2 Water quality, chemical	Acre-Feet	Minor Effect
1.8 Other Impacts		None
1.9 Combined or interactive effects		No Additional
1.10 NET EFFECT NO SIGNIFICANT LONG-TERM BENEFICIAL OR DETRIMENTAL EFFECTS		
2. Ground water		
2.1 Raising/lowering of ground water levels		
2.1.1 People	Gal/Year	No Effect
2.1.2 Plants	Acres	No Effect
2.2 Chemical contamination of ground water (exclusing salt)		
2.2.1 People	Gal/Year	No Effect
2.2.2 Plants	Acres	No Effect

TABLE 10.11-2

COST DESCRIPTION OF PROPOSED FACILITY AND TRANSMISSION HOOK-UP
(Continued)

Environmental Costs			UNITS	MAGNITUDE
	2.3	Radionuclide contamination of ground water		
		2.3.1 People	Rem/Year	No Effect
		2.3.2 Plants and animals	Rad/Year	No Effect
	2.4	Other impacts on ground water		None
3.	Air			
	3.1	Fogging and icing (caused by evaporation and drift)		
		3.1.1 Ground transportation	Hours/Year	No Effect
		3.1.2 Air transportation	Hours/Year	No Effect
		3.1.3 Water transportation	Hours/Year	No Effect
		3.1.4 Plants	Hours/Year	No Effect
	3.2	Chemical discharge to ambient air		
		3.2.1 Air quality, chemical	Pounds/Year	No Effect
		3.2.2 Air quality, odor		
	3.3	Radionuclides discharged to ambient air and direct radiation from radioactive materials		
		3.3.1 People, external	Rem/Year	1.1×10^{-4}
		3.3.2 People, ingestion	Rem/Year	1.3×10^{-4}
		3.3.3 Plants and animals	Rad/Year	1.9×10^{-3}
4.	Land			
	4.1	Site selection		
		4.1.1 Land, amount	Acres	660
	4.2	Construction activities (including site preparation)		
		4.2.1 People (amenities)	Noise	19 Residences
		4.2.2 People (accessibility of historical sites)		No Effect

COST DESCRIPTION OF PROPOSED FACILITY AND TRANSMISSION HOOK-UP

(Continued)

Environmental Costs	UNITS	MAGNITUDE
4.2.3 People (accessibility of archeological sites)		No Effect
4.2.4 Wildlife		Minor Effect
4.2.5 Land		No Erosion
4.3 Plant Operation		
4.3.1 People (amenities)	Noise	No Effect
4.3.2 People (aesthetics)		Minor Effect
4.3.3 Wildlife		No Effect
4.3.4 Land, flood control		None
4.4 Salts discharged from cooling towers		
4.4.1 People	Pounds/Acre	None
4.4.2 Plants and animals	Acres	None
4.4.3 Property resources	$/Year	None
4.5 Transmission route selection		
4.5.1 Land, amount	Miles	48.6
4.5.2 Land use and land value	Miles	6.0
4.5.3 People (aesthetics)	Miles	2.7
4.6 Transmission facilities construction		
4.6.1 Land adjacent to right-of-way	Miles	54
4.6.2 Land, erosion	Tons/Year	Minor
4.6.3 Wildlife		Minor
4.7 Transmission line operation		
4.7.1 Land use	Percent	None Planned
4.7.2 Wildlife		None

COST DESCRIPTION OF PROPOSED FACILITY AND TRANSMISSION HOOK-UP

(Continued)

Environmental Costs	UNITS	MAGNITUDE
4.8 Other land impacts		None
4.9 Combined or interactive effects		None
4.10 Net effects		Minor

11. SUMMARY BENEFIT-COST ANALYSIS

The Benefits of the Seabrook Facility

An evaluation of the desirability of the proposed facility must take into account its direct as well as indirect benefits. The direct benefits are represented by the generating capacity to be added and its value to consumers.

The monetary value of the added generation will be summarized below. However, it should be noted that this monetary value undoubtedly represents a minimum value.[1] If the facilities are not approved and constructed, Public Service Company of New Hampshire will face a situation where it cannot meet its load as early as 1979 (Table 1.1-13). Even after taking into account all possible purchases from other systems, the gap between generating capability and load will widen, reaching a level of 890 megawatts by 1982.

If both Seabrook units are constructed and operated on schedule, Public Service Company of New Hampshire will be able to meet its expected load levels with reserve margins (11.1 percent in 1982) barely adequate to assure a reasonable degree of reliability. Another benefit of the facility is the added reserve and improved reliability which it will

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[1] No attempt has been made to estimate the value of the benefits based on prices consumers would be willing to pay.

provide for electricity supply; without the Seabrook units New England reserves will reach the perilous level of 7.7 percent in 1982, while with Seabrook on line, reserves will reach the more nearly adequate level of 15.8 percent.

The monetary value of the added generating capacity is hard to establish. By necessity, it reflects presently prevailing prices for the output rather than the maximum value which the consumer places upon his use of electricity. Nor does it take into account possible inflationary trends which would increase the monetary value of the aforementioned benefits. Nonetheless, current prices do offer a minimum estimate of the benefits to consumers.

A bare minimum value for the benefit of the electricity supplied by Seabrook can be derived by multiplying its total generation by 1.93 cents, which is the price per kilowatt-hour derived as the weighted average of actual 1972 prices and expected 1982 sales distribution by type of customers. Under the conservative assumption of only 2,000 megawatt capacity, 7,000 hours per year (80 percent capacity factor) and a 5.6 percent energy loss rate, we estimate the value of electric sales from the two units to be in excess of one-quarter billion dollars annually (Section 8.1 and Table 10.11-1).

An alternative source of the same quantity of electricity would, of course, provide similar benefits. For the purposes of this benefit-cost analysis, therefore, the net benefit advantage of the Seabrook plant will depend upon the difference between the cost of electricity generation to be supplied by Seabrook and the cost of electricity from alternative sources, including the cost of their respective environmental effects.

Failure to meet the growth in electricity demand is not an acceptable alternative. The owners of Seabrook, like other electric utilities, have a responsibility and obligation to serve all consumers and meet their demands for electric energy at all times. Electric utilities may not restrict arbitrarily the use of electricity, refuse to serve anyone requesting service, or in any other way limit electricity use in their service territories. Public Service Company of New Hampshire, therefore, must plan to satisfy anticipated demand for service in the most economical manner feasible. These demands are expected to expand as population grows and economic development continues.

The growth of the New Hampshire economy and its population are also expected to increase greatly the demand for electricity for all purposes, including schools, hospitals, street lighting, sewage treatment and a wide range of other public services. The load of Public Service Company of New Hampshire has increased by about 65 percent in the last five years and is expected to grow another 165 percent from 875 megawatts in 1972 to 2,323 megawatts in 1982 (Table 1.1-13). Therefore, the only meaningful question is what alternative to Seabrook might be preferable, not whether additional capacity is necessary. This must be evaluated in light of the associated economic costs as well as the cost of the environmental impacts.

In concluding this section on the benefits of the facility, we summarize the indirect, or spill-over benefits of the Seabrook units. These encompass the beneficial impact of the plant on regional employment, income and other aspects of human activity.

Conservative estimates of the impact of the construction of the plant on regional income suggest a rise of \$102 million (Table 8.2-1). Purchases of material and equipment will amount to \$25 million in the New England area and can be expected to give rise to value added of \$17 million.

Section 11.2

The Costs

Having considered the benefits of the proposed facility we turn to an examination of its costs. In particular, we summarize the relationship of these costs to alternative fuels and sites.

Section 11.2.1

Selection of Sites

The procedures which were followed in the site selection and the underlying criteria are described in Section 9.2. The analysis took explicit account of existing land use patterns, the availability of adequate flows of cooling water for the generating plant, transmission costs, environmental and economic development costs, transportation facilities and costs of delivered fuel. After considering all these factors it was concluded that Seabrook represented the most desirable location for a new generating facility, be it fossil- or nuclear-fueled. The decision on the type of plant, therefore, must be guided by other considerations, namely, by economic and environmental factors. These are summarized in the next section.

Section 11.2.2

Alternative Fuels

As explained in Section 9.2, the only realistic alternative fuel is residual oil. Because of air quality regulations and severe limitations on the available supply of low sulfur coal, coal does not offer a viable alternative. The large amount of land for storage and handling required for a coal-fired plant also militates against its feasibility.

Similarly, natural gas cannot be considered to offer a realistic alternative, although it would satisfy existing air quality regulations, because natural gas supply is severely limited, especially in New England.

Combustion turbine peaking units do not offer a practical alternative to base load fossil or nuclear units.

Such peaking units are designed to operate for only a relatively few hours during the year. They are not capable of operating over extended periods of time as are base load fossil or nuclear units. Operation of combustion turbines much in excess of 1,000 hours annually would result in very high maintenance and replacement costs and would impair the reliability otherwise afforded by their dependable availability during peak periods. Such peak units, therefore, cannot substitute for units designed to operate for long hours. In addition, peaking turbines are extremely costly sources of power. While their capital cost is somewhat lower than the cost of base load units, they use No. 2 fuel oil which is more expensive than the oil consumed in steam boilers.[2] Furthermore, their thermal efficiency is about one-third lower than the thermal efficiency of base load steam generation. The extended use of combustion turbines, therefore, would have a significant adverse effect on costs as well as on the already hard-pressed supply of distillate oil.

Purchasing power from other electric utilities outside New England is not a feasible alternative. The full amount of energy currently available to New England over the interconnection with New Brunswick, Canada, is already being

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[2] At the present time in New England, fuel oil for combustion turbines costs about 95 cents per million Btu compared with about 70 cents per million Btu for the low-sulfur No. 6 oil used in steam boilers.

purchased. The power supply situation in New York State, as has been well publicized, is itself marginal. Uncertainties regarding the licensing of nuclear plants scheduled for operation in the near future create further questions as to the reliability of the New York State power supply. If Seabrook is not constructed, the power supply situation in New England would be extremely tight and the reliability of electric service to the public would be in jeopardy. The possibility of obtaining supplementary supplies of power from areas outside New England has been investigated and found to be unavailable.

We conclude, therefore, that an oil-fired base load unit is the only feasible alternative to the Seabrook plant. No other reasonable option is open.

Section 11.2.3

The Comparative Economics of Oil-Fired Generation

The costs of the nuclear and residual oil alternatives are reported in Table 9.3-1. These show that when all costs--fixed as well as operating--are taken into account, a nuclear plant will have an advantage of $39 million a year. This saving reflects the fuel cost advantage of Seabrook which more than offsets the larger investment cost which must be made in a nuclear facility. We note that the comparison is based on present fuel costs per kilowatt-hour and therefore understates the advantage of the nuclear unit. There is little doubt that even if nuclear fuel costs are going to rise, oil prices are likely to rise at a more rapid rate, thereby increasing the cost saving offered by a nuclear plant.

Section 11.2.4

Comparative Environmental Costs

Having determined the inherent economic advantage of a nuclear plant over oil-fired units, one must examine the comparative environmental costs of the two alternatives.

The major environmental effects of the nuclear units which need to be evaluated are those which may result from the operation of the condenser cooling water system and the amounts of radiation, particulate and gaseous effluent. As summarized in Table 10.11-2, the environmental impact on aquatic ecology of the operation of Seabrook is extremely low and insignificant. The heated discharge water from an oil-fired plant would be less than from a nuclear plant. However, with the Atlantic Ocean as a heat sink and with proper engineering design the impact will be minimal in either case.

Because of the discharge into the ocean and the ability to design a heated water discharge system which will have an extremely small and insignificant effect on the aquatic ecology, a once-through condenser cooling system was selected rather than a wet cooling tower with its potential environmental effects, especially when operating on salt water. The selection of the heat dissipation system is described in Section 3.4. Two discharge systems are presently under study. The first is a single port or "submerged buoyant jet" which discharges the heated circulating water for each unit through a single port some distance above the ocean bottom. The second is a submerged multi-port diffuser in which the discharge from each unit is discharged through a number of ports spaced along a diffuser pipe. The same amount of total heat, 16×10^9 Btu/hour, is rejected by both systems. The final choice between these two systems will be based on studies now under way. The systems are described in Section 10.3, and the effects of their operation are discussed in Section 5.1. There appears to be no reason, in any case, to expect any difference in the aquatic effects of Seabrook and those of an oil-fired alternative.

The second major environmental cost to be considered is radiation emission of the Seabrook units, and the gaseous and particulate effluents of an oil-fired alternative. The radiation monitoring program to be employed at Seabrook has been described earlier in Section 6.2. The expected gaseous and liquid radioactive releases also have been described earlier in Section 3.5. No significant releases are anticipated. The AEC lowest practical standard for radiation releases will be met. It is concluded, therefore, that there will be virtually no environmental effects of radiation releases from the Seabrook plant.

An oil-fired alternative to Seabrook would affect air quality. As reported in Section 9.3, with present equipment and air pollution regulations, two 1,150 megawatt residual fuel oil plants would release annually 112 million pounds of SO_2 and 42 million pounds of NO_x. Assuming 98 percent efficiency in removing particulate matter, 560 thousand pounds of particulates can still be expected to escape out of the stack of the oil-fired plant. These significant air pollution effects are avoided by the planned nuclear facility.

In addition, an oil-fired plant would require a large area for oil storage. It would necessitate the construction of facilities for docking large ocean-going oil tankers with their associated environmental risk of oil spills. Finally, it would require a delivery pathway from the dock to the plant. Thus, environmental considerations show a decided advantage for the planned nuclear facility over an alternative oil-fired plant.

Section 11.3

Conclusion

This report has addressed itself to an evaluation of the benefits and costs of the proposed Seabrook nuclear plant, and has considered the available alternatives. It is clear that the only feasible alternative to the proposed nuclear plant would be an oil-fired base load plant. A comparison of the economic costs clearly shows that the proposed

Seabrook plant offers a significant net benefit over the alternative.

The annual cost advantage of the nuclear unit over the oil-fired alternative is about $39 million a year. The total cost advantage over the plant's 30-year life, even with the conservative assumptions that have been used for purposes of this analysis, would be in excess of $1.1 billion. The evaluation of the several possible environmental effects also shows that the Seabrook nuclear plant represents the socially preferable alternative. Thus, on both economic and environmental grounds, the proposed Seabrook nuclear plant is the appropriate choice for meeting the anticipated growth in electric energy requirements in New Hampshire and more generally in New England.

12. ENVIRONMENTAL APPROVALS AND CONSULTATIONS

12 ENVIRONMENTAL APPROVALS AND CONSULTATION

12.1 Site Evaluation Committee

The State of New Hampshire has taken action to assure the State an adequate and reliable supply of electric power in accordance with sound environmental utilization. The procedures for accomplishing this were enacted by the State Legislature on June 25, 1971. The declaration of purpose of that act (RSA 162-F) follows:

ELECTRIC POWER PLANT AND MAJOR TRANSMISSION
SITING AND CONSTRUCTION PROCEDURE

162-F:1 Declaration of Purpose. The legislature finds that the present and predicted growth in electric power demands in the state of New Hampshire requires the development of a procedure for the selection and utilization of sites for generating facilities and the identification of a state position with respect to each proposed site. The legislature recognizes that the selection of sites and the routing of associated transmission lines will have a significant impact upon the welfare of the population, the location and growth of industry, and the use of the natural resources of the state. The legislature, accordingly, finds that the public interest requires that it is essential to maintain a balance between the environment and the need for new power sources; that electric power supplies must be constructed on a timely basis; that in order to avoid undue delay in construction of needed facilities and to provide full and timely considerations of environmental consequences, all electric entities in the state should be required to engage in adequate long-range planning and provide full and complete disclosure to the public of such plans; that a certifying body be established for the preconstruction review of bulk power supply facility sites and all related bulk power supply facilities; that the siting of bulk power plants and high-voltage transmission lines should be treated as a significant aspect of land-use planning in which all environmental economic and technical issues should be resolved in an integrated fashion; that existing laws do not provide an adequate procedure for the coordination of reviews to assure protection of environmental values and certifying the construction, operation or maintenance of bulk power supply facilities so as to assure the state an adequate and reliable supply of electric power in conformance with sound environmental utilization; and that existing laws do not provide adequate public voice in the decision on the location of bulk power supply facilities at a specific site. The legislature, therefore, hereby establishes a procedure for the planning, siting and construction of bulk power supply facilities.

The membership of the Site Evaluation Committee is defined by the Act:

> 162-F:3 Site Evaluation Committee. The bulk power supply facility site evaluation committee shall consist of the executive director and the chief aquatic biologist of the water supply and pollution control commission, the commissioner of the department of resources and economic development, the director of fish and game, the director of the office of planning, the chairman of the water resources board, the director of the radiation control agency, the executive secretary of the air pollution control commission, the commissioner of the department of health and welfare, the director of the division of parks, the director of the division of resources, the chairman of the public utilities commission and the chief engineer of the public utilities commission. The director of water supply and pollution control commission shall be chairman of the committee. Provided that in the event there is created an agency or department whose function is the protection and preservation of the environment of the state, then the director of that agency shall be the chairman of the committee.

The Applicant filed with the Public Utilities Commission on February 1, 1972, an application pursuant to RSA 162-F:7 (IV) to construct a 2200 MWe generating station and associated transmission lines. Through this one proceeding the Applicant will receive all permits required from the State prior to the start of construction. The findings required of the Site Evaluation Committee and the Public Utilities Commission are listed below:

> 162-F:8 Findings.
> I. The site evaluation committee, after having considered available alternatives and the environmental impact of the site or route, must find that the site and facility will not unduly interfere with the orderly development of the region with due consideration having been given to the views of municipal and regional planning commissions and municipal legislative bodies and will not have an unreasonable adverse effect on esthetics, historic sites, air and water quality, the natural environment, and the public health and safety, and shall send its findings to the commission within eighteen months of the filing of an application for a certificate of site and facility. The commission shall issue or deny a certificate and shall be bound by the findings of the site evaluation committee. In its decision, the commission must find that the construction of the facility:
> (a) Will not unduly interfere with the orderly development of the region with due consideration having been given to the views of municipal and regional planning commissions and municipal legislative bodies;
> (b) Is required to meet the present and future demand for electric power;

(c) Will not adversely affect system stability and reliability and economic factors; and

(d) Will not have an unreasonable adverse effect on esthetics, historic sites, air and water quality, the natural environment, and the public health and safety.

II. Findings by the site evaluation committee to the public utilities commission shall be made after a vote of the committee. A majority vote of the committee shall be conclusive on all questions of siting, land use, air and water quality. The commission shall grant a certificate only after it has reasonable assurance that all applicable state standards and requirements shall be met by the applicant and that the commission shall incorporate in its certificate such lawful terms as may be supplied to it by the site evaluation committee and those state agencies having permit or license granting responsibilities under state law.

III. In the consideration of applications for certificates of site and facility, the site evaluation committee and the commission shall assure full public review and adequate consideration of all environmental values and other relevant factors bearing on whether the objectives of this chapter would be best served by the issuance of the certificate. The site evaluation committee and the commission may consult with interested regional agencies and agencies of border states in the issuance of such certificates.

IV. A certificate of site and facility shall either be issued or denied by the commission within two years of the date of the application being submitted and may contain such reasonable terms and conditions as it deems necessary and may provide for such reasonable monitoring procedures as may be necessary. Such certificates, when issued, shall be final and subject only to judicial review.

Hearings as required by RSA 162-F:7 commenced on June 19, 1972, before the Site Evaluation Committee, the Public Utilities Commission, and the Special board on dredge and fill. The general intervenors in the proceedings are:

Council for the Public

U.S. Environmental Protection Agency

Society for the Protection of New Hampshire Forests

Seacoast Anti-Pollution League

Elizabeth Weinhold (Mrs.)

Audubon Society of New Hampshire

Frances Tolland (Mrs.)

Willard N. Brownell - Marine Biologist & Environmental Planner

Peter E. Randall - Conservation Commission

Rudi Smith - North Hampton Conservation Commission

The role of Counsel For The Public is defined by RSA 162-F:9:

> 162-F:9 Counsel for the Public. After the commission has received an application, filed pursuant to RSA 162-F:6 hereof, the attorney general shall appoint an assistant attorney general as a counsel for the public. The counsel shall represent the public and its interests in protecting the quality of the environment and in the assurance of an adequate electric power supply for the duration of the certification proceedings and until such time as the certification is issued or denied. He shall be accorded all the rights, privileges and responsibilities of an attorney representing a party in a formal action. This section shall not be construed to prevent any person from being heard or represented by counsel in accordance with other provisions of this chapter.

A brief summary of the hearings held to date follows:

<u>1972</u>

June 19	Opening Statement & Summary of Direct Testimony Applicant's Direct Case on Need for Power
June 20	Applicant's Direct Case on Plant Design, Ecological Effects (condensing water studies), and Alternatives
June 21	Applicant's Direct Case on Transmission Lines, Ecological, Thermal Effects, Development of Area
October 2	Limited Appearances (Statements & Testimony) Cross-examination of Company Testimony on Power Needs and Cost Reliability
October 3	Limited Appearances Cross-examination of Participation Agreement and Power Needs
October 4	Limited Appearances Cross-examination of Power Needs
October 30	Limited Appearances Cross-examination of Industrial Development and Power Needs
October 31	Cross-examination of Cost Savings Against Other Proposals, Power Needs, Planning of Generation, Site Study, Circulating Water System
November 1	Limited Appearances Cross-examination of Costs and Savings of Seabrook, Studies, Barge-Mounted Nuclear Plants, Nuclear Fuel Costs
November 14	Cross-examination of Plant Design (pipe routes), Alternatives (off-shore plant), Delivery Routes, Land Use, Restricted Areas, Labor Force, Radiological

November 15	Cross-examination - Redirect - Recross of Radiological Studies, (accidents, releases, plant design), Costs, Condensing Cooling Water (pipe route)
November 20	Limited Appearance Cross-examination of Ecological, Biological
November 21	Cross-examination - Redirect of Ecological, Environmental Cross-examination of Transmission
December 6	Cross-examination - Redirect - Recross of Transmission
December 7	Limited Appearance Cross-examination - Redirect - Recross of Ecological, Geological, Geophysical, Seismology
December 12	Cross-examination - Redirect - Recross of Discharge Design, Land Planning Direct - Cross-examination - Redirect of Meteorological Data
December 19	Limited Appearances Cross-examination - Redirect - Recross of Thermal Effects

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January 11	Cross-examination - Redirect of Discharge Plant Design (ocean) Cross-examination - Redirect - Recross of Discharge Plant Design (ocean)
January 12	Cross-examination - Redirect - Recross of Biological, Ecological, Marine Construction
January 18	Direct Testimony - Intervenors: Society for the Protection of New Hampshire Forests. Elizabeth Weinhold

Other meetings and actions in support of the application for a Certificate of Site and Facility include:

<u>1972</u>

June 9	Tour Connecticut Yankee Plant to discuss technical and environmental similarities and differences
August 31	Response of Public Service Company of New Hampshire to Interrogatories Nos. 53 through 372 submitted by Donald W. Stever, Jr., Counsel for the Public
August 31	Response of Public Service Company of New Hampshire to Interrogatories submitted by Karin P. Sheldon, Counsel for Seacoast Anti-Pollution League - Set I and Set II

September 14	Response of Public Service Company of New Hampshire to Interrogatories Nos. 1 through 53 submitted by Robert A. Backus, Counsel for the Society For Protection of New Hampshire Forests
October 24	Special Board Hearing on request by Public Service Company of New Hampshire to conduct a marsh recovery study
November 29	Meeting with State Officials and Battelle Memorial Institute to discuss Seabrook Application and environmental effects
November 30	Continuation of November 29th meeting with a tour of the site and its environs

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February 8	Public and SAPL Direct Case

The public hearings will continue until cross-examination of the intervenors' cases, rebuttal testimony, and direct questioning of the parties by the committee are completed. With the satisfactory conclusion of the hearings, the state permits listed in the following section will be obtained. The Applicant expects that some of these will be conditional and that the conditions can and will be satisfied.

12.2 Licenses, Permits and Approvals

The following licenses, permits and approvals are believed to be necessary in connection with the proposed project:

Agency Issuing Permit	Item Requiring Permission	Status
New Hampshire Public Utilities Commission & N.H. Site Evaluation Committee (PUC & SEC)	Certificate of Site & Facility (RSA 162-F:8)	Pending Application February 1, 1972
New Hampshire PUC	Extension of Franchise Area (RSA 374:22)	Pending, include with application to SEC
New Hampshire PUC	Transmission Water Crossing License Powwow River in South Hampton (RSA 371:17-20)	Pending, include with application to SEC
New Hampshire PUC	License for Water Conduits & Intake Pumping Facility on State Owned Land & Under or Across Public Waters (RSA 371:17-23)	Pending, include with application to SEC
New Hampshire Special Board & Water Resources Board	Permission to Construct Temporary Roads & Install Buried Ground Wire Through Certain Surface Waters (RSA 483-A:1)	Pending, include with application to SEC
New Hampshire Water Supply & Pollution Control Commission	Permission to Construct Temporary Roads & Install Buried Ground Wire Through Certain Surface Waters (RSA 149:8a)	Pending, include with application to SEC
New Hampshire Special Board & Water Resources Board	Permission to Install Intake Pipes & Pump Facilities from Ocean to Plant (RSA 483-A:1)	Pending, include with application to SEC
New Hampshire Water Supply & Pollution Control Commission	Permission to Install Intake Pipes & Pump Facilities from Ocean to Plant (RSA 149:8a)	Pending, include with application to SEC
New Hampshire Dept. Public Works & Highways	Permission to Install Intake Pipes Under State Highway (Route 1A) (RSA:255)	Pending, included with application to SEC
New Hampshire Water Supply & Pollution Control Commission	Permission to Discharge Heated Water & Waste into Surface Waters & Permission to Operate Said Facilities (RSA 149:8)	Pending, include with application to SEC
New Hampshire Dept. Public Works & Highways	License for Overhead Wires Crossing State Roadways (RSA:254)	Pending, included with application to SEC

New Hampshire Special Board & Water Resources Board	Permission to Fill Existing Fresh Water Pond on Site (Doctor's Pond) (RSA: 483-A:1)	Pending, amendment to application to SEC
New Hampshire Water Supply & Pollution Control Commission	Permission to Fill Existing Fresh Water Pond on Site (Doctor's Pond) (RSA 149:8-a)	Pending, amendment to application to SEC
New Hampshire Special Board & Water Resources Board	Permission to Excavate Marsh to Ascertain Vegetation Recovery (RSA: 483-A:1)	Permission Received Permit #P-128 Dated 11/9/72
New Hampshire Water Supply & Pollution Control Commission	Permission to Excavate Marsh to Ascertain Vegetation Recovery (RSA: 149:8-a)	Permission Received
Atomic Energy Commission (AEC)	Construction Permit	To Be Filed March 1973
AEC	Operating License	Not Requested Yet
AEC	License for Source Material	Not Requested Yet
AEC	License for Special Nuclear Material	Not Requested Yet
AEC	License for By-Product Materials	Not Requested Yet
U.S. Environmental Protection Agency	Permit for Discharge of Industrial Waste (Sect. 402 of Fed. Water Pollution Control Act Amended 1972) (40CFR124)	Not Requested Yet
U.S. Corps of Engineers	Permission to Install all Temporary & Permanent Structures that May be a Hazard to Navigation or Anchorage (33CFR403)	Not Requested Yet
U.S. Corps of Engineers	Permission to Dredge & Dispose of Dredged Material for the Installation of Intake & Discharge Facilities (33CFR403)	Not Requested Yet
U.S. Corps of Engineers	Permission to Dredge & Dispose of Dredged Material for the Installation of Barge Landing Facilities (33CRF403)	Not Requested Yet
U.S. Corps of Engineers	Permission to Take Soil Samples & Core Boring Below Mean High Water (33CFR403)	Unrequested

U.S. Coast Guard	Permission for Constructing & Marking All Temporary & Permanent Obstructions to Navigation ( )	Unrequested
U.S. Coast Guard	Permission for any Vessel to Carry Explosives for Construction or Scientific Investigatory Work (33CFR126:19)	Unrequested
Federal Aviation Agency	Permission to Light Structures that May be a Hazard to Air Navigation (FAR 77)	Unrequested
Federal Aviation Agency	Permission to Light Meteorological Tower (FAR 77)	F.A.A. Study 71-NE 235-OE Approval Received 8/6/71
New Hampshire Port Authority (HarborMaster)	Permission for Temporary and/or Permanent Anchorages in Hampton Harbor	Unrequested
State Fire Marshall via Local Fire Chief	Permission to Install #2 Oil and Diesel Oil Tanks	Unrequested
New Hampshire Dept. Public Works & Highways	Permission for New Access Road onto State Highway (Rt. 1 in Seabrook)	Unrequested
New Hampshire Dept. Public Works & Highways	Permission to Transport Oversized & Overweight Loads on State Highways	Unrequested
New Hampshire Air Pollution Control Agency	Permission to Run Auxiliary Boilers (RSA 125:92)	Unrequested
New Hampshire Water Supply & Pollution Control Commission	Permission to Construct Individual Sewage Disposal System on Site (RSA 149:E-3)	To be Filed as Amendment to SEC
New Hampshire Water Supply & Pollution Control Commission	Permission to Discharge Yard & Roof Drains to the Surface Waters of the State (RSA 149:8-a)	To be Filed as Amendment to SEC
New Hampshire Water Supply & Pollution Control Commission	Permission to Take Soil Samples & Core Borings Below Mean High Water (RSA 149:8-a)	Application Pending
New Hampshire Special Board & Water Resources Board	Permission to Construct Discharge Facilities for Yard & Roof Drains (RSA 483-A:1)	To be Filed as Amendment to SEC

New Hampshire Special Board & Water Resources Board	Permission to Take Soil Samples & Core Borings Below Mean High Water (RSA 483-A:1)	Application Pending
Town of Seabrook	Building Permit for Plant, Substation & Part of Circulating Water System	Unrequested
Town of Hampton Falls	Building Permit for Part of Circulating Water System	Unrequested
Town of Hampton	Building Permit for Part of Circulation Water System	Unrequested
Several New Hampshire Towns	Building Permits as Required for Transmission Lines	Unrequested

12.3 Water Quality Certification

The Applicant will receive certification from the State of New Hampshire for its use of ocean water for condenser cooling following the successful conclusion of the Site Evaluation Committee hearings described in Section 12.1.

12.4 Planning Meetings

The plans for Seabrook Station and its associated transmission lines have been discussed with the selectmen, planning boards and conservation commissions of the affected towns. The regional planning agencies and spokesmen of conservation groups have also been consulted. In the towns of Portsmouth, North Hampton, Hampton, Hampton Falls, South Hampton, Danville, and Kingston these meetings resulted in changes to transmission line routes to better suit local land-use plans and to protect areas of natural interest. The meetings held for this purpose are listed chronologically below:

Meetings with Town and Regional Officials

1/25/72 - Seabrook

Selectmen - E. N. Eaton, J. S. Eaton, B. G. Brown

PSCo - DES, EP, DAL

Update of Seabrook Project Plans and notification of proposed filing with state.

4/21/72 - Hampton Falls

Selectmen - R. M. Farley, D. Janvrin, G. W. Pond

Planning Board - M. E. Kelley, S. Brickett, J. Cram, G. E. Rollins

Board of Adjustment - H. A. Biggi, B. O. Bohm, H. L. Wagner

PSCo - EP, DES, JEH, NRC

Discussed project in general and transmission in detail.

5/2/72 - Seabrook

Selectmen - J. S. Eaton, B. G. Brown, P. A. Daneau

Planning Board - R. K. Parker, A. Boyd, W. Crawford, V. R. Small

Conservation Committee - H. L. Janvrin, H. R. Knowles, E. P. Mason, B. L. Richardson

PSCo - EP, JEH, DAL, BBB, NRC, Ed Daley - Real Estate Rep.

Discussed status of Seabrook Project and transmission line routing.

5/8/72 - Southern N. H. Regional Planning Commission

Executive Director - R. Walker

PSCo - DAL, JEH, RAN, D. Hickey, S. Macrigeanis

Discussed general plan of Seabrook Project and detail of transmission in Commission area (Derry, Chester, Londonderry).

5/8/72 - Hampton

Selectmen - A. J. Norton, H. W. Hayden

Planning Board - B. N. Lougee, R. S. Garnett, A. L. Jacques, D. F. Surprenant, W. Wentworth, J. T. Doheny, S. A. Towle

City Manager - N. C. Cole

Conservation Committee - P. Randall (also Officer of SAPL)

PSCo - DES, DAL, JEH, NRC

Discussed Project in general and transmission in detail.

5/9/72 - Sandown

Selectmen - J. Holmes, P. Castonguay, C. Nicholarsen

Planning Board - L. Lassarde, R. Frye, A. Oestrich, A. Maroncell

Town Clerk - E. Pillsbury

PSCo - DAL, FDC, DJH, S. Macrigeanis, W. E. Howard

Discussed Project in general and transmission in detail.

5/10/72 - Derry

Selectmen - W. Boyce, F. Thompkins, H. DiPietro

Planning Board - P. Collette, J. Conroy, S. Gilman, J. Gifford

Conservation Committee - E. Sentkowski, C. Myette, G. Burdick

PSCo - DAL, JEH, SM, DJH, WEH

Discussed Project in general and transmission in detail.

5/10/72 - Portsmouth

City Manager - C. Canney

Planning Director - R. Thorensen

PSCo - DAL, MPT

Discussed Project in general, transmission in detail and requested meeting with Planning Board and Conservation Committee.

5/16/72 - Southeastern N. H. Regional Planning Commission

Executive Director - C. Tucker

Regional Planner - O. Perry

PSCo - DAL, JEH, RAN, SM, MPT

Discussed total Project and requested to meet with Commissioners.

5/17/72 - Greenland

Selectmen - G. Gowen, F. Emery

Planning Board - F. Moranis, F. Beck, R. Collins

Conservation Commission - F. Borassa, E. Irland

PSCo - DAL, RAN, SM, JEH

Discussed Project in general and transmission in detail.

5/18/72 - Newington

Selectmen - S. Frink, P. DeRochmont, P. Kent

Planning Board - R. Lampson, F. Smith

Conservation Commission - R. Spinney

Discussed Project in general and transmission in detail.

5/22/72 - Danville

Selectmen - J. Carr, J. Fawlor

Planning Board - W. Byron, P. Emelio

Conservation Commission - M. Kimball, C. Strafford, R. Shooshan

Town Clerk - R. Cauldwell

PSCo - JEH, SM, DJH, RAN

Discussed Project in general and transmission in detail.

5/25/72 - Kingston

Selectmen - M. Priore, D. Clark

Planning Board - F. Murphy, H. Federhen, D. Smith, A. Meehan, L. Roberts, L. Sanborn

PSCo - DAL, HJE, RAN, SM, JEH, DJH

Discussed Project in general and transmission in detail.

6/1/72 - East Kingston

Selectmen - F. Smith, W. Osgood, D. Bodwell

Planning Board - R. Pelley, P. Furnam

Conservation Commission - D. Boudreau, E. Frink, A. Moffett, G. Brinkerhoff

PSCo - DAL, RAN, SM, JEH, DJH

Discussed Project in general and transmission in detail.

6/5/72 - North Hampton

Selectmen - M. Kierstead, B. Kirby, S. Berry

Planning Board - P. Kelleher, L. Sheir, G. Frennette, V. Seavey

Conservation Committee - R. Smith, R. Knowles, C. Brooks

PSCo - DAL, JEH, SM, DJH, RAN, E. Daley, Real Estate Rep.

Discussed Project in general and transmission in detail.

6/7/72 - Southern Rockingham Regional Planning Commission

Planning Commission - H. Weinroth, Planning Consultant

PSCo - DAL, JEH, RAN

Discussed Project in general and transmission in detail and requested meeting with Commissioners.

6/9/72 - Kensington

Selectmen - F. Rosencrantz, C. Eastman, H. Bodwell

Planning Board - H. Grant, M. Gamblin

Conservation Committee - S. Carey, S. Evans, M. Armstrong, R. Sargeant

PSCo - DAL, JEH, DJH, SM

Discussed Project in general and transmission in detail. Considerable discussion of broad issues, waste disposal, ECCS, etc.

6/12/72 - South Hampton

Selectmen - M. Santosuosso, C. Ducharme, J. Currier

Planning Board - 3 members

Conservation Commission - 3 members

PSCo - DAL, JEH, RAN, SM

Discussed Project in general and transmission in detail plus many broad issues.

6/15/72 - Town Officials and Seacoast Anti Pollution League

Town officials of Seabrook, Hampton Falls, North Hampton, Hampton and members of SAPL visited Connecticut Yankee to discuss technical and environmental similarities and differences between Connecticut Yankee and Seabrook.

6/15/72 - Portsmouth

Planning Board - E. Clark, H. Berunski, C. Canney, W. Shea, B. Graves, J. Griffin, C. Regan, C. Vaughn (also conservation)

Conservation Committee - C. Vaughn, S. Maddox, B. Griffin, H. Crossman, G. Hanchett, A. Harmon

PSCo - RAN, MPT, DJH, SM, E. Daley, Real Estate Rep.

Discussed Project in general and transmission in detail, particularly Packer and Great Bogs, after motion by Vaughn to disallow presentation was defeated.

6/20/72 - Informal meeting with C. Vaughn, Portsmouth Planning Board and Conservation Committee.

PSCo - DAL, JEH, MPT

Discussed Packer and Great Bogs routing and line construction and maintenance methods.

6/21/72 - Southern Rockingham Regional Planning Commission

Commission - R. Coish-Chairman, H. Weinroth-Consultant, 7 Commissioners

PSCo - DAL, DJH, SM

Discussed Project in general and transmission in detail, plus demand forecasts, energy exchange and alternatives.

6/26/72 - Chester

Selectmen - C. Olivia, J. Towle, Jr., D. Reed

PSCo - DAL, RAN, SM, DJH, F. Clark

Discussed Project in general, transmission in detail and unrelated problems with existing lines.

7/13/72 - Southeastern N. H. Regional Planning Commission

Commission - D. Sanderson-Chairman, C. Tucker-Executive Director, 8 Commissioners

7/13/72 - Southeastern N. H. Regional Planning Commission (Continued)

PSCo - DES, DAL, RAN

Discussed Project in general, transmission in some detail and broad issues of safety, thermal, impact on area, waste disposal, etc.

8/30/72 - Office of State Planning, Concord

State - W. Humm, F. Shaine

PSCo - DES, DAL

Kling Partnership - K. Sharma, G. Daher

Explained purpose of site development study and requested views and opinions.

8/30/72 - Seabrook

Planning Board - R. Parker, Chairman

PSCo - N. Cullerot, DAL

Kling Partnership - K. Sharma, G. Daher

Explained purpose of site development study and requested views and opinions.

8/31/72 - Southeastern N. H. Regional Planning Commission

Commission - C. Tucker-Executive Director, P. McDonough-Rockingham County Planner

PSCo - DAL

Kling Partnership - K. Sharma, G. Daher

Explained purpose of site development study and requested views and opinions.

8/31/72 - Hampton

Acting Town Manager - G. Hardardt

PSCo - DAL

Kling Partnership - K. Sharma, G. Daher

Explained purpose of site development study and requested views and opinions.

9/21/72 - Portsmouth

Regular Planning Board Meeting

PSCo - DAL, HJE, MPT, JEH, SM

9/21/72 - Portsmouth (Continued)

Explained change in bog route and construction and maintenance methods.

9/22/72 - Hampton Falls

Selectmen - George Pond

Planning Road - M. Kelley, J. Cramm, G. Rollins, S. Brickett, F. Brown

Kling Partnership - N. Day, K. Sharma

PSCo - DAL, NRC

Explained purpose of site planning study and requested views and opinions. Offered use of land on Brimmer Lane for conservation commission use.

11/17/72 - Portsmouth

Conservation Committee - Mrs. D. Strauss-Acting Chairman

PSCo - DAL, RAN

Explained bog route and construction and maintenance methods. Discussed alternatives.

11/29/72 - Portsmouth

Conservation Committee - Mrs. D. Strauss-Acting Chairman

PSCo - RAN, DAL, D. Thompson

Viewed bog route by helicopter.

1/18/73 - North Hampton

Conservation Committee - W. Tingle-Chairman (also SAPL officer)

PSCo - DAL, RAN, JEH

Discussed transmission routing in Town. Viewed road crossings.

Meetings have been held with officials of other agencies which may be affected by the proposed project. On September 26, 1972, a meeting was held with Commissioner Arthur W. Brownell of the Massachusetts Department of Natural Resources to discuss the project and whether it might be expected to affect the Massachusetts fisheries. The meeting served to establish communications between the DNR and the Applicant. The Applicant does not feel that the plant could or would affect the coastal waters of Massachusetts since the plant effluent will be diffused in the immediate area of the discharge. Massachusetts has classed the coastal waters south of the state line as Class SA - suitable for shell fishing and contact sports.

In addition to the participation of the Regional Office of the Environmental Protection Agency at the Site Evaluation Committee hearings, two meetings have been held with EPA staff members to familiarize them with the project. On October 17th a meeting was held at the EPA Regional Headquarters and on November 3 a tour of the site and its environs was conducted.

13. REFERENCES

13. References

References are listed at the end of each section in this report.

SUPPLEMENTAL
INFORMATION

PUBLIC SERVICE
Company of New Hampshire 1000 Elm Street, Manchester, N. H. 03105

May 29, 1974

Docket Nos. 50-443
50-444

United States Atomic Energy Commission
Directorate of Licensing
Office of Regulation
Washington, DC 20545

ATTENTION: Dr. R. P. Geckler

Supplementary Information
Environmental Report
License Application Dated March 30, 1973

Gentlemen:

Pursuant to the Atomic Energy Act of 1954, the Commission's rules and regulations thereunder, and the National Environmental Policy Act of 1969 as implemented by Appendix D of 10CFR50, Public Service Company of New Hampshire, hereby supplements the Environmental Report portion of the license application filed on March 30, 1973, as heretofore supplemented, by supplying the following information:

Two hundred copies of new pages sequentially numbered from S2-13 to S2-60 to be inserted in the Environmental Report. Three signed originals and 197 additional copies are being sent to you at this time; 100 additional copies are being retained until you advise us of any further distribution.

Respectfully Submitted,

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE

D. N. Merrill
Executive Vice-President

DNM:BBB:amg

cc: All Parties of Record

CERTIFICATE OF SERVICE

I, Bruce B. Beckley, hereby certify that on May 31, 1974, I made service of the within document by mailing copies thereof, postage prepaid, first class or airmail, to:

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Atomic Safety and Licensing
Board Panel
U.S. Atomic Energy Commission
Room 1211D, Landow Building
7910 Woodmont Avenue
Bethesda, Maryland 20014

Joseph F. Tubridy, Esquire
4100 Cathedral Avenue, N.W.
Washington, D. C. 20016

Dr. Marvin M. Mann
Atomic Safety and Licensing
Board Panel
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Bethesda, Maryland 20014

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Washington, D. C. 20545

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Bruce B. Beckley

Bruce B. Beckley

SUPPLEMENTAL INFORMATION TO THE

SEABROOK STATION ENVIRONMENTAL REPORT

CHAPTER 1

Question 1.1 Provide ten years of historical data on load and resource evaluation.

Answer 1.1 Please see the Environmental Report, Volume I, Subsection 1.1, Tables 1.1-4, 1.1-7, 1.1-12 and 1.1-13 (all revised as of June, 1973).

CHAPTER 2

Question 2.1 (Section 2.3)

The applicant has not provided evidence of contact with the Historic Preservation Officers of the states involved. Copies of their comments concerning the effect of station construction and operation on historic, archaeological and cultural resources are not included. The rationale in reaching the conclusion that "there are no known or expected points of archaeological significance on or near the site" is not stated. Since the transmission lines will cross Cedar Swamp and will pass close to Pulpit Rock, the meaning of the statement "none of the historic markers or sites will be affected by the proposed transmission lines" needs further explanation.

Answer 2.1

The historic areas in the vicinity of the Seabrook site were described before the New Hampshire Site Evaluation Commission. An evaluation of the impact of the transmission lines on historic areas was also presented by a Company consultant. As shown in Chapter 12 of the Environmental Report, the Site Evaluation Committee must consider the effects of the proposed facility on historic sites. The State Historic Sites Preservation Officer who is also the Commissioner of the Department of Resources and Economic Development sits upon the committee.

The applicant considers that the impact on the historic sites has been discussed with the committee and that the committee findings, if favorable, will constitute a review of the impact.

The affect the proposed 345 KV transmission line will have on Cedar Swamp is primarily visual. It is proposed to span the swamp with no towers located in the swamp and no roadway constructed across it. Access to structure location will be from each side. Structures will be located back from the edges of the swamp on solid ground. The visual affect will be localized primarily to those who may travel the limited waterway through the swamp and those who have camps on County Pond. The structure locations are such that the travelling public will have very limited view of the tops of the structure. See Section 4.2 for aerial photo of Cedar Swamp (Figure #4.2-1).

Clearing will be limited to the structure locations to allow for construction. Clearing on the spans either side of the swamp will be limited by selective cutting to those species which will endanger the reliability of the line.

Pulpit Rock in Chester is approximately 700 feet from the closest point on the proposed line as noted on Figure #2.3-1 and is screened very effectively by tall hardwood and some softwood growth. There will be a period of time with the leaves off the trees when the location of the line can be determined, but it will not be highly visable due to the orientation of the line in relation to the Pulpit Rock area. The growth of the hardwood forest in this area is very high with 60 to 80 foot trees.

Question 2.2 (Section 2.5) Additional information on the seasonality of estuarine thermal, physical and chemical characteristics is required. Such information is needed to evaluate potential estuarine changes arising during construction of the intake-discharge system which may result in adverse effects on the local biota.

Answer 2.2 Information provided within Section 2.5 Hydrology concerning the thermal, physical and chemical characteristics of the present Hampton Harbor estuarine configuration summarized the known studies that have been made to the date of submittal for preliminary review. The most recent system

Question 2.1

Figure #2.3-1

consisting of deep underground tunnels for intake and discharge will not involve construction or operation in or on the estuary. Provided herein are the results of a study that was made during April and May of 1973. This study involved the periodic measurement of temperature, salinity and dissolved oxygen at locations near the Hampton Harbor Bridge in order to observe the influence of spring runoff from the watershed on the estuary.

These recent hydrographic data collected by Normandeau Associates, Inc. during 1973 (Table I) further delineate seasonal aspects of estuary behavior which are described in the Environmental Report. In the winter, near surface water temperatures offshore are about 1°F colder than near bottom temperatures (about 38.5°F), reflecting the heat loss to the atmosphere which occurs in the estuary when water is ponded across intertidal flats. At this time of year salinities are quite high (about 32.3^{o}/oo).

During late winter and early spring, water temperatures begin to rise gradually with warmest temperatures found near the surface. Temperatures in the estuary at low water are as much as 8°F warmer than those at high water due to the radiational warming which occurs in the estuary. Temperatures at high water are colder and more uniform with depth due to the flooding of Gulf of Maine water into the estuary. The salinity data clearly demonstrates the freshening effect of land runoff of rainfall and melting snow. Lowest salinities occur during low water as ebb tidal flow drains the marshes with lowest values generally found at the surface (down to 15.1^{o}/oo after the violent northeast storm of early April). At high water salinities are much higher (up to 31.4^{o}/oo on April 17, 1973) due to influence of the Gulf of Maine waters. In general,

TABLE I. Hydrographic measurements made at Hampton Harbor Bridge, Hampton Harbor estuary, New Hampshire

SAMPLING DATE (1973) - TIDE STAGE, AND TIME	TEMPERATURE, °F			SALINITY, °/oo			DISSOLVED OXYGEN, mg/l			DATA SOURCE
	Surface	Mid-depth	Bottom+	Surface	Mid-depth	Bottom+	Surface	Mid-depth	Bottom+	
APRIL 4										
HIGH WATER (1130)	39.2	38.8	38.8	27.3	27.5	27.5				1
APRIL 6										
LOW WATER (0746)	48.2	47.7	47.7	15.1	18.0	18.0	9.0			1
HIGH WATER (1234)	43.2	43.2	43.2	28.0	28.6	28.7	9.2	9.3	9.3	
APRIL 17										
HIGH WATER (1245)	39.7	39.6	39.6	31.4	31.2	31.2	7.0			2
LOW WATER (1701)	47.3	46.9	46.8	26.7	28.0	28.2	8.9			
MAY 1										
HIGH WATER (1029)	46.4	46.2	46.0	28.6	28.9	29.1	10.4			2
LOW WATER (1625)	52.2	52.2	52.2	22.9	24.8	25.0	10.3		10.2	
MAY 16										
HIGH WATER (1153)	50.4	50.0	50.0	27.6	27.9	28.0	10.1		10.2	2
LOW WATER (1721)	54.9	55.0	54.7	23.4	24.1	24.5				

Data sources:

1. Measurements made with Martek Mark II Metering systems; temperature accuracy ± 0.36°F; salinity accuracy ± 1.1 °/oo; dissolved oxygen by azide modification of the Winkler method.
2. Measurements made with Beckman RS 5-3 Induction Salinometer; temperature accuracy ± 0.9°F; salinity accuracy ± 0.3 o/oo; dissolved oxygen as above.

+. Water depth about 30 feet at mean low water.

during this part of the year the pronounced runoff from nearby rivers and estuaries such as the Piscataqua and Merrimack causes the freshening of offshore waters observed on the other survey days (about 27 - 29°/oo). Dissolved oxygen values are somewhat scattered but show a range of 7.0 - 10.4 mg/l. In general, oxygen levels are at or above 100 percent saturation levels for the given temperature and salinity conditions.

Question 2.3 (Section 2.6) A monthly presentation should be provided of the moisture deficit data addition to the seasonal summary provided.

Answer 2.3 Please see the Environmental Report, Volume I, Section 2.6, page 2.6-3 and Table 2.6-2 (both revised as of June, 1973).

Question 2.4 (Section 2.6) A monthly presentation should be provided of the wind and stability data in addition to the seasonal and annual summaries already provided.

Answer 2.4 Monthly summaries of wind and stability joint frequency distributions are submitted as supplementary information, three copies of which are provided in separate binders.

Question 2.5 (Section 2.6) The applicant has provided no discussion as to the probability of occurrence of hurricanes and what the maximum probable effects would be.

Answer 2.5 Please see the Environmental Report, Volume I, Section 2.6, pages 2.6-7 and 2.6-7a (both revised as of June, 1973).

Question 2.6 (Section 2.7) Quantitative information on the distribution and abundance of terrestrial and aquatic flora and fauna in the site vicinity and in the intake and discharge areas is required. There should be an accentuation of description of organisms at the intake and discharge and along the prospective pipeline routes. Much quantitative data is implicated in this section, but little is shown. In order for a reasonable assessment, the reports of Normandeau Associates, Inc. should be made available. In terms of baseline data for later evaluation of construction or operation effects, there are indications that the sampling may not be sufficient. It appears to have been carried out too aperiodically to indicate natural yearly variation, for example.

Answer 2.6 This information will be provided in a subsequent amendment to the Environmental Report.

CURRENTS IN THE COASTAL WATERS

The following information supplements information in Section 2.5.1.2:

The seasonal aspects of residual net non-tidal drift in New Hampshire coastal waters and the western Gulf of Maine have been under detailed study by Normandeau Associates, Inc. since September, 1972. The circulation patterns of near surface waters are being studied by means of ballasted eight-ounce flint glass drift bottles with postage paid reply card inserts. To date more than 2300 have been released and almost 20% have been recovered. Concurrently, the net drift of near bottom waters is being documented by means of umbrella-shaped polyethylene sea bed drifters, which are weighted to move along the sea floor. Of more than 2200 released to date nearly 40% have been recovered. At any given station during a month, 10 drift bottles and 10 seabed drifters were released. In interpreting this type of data, it should be noted that one knows where and when the drifter was released, and assuming the finder makes an accurate report, where and when the drifter was recovered. The drifter trajectories, from release to recovery points, are shown as straight lines, but actually the drifters may have followed a circuitous route before being picked up. Their rate of movement is quite variable, in part due to snagging enroute, or burial before being discovered. Given the year round interest in beachcombing along this coast, it is believed that relatively little seasonal variation exists in the probability of a stranded drifter being reported. Recoveries of seabed drifters offshore may be biased by the intensity of bottom trawling in certain areas. The preliminary results of these studies are shown in Figures 1 to 6. The number of releases per month and percent of recovery, both in the study area from York, Maine south to Rockport, Massachusetts, and outside of the study area are shown on each figure. Recoveries outside of the study area are noted as follows: MB for Massachusetts Bay and Cape Cod Bay, CC for the Atlantic coast of Cape Cod, including Nantucket Sound and Buzzards Bay, ME for Maine, and NS for Nova Scotia and the Maritime Provinces.

1. Late Summer (September, 1972)

The movement of drift bottles (Figure 1a) released out to 10 - 15 miles offshore during the month was strongly southward and southwestward along the coast down to Cape Ann, at rates of about 0.7 to 3.4 nautical miles per day. Bottles released further offshore showed mostly southward flow, well off Cape Ann, with proportionately fewer recoveries, most of which were on Cape Cod or in Massachusetts Bay. Their movement ranged from 0.9 to 4.3 n.m. per day. Seabed drifters (Figure 1b) showed a southwest trajectory from the Isles of Shoals onto the coast, at about 0.1 to 0.2 n.m. per day, whereas those released well out to sea showed lower recovery percentages and movement down into Massachusetts Bay and onto Cape Cod (drift rates were 0.1 to 0.4 n.m per day.

2. Late Fall (December, 1972)

All the drift bottles recovered drifted rapidly southward toward Cape Ann at 0.5 to 9.0 n.m. per day (Figure 2a). Only one of the bottles from the seaward stations was recovered, suggesting strong southward flow past Cape Ann

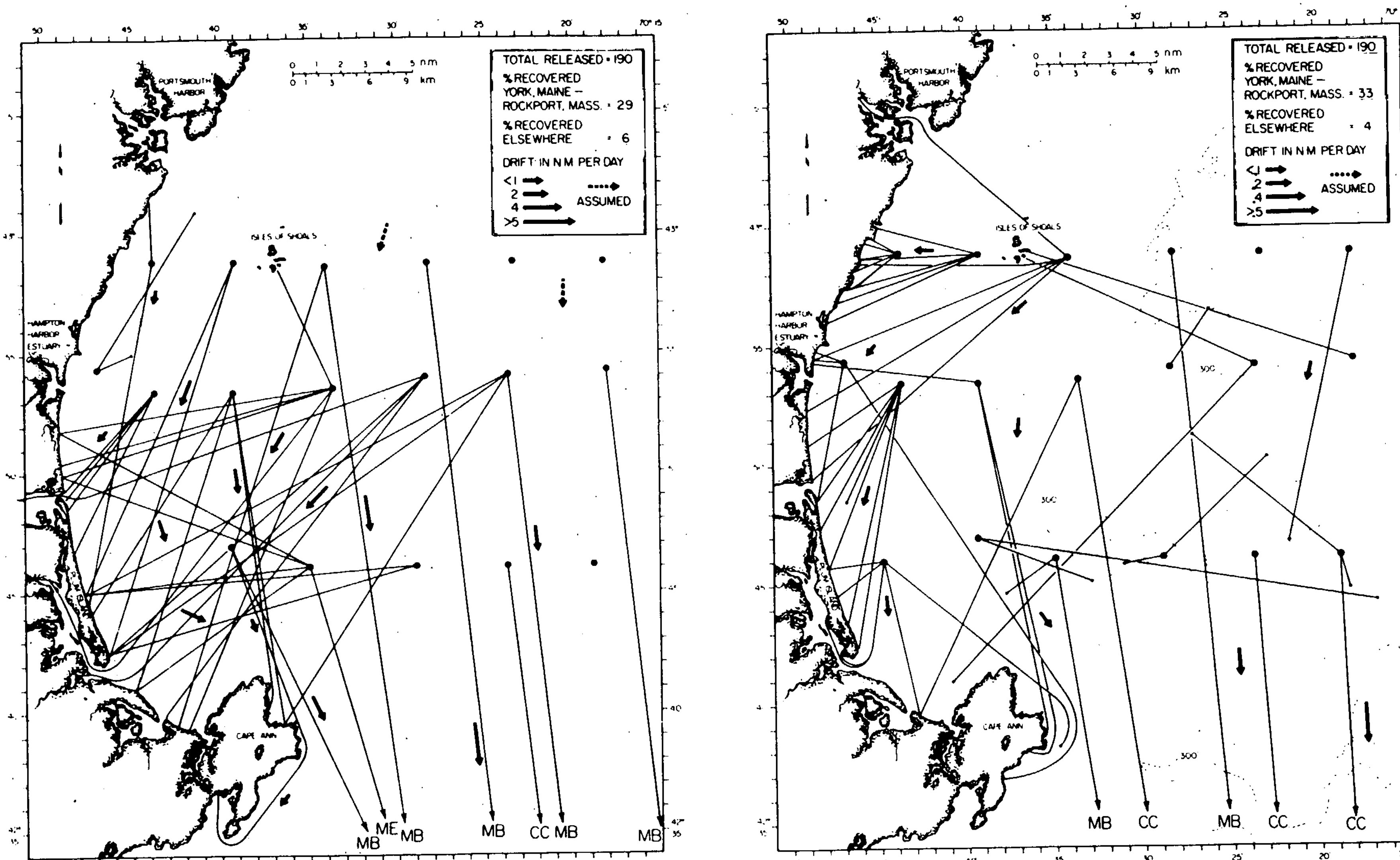


Figure 1: Net drift patterns of drifters released in September 1972 by Normandeau Associates, Inc.; (a) left, drift bottles and (b) right, sea bed drifters. Number released, percentage recovery, and mean drift rates are indicated.

MAY 1974

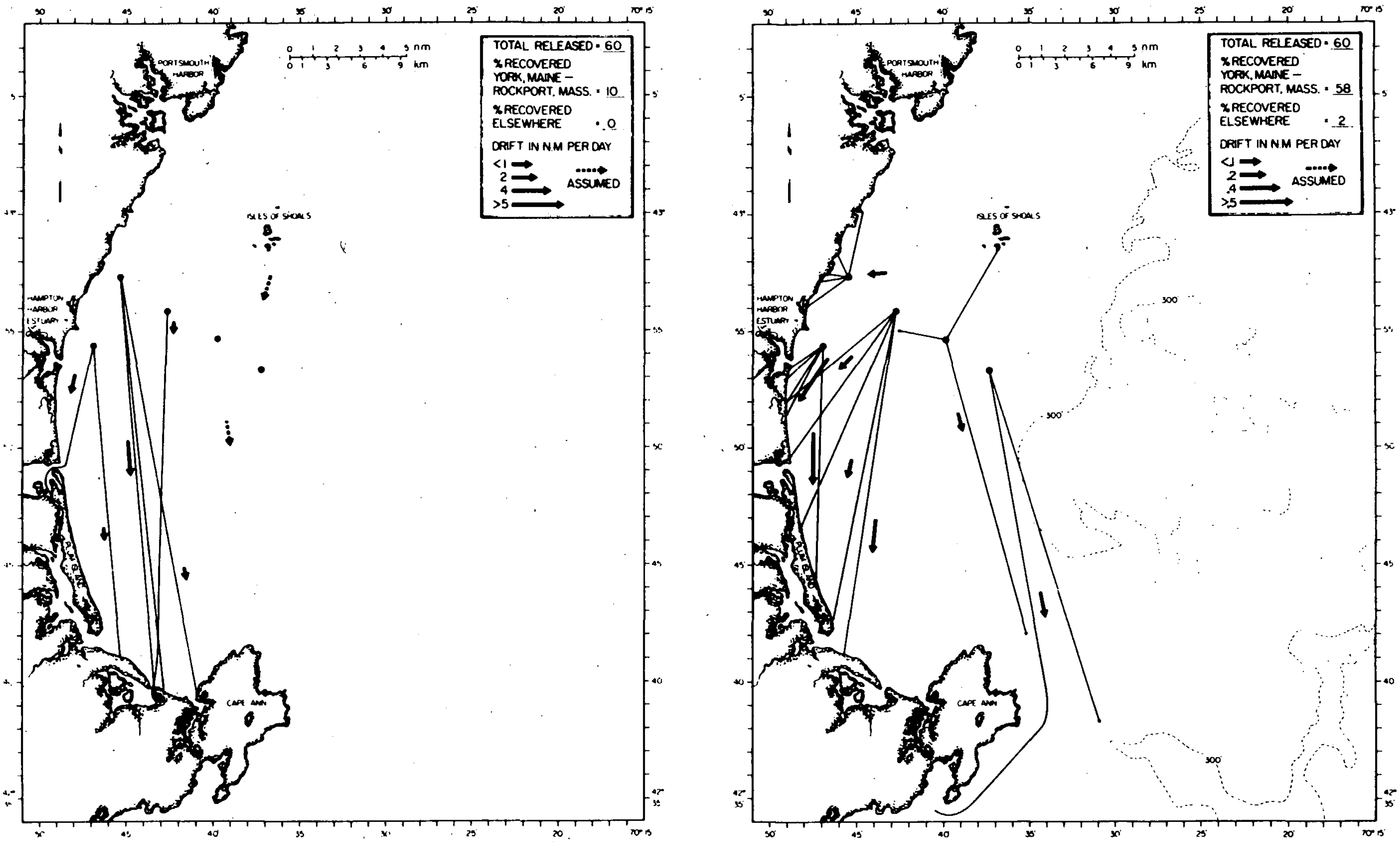


Figure 2: Net drift patterns of drifters released in December 1972 by Normandeau Associates, Inc.; (a) left, drift bottles and (b) right, sea bed drifters.

and out into the Gulf of Maine. Seabed drifters showed flow southwestward toward Plum Island and southward out around Cape Ann at 0.1 to 0.3 n.m per day (Figure 2b).

3. Winter (January, 1973)

The movement of drift bottles showed a very different surface flow from earlier months -- well out to sea past Cape Ann into Massachusetts Bay and onto Cape Cod with only one recovery along the coast (Figure 3a). Drift rates ranged from 0.9 to 6.3 n.m. per day with extremely low percentages of recovery from the offshore stations. At least 3 bottles were found on Nantucket. This flow pattern is probably due to the dominance of northwest winds during the season, which tend to blow surface waters offshore. The seabed drifters released during this month showed a southwestward movement close to shore at 0.1 to 0.3 n.m. per day as a possible compensation for the seaward, near surface drift (Figure 3b). However, further offshore, many of the drifters showed a southward flow at 0.2 to 0.8 n.m. per day.

4. Spring (April, 1973)

Drift bottles released in April showed a generally southwestward drift toward shore at 0.5 to 2.8 n.m. per day, however right along the coast a number of bottles moved northward (Figure 4a). This flow pattern is believed due to several large northeast storms which struck the coast during the month, carrying storm driven surface currents southward, and to a somewhat unusual period of

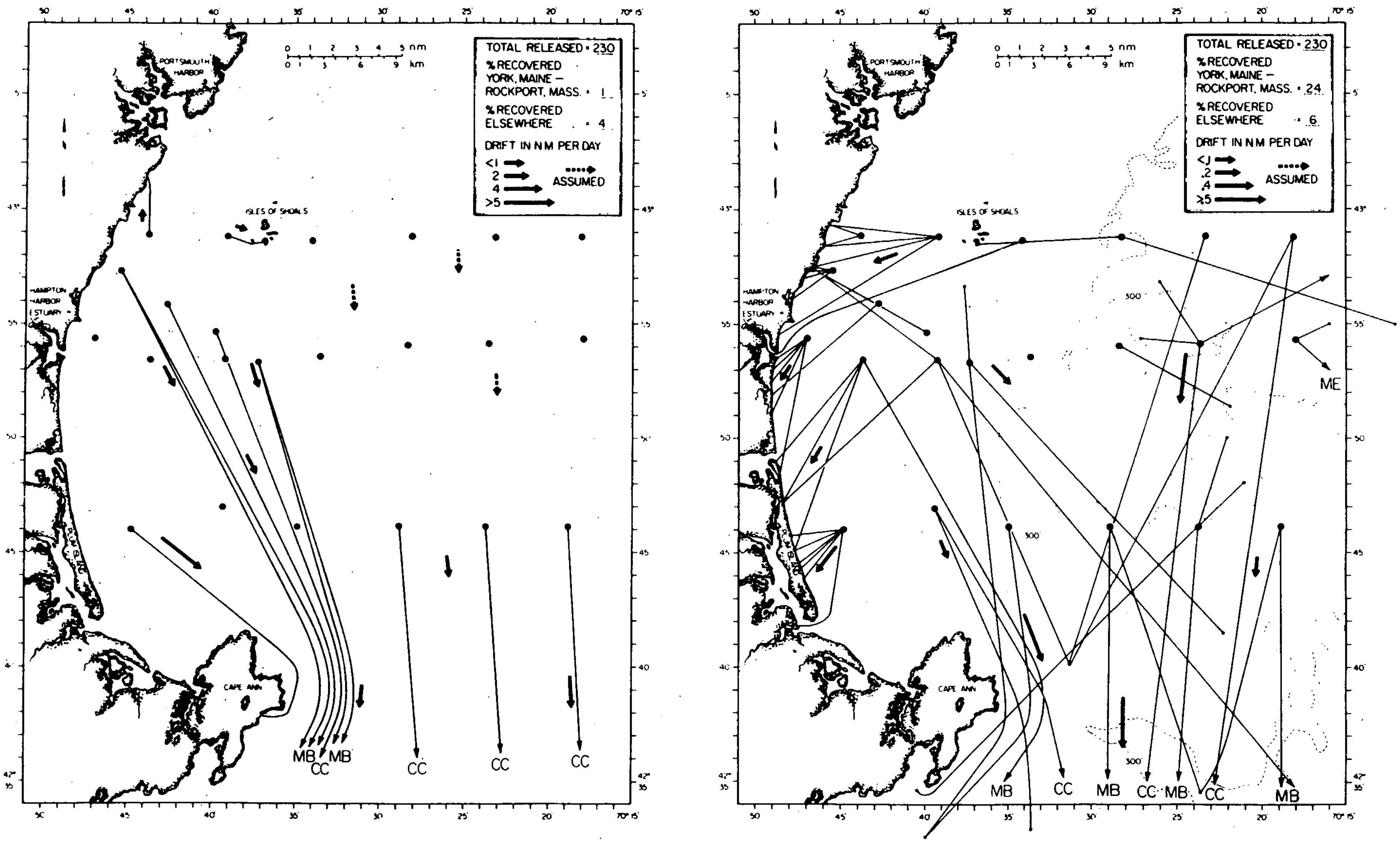


Figure 3: Net drift patterns of drifters released in January 1973 by Normandeau Associates, Inc.; (a) left, drift bottles and (b) right, sea bed drifters.

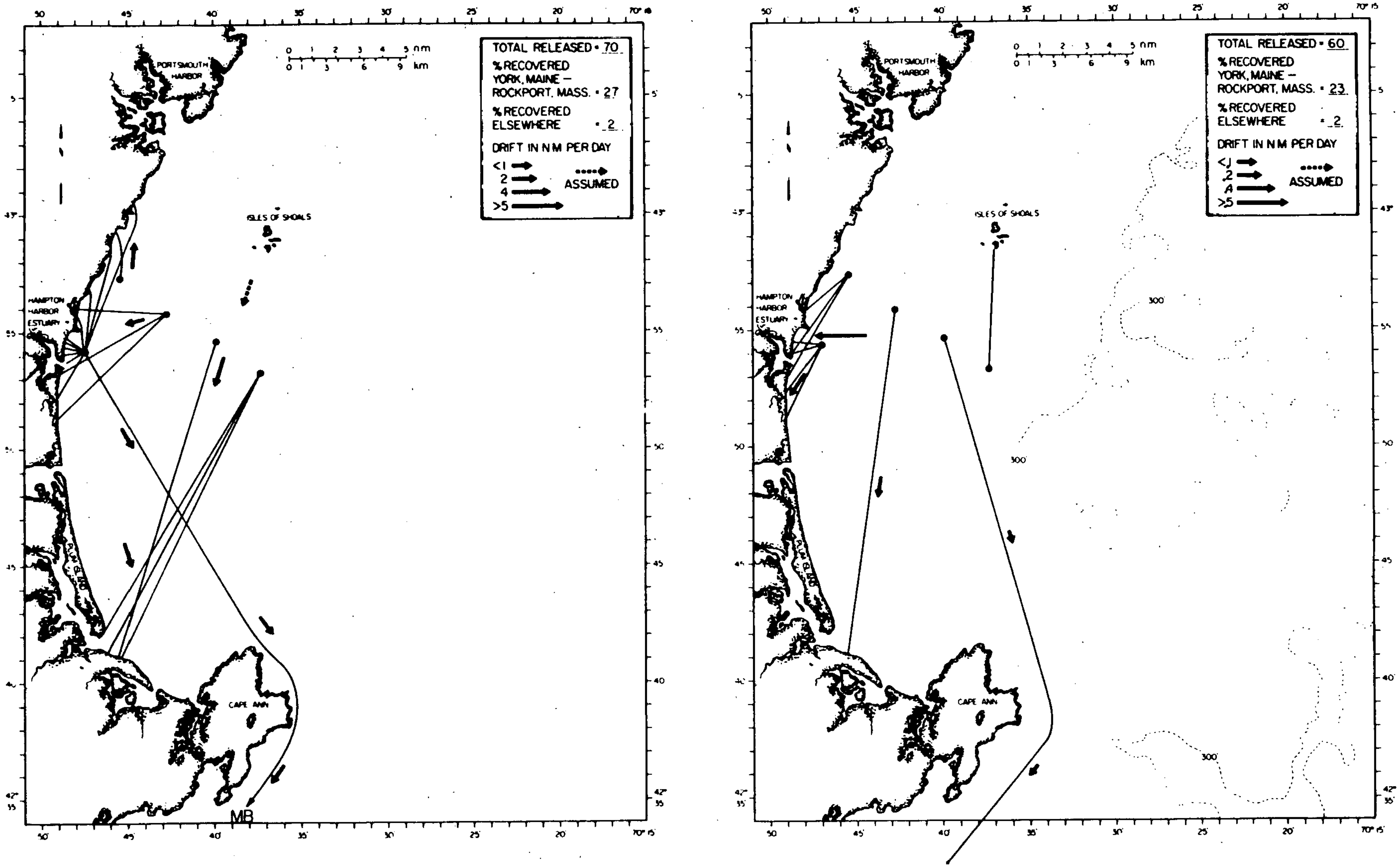


Figure 4: Net drift patterns of drifters released in April 1973 by Normandeau Associates, Inc.; (a) left, drift bottles and (b) right, sea bed drifters.

northward flow along the coast, which was documented by the Normandeau Associates, Inc. current meters off Hampton Beach, New Hampshire. Near bottom flow, as shown by sea bed drifters, was generally southward at 0.1 n.m. per day with very few recoveries from seaward release points (Figure 4b). One set of 4 drifters was brought ashore at Hampton Beach at 1.3 n.m. per day, immediately following a powerful northeaster. This illustrates that much of the actual movement of seabed drifters in the near bottom waters occurs concurrent to northeast storms, which set southwestward near-surface currents in motion.

5. Early Summer (June, 1973)

Surface drift in June was much like that of spring -- generally southward offshore with few recoveries from the seaward stations but some isolated northward flow along the coast from nearshore stations (figure 5a). Drift rates were 1.1 to 4.1 n.m. per day. At least 5 of the bottles were recovered in Nova Scotia, including one released from off Hampton Beach, which crossed the Gulf of Maine, moving some 280 n.m. in 70 days or 4.0 n.m. per day. The seabed drifters showed southwestward flow toward shore at generally less than 0.1 n.m. per day, and southward flow offshore with relatively few recoveries (Figure 5b).

6. Mid-Summer (August, 1973)

Near surface drift was strongly to the southeast offshore and around Cape Ann at 1.7 to 5.8 n.m. per day (Figure 6a). No recoveries were made from

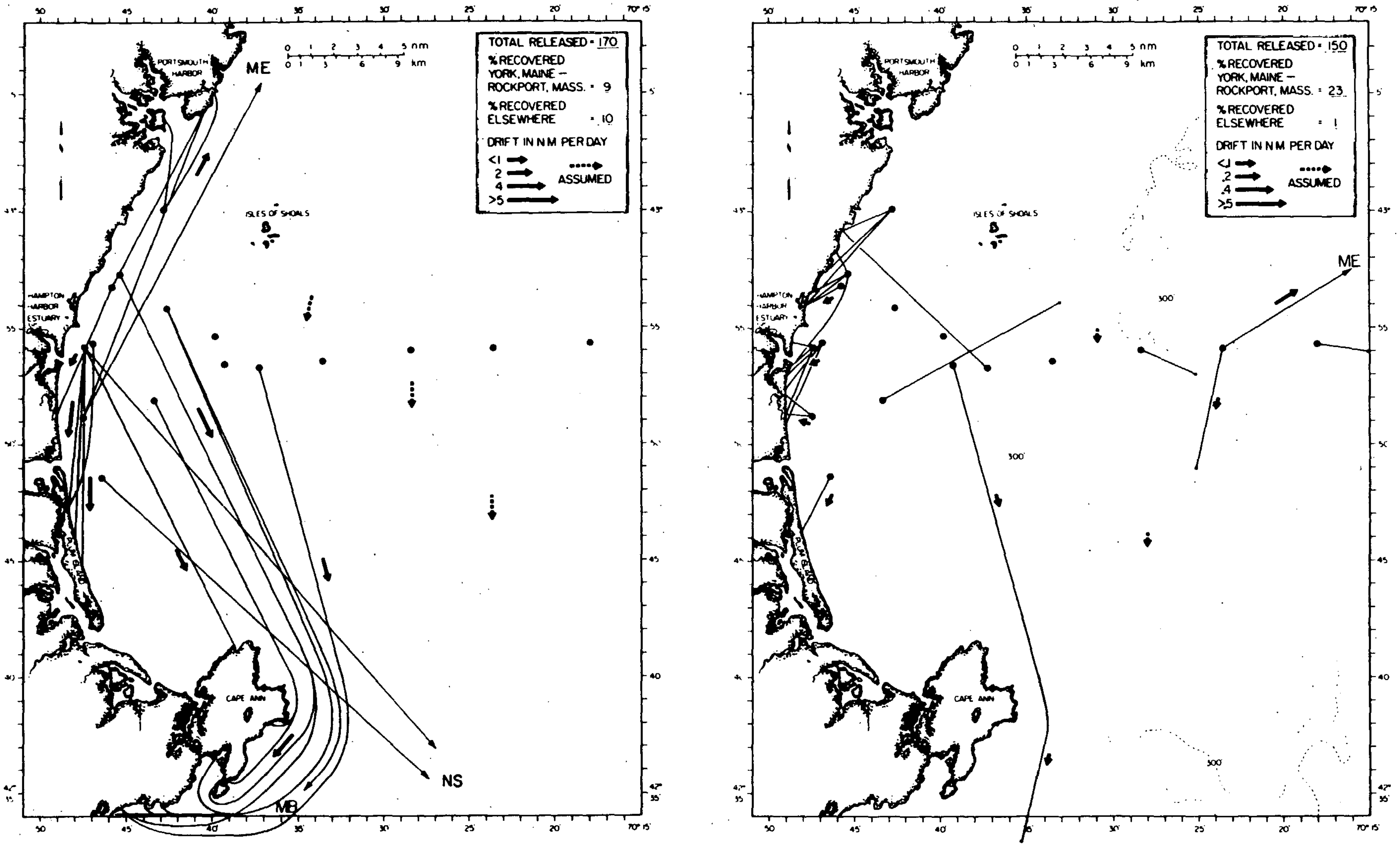


Figure 5: Net drift patterns of drifters released in June 1973 by Normandeau Associates, Inc.; (a) left, drift bottles and (b) right, sea bed drifters.

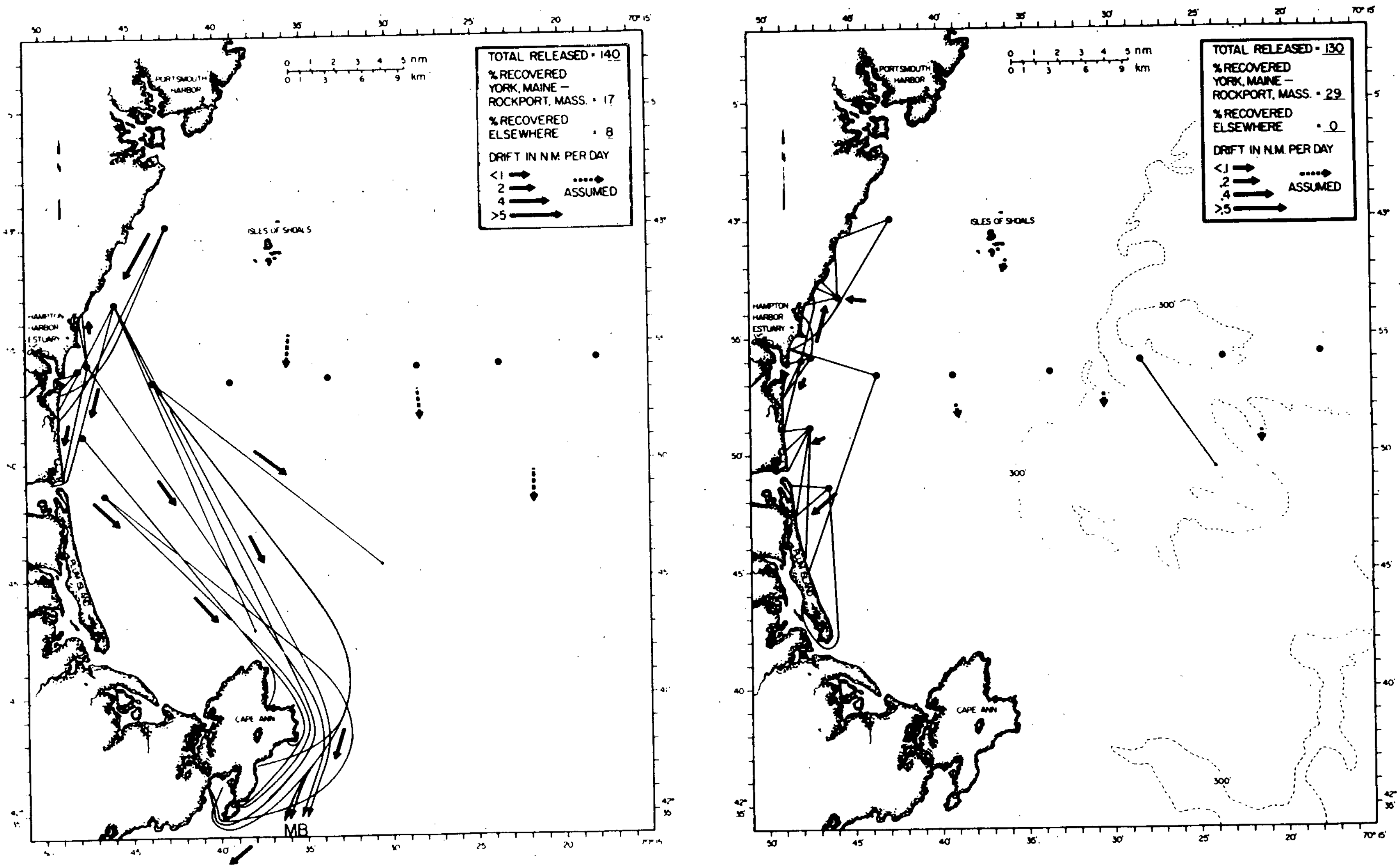


Figure 6: Net drift patterns of drifters released in August 1973 by Normandeau Associates, Inc.; (a) left, drift bottles and (b) right, sea bed drifters.

the seaward stations, suggesting flow well out into the Gulf of Maine gyre. Almost all the sea bed drifter recoveries were right along shore, showing southward drift of <0.1 to 0.4 n.m. per day (Figure 6b). Only one recovery was made from the seaward stations and it showed weak southward drift.

Thus, net drift in these waters is to the south at all times of the year except for isolated periods of northerly flow near the coast, which seems to follow periods of strong winds from the south and southwest or compensation flow after severe northeast storms. Surface flow is generally at least 10 times faster than near bottom flow. The surface flow is usually southward and offshore, out past Cape Ann, whereas the seabed drifters show bottom flow almost always with a southwestern component toward shore. This is probably due to the dominance of northeast storms, which appear to drive much of the bottom flow and is also due to compensation flow of saline waters, intruding landward at depth below seaward moving surface layers. Some of the variation in bottom drift is due to irregularities in bottom topography, but from the deeper stations, flow is southward, up out of Jeffreys Basin and Scantum Basin and onto the coastal shelf. Drifters released out to about 5 - 6 miles offshore generally strand between York, Maine, and Cape Ann; but seaward of this area, the higher number of distant returns and significantly lower recovery percentages document the dominance of the Gulf of Maine gyre flowing southward toward Cape Cod.

TEMPERATURES IN THE INLET AND DISCHARGE AREAS

The following information supplements information in Section 2.5.1.3:

Surface water temperature in the offshore area near the site of the proposed discharge undergoes a pronounced seasonal cycle shown in Figure 1. Coldest conditions occur during January and February (monthly mean of daily minima is about 36.4°F). Warmest conditions occur during August (monthly mean of daily maxima is about 63.6°F). Temperature conditions at mid-depth near the discharge site are shown in Figure 2. They range from a mean daily minima of 36.6°F in February to a mean daily maxima of 59.8°F in August. Data from mid-depth at the intake site are shown in Figure 3. Coldest conditions were in February and March (mean daily minima of 36.0°F) whereas warmest temperatures occurred in August (mean daily maxima 55.8°F). Pronounced thermal stratification occurs from June through September and for the remainder of the year temperatures are nearly uniform throughout the water column.

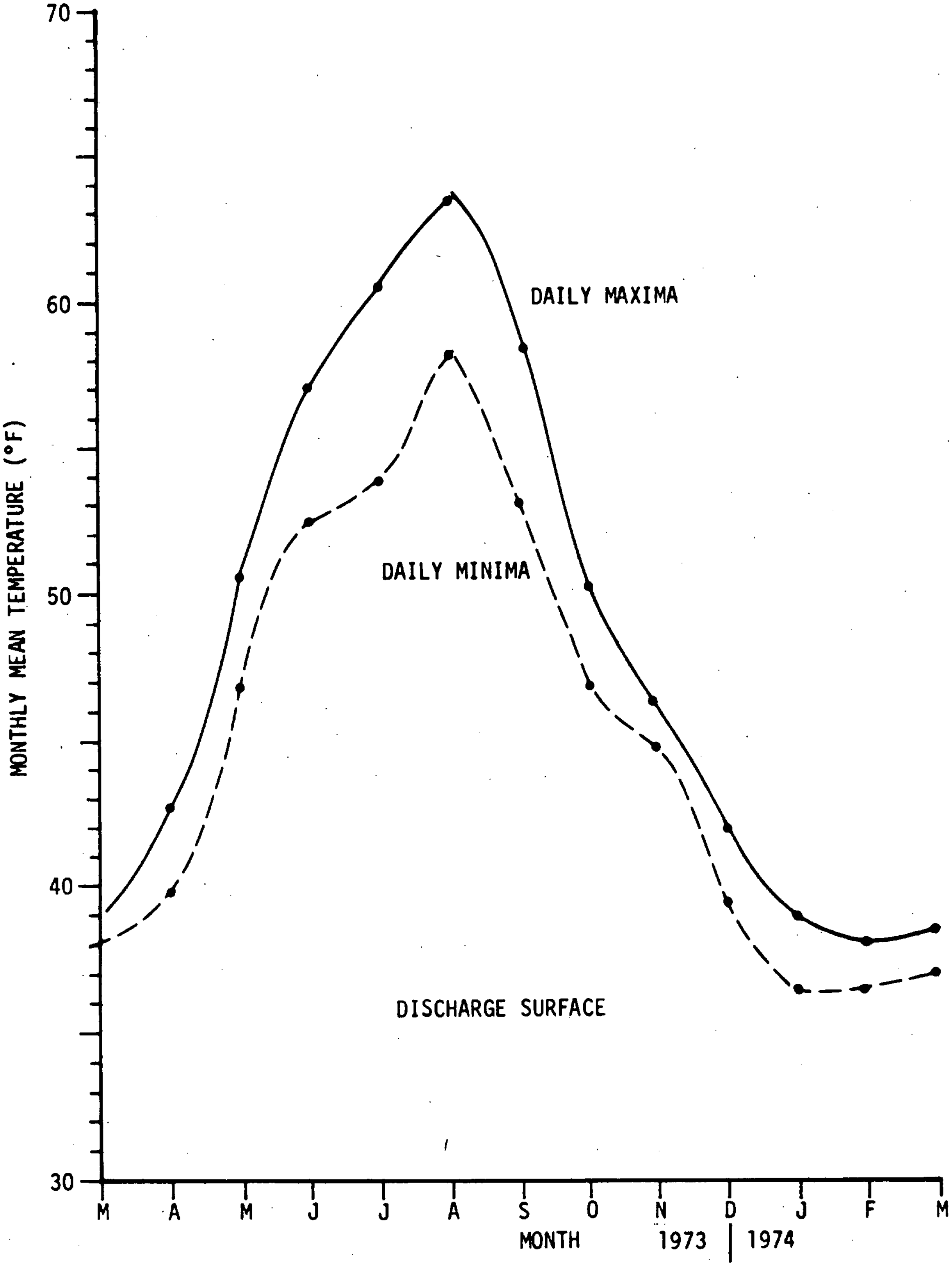


Figure 1. Monthly means of daily maximum and minimum water temperatures near the surface at the proposed discharge site. Data from March 30 to November 9, 1973 is from Mooring 4; from November 9, 1973 to date is from Mooring 12.

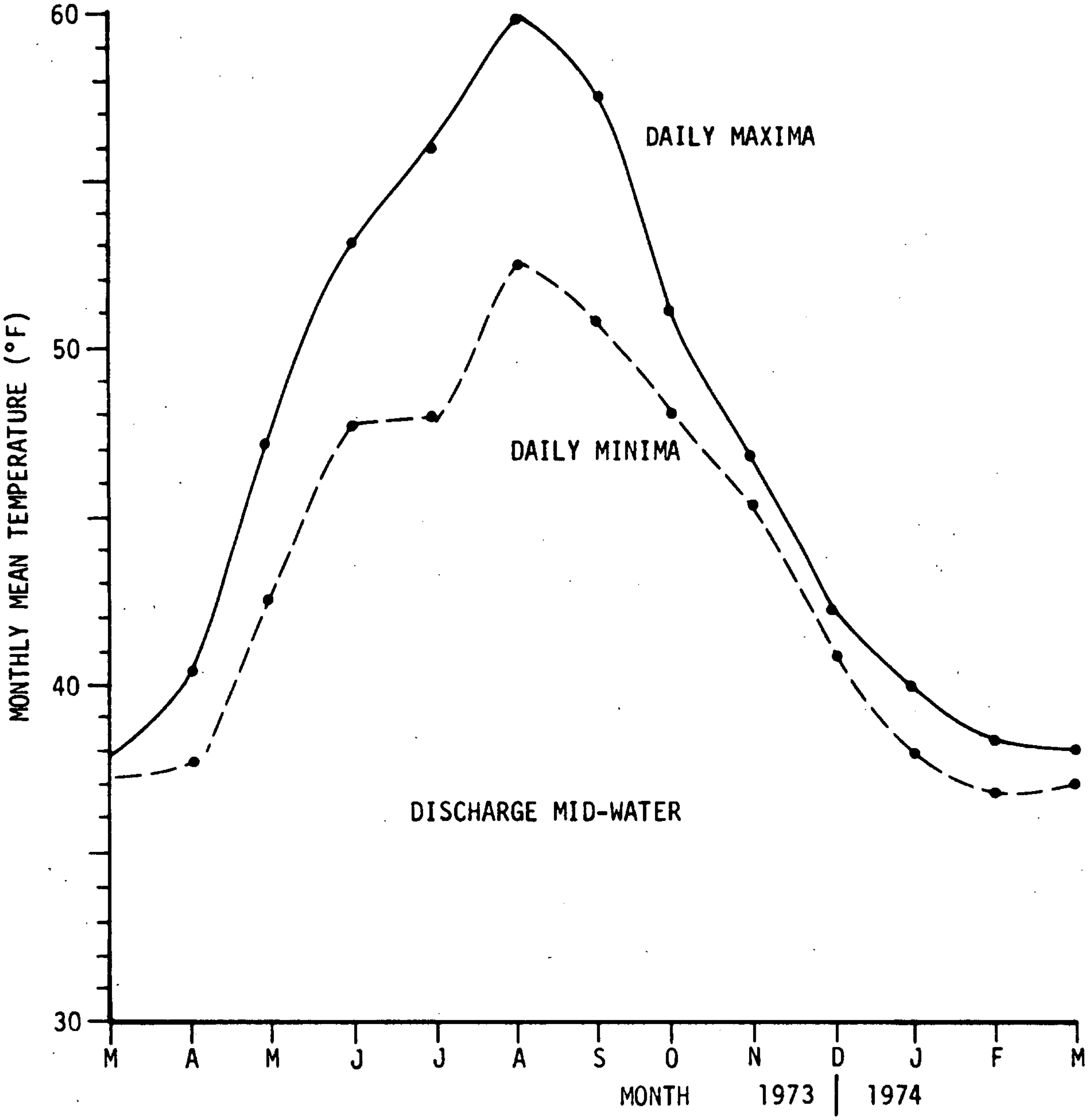


Figure 2. Monthly means of daily maximum and minimum water temperatures from mid depth at proposed discharge site. Data from March 26, to October 19, 1973 is from Mooring 4; from October 19, 1973 to date is from Mooring 10.

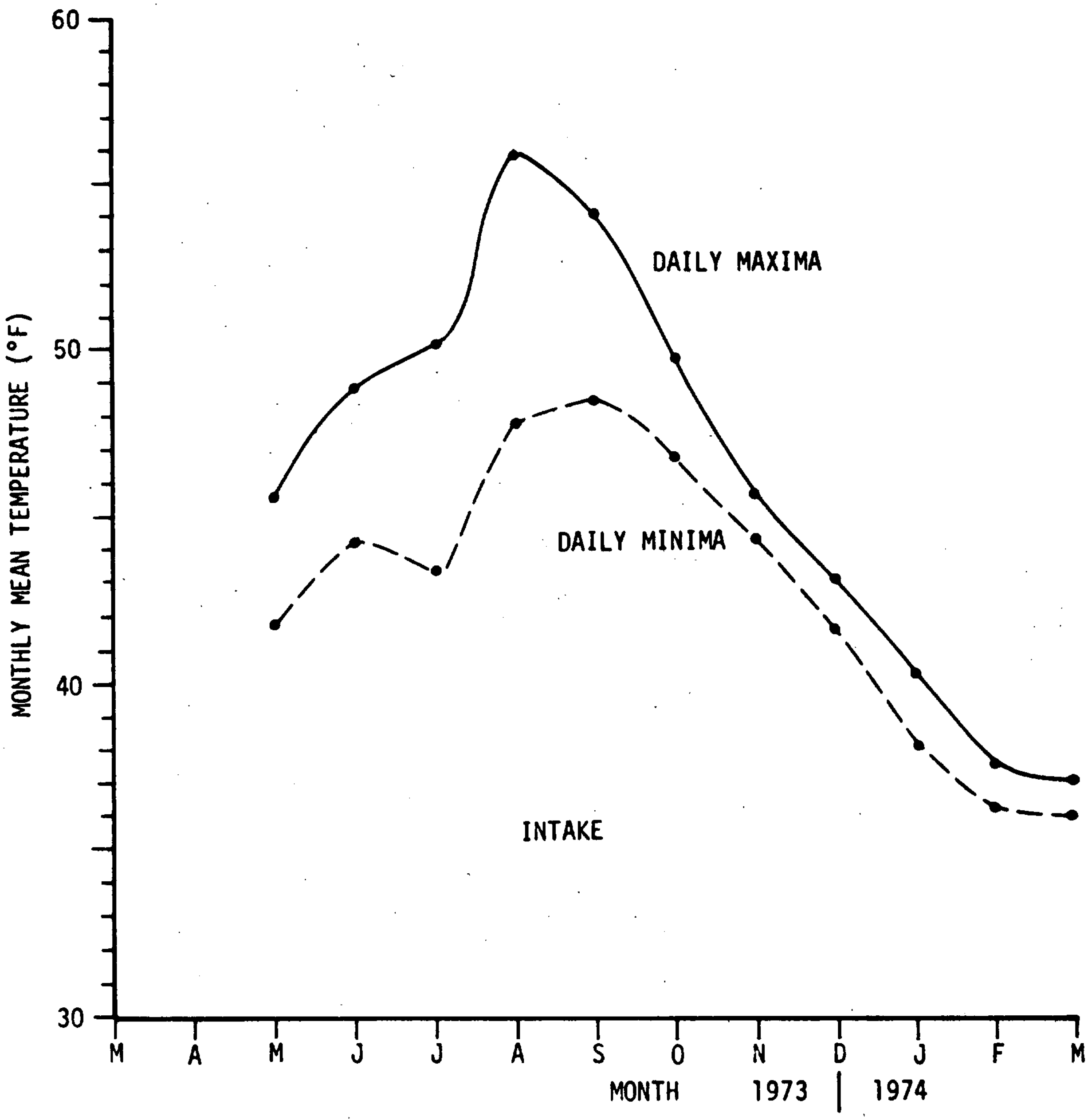


Figure 3. Monthly means of daily maximum and minimum water temperatures from mid depth at the proposed intake site. Data from May 4, 1973 to date is from Mooring 5.

HYDROGRAPHIC DATA PROGRAM

Since September, 1972 extensive hydrographic and meteorological data have been collected by Normandeau Associates, Inc. near the proposed intake and discharge areas of the Seabrook Station. The data consist of the following:

1. Monitoring from moored buoys
   a. current speed and direction at the eleven moorings listed in Table 1 with some beginning in January, 1973 (see location map Figure 1) as well as short term measurements at several others located farther offshore.
   b. Water temperature at moorings 1, 4, 5, 10, 11 and 12 (see location map Figure 1).
2. Monitoring of Wind Conditions

   Wind speed and direction measured continuously since December, 1972, at a single point on Hampton Beach at an elevation of 10 m. (see location map, Figure 1).
3. Monitoring of Tidal Height

   Tidal height measured continuously since December, 1972 at a tide gage in the Hampton Harbor estuary (see location map, Figure 1).

TABLE 1. SUMMARY DATA ON CURRENT METER MOORINGS

OFF HAMPTON BEACH, NEW HAMPSHIRE[1]

MOORING NUMBER	DISTANCE OFFSHORE, FEET	WATER DEPTH AT MLW, FEET	CURRENT METER DEPTH BELOW MLW, FEET	DATE ACTIVATED	DATE DEACTIVATED
NEAR SHORE MOORINGS					
1	7,700	69	41	January 19, 1973	November 2, 1973
2	10,400	80	43	January 29, 1973	April 3, 1974
3	8,100	63	30	January 23, 1973	April 3, 1974
4	5,600	43	23	February 19, 1973	February 27, 1974
5	3,000	31	23	June 22, 1973	still operating
6	7,000	66	42	February 19, 1973	April 5, 1974
7	4,100	45	20	May 7, 1973	October 2, 1973
9	6,800	70	32	September 25, 1973	still operating
10	6,000	60	15	October, 12, 1973	still operating
11	6,000	60	46	October 12, 1973	still operating
12	6,000	60	5	November 16, 1973	still operating
OFFSHORE MOORINGS					
8	25,100	132	61	June 19, 1973	still operating
14	16,740	89	20	September 11, 1973	November 6, 1973
15	16,740	89	64	September 11, 1973	December 6, 1973

[1] Status as of May 15, 1974.

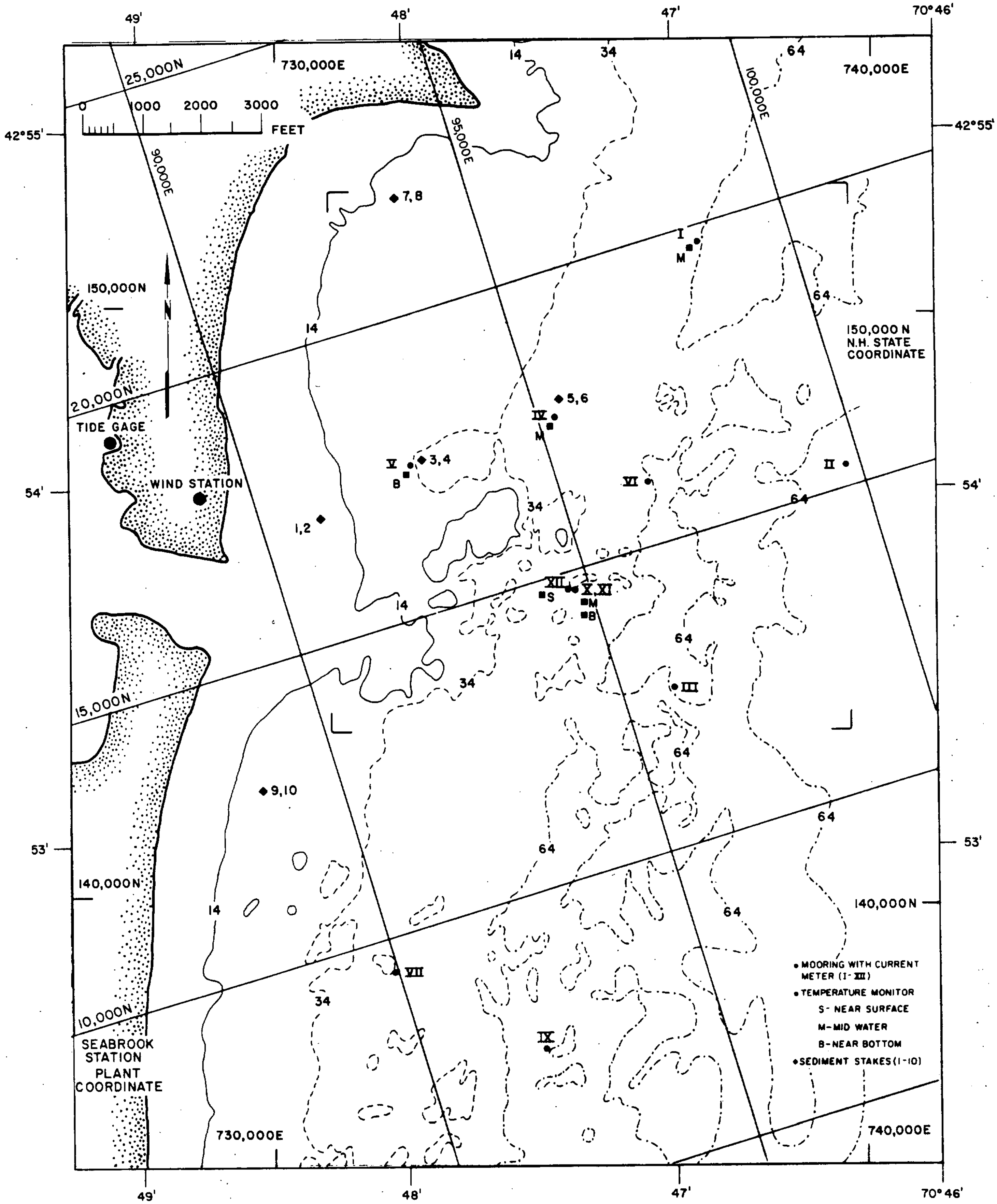


Figure 1: Location map of Normandeau Associates, Inc. moorings and temperature monitors off Hampton Beach, New Hampshire.

4. Hydrographic Profiling

   a. Slack Water surveys at high and low water from the estuary out into the offshore waters to measure profiles of temperature, conductivity, salinity, density, and dissolved oxygen at about 10 stations; surveys have been run bi-weekly since April, 1973.

   b. Offshore surveys monthly along transects out to 25 miles offshore to measure the same parameters as above at about 20 stations.

5. Anchor Stations

   Periodic 13 hour anchor stations in the study area since September, 1972 to measure profiles of water currents, temperature, conductivity, salinity, density, and dissolved oxygen; concurrently streamer observations are performed by divers and drogues are tracked during daylight hours.

6. Drifter Studies

   Since September, 1972 more than 2300 drift bottles and 2200 sea bed drifters have been released at numerous stations out to about 25 miles offshore in conjunction with the above studies in order to document long term net circulation patterns in the western Gulf of Maine.

The annual variation in hydrographic parameters at low water in the waters adjacent to the proposed intake is shown in Figure 2. This figure shows how temperature, salinity, density, and dissolved oxygen vary with depth and season from April, 1973 through April, 1974. These data show the pronounced thermal stratification which develops in late May and persists through late September. During the fall the water column is nearly isothermal but as the winter progresses the surface waters actually become colder than those at depth. Lowest salinities occur during the spring when fresh water runoff is greatest. Density values are somewhat variable but show the same general cycle of stratification during the year. Highest concentrations of dissolved oxygen occur during the spring when photosynthesis is most pronounced; resulting in supersaturated conditions up to about 120%. Lowest concentrations down to about 80% saturation occur during the summer and early fall.

A similar plot for the discharge site at high water is shown in Figure 3. The general pattern of the seasonal cycle is about the same as at the intake but shows somewhat less variability; especially in the density structure.

The current meter data obtained to date indicate that there are three main types of flow which can be categorized as follows:

1. Transient Currents - Tidal Effects

Interval when current meter vectors demonstrated periodic behavior in flow pattern such as flood and ebb reversals on a six-hour basis

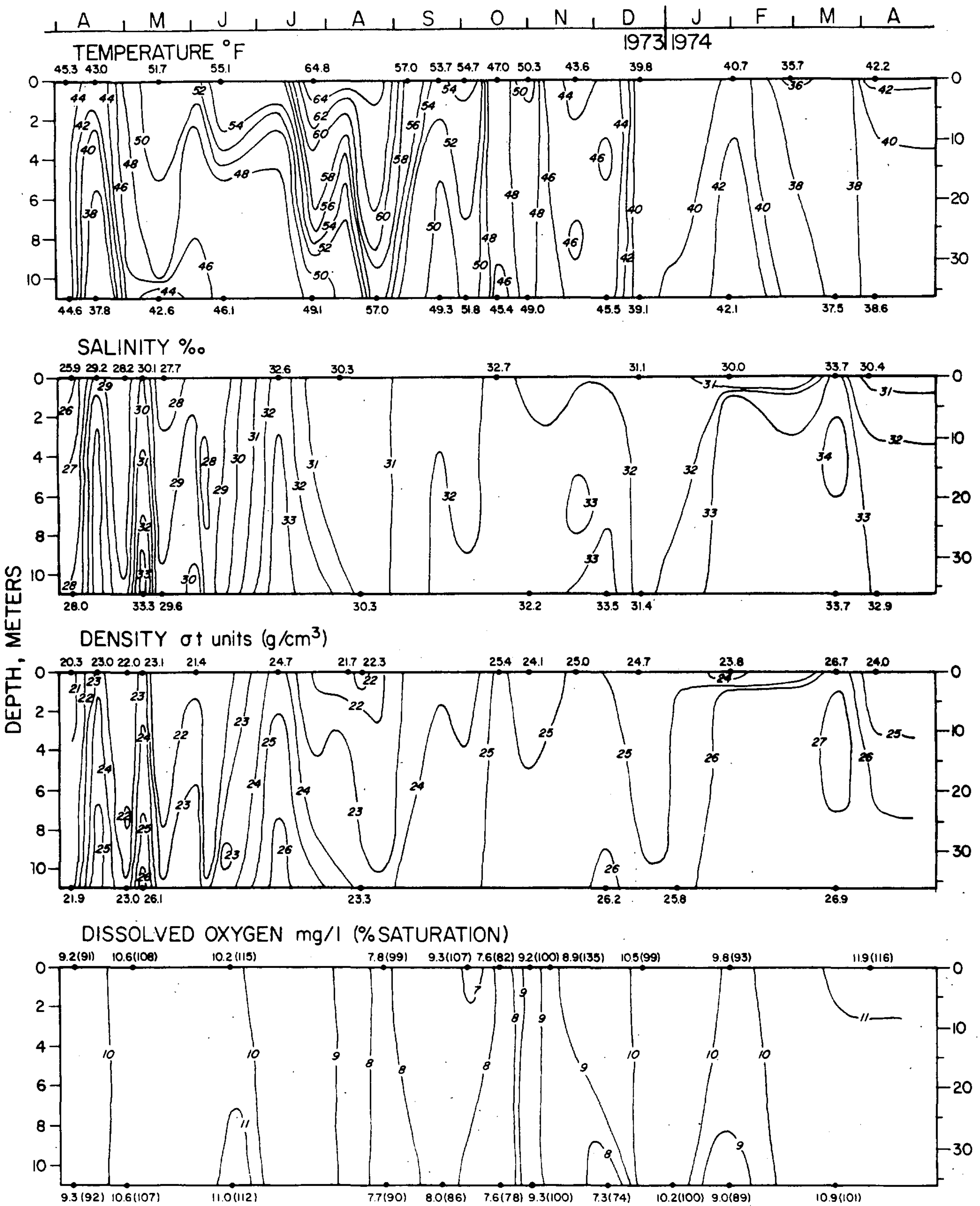


Figure 2: Annual variation in hydrographic parameters of the waters at the proposed intake site; all measurements made at low water at approximately 2 week intervals throughout the year.

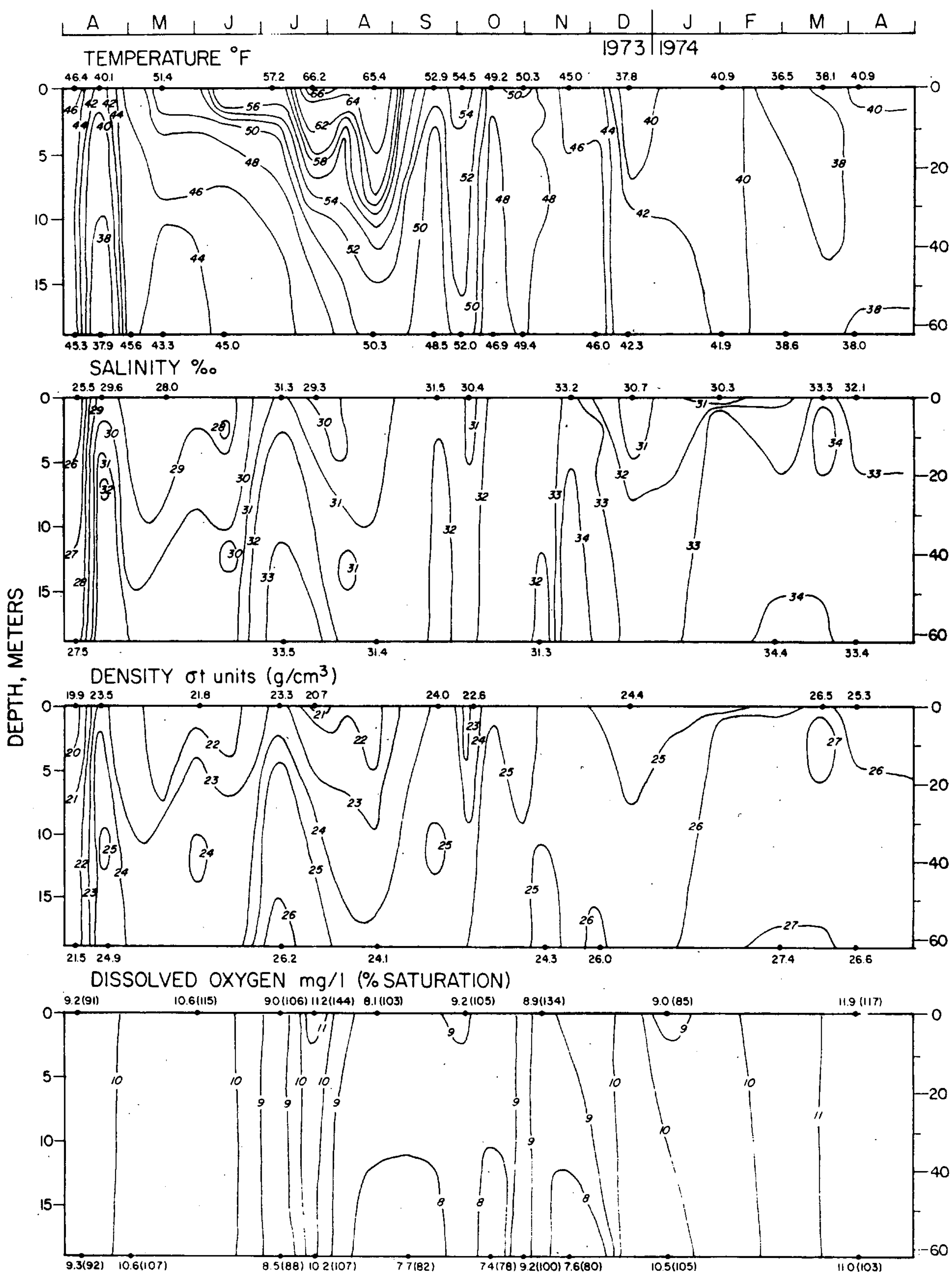


Figure 3: Annual variation in hydrographic parameters of the waters at the proposed discharge site; all measurements made at low water at approximately 2 week intervals throughout the year.

or a variable weak flow with some shifting of speed and direction. These were subdivided into:

a. Weak tidal flow - somewhat random flow with a tendency toward 180° reversal.

b. Reversing flood and ebb tidal currents - rhythmic periodic six-hour reversal of direction from a northward-flowing flood tidal current to a southward-flowing ebb tidal current and vice versa; generally accompanied by a short weakening or "slacking" of current speed as reversal occurred; on some days also demonstrated a more rotary character with little speed loss as direction changed.

2. Steady State Currents - Flow Toward the South

Interval when current meter vectors showed a sustained steady state flow along the coast toward the south. These were subdivided into:

a. Moderate flow (about 0.2 to 0.3 knots) slightly stronger than mean speeds.

b. Strong flow (greater than about 0.3 knots) much stronger than mean speeds.

3. Steady State Currents - Flow Toward the North

Interval where current meter vectors showed a sustained steady state flow along the coast toward the north. These were subdivided into:

a. Moderate flow (about 0.2 to 0.3 knots) slightly stronger than mean speeds.

b. Strong flow (greater than about 0.3 knots) much stronger than mean speeds.

In terms of actual current directions, it should be noted that the "flow toward the south" or "flow toward the north" categories are essentially the same as the ebb or flood portions of a reversing tidal flow respectively except they have persisted for a longer time as a steady state condition. Table 2 summarizes the number of days per month that each of these conditions occurred and the percentage frequency of each type of flow.

In view of the dominance of the tides on circulation in New Hampshire coastal waters, it is not surprising that 46.3% of the study days or nearly one-half of the year showed tidal effects. The next largest factor in coastal circulation is the effect of northeast storms which periodically lash the coast, causing strong shoreward drift of near surface waters and large waves, accounting for the 27.6% of days with flow toward the south or more than one-fourth of the year. About equally common is flow to the north which usually follows periods with strong winds from the south and southwest or after large northeasters as possible seiching from storm surges. This type of flow was observed about 25.9% of the time or one-fourth of the year.

Seasonal aspects of these flow patterns are clearly illustrated by means of rose diagrams. During the summer months tidal effects predominate in the absence of intense storms. The rose diagram for the period from April 30 to September 23, 1973 shown in Figure 4 illustrates these tidal flows which are periodically reinforced by southward flow during northeast storms. In marked contrast Figure 5 illustrates winter conditions from January 24 to April 29, 1973 and September 24, 1973 to January 20, 1974. During this period the northward and southward flows caused by coastal storms predominate.

TABLE 2. PERCENTAGE FREQUENCY OF OBSERVED TRANSIENT

AND STEADY STATE CURRENT TYPES; JANUARY 25, 1973 - JANUARY 31, 1974

MONTH	NO. OF DAYS	NUMBER OF DAYS PER MONTH: TRANSIENT FLOW, TIDAL EFFECTS: Weak Tidal Flow	Reversing Flood and Ebb Currents	STEADY STATE FLOW: FLOW TOWARD THE SOUTH: Moderate .2-.3 KTS	Strong >.3 KTS	FLOW TOWARD THE NORTH: Moderate .2-.3 KTS	Strong >.3 KTS
1973 January	7	2.0		3.0	2.0		
February	28	2.0	8.0	9.0	8.0	1.0	
March	31	8.0	6.0	3.5	10.0	3.5	
April	30	3.0	9.0	2.0	5.5	4.0	6.5
May	31	4.0	16.5	6.0	4.0	0.5	
June	30	6.0	12.0	5.5	4.0	2.5	
July	31	4.5	20.0	6.0		0.5	
August	31	4.5	13.0	9.0	3.0	1.5	
September	30	8.5	16.0		2.0	2.5	1.0
October	31	3.0	9.5	2.0	4.0	7.5	5.0
November	30	0.5	3.5	0.5		15.5	10.0
December	31	2.5	3.0	5.5	2.5	14.0	3.5
1974 January	31	4.0	3.5	2.5	3.5	14.5	3.0
Total	372	52.5	120.0	54.5	48.5	67.5	29.0
Percent		14.0	32.3	14.6	13.0	18.1	7.8
Percent by type		46.3		27.6		25.9	

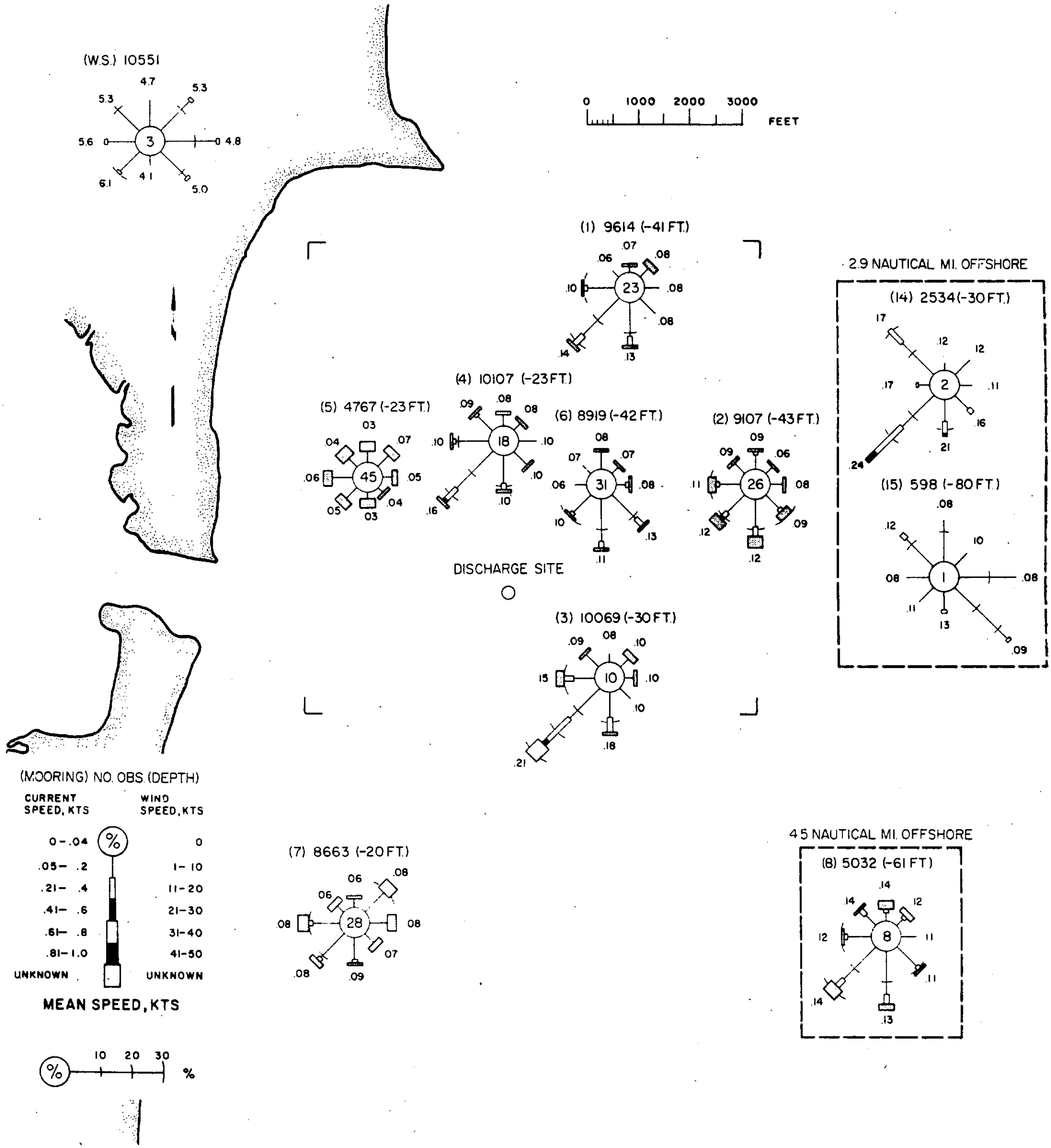


Figure 4: Rose diagrams of summer current conditions from April 30 to September 23, 1973 showing dominance of the tide.

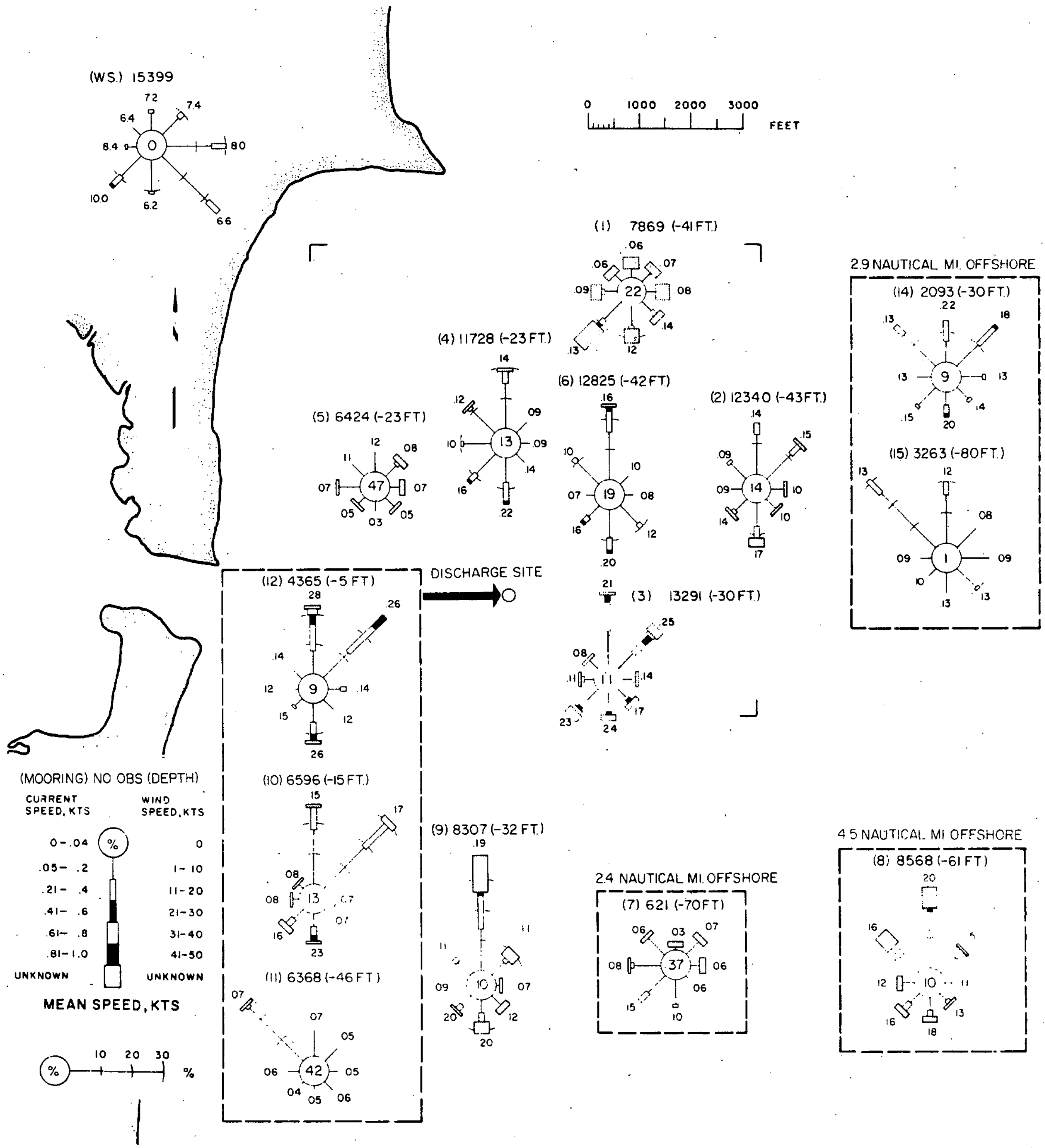


Figure 5: Rose diagrams of winter current conditions from January 24, to April 29, 1973 and September 24, 1973 to January 20, 1974 showing dominance of storms.

Table 3 is a tabulation of percentage frequency of current speed irrespective of current direction for the period from January 24, 1973 to January 20, 1974. These data show that about 27% of the flow is less than 0.04 knots, threshold speed of the current meters. Another 39% is from 0.05 to 0.12 knots and 18% from 0.13 to 0.2 knots. Thus 85% of the flow was less than 0.2 knots. Highest speeds were observed at moorings 3 and 6 and near the water surface where flows occasionally exceeded 1 knot, especially during northeast storms. The lowest percentage of slow speeds occurred near the bottom at mooring 5.

Table 4 is a tabulation of percentage frequency of observed current direction irrespective of speed for the period from January 24, 1973 to January 20, 1974. These data show the predominance of north and south flows with relatively little east or west component. Dominant directions are to the south and southwest which has also been documented by the results of the NAI drifter studies described elsewhere.

TABLE 3 . PERCENTAGE FREQUENCY OF CURRENT SPEED

IRRESPECTIVE OF CURRENT DIRECTION

JANUARY 24, 1973 - JANUARY 20, 1974

MOORING NUMBER	DEPTH BELOW MLW, FEET	TOTAL OBSERV-ATIONS	CURRENT SPEED, KNOTS						
			0-.04	.05-.12	.13-.2	.21-.4	.41-.6	.61-.8	.81-1.(
1	41	14,527	28.5	41.2	18.3	9.7	1.8	0.5	0.06
2	43	19,817	21.4	39.4	23.4	14.2	1.7	0.02	
3	30	21,525	13.4	29.9	22.2	25.4	7.3	1.6	0.3
4	23	21,244	16.0	42.1	25.1	14.3	2.3	0.2	TR
5	23	9,990	52.8	36.0	7.0	2.5	1.2	0.4	0.2
6	42	21,443	25.0	38.0	20.2	14.3	2.2	0.3	TR
7	20	8,034	33.3	48.1	14.9	3.7	0.05		
TOTAL		116,580							
MEAN PERCENT			27.2	39.2	18.7	12.0	2.4	0.5	0.2

MAY 1974

TABLE 4 . PERCENTAGE FREQUENCY OF OBSERVED CURRENT

DIRECTION IRRESPECTIVE OF SPEED

JANUARY 24, 1973 - JANUARY 20, 1974

DIRECTION CURRENT IS FLOWING TOWARD, DEGREES TRUE

MOORING NUMBER	DEPTH BELOW MLW, FEET	TOTAL OBSERV-ATIONS	N	NE	E	SE	S	SW	W	NW
1	41	17,483	7.8	8.8	9.1	11.4	16.8	25.2	13.2	7.6
2	43	21,447	16.6	14.7	7.8	10.4	18.0	13.7	9.9	8.9
3	30	23,360	18.3	15.9	6.6	7.4	12.4	22.2	9.1	7.9
4	23	21,835	14.7	6.7	5.4	7.3	16.1	20.7	14.2	15.0
5	23	11,191	13.6	17.2	11.2	11.9	13.0	10.8	12.9	11.8
6	42	21,742	21.3	7.1	5.6	15.3	19.4	12.2	6.7	12.4
7	20	9,284	6.4	17.3	12.3	8.4	11.4	17.9	18.3	8.1
TOTAL		126,342								
MEAN PERCENT			14.1	12.5	8.3	10.3	15.3	17.5	12.0	10.2

MAY 1974

SUPPLEMENTAL INFORMATION ON ARCHEOLOGICAL SITES

The applicant retained Charles E. Bolian, an archeologist and Professor on the staff of the University of New Hampshire, to perform an archeological Reconnaissance of the Seabrook Station Site. The report prepared by Dr. Bolian at the conclusion of his survey begins on Page S2-44. This report contains the answers to questions raised in the letter of November 15, 1973, from George W. Knighton to Charles E. Bolian.

Since Professor Bolian's survey, the applicant has found four other areas exhibiting similar characteristics to those found by Bolian which are on site but outside the construction-affected area. These are in addition to the known site on Hunt's Island. Carbon dating analysis was applied to shell samples removed from the not-to-be-disturbed sites (Sample B) and those identified by Bolian (Sample A). The results are tabulated below:

ISOTOPES Sample Number	Sample	$-\delta C^{14}$	Age in Years B.P.	Date
I-7723	Sample A	76 ± 9	635 ± 80	1315 A.D.
I-7724	Sample B	73 ± 9	610 ± 80	1340 A.D.

After discussions with Professor Bolian, it has been agreed that the applicant will fund a program planned and directed by the University to recover and package artifacts from area 3 and area 4. Items to be salvaged will be identified with a locating coordinate number and depth and packaged for storage offsite. Artifacts found become the property of the University. In addition to these arrangements, Professor Bolian is granted access to other areas of the site subject to usual safety precautions.

MAY 1974

REPORT

An Archaeological Survey of the Seabrook Site

Charles E. Bolian
University of New Hampshire

The following report is the result of an archaeological survey of the Public Service Company of New Hampshire Seabrook Site as described in PSNH letter SA-366 of 10/11/73. This survey was carried out during the period from 10/19/73 through 11/11/73.(See attached log for more exact details as to activities)

The archaeological survey consisted of a surface reconnaisance of the Seabrook Site and selected test excavations in areas considered to bear evidence of man's prehistoric and historic occupation of the site. This work was carried out with the assistance of members of the New Hampshire Archaeological Society, paid student labor(students with prior archaeological field experience) and volunteer student labor(students with no prior field experience).

Archaeological site locations are made in reference to the map, "Topography: Seabrook Nuclear Site, Seabrook, N.H." by McKenna Associates and approximate locations are indicated on the enclosed copy of the Seabrook Station Site Orientation Plan. Estimates of the sizes of the archaeological sites were made on the basis of controlled test excavations and probes. Because of the nature of the ground cover and the fact that culturally sterile soil covers much of the archaeological deposits, exact definition of site boundaries would have required time consuming, expensive excavations which were beyond the scope of this survey.

The Seabrook Nuclear Site was surveyed as intensively as possible in the amount of time that was available. However, it is possible that other archaeological sites exist at Seabrook and that they were not discovered during the course of this survey. Therefore, I would like to continue the survey during the spring at my own expense with volunteer labor so that we can be certain that all of the archaeological sites have been located.

DESCRIPTION OF THE SITES

Site 1

Archaeological site 1 is located along the southern margin of the area to be disturbed during the construction of the Seabrook Station. It is in the southern part of section 20,000N-20,400N X 79,500E-80,000E and adjacent to the scattered ledge outcrop. It extends into the western part of section 20,000N-20,400N X 80,000E-80,500E. The site is at least 100 meters long and varies from 5 to 25 meters in width.

Several probes were made to define the limits of this site and a 1 meter square test pit was excavated. Most of the site was covered with leaf mold and humus which contained no cultural materials. This was underlain by archaeological deposits up to 20 cm. thick. The archaeological deposits were primarily made up of tightly packed clam shells in a matrix of black, sandy soil. Abundant animal bone was also found in the test pit, giving additional information on the diet of the prehistoric inhabitants of Site 1. Tentative identification of the bone indicates that deer, birds and fish(species unknown) weere eaten in addition to shellfish.

Artifacts that were found include small fragments of pottery and fragments of projectile points. Based on comparisons with cultural remains from other parts of New England, the artifacts indicate that the site was probably occupied at A. D. 900 or later. This time estimate is tentative since the sample was very small and only small part of the midden was excavated.

Site 2

Archaeological site 2 is located south of the area to be disturbed. It is in the southern and central section of section 19,600N-20,000N X

79,000E-79,500E. Site 2 is approximately 70 meters long and 8 meters to 20 meters in width.

Probes were made to define the limits of the site and 3-1 meter square test pits were excavated into the site. In those areas that were tested, the archaeological deposits were overlain by 5 to 10 cm. of leaf mold and top soil which were culturally sterile except for remains of glass and shotgun shells which have been deposited on the site since the European occupation of the area. This was followed by 10 to 20 cm. of midden deposits which were primarily made up of tightly packed clam and mussel shells in a matrix of black sandy soil. Fragments of bone and pottery were found and are further indications of the prehistoric occupation of the site. A few chips of flint were found which were the refuse from the manufacturing of stone tools but no complete stone artifacts were found.

A tentative date of A. D. 900 or later is likely for this site. This date is based upon the comparison of the pottery recovered in the test excavations with pottery of known date from other parts of New England.

Site 3

Archaeological site 3 is located in the north central part of section 20,000N-20,400N X 79,500E-80,000E. The site is approximately 40 meters long and 30 meters wide. Numerous probes were conducted on site 3 as well as one test pit 1 meter square and another 1 meter by 2 meters. The test pits revealed a black, sandy midden soil with sparse shell deposits, bone, flint flakes from the manufacture of stone tools, pottery, a quartz scraper, and a projectile point of Levana or Madison type. A hearth was discovered in the 1 meter by 2 meter test pit along with burned stone.

The midden deposits were up to 25 cm. in depth over most of the site but the hearth extended to a depth of about 30 cm. Large amounts of charcoal were found in the hearth area and would be suitable for carbon 14 dating.

The artifacts discovered in site 3 indicate a late prehistoric occupation of this site, possibly as late as A. D. 1350. Site 3 has been disturbed in the recent past by drilling operations which have taken place. Trees have been uprooted which has disturbed the deposits and one large hole was dug which disturbed the western edge of the site.

Site 4

Archaeological site 4 is an historic site located in section 20,400N-20,800N X79,000E-79,500E and section 20,400N-20,800N X 79,500E-80,000E. It is also possible that this site has a prehistoric component consisting of shell midden but it was impossible to determine this in the amount of time available. The shell midden could possibly also relate to an early use of shellfish by settlers of European descent. A cellar hole is present and refuse can be expected in the surrounding area. Probes in the cellar hole yielded fragments of a brown glazed pottery from the historic time period.

Historic research will have to be undertaken by a qualified historian to determine the full importance of this site. A University of New Hampshire graduate Student of history who has had experience in historical archaeology will examine the site in the near future.

Site 5

Archaeological site 5 is a prehistoric site located in the southeastern part of section 20,000N-20,400N X 80,500E-81,000E and the southwestern part of 20,000N-20,400N X 81000E-81,500E. Site 5 is about 35 meters long by 20 meters wide. The archaeological deposits are present on the surface in some parts of site 5 and covered by 2 to 5 cm. of culturally sterile soil in others. Site 5 was investigated in my own spare time with volunteered labor since it is outside of the area that is supposed to be disturbed. It was investigated because it was reported to me that it is currently being disturbed. The report was correct. The area is suffering compaction, erosion and mixing as a result of vehicular traffic.

A 1 meter square test pit was excavated into site 5. It revealed cultural deposits up to 45 cm. deep. The upper 20-22 cm. consisted of midden deposits of very tightly packed clam and mussel shells. The lower part of the deposits were made up of midden soil with sparse clam and mussel shells. This second natural strata extended to a depth of 45 cm. below the ground surface. The earliest cultural materials had been deposited directly upon ledge outcrops.

Cultural materials from site 5 consisted of flakes from stone tool manufacturing, a probable gouge fragment and a ground stone gorget. Animal bone was also present in site 5.

Summary and Recommendations

Five archaeological sites are located at the PSNH Seabrook Station Site. Archaeological Sites 1 and 5 were known previously because of test excavations that had been undertaken by members of the New Hampshire Archaeological Society. The presence of these archaeological sites at Seabrook has been known for several years by some members of the New Hampshire Archaeological Society. The remainder were discovered as a result of an archaeological survey sponsored by the Public Service Company of New Hampshire. This survey consisted of a surface reconnaisance and test excavations. No publications have resulted from the excavations conducted by the members of the New Hampshire Archaeological Society or from the survey conducted by myself. A formal presentation of the data from the survey will probably be made to the New Hampshire Archaeological Society at its spring meeting. The only documentation to support the presence of these sites is this report.

These sites contain data which will add immensely to our knowledge about the history of New England in general, and of New Hampshire in particular regarding both the prehistoric Indians and the early European settlers. The artifacts recovered will reveal information about the technology in bone, stone and ceramics. The kinds of stone found will possibly also yield information on prehistoric trade networks. It is likely that information will be recovered which will reveal house patterns in particular sites. This information, combined with the distribution of artifacts in the sites should make interpretations possible concerning such differences as status and wealth in the prehistoric Indian societies of the coastal region.

Data from these sites will also help in understanding the prehistoric human ecology of the coastal region. Bone and shell are very well preserved in the sites tested. It is possible that plant remains also exist which will give information on what vegetable resources were exploited. From an ecological point of view, these kinds of remains should allow inferences as to exactly which parts of the environment were exploited, how intensively they were exploited and what time of year the sites were inhabited. There have been few sites excavated in New England in which the preservation of food remains was such that these kinds of interpretations could be made.

Site 4 which is the only historic site in the area to be disturbed will yield information of a different time period and a different culture, the culture of the early European migrants to New England. Site 4 is very small and probably represents the home of a common colonist as opposed to the political or business leaders. The common man is the one about whom we have the least information in the historical records. The excavation of site 4 should yield information which will aid in the understanding of the colonist in the early historic period in New England. Information should be recovered which will enable the archaeologist to determine how much the occupants of the house followed the way of life of their European homeland and how much they followed the example of the American Indians in their adaptation to the environment of Seabrook.

There have been no other archaeological investigations along the New Hampshire coast which have located sites similar to those at Seabrook. One location at the Edgerly Site, at Hampton Falls, appears to have had a similar prehistoric component but only test excavations were conducted. These have not been fully reported. The Edgerly Site is also scheduled for destruction. It is likely that many archaeological sites similar to those at Seabrook have been destroyed by modern development in the coastal area. The short length of the New Hampshire coast line and the extent of realestate development in the area precludes the possibility of many such sites existing at the present time.

Excavations that have been conducted in other areas of coastal New England indicate that there are differences in the subsistence systems of the prehistoric inhabitants of those areas and Seabrook. A preliminary identification of the faunal remains at the Seabrook sites indicates that its prehistoric inhabitants had a very narrow subsistence base, mainly soft clams and mussels. In areas such as Cape Cod, a wider variety of marine resources were exploited. The excavation of the archaeological sites at Seabrook should give the reasons for these differences. The reasons could be the result of environmental differences or cultural preferences.

Unexplored archaeological sites such as those at Seabrook can be protected in two ways. The first way is to prohibit construction of any facility which will destroy the archaeological sites. The second is conducting an archaeological salvage operation and allowing adequate time for archaeologists to recover the data that the archaeological sites contain before destruction. Although the first alternative is the ideal, it is often necessary to compromise and accept the second alternative as the most feasible. If the Public Service Company of New Hampshire is able to satisfactorily fulfill all of the other environmental requirements regarding the Seabrook Station and if the Public Service Company is willing to adequately fund an archaeological salvage project and to allow time for that project to be carried out, I do not believe that it would be logical to prevent the construction because of the archaeological sites. Under these conditions, I believe that the requirements of the National Environmental Policy Act of 1969(Public Law 91-190; 83 Stat. 852; 42 U.S.C. 4321-4347) will have been satisfied. This would mean that time and funds will have to be allowed for the excavation of sites 1, 3, and 4. If the disturbance of site 5 is to continue, funds and time will also have to be allocated for that site.

A program of salvage archaeology should be carried out at the above sites because of the valuable scientific data that they will yield concerning man's history and prehistory in coastal New Hampshire. The kinds of information that can be expected are outlined above. It must be emphasized that archaeological sites are a non-renewable resource and that once they are destroyed, the information that they contained is lost forever. We can not regard this information as simply the material objects recovered from excavations, but what these objects can tell us about the lifeways of historic and prehistoric peoples. Since no sites of a similar nature have been reported form coastal New England, it is imperative that they be excavated prior to construction of the Seabrook Station.

Excavation of the archaeological sites at Seabrook will take two summers of field work. It is doubtful that all of the archaeological materials at the affected sites could be salvaged in that period of time, but it should be possible to collect a representative sample of the cultural materials. In estimating a period of two summers to excavate the sites, I am assuming adequate financing for professional staff, supervisors and laborers as well as supplies and equipment. Under normal circumstances, a large sample of cultural materials would be collected over a period of many years with small crews of laborers. However, under circumstances such as these, in which archaeological sites will be destroyed, with no possibility for future excavations, it is necessary to operate with a large labor force and adequate supervisors in order to accomplish reasonable scientific goals. Through careful planning and cooperation it should be possible to conduct the archaeological excavations and cause minimal or no disruption to the construction schedule of the Seabrook Station.

The Department of Sociology-Anthropology of the University of New Hampshire has an interest in seeingthat the required research is conducted at the Seabrook site. As a part of the larger University community, the Department of Sociology-Anthropology is well equipped to manage such a project. The Department has the professional staff and facilities for such a project and the University accounting procedures guarantee fiscal responsibility. The Department is also in a position to recruit personnel from other departments who may be needed on a part time basis for such tasks as identifying plant and animal remains. It is possible that the History Department may also be able to cooperate in the excavation and analysis of data from site 4, the historical site. Because of its staff and facilities, the University of New Hampshire is the most logical agency within the state of New Hampshire to undertake this project.

The excavation of the archaeological sites at Seabrook will be given top priority for an archaeological salvage operation with excavations scheduled for the summers of 1974 and 1975. Some minor excavations could be undertaken during the late spring and early fall of these years in so long as it does not interfere with the normal academic duties of the professional staff and student laborers. If adequate notice is given regarding funding of the projected excavations, clearing, surveying, and setting up a grid system for the excavations could be accomplished prior to the summer of 1974 enabling excavation crews to begin work immediately upon the end of the regular academic year.

The New Hampshire Archaeological Society has also expressed an interest in archaeological research at the Seabrook site(see attached letter). The Society realised that its members are employed full time in various occupations and cannot be responsible for such a large project but they will assist in any way possible.

Charles E. Bolian

Charles E. Bolian

ACTIVITY LOG

10/19/73 General reconnaisance of Seabrook Station Site with members of the New Hampshire Archaeological Society. Discovery os Sites 1 and 5.

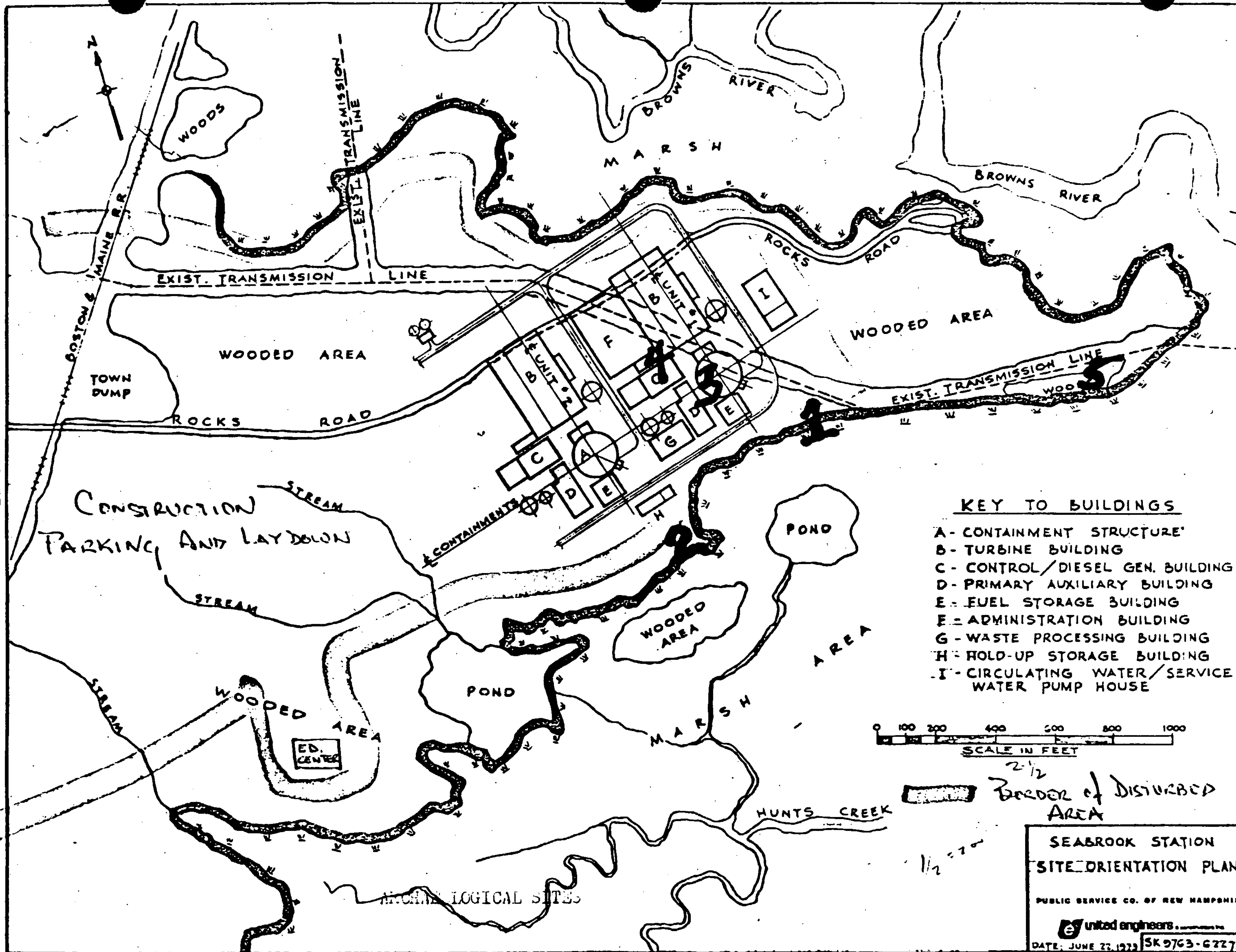
10/21/73 Test pit in site 1 and discovery of site 2.

11/3/73 Test pits(3) put into site 2. Site 3 discovered.

11/4/73 Finished test pits in site 2. First test pit excavated into site 3.

11/10/73 New Test pit excavated into site 3. Site 4 discovered and probed.

11/11/73 Test pit completed in site 3. Test pit excavated into site 5.



S2-57

MAY 1974

MAY 1974

THE NEW HAMPSHIRE ARCHEOLOGICAL SOCIETY, Inc.

Box 589
Center Harbor, NH 03226
Nov. 20, 1973

Prof. Charles Bolian
Department of Anthropology
University of New Hampshire
Durham, New Hampshire

Dear Charlie:

I am wondering what progress you may have made on your survey of the archeological resources in the area of the projected nuclear power plant in Seabrook.

If your results indicate a need for further investigation, which I suspect will be the case, I want you to know the N.H. Archeological Society stands ready to provide such labor as it can and such other support as it can give to your efforts.

Sincerely,

Howard

Howard R. Sargent
President

HRS:eas

MAY 1974

VITAE

Name: Charles E. Bolian

Address: 424 Social Science Center
Dept. of Sociology-Anthropology
Durham, N. H. 03824

Birth Date and Place: 6/6/38 New Orleans, Louisiana

Marital Status: Married, two children

Degrees: B. A., Ph. D candidate-expected spring 1974

Education: University of Mississippi 9/56-6/57(Engineering) No Degree
Tulane University(Night) 9/57-1/60(LAS) No degree
Mississippi State University 9/63-6/65(History) B. A.
University of Illinois(Urbana-Champaign) 9/65-6/71(Anthropology)
Ph.D. complete except for dissertation

Professional Experience:

Research Assistant(1965-1967)Illinois State Geological Survey

Teaching Assistant(1970) Dept. of Anthropology, U. of Illinois

Research Assistant(1971) Dept. of Anthropology, U. of Illinois

Instructor(1971-present) University of New Hampshire

Research Experience:

Precolombian Metallurgy of the Northern Andes

Archaeological Survey of the Trapecio of Amazonas(1968)

Archaeological Excavations on the Colombian Amazon(1970)

Land Utilization Among the Tikuna(Trapecio of Amazonas, Colombia)

Artistic Expression among the Tikuna(Trapecio of Amazonas, Colombia)

Archaeological Survey of Seabrook, New Hampshire

Membership in Professional Organizations:

American Association for the Advancement of Science

American Anthropological Association

Society for American Archaeology

Grants Received:

Department of Anthropology Summer Research Grant:University of Illinois(1968)

National Science Foundation Doctoral Dissertation Grant(1970-71)

Papers and Publications:

1969 Review of: ORFEBRERIA PREHISPANICA DE COLOMBIA: ESTILOS QUIMBAYA Y OTROS by Jose Perez de Barradas. AMERICAN ANTIQUITY, Vol. 34, no. 4.

1970 Nota sobre investigaciones preliminares en el Trapecio de Amazonas. Ms. submitted to the Instituto Colombiano de Antropologia.

1970 Similarities in the Precolombian Gold Styles of Colombia and Central America. Paper presented at the XXXIX Congreso Internacinal de Americanistas, Lima.

1971 Informe sobre investigaciones arqueologicas en el Trapecio de Amazonas, Colombia. Ms. submitted to the Instituto Colombiano de Antropologia.

1971 Manioc Cultivation in Periodically Flooded Areas. Paper presented at the 70th annual meeting of the American Anthropological Assn.

1972 On the use of Temper as a Criterion in Ceramic Analysis. Paper presented at the 37th annual meetings of the Society for American Archaeology.

1972 An Archaeological Survey of the Trapecio of Amazonas, Colombia. Paper presented at the 1972 Northeastern Anthropological Association Meetings.

1972Late Prehistoric Migrations in the Amazon Basin. Paper presented to the New Hampshire Archaeological Society.

1973 Finca Rivera: A Polychrome Site in the Trapecio of Amazonas, Colombia. Paper presented at the 38th annual Meetings of the Society for American Archaeology.

1973 Seriation of the Darien Style Anthropomorphic Figure. in Variation in Anthropology edited by Lathrap, D. and Douglas, J. Illinois Archaeological Survey: Urbana.

CHAPTER 3

Question 3.1 (Section 3.3) Provide estimates of consumptive use in (a) municipal water supply, (b) condenser and service water (including leakage).

Answer 3.1 Please see the Environmental Report, Volume I, Section 3.3, pages 3.3-1 and 3.3-2, (both revised as of June, 1973).

Question 3.2 (Section 3.4) The location, configuration and dimensions of the intake structure have not been provided. A choice of discharge design must be made before the environmental review can be completed. The applicant should submit results of multi-port diffuser studies on a timely basis after completion.

Answer 3.2 The location, configuration and dimensions of the ocean intake is provided in Figure 3.4-4. The preliminary arrangement of the intake structure (pump house) is shown in Figure 3.4-5 and 3.4-6.

A description of the hydrographic survey and hydro-thermal model studies is included in subsection 3.4.3 (pages 3.4-12 through 3.4-17). A choice of discharge design cannot be made until these studies are completed. As indicated, these studies will continue through 1973 and will terminate when an acceptable design is achieved. The results of the multi-port diffuser studies will be made available to the Atomic Energy Commission on a timely basis.

Question 3.3 (Section 3.5) Factual disagreement exists between these source term calculations and the assumptions standardized by DRL for gaseous wastes. This leads to an over-optimized radioiodine release in relation to the plant design and the equipment provided. The error is of the order of a factor of 50 and its acceptance would seriously discredit previous assessments of similar plants with significantly better engineered cleanup systems.

Specifically the applicant has assumed a radioiodine reduction factor of 100 for a charcoal adsorber while experience is that a factor of 10 or less is applicable.

In this plant the containment kidney filter is so small (4000 cfm) that it cannot afford a cleanup factor of more than 2 in 16 hrs and this is doubtful.

The auxiliary building has a charcoal filter on only 7000 cfm while a similar plant has nearly 100,000 cfm. The rest of the ventilation is untreated in this plant.

The turbine building has no treatment and while the applicant says he will operate the plant at a high steam generator blowdown rate (50 gpm) provided he experiences a 20 gpd steam generator leak, which would lower the release rate, experience will probably be that he will have a lower leak rate and therefore requisite blowdown should be specified.

Answer 3.3 The source term calculations for Seabrook were prepared using the best estimates available for source term assumptions considering the present state of the art. All engineered cleanup systems considered practicable, have been included at Seabrook. We have no knowledge of similar plants with significantly better cleanup systems. To speak of an error of a factor of 50 is misleading as it implies a greater degree of knowledge of source terms than currently exists. The survey of several PWR installations, which we understand to be underway, should shed some light on this somewhat confused area of evaluation.

An iodine removal efficiency of 99 percent for charcoal adsorbers on ventilation systems has been assumed. New systems typically have elemental iodine efficiencies of greater than 99.9 percent. It is expected that this efficiency will degrade with time. However, with conscientious maintenance of the filter system, the average efficiency for elemental iodine should be at least 99 percent. We have had no experience that shows that a decontamination factor of 10 or less is applicable.

The containment kidney filter was intended for long term cleanup of the containment atmosphere. No credit was taken for this system in the gaseous release calculations.

Those areas in the primary auxiliary building that contain equipment handling hot reactor coolant have been segregated and are exhausted through charcoal and HEPA filters. This segregation concept has been chosen rather than providing an extremely large filter system for processing the entire auxiliary building which contains many areas with very low potential for airborne contamination. The resulting small filter system will be more easily maintained and tested and should prove to be a more reliable system.

The blowdown rate from the steam generators depends on the feedwater solids content and on steam generator tube leakage. However, low levels of tube leakage have a minimum impact on blowdown. For example, the 20 gpd tube leakage assumption used in the source term analysis adds only 1 - 2 gpm to the required blowdown rate. It is not expected that the blowdown rate would ever be significantly below 50 gpm during normal operation.

Question 3.4 (Section 3.6) The chemical and biocide section is seriously lacking in detail, and only the chlorination process is discussed significantly. A complete summary of all other chemicals and industrial wastes in the plant effluent is necessary including dilution factors and water and air quality standards to be met.

Answer 3.4

Please see the Environmental Report, Volume I, Section 3.6, pages 3.6-2a and 3.6-2b (both revised as of June, 1973) for details of design of both the makeup demineralizer system and the blowdown system. No additional biocide systems other than that described for chlorination are being contemplated.

A complete description of the chemical and industrial wastes is included in Section 3.6. The dilution quantities are as shown in Section 3.3 (Plant Water Use) and the resulting discharge concentrations are provided in Section 5.4. Section 5.4 also compares discharge concentrations with known water quality standards or discharge criteria. Section 5.5 compares gaseous discharges with applicable Federal and State standards.

CHAPTER 4

Question 4.1 (Section 4.1) The amount of dry land, marsh land and harbor bottom that will be disturbed by construction of the cooling water system should be indicated. An estimate of the flora and fauna destroyed and the effects of higher turbidity levels on biota adjacent to the construction area should also be provided. The applicant should present evidence, if available, (e.g., from other projects of this nature) to support the contention that disturbed marsh and tidal areas will naturally revert to their preconstruction status.

Water Use: Disposal areas should be identified and their use discussed. Dewatering effects of plant and pipelines on groundwater should be discussed. Any potential for saltwater intrusion should be discussed. In general the biological surveys (terrestrial) are adequate. However, the following should be provided for the site:

a. Vegetation map
b. Figures showing temporary and permanent facilities in relation to site conditions, vegetation, and other significant features of the area.
c. Concise estimates of acreages requiring clearing, quantities of earthwork, and borrow areas.
d. Quantitative estimates of sound levels, emissions from construction equipment, and particulate emissions such as from a concrete batch plant.
e. Dredging should be more thoroughly described with especial attention to time-periods involved, season it is to be done, amounts of material moved, etc. Some of the Phase III studies should be completed and allow firmer statements regarding methods and effects.

Answer 4.1 No disturbance will occur on the marsh land and harbor bottom because of the circulating water system construction. However, a minimal amount of land disturbance will occur at the plant site while the pumphouse and the two (2) tunnel shafts are being installed. These items plus the use of land during the tunnel construction will require about ten (10) acres.

Excavated material from the tunnels will be disposed of either on or off the plant site and will be done in such a manner as not to present any environmental concerns.

The groundwater effects of dewatering and potential salt water intrusion may be evaluated by reviewing Section 2.2 and subsection 2.5.2.

Appendix I discusses ground clearing and vegetation and relates to permanent facilities and site conditions. Present estimates indicate that a total of 165,000 cubic yards of overburden and 185,000 cubic yards of rock will be excavated.

Sound level emission from construction cannot be determined at this time, however, limits as prescribed in the Occupational Safety and Health Act of 1970 will be adhered to. Particulate emissions will be controlled by the Laws and Regulations Governing the Control of Air Pollution as set forth by the New Hampshire Air Pollution Control Agency.

The only dredging anticipated at this time will take place offshore during the excavation of the diffuser. This work will be done under permit of a governing agency and will be done in accordance with their regulations. This work is located about 5,000 feet offshore and no threat to the recreational use of the area is expected. No limits involving time periods are attached to this work. It may be done in any season.

Studies are still underway to determine design features of the diffuser but the excavated material is estimated to amount to 10,000 cubic yards. Depending on the type of material and conditions of the permit, disposal can be used to replenish Hampton Beach, hauled to designated dumping areas at sea or allowed to be spoiled, under permit conditions, near the diffuser zone.

Question 4.2 (Section 4.1) The following should be submitted for transmission facilities:

a. Concise estimates of total line length, lengths of access roads, number of towers, ruling spans, etc., are lacking in this section. These are covered in part under alternatives, but should be related to construction impacts.

b. Concise vegetation map, land use map, or other information specifying land usage along the routes, except for expression of percent forested and percent open or field lands is needed.

c. Transmission line effects of passage through the marsh and Cedar Swamp and the methods involved in ameliorating them should be more fully treated.

Answer 4.2 This information will be provided in a subsequent amendment to the Environmental Report.

Question 4.3 (Section 4.3) Ground water use should be acknowledge.

Answer 4.3 Please see the Environmental Report, Volume I, Section 4.3, pages 4.3-1, 4.3-2 and 4.3-3 (all revised as of June, 1973).

CHAPTER 5

Question 5.1 (Section 5.1)

A fuller description of the discharge especially with multi-port diffusers is necessary. In general, the physical data is insufficient for this area. It is obvious that entrained organisms will be subjected to rather large mechanical (Pressure) changes, but these are not mentioned. The traveling screen system which will transport the fish back to the ocean should be described.

The following should be provided for the site:

a. An assessment of operational impacts of the nuclear plant in terms of aesthetic impact, noise, and relationships of wildlife adaption to restructured vegetation types and increased human activities associated with plant operation.

Answer 5.1

Please see the Environmental Report, Volume II, Section 5.1, pages 5.1-8 through 5.1-15, 5.1-18, 5.1-24 and 5.1-25 (all revised as of June, 1973).

Question 5.2 (Section 5.1)

The following should be provided for transmission facilities:

a. Considerations of continuing aesthetic impacts -- these should conform approximately to construction effects.
b. Considerations of operational hazards such as:
    1. Coronal ozone production and
    2. Interference with avain species.
c. Plans to restrict access by motorcyclists, 4-wheel drive afficionnados, etc., to areas along transmission rights-of-way having unique potential as natural areas, high erosion potential, or other significant features.
d. Plans for monitoring for potential erosion, or siltation problems along transmission corridors and access roads.

Answer 5.2 — This information will be provided in a subsequent amendment to the Environmental Report.

Question 5.3 (Section 5.1) — Recirculation potential is not discussed.

Answer 5.3 — Please see the Environmental Report, Volume II, Section 5.1, pages 5.1-22 and 5.1-23 (all revised as of June, 1973).

Question 5.4 (Section 5.2)

a. In calculating doses from liquid effluents to terrestrial fauna, via aquatic vegetation consumption, justify the assumption of an annual average dilution factor of 500.

b. Show the reference or calculational model for iodine dose factors tabulated in Tables 5.2-9 and 5.2-10.

Answer 5.4

a. Please see the Environmental Report, Volume II, Section 5.2, page 5.2-5 (revised as of June, 1973).

b. Please see the Environmental Report, Volume II, Section 5.2, page 5.2-11a and Tables 5.2-9 and 5.2-10 (all revised as of June, 1973).

Question 5.5 (Section 5.3)

a. Show the mathematical models for total body and significant organ doses from all external and internal exposures listed in Table 5.3-2.

b. Were thyroid dose calculations based on the dose conversion factor of 0.13 mrem/yr per pCi/m^3 shown on the list on page 5.3-15, or on 13.0 mrem/yr per pCi/m^3 as the Draft Environmental Statement - As Low as Practicable (DESALAP) Appendix C lists it. What dose model was used for all pathways to the thyroid. Provide an appendix for these calculations as well as those required by questions concerned with Section 5.2.

c. A more complete reference to the x/Q values used should be provided.

Answer 5.5

a. The mathematical models for each exposure pathway are described below. The following list of terms will serve the expressions presented:

Symbol	Term Description	Units
i	Radionuclide Designation	-
n	Number of Radionuclides in Seabrook Liquid Discharges	-
D	Dose	mRem/year
IDCF	Immersion Dose Conversion Factor	mRem/year per uCi/ml
Ts	Swimmer Immersion	hours/year
DF	Radionuclide Dilution Factor between Discharge Point and Point of Interest	-
AD	Areal Radionuclide Density for Clam Flats	pCi/m^2
SCF	Sediment Dose Conversion Factor	mRem/hr per pCi/m^2
T_{CD}	Clam Digger Occupancy	hours/years
BCF	Biological Concentration Factor	uCi/gm per uCi/ml
CR	Marine Biota Consumption Rate	gm/day
DCF_{WB}	Whole Body Dose Conversion Factor	mRem/year per uCi/ml
$MPC_{W,1}$	ICRP 168 hr. wk. Maximum Permissible Concentration in Water	uCi/ml
DCF_{CD}	Critical Organ Dose Conversion Factor	mRem/year per uCi/ml
$MPC_{W,2}$	10CFR20 Table II, Col. 2 Maximum Permissible Concentration in Water	uCi/ml

1. Calculation of External Radiation Exposures

a. Swimming

The dose is given by:

$$D = \sum_{i=1}^{n} \frac{(DC)_i \; (IDCF)_i \; (Ts)}{(DF) \; (8760 \text{ hours/year})}$$

DC_i is given in ER Table 3.5-5.
$IDCF_i$ is given in ER Table 5.2-5.
Ts and DF are as assumed on page 5.3-10.

b. Clam Digging

This dose calculation is based on the amount of radioactivity deposited on the clam flats. This amount is calculated by the expression appearing on ER page 5.2-8 divided by the dilution factor between the discharge point and the clam flats - 500.

This amount of activity (A_i) distributed over the clam flat area gives the areal radionuclide density, AD_i.

The dose is then given by:

$$D = \sum_{i=1}^{n} (AD)_i \; (SCF)_i \; (T_{CD})$$

$(SCF)_i$ is given for both skin and whole body exposures in Table III-34 of "HERMES - A Digital Computer Code for Estimating Regional Radiological Effects from the Nuclear Power Industry" HEDL - TME - 71-168, December, 1971.

T_{CD} is as assumed on ER page 5.3-11.

2. Calculation of Internal Radiation Exposures

The dose assessments performed for the consumption of finfish, shell fish, and marine plants were calculated as follows:

a. Whole Body Dose,

$$D = \sum_{i=1}^{n} \frac{(DC)_i \ (BCF)_i \ (CR) \ (DCF)_{WB,i}}{(DF) \ (2200 \text{ gm/day})}$$

$$(DCF)_{WB,i} = \frac{5000 \text{ mRem/year}}{(MPC_{W,1})_i}$$

Values for the remaining parameters are as specified or referenced in ER pages 5.3-6 through 5.3-10.

b. Critical Organ Doses,

$$D = \sum_{i=1}^{n} \frac{(DC)_i \ (BCF)_i \ (CR) \ (DCF)_{CO,i}}{(DF) \ (2200 \text{ gm/day})}$$

$(DCF)_{CO,i}$ is derived as follows:

Bone - all isotopes except Sr-89, Sr-90

$$(DCF)_{bone,i} = \frac{30{,}000 \text{ mRem/year}}{(MPC_{W,1})_i}$$

Bone - Sr-89, Sr-90

$$(DCF)_{bone,i} = \frac{500 \text{ mRem/year}}{(MPC_{W,2})_i}$$

Thyroid (Adult)

$$(DCF)_{thyroid,i} = \frac{30{,}000 \text{ mRem/year}}{(MPC_{W,1})_i}$$

G.I. Tract - all isotopes

$$(DCF)_{G.I.,i} = \frac{15,000 \text{ mRem/year}}{(MPC_{W,1})_i}$$

b. The thyroid dose conversion factor used for the air inhalation calculations was 13 mRem/yr per pCi/m^3, not 0.13.

c. The χ/Q values used are given in subsection 5.3.3.B and are based on the meteorology discussed in subsection 2.6.6.

CHAPTER 6

Question 6.1 (Section 6.1)

a. Explain the omission, from the environmental monitoring program, of soil and meat (small game) samples.

b. Describe the action that will be taken to activate the three close-in area monitoring samplers used for atmospheric monitoring if there is no access to year round availability of power. (Refer to subsection 6.1.5.1).

Answer 6.1

a. Please see the Environmental Report, Volume II, Section 6.1, pages 6.1-39 through 6.1-47 and Tables 6.1-4, 6.1-5, 6.1-6, 6.1-7, 6.1-13, 6.1-14 and 6.1-15 (all revised as of June, 1973)

b. Consideration of year round access and availability of power at the three closest air monitoring locations A1.4- Farm Dock, A1.6- Dow's Lane and A1.7- Brimer's Lane were factors in their selection. Thus, these sites can be reached in inclement weather and are each located near a source of power with which to operate sample pumps.

Questions 6.2 (Section 6.2)

a. In accordance with Regulatory Policy, milk samples should be analyzed for I-131 on a weekly basis. The operational radiological environmental monitoring program should, therefore, be adjusted (Table 6.2-2) to allow for this sampling frequency in lieu of the monthly criterion.

b. The applicant noted that he will analyze for SR-89 and 90 only if Cs-137 is detected in a sample related to the station's operations. The staff requires that SR-89 and 90 analysis be made of all samples of concern, as described in Table 6.2-1, whether or not Cs-137 is detected in a sample.

Answer 6.2

a. Please see the Environmental Report, Volume II, Section 6.2, pages 6.2-6 and 6.2-6a and Table 6.2-1 (all revised as of June, 1973).

b. Please see the Environmental Report, Volume II, Section 6.2, pages 6.2-4, 6.2-5, 6.2-6, 6.2-6a, 6.2-7, 6.2-8 and Table 6.2-1 (all revised as of June, 1973).

Question 6.3 (Section 6.2)

The applicant should provide the accuracy of the ΔT measurements.

Answer 6.3

Please see the Environmental Report, Volume II, Section 6.2, pages 6.1-29 and 6.1-29a (both revised as of June, 1973).

CHAPTER 9

Question 9.1 (Section 9.2) More detailed information needs to be drawn out on the principal site alternatives, to allow the reader to arrive at the same conclusions. Also, there is inadequate detail provided to allow following of the nuclear vs. fossil plant comparison.

Answer 9.1 Please see the Environmental Report, Volume II, Section 9.2, pages 9.2-10 through 9.2-39 and Figures 9.2-8 and 9.2-10 through 9.2-21 (all revised as of June, 1973).

Salt deposition calculations do not seem appropriate to Chapter 9. They are discussed in 10.1 and references 3 and 4 of that section discuss the salt deposition calculations and effects of deposition.

Discussion of reduced-impact design is covered in Chapter 10 in accordance with Regulatory Guide 4.2.

Social impact discussions are not required by Regulatory Guide 4.2 for alternative sites. The plant economics have been discussed wherein differences are significant, such as long transmission lines.

The study which demonstrated that nuclear energy should be used to supply base-load demands was documented in "Interconnected New England Generation Study" prepared by the Generation Task Force of NEPOOL in May 1971 for the New England Planning Committee. The findings of that detailed study were reconfirmed by Public Service Company in the spring of 1972. Public Service Company findings have been presented and cross-examined in the New Hampshire Site Evaluation Hearing. The information in Table 9.1-1 is a summary of the information from these computer studies.

Factors that are considered in the generation studies are values year by year of: Plant availability, scheduled maintenance period duration, fixed charge rates, energy costs, and operation and maintenance costs. The computer dispatches the generation under study (fossil, nuclear or mixed) against the hourly load requirements of the system. From this are computed the plant factor and total annual cost for the system. Separate runs are made for each generation mix and the annual costs of each option are compared to determine the preferred energy source.

It should be noted that even if the fossil costs appeared to be less than the nuclear costs, which they are not, the company might still choose the nuclear route for reasons of fuel supply security, balance of payment considerations and to achieve reduced environmental impacts.

Question 9.2 (Section 9.2) The evaluation of the coal alternative should include consideration of stack gas treatment. The applicant's assessment is predicted on how sulfur coal; high sulfur fuel with stack gas treatment by 1980 will be a viable alternative of this.

Answer 9.2 The use of high-sulfur coal, which is readily available in the east for use with stack gas treatment has been considered by the Applicant, but found to be unsuitable. The lack of an effective method for treating the stack gases for sulfur removal that can reliably meet existing air pollution regulations for new sources has not been proven commercially feasible at this time. The recent court decision in the case of <u>Commonwealth of Pennsylvania v. Pennsylvania Power Company</u>[1] verbalizes and affirms this view. In its opinion the court states, in part:

> "The present state of technology relative to the control of sulfur dioxide emissions by the use of devices or processes for removal thereof from flue gases remains theoretical. No device is commercially available today,

[1] In the Court of Common Pleas of Lawrence County, Pennsylvania No. 2 of 1972 in Equity, April 19, 1973

> as distinguished from technique or theory, with an adequate degree of reliability to solve the problems of sulfur dioxide control ..."

Even if such a process were proven to be commercially available in the next 3 to 5 years, the Applicant does not feel that this would be soon enough to be utilized to meet the generation needs of 1979 and 1981. These needs must be planned for with a proven technology. In addition, the economics of stack gas treatment for sulfur removal are not very favorable when compared to a nuclear or even an oil energy source. Present cost and performance estimates, which must be considered very preliminary since they are based upon small scale test facilities, project an added capital cost of 50 to 75 dollars per KW_e. These costs, as well as other environmental costs associated with the use of coal, are greater than the cost of an oil-fired plant and would increase the overall advantages of the proposed nuclear facilities.

For these reasons the Applicant considers the use of high-sulfur coal with stack gas treatment to be technically unsuitable, economically impractical and environmentally unsound to meet the power generation needs in the next decade.